Evaluation of effects of agri-environmental measures on rangeland degradation in two less favoured areas in Portugal

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Chapter 1

Introduction

1 Introduction

1.1 The problem

In 1986 Portugal became member of the EU. Since then a number of programs and measures have supported agriculture in less favoured areas. The effect of these measures on the desertification of rangelands is unknown.

By providing incentives for specific agricultural and forestry practices, agri-environmental measures (AEM) within the Common Agricultural Policy (CAP) have influenced the use and desertification of rangelands. AEM support environmentally friendly practices (e.g. maintenance of pastoral farming, or reduced input use and animal stocking densities) which were somehow discouraged in the past by CAP price support policies. The CAP 2003 reform represented a movement from a sectorial to a spatial policy reinforced in the framework of the most recent reform (Mantino, 2011). However, the impacts of such policies are difficult to evaluate because landscapes are complex and the effects of policy are rarely immediate or causal (Onate et al., 2000). This certainly applies to the impacts of measures targeting soil conservation which by the nature of soil biophysical processes tend to be slower and not spatially confined.

Some AEM support the delivery of ecosystem services related with soil conservation. The ecosystem function approach has been widely used in ecological economics to value ecosystems goods and services (de Groot, 2006; Turner and Daily, 2008). Since many of the indirect services are by their nature not confined chronologically nor geographically, a correct impact assessment should also consider their temporal and spatial distribution. However conventional economic analyses do neither consider the multiservice dimension of agro-ecosystems nor the multiple time and spatial scales at which the impacts of policies are produced (Brouwer and Lowe, 2000; EFTEC, 2005).

So far soil conservation measures have been delivering rather unsatisfactory results (Kutter et al., 2011). The research undertaken by Prager et al. (2011) supports that the best approach for tackling soil degradation is a policy mix with regulatory instruments enforcing a minimum standard, complemented with locally adapted agri-environmental schemes and enhanced by advisory measures.

This thesis aims to assess the impact of some selected agro-environmental policies on agro-ecosystem goods and services and land degradation of rangelands at the farm and regional levels.

1.2 Land use changes

In many areas of Europe's countryside the use of land for agriculture has been decreasing in favour of forest and shrub lands (Daveau, 1995 ; Serra et al., 2008; Geri et al., 2010). Socioeconomic drivers such as agricultural technology, demography, and policies have imprinted different land use changes. Such drivers acted upon a diversity of farming systems, which in Central and South Portugal, the focus area of this thesis, have favoured self-provision and rent maximization strategies, respectively (Baptista, 1993; Caldas, 1998; Moreira et al., 2001).

The intensification of some farming systems occurs simultaneously with the reduction and ultimate abandonment of others, influencing their delivery of environmental benefits (Fleskens and de Graaff, 2010). The abandonment of agricultural land leads to poorly managed forest areas (Van Doorn and Bakker, 2007), and is a major concern in desertification prone areas (Kosmas et al., 2014a). The trend on the abandonment of agricultural land has in Portugal also favoured the expansion of intensive livestock production at the expense of other more suitable land uses such as agro-forestry (Pinto-Correia, 1993). Both processes are in biophysical terms contributing to the ongoing desertification (Pereira et al., 2006).

1.3 Desertification

A large part of the Western Mediterranean Europe is characterised by rather dry and hilly conditions, and hence subject to various forms of land degradation, also referred to as desertification (UNCCD, 1994). Climatic and human-induced factors contribute to desertification, but the process has been magnified by agriculture malpractices (Puigdefabregas and Mendizabal, 1998). In consequence of agricultural abandonment on the one hand, and agricultural intensification on the other hand, rangelands are at the crossroads of resource management (Asner et al., 2004). Rangelands are the largest land use in the Mediterranean area (128 Mha) where drylands occupy a large share (47.5%) (Zdruli, 2014). Intensification of low-input management is giving space to more intensive pasture renewal, overstocking (Lorent et al., 2009), and abandonment of more marginal areas with woody plant encroachment (Beaufoy et al., 1994; Moreira et al., 2011). This has resulted in more erosion and fire risk. In fact according to the United Nations Global Assessment of Soil Degradation (GLASOD) 35% of the pasture land in Europe was in 1990 already affected by human-induced soil degradation particularly in dryland rangelands (Oldeman, 1992).

Most low-intensity farming systems operate in marginal agricultural areas, where yields are considerably sub-optimal (Rabbinge and van Diepen, 2000). Yet they foster a high potential for ecosystem services provision, making a more efficient use of on-farm resources and closed nutrient cycles than high input farming (Poux, 2007). In the context of a rising demand for improved policy delivery (Reed et al., 2014) such performance features might constitute an opportunity for these systems. In fact, Portugal has the highest share of degraded land among Mediterranean European Union (EU) countries with 16 % of the available land severely affected by human-induced degradation (ISRIC/FAO, 1990; MEDACTION, 2004). Rosario (2004) showed that not less than 36 % of the country area is prone to desertification.

Forest and pastoral land use cause less soil loss than agricultural land use (Pimentel, 2006). While their increase can be beneficial, inadequate management practices can jeopardize investment as a consequence of new species distribution or increased fire risk, currently exacerbated by the warming trend associated with climate change (Pereira et al., 2007). Shakesby and Coelho (2002) claim that the protective effect of the arable land and oak forest combination, known as “montado”, and which is traditional in southern Portugal is strongly dependent on land management practices. Kosmas et al. (1997) already showed the importance of land management on the soil-protection qualities of some permanent crops; for instance, olive trees with understory vegetation ranked higher in soil protection than vines and Eucalyptus forest. And Roxo (1994) documented already the extent of erosion problems in the Alentejo region due to intensive tillage and grazing.

1.4 EU policy development

In Portugal, as in other countries in the European Union, small farmers in dry and mountainous zones have since the 1960s lost the competition with large scale mechanized farms. In order to try to stop or even reverse such trend the EU has earmarked so-called Less-favoured Areas (LFA) and Agri-environmental Measures (AEM) in its policy framework for special assistance. Most of the northern part of Portugal falls under Article 32(a) of Regulation (EC) 1305/2013: Mountain areas, and most of southern Portugal falls under Article 32(b) of the same regulation: other areas facing significant natural constraints (EU, 2013). Altogether more than 50% of Portugal's agricultural area falls into LFA (Agro.Ges, 2009). Although the less favoured area (LFA) designation has now been re-labelled as area facing natural constraint (ANC), we will hereafter hold to the first designation.

Incentives-based instruments were introduced by the EU Common Agricultural Policy (CAP) in 1985 under Article 19 of the Reg. (EC) 797/85 for farmers who voluntarily adopted agricultural practices favouring nature/countryside conservation (Baldock and Lowe, 1996; Facchini, 1999). Such instruments are voluntary for farmers. In the context of abandoned farmland and increasing shrub land vulnerable to forest fires, the conservation of permanent grassland and extensive livestock grazing supported by some AEM could have the dual advantage of reducing forest fire and erosion hazards and retaining a source of income for farmers. The question to investigate is to what extent they have played that role up to now in LFA.

Since the Agenda 2000, AEM were integrated in the CAP Pillar 2. During the recent public debate on CAP reform launched by the European Commission, many stakeholders agreed that policy should deliver diversified farming systems and public goods across Europe, particularly in marginal areas. Taking all sides into consideration, a new CAP should secure food provision while safeguarding the resources and providing a harmonised territorial development (GPP, 2011). This will involve a reinforcement of the rural development pillar (CAP pillar 2), under which the AEM fall, a "greening" of the direct income support for farmers (CAP pillar 1), or both. In any case a better linkage of the payments with the delivery of public goods will be required, which could be achieved by improved spatial targeting of the measures and by ensuring that the most environmentally friendly forms of farming are supported (EC, 2013).

1.5 Research questions

For the impact assessment of the agro-environmental policies, as main objective of this research project, four research questions have been formulated. And two research sites have been selected in two different less favoured areas in Portugal.

1) What land use changes have occurred in the past 20 years and what implications did those changes have for land degradation and conservation?

2) How have the farming systems developed during that period and what has been their contribution to sustainable land management?

3) What have been the physical and financial effects of past AEM policies supporting permanent pastures and extensive livestock production?

4) What will be the future effects of alternative policy measures regarding pasture and extensive livestock development on production and on the environment?

1.6 Evaluation framework

Several evaluations of AEM have been conducted in Portugal (Pinto-Correia, 2000; Rodrigo and Veiga, 2008; Agro.Ges, 2009). Those evaluations focus on the extent of farmers' participation or "uptake" (number of beneficiaries, and area under agreement) as indicator of policy performance. Primdahl et al. (2003; 2010) refer to policy performance and Moxey et al. (1998) to policy outputs, as the effects of policy on farming practices and the first step for the appraisal of AEM effectiveness. In this thesis this type of analysis is also considered as the first step in the evaluation of policy measures. So far, the effects of policy implementation have been documented for measures with a territorial base of implementation (Moreira, 1999; Marta-Pedroso et al., 2007). These evaluations suggest that AEM have been more effective as income support for farmers than as effective conservation of the countryside. Such a conclusion is not exclusive to Portugal (see for example Hodge and Reader, 2010; Parissaki et al., 2012).

The second step in the evaluation of policy measures would be to focus on the physical impact of the AEM on the environment, and this could then be followed by translating the physical effects into financial and economic effects (Figure 1.1).

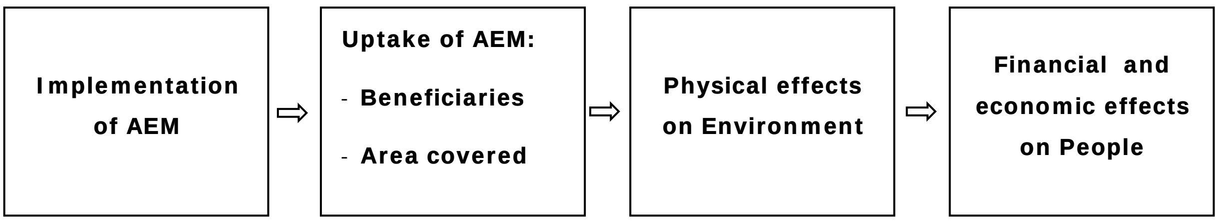

Figure 1.1 Evaluation framework

Among the diversity of AEM, some have the objective to support the preservation and improvement of permanent grasslands. Conventionally in Portugal farmers re-sow pastures to obtain more palatable swards (Belo et al., 2007), constituting a form of ley farming. Sometimes fire is also used to eliminate shrubs and obtain re-sprouts (Pereira et al., 2006; Carmo et al., 2011). Both tillage and fire have damaging effects on soil structure and fertility (e.g. Lammerding et al., 2011; Esteves et al., 2012). Therefore reducing pasture renewal interventions can bring significant environmental benefits. Moreover, through an improved targeting of AEM in LFA the upkeep of extensive livestock can ensure the upkeep of the landscape mosaic and forest discontinuity, which ultimately contributes to avoid large forest fires (Moreira et al., 2011).

Agri-environmental measures (AEM) have been criticised for lack of targeting (Kleijn et al., 2006; Uthes et al., 2010; Parissaki et al., 2012). So far, the existing research fails to provide a holistic view for policy design at the relevant farm or regional level, neglecting often the role of the available budget for AEM spending (Uthes and Matzdorf, 2013). The improvement of poor pasture areas through forage legumes could lead to a win-win situation where the carrying capacity could be enhanced as well as the delivery of environmental benefits such as water and soil protection, and carbon sequestration (Porqueddu, 2007; Porqueddu et al., 2013). Although opportunities for the delivery of public goods by low-input pasture areas exist, there is a risk that because management practices are minimal (e.g. seasonal grazing) the extent of the environmental benefits delivered is overlooked (Beaufoy et al., 2011). There is a need to target support policies such as AEM to the preservation of a viable livestock production in marginal areas, in order to ensure the delivery of potential environmental benefits such as the reduction of fire hazard and erosion risk.

1.7 Key definitions and concepts

Land degradation is defined as the diminution or destruction of the biological productivity of the land, comprising soils, plants, and water resources (Dregne, 2002). Land degradation includes a variety of processes, among others: water and wind erosion, soil salinization, water stress, forest fires, and over-grazing (Kosmas et al., 2014b). In this thesis we will consider water erosion, forest fires, and over-grazing effects.

Land degradation in dry and sub-humid areas is designated by desertification. Desertification affects natural, semi-natural and agricultural systems in arid, semi-arid, and dry sub-humid areas (UNCCD, 1994).

Semi-natural grasslands designate a land cover mainly constituted by mixtures of spontaneous and sown grassland species. Such land cover when used and managed by livestock producers themselves or in association with farmers is designated as rangeland. Rangelands are therefore more than a land cover category; they refer to a land use. Rangelands can result from the degradation of forest after fire or from the abandonment of farmland.

The system approach in agricultural research stems from the need to understand innovation within the 'exceptional' context of family farming putting in evidence the interplay of the several farm components (Simmonds, 1985). In this thesis we refer to ley farming systems to those systems which include rotations of a fodder crop, followed by a variable number of fallow years (Ruthenberg, 1980). Ley systems are also a low-input farming system. In this thesis a 'ley system' includes up to four years of fallow.

Permanent pasture is here defined as "*land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or longer*" (EC, 2004). This definition excludes ley, but includes a large array of permanent pastures from poor semi-natural grasslands to improved pastures with clover species.

1.8 Methodology

Research areas

Because of the distinct features and past changes in the agro-ecosystems in the Less Favoured Areas in Portugal two research sites were selected (Figure 1.2). Hereby attention was paid to the National Action Plan (NAP) to combat desertification, which includes five pilot areas.

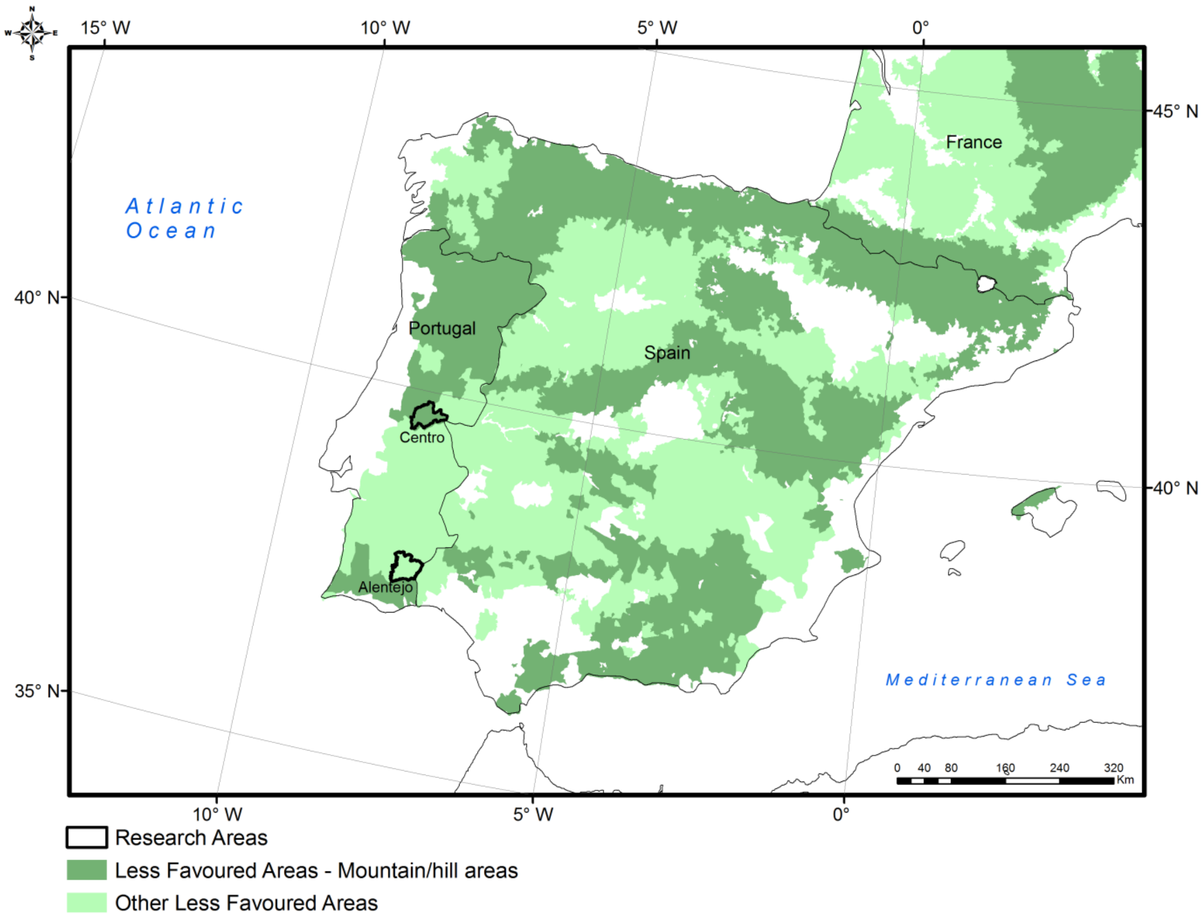

Figure 1.2 Location of Less Favoured Areas (LFA) and research areas Centro and Alentejo.

The two of these pilot areas chosen were respectively in the Centre of Portugal including three municipalities among which Mação, and referred to as Centro (research area), and in the southern Alentejo region, encompassing Mértola municipality and referred to as Alentejo (research area).

Centro research area covers 112,000 ha and lies on the border of the sub-humid climatic zone, with average annual rainfall ranging between 700 and 1400 mm. The most common soil types are Eutric Lithosols and Hortic Luvisols (CAN/SROA, 1978). The dominant land use is forest, mainly maritime pine (*Pinus pinaster L.*). The total population in this area is about 19,000, and agricultural employment is very low (3%). The about 3,000 farms manage 11,360 ha of land and have about 1,000 Livestock Units, mainly sheep and goats (INE, 2011b).

Alentejo research area covers 128,000 ha and lies in the semi-arid climatic zone, with average annual rainfall ranging between 400 and 600 mm. The most represented soil types are Eutric Lithosols and Ferric Luvisols (CAN/SROA, 1978). The dominant land use consist of grain crops combined with open oak stands (*Quercus ilex L.* and *Quercus suber L.*). Harvested grain fields in the plains are often grazed for the stubble and on the poorer schist hills shrubs are grown. The total population is only around 7,000, and quite a high percentage of those are involved in agriculture (21%). The about 700 farms manage not less than 90,000 ha of agricultural land with 11,670 Livestock Units, mainly cattle and sheep (INE, 2011b).

Methodologies applied

For the comprehensive assessment of the drivers acting on land use changes we reviewed scientific and grey literature, searching for changes in socioeconomic variables (agricultural technology, demography, and land use policy) and identifying land-use changes in national statistics. The implications of recent land-use changes on land degradation were investigated with the Revised Universal Soil Loss Equation (RUSLE) (Wischmeier and Smith, 1978; Renard et al., 1997), using land cover data from CORINE Land Cover (CLC) (INE, 1990; INE, 2000; IGP, 2010); soil and climate data from national monitoring systems (CNA/SROA, 1978; CNA, 1982); and ArcGIS 9.3 ESRI software.

With the aim to characterise the main farm types we conducted a farm survey (39 households), covering about 12% of agricultural land in each research area. The interviewees were selected randomly from the IFAP and the lists of local farmers' associations, and the contacts were facilitated through local technicians. In single contact interviews we collected primary data on cropping area, forest, livestock, and off-farm activities of farmers. We grouped similar farms through cluster analysis (SPSS/PASW 18) (Field, 2005). We characterised each group with regard to farm structure, economic results, and farm management based on data from the National Agricultural Census (NAC), the National Accountancy Network (FADN), and the Normalised Difference Vegetation Index (NDVI) computed from Landsat 4–5 Thematic Mapper (TM) and Landsat Enhanced TM+ images.

For the assessment of the physical effects of two selected AEM, we linked AEM uptake (number of beneficiaries, area under management) with two performance indicators: soil cover and stocking rate, using data from the Land Parcel Information System (LPIS). From all beneficiary farms in 2005-2009 registered in LPIS, we considered those eligible for the selected AEM, and among those we distinguished three groups: farms with no AEM, farms with other AEM, and farms with the selected AEM. We tested the significance of the effects of AEM participation with a Chi-square test comparing stocking rate and soil cover trends among the three groups of farms.

To assess the financial effects of the implementation of the selected AEM at the farm level we used the net benefit/investment ratio (N/K ratio), and at the regional level we used a goal achievement index built with the previously estimated indicators: stocking rate and soil cover. For net benefit/investment ratio we used crop and livestock budgets from the Ministry of Agriculture (GPP, 2011) updated with survey information (2010/2011) and secondary data from grey literature (e.g. Crespo, 2009).

For the assessment of the environmental effects of future policy scenarios we built a mixed integer programming (MIP) optimisation model to obtain future land use maps resulting from farmers' options for pasture management. We used the plot delimitation of 2009 provided by the Land Parcel Information System (LPIS). The objective function maximizes farm net income subject to constraints on resource availability (labour, capital, and land), carrying capacity, and possibilities of interchanges between pasture options. The results are then displayed with ArcGIS, and the environmental benefits resulting from each policy scenario are compared with resource, output, result, and impact indicators. As resource indicator we assessed policy spending (€), as output indicators we considered net farm income (€) and on-farm feed (% of total), as result indicators we estimated the arable land not abandoned (% of initial arable area), the area of permanent pasture (% of targeted area), and the share of grazing livestock (% of total), and finally, as impact indicators we considered the erosion avoided (t/ha) and the fragmentation of the high fire risk patch (effective mesh density). The erosion avoided was assessed through RUSLE (Renard et al., 1997).

1.9 Outline of the thesis

This thesis contains seven chapters. This introduction chapter (Chapter 1) presents the overall scope and aim of the study, the problem statement, objectives and research questions, the state of the art and evaluation framework, the methodology, including the description of the study areas, and this outline of chapters. The following five chapters address the respective research questions, whereby Chapters 4 and 5 are both dealing with the third research question. The final Chapter 7 provides the Synthesis.

Chapter 2 deals with land use changes and their implications for land degradation. The analysis provides an overview of the past and recent land use changes in two Portuguese LFA. The identified land use changes are then analysed in relation with technological, demographic, and land-use policy changes. Through estimates of potential erosion obtained with RUSLE we make conclusions about the impact of the most recent land-use changes on soil conservation.

Chapter 3 examines the farming systems of the two research areas, and how the different farm types affect sustainable land management. The type and numbers of livestock, and forage management practices such as rotation and fallow are analysed with some details from a sample of interviewed farms. Conclusions are derived on the implications of the different practices for sustainable land management.

Chapters 4 and 5 provide insight in the role of policy measures targeting the preservation of extensive grazing in marginal areas. Chapter 4 deals with the physical effects and Chapter 5 with the financial effects of the implementation of such measures. In Chapter 4 we analyse the effects of two AEMs on the animal stocking rate and soil cover with the use of statistics and remote sensing tools, and in Chapter 5 we use partial budgeting to compare the policy and no-policy situations.

Chapter 6 explores the options for the improvement of the design and implementation of agri-environmental measures. Using the conclusions of Chapters 4 and 5, and in view of the recent decisions on CAP reform we envision three possible scenarios with increasing implementation demands. With the use of integer linear programming and spatial analysis with ArcGIS we conclude on the regional benefits in terms of erosion and fire risk reduction.

Chapter 7 synthesises and discusses the major conclusions from the study and their implications for policy design and implementation. In this final Chapter we seek to provide answers for the research questions raised earlier in this Introduction. It also presents some recommendations for future policy research, and points of integration with other research fields.

Chapter 2

Historical review of land use changes in Portugal (before and after EU integration in 1986) and their implications for land degradation and conservation, with a focus on *Centro* and *Alentejo* regions

Abstract

Changes in land use and production systems are to a large extent responsible for land degradation. In Portugal this process has been triggered mainly by socioeconomic drivers, such as agricultural technology, demography and policy changes. In this article land use changes in Portugal are discussed in terms of their main drivers and impacts, focussing on land degradation and conservation. The discussion includes a brief outline of historical land use changes in Portugal and a more detailed account of the changes in the period after 1986, when Portugal joined the European Union. An assessment of recent (1986-2006) land use changes and their impact was conducted for two selected research areas in the Centro and Alentejo regions. This assessment was based on information from the CORINE Land Cover programme (1985 and 2006) and the National Agricultural Census (1989 and 1999). In the Centro research area the land under forest declined from 52% to only 22% of the area, mainly as a result of forest fires. In the Alentejo research area the major change was the decline of miscellaneous shrub, declining from 23% to 11%, to open forest land, increasing as a result of afforestation measures from 1% to 22%. These land use changes resulted in a significant increase of soil loss estimates through RUSLE. In the Centro research area soil losses greater than 10 t ha $^{-1}$ yr $^{-1}$ were estimated to occur in 57% of the area in 1990, increasing as a result of land use change to 64% in 2006. In the Alentejo research area this change was from 65% in 1990 to 72% in 2006. The research raises questions regarding land use management, in relation to the Common Agriculture Policy support during the 1986-2006 period. Despite the increase in forest and permanent grassland areas, soil loss rates remain very high in the two research areas.

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Historical review of land use changes in Portugal (before and after EU integration in 1986) and their implications for land degradation and conservation, with a focus on *Centro* and *Alentejo* regions

2.1 Introduction

Similar to the trend seen elsewhere in Europe, the use of land for agriculture in Portugal has been decreasing since the mid-1950s, in favour of forest and shrubland (Daveau, 1995; Geri et al., 2010; Serra et al., 2008). This change has been constrained by the contrasting farm structure, which characterises Portuguese farming, namely the minifundia associated with family farming in the North and Central (hereinafter, Centro) regions and the latifundia in the South region. As a result of the distinct farm structure, socioeconomic drivers such as agricultural technology, demography, and policies (Castro-Caldas, 1991 ; Moreira et al., 2001; Pereira, 1971) have led to quite different farming rationalities. In the North and Centro, farming systems favour self-provision of farm households, while in the South region rent maximization for landowners is more common (Baptista, 1993). The way in which the socioeconomic drivers just mentioned have stimulated the appearance of multifunctional agro-ecosystems in the past is used in this paper as a starting point to address the less well-defined recent land use changes and their impact on land degradation and conservation. Today, the intensification of some farming systems occurs simultaneously with the reduction and ultimate abandonment of others. The abandonment of agricultural land constrains the sustainability of multifunctional agro-ecosystems and leads to poorly managed forest areas (de Graaff et al., 2008b; Duarte et al., 2008; Moreira et al., 2001; Van Doorn and Bakker, 2007).

In general, forest and pastoral land use cause less soil loss than agricultural land use (Pimentel, 2006). While their increase can be beneficial, inadequate management practices can jeopardize investment as a consequence of new species distribution or increased fire risk, currently exacerbated by the warming trend associated with climate change (Pereira et al., 2007). Shakesby and Coelho (2002) claim that the protective effect of the arable land and oak forest combination - known as “montado”, and which is traditional in the South - is strongly dependent on land management practices. Kosmas et al. (1997) also show the importance of land management on the soil-protection qualities of permanent crops. In his research, olive trees with understory vegetation ranked higher in soil protection than vines and Eucalyptus forest. Roxo (1994) documented the extent of erosion problems in the Alentejo region due to intensive tillage and grazing.

Considering the historical and recent land use changes, two research areas were selected in the Centro and Alentejo regions. Together they represent the two main trends: increase in shrubland and abandonment of agricultural land. Under favourable management this re-naturalization of agricultural areas could have beneficial impacts in terms of land degradation. However, the question is whether these land use changes will indeed reveal such benefits in the long term (Rosário, 2004).

The goal of this paper is twofold: 1) to clarify the way in which socioeconomic drivers have influenced land use change, and 2) to investigate the implications of land use changes on land degradation. After providing an historical review of the main land use changes in Portugal and their socioeconomic drivers, we focus on the changes that have occurred in the last 20 years in the two research areas. It is hypothesized that although afforestation measures of marginal agricultural areas have been effective, the control of land degradation on those areas will demand in the future a more integrated management in order to avoid poor cover development.

2.2 Research areas and methods

Research areas

Portugal's climate features a hot and dry summer, with rainfall concentrated in the winter. The rainfall distribution is mainly influenced by altitude and the Atlantic proximity. Northern and central mountains provide a natural division between the North and South. In the North 95% of the area lies above 400 m; while in the South 62% of the area is below 200 m (Ribeiro, 1955). The Portuguese mainland comprises about 9.2 million ha.

The total population of the country is about 10 million, concentrated mostly in the coastal areas. More than 60% live in the suburban area of the two major cities: Lisboa and Porto. The less densely populated areas are located in the eastern part of the Alentejo and Centro regions.

For this research two areas were selected: one in the Centro region and another in the Alentejo region. The Centro research area (112,000 ha) includes three municipalities: Mação, Proença-a-Nova, and Vila Velha de Rodão, which lies on the border of the subhumid climate area with desertification risk identified by DISMED project (Rosário, 2004; Figure 2.1). The average annual rainfall in the area ranges between 700 and 1400 mm and is distributed over 50-75 days. The average temperature lies between 12.5 ºC and 15 ºC. The most common soil types are Eutric Lithosols (more than 70% of the area) and Hortic Luvisols. The dominant land use is forest, mainly maritime pine (*Pinus pinaster* L.). Terraced olive groves and grain crops are found, respectively, at medium altitude and in the valleys (Ribeiro et al., 1991).

The Alentejo research area (128,000 ha) includes one municipality - Mértola, which lies in the semiarid climate area highly susceptible to desertification (Figure 2.1). The average annual rainfall ranges between 400 and 600 mm, distributed over 50-75 days, and the average mean temperature is between 15 ºC and 17.5 ºC. The most represented soil types are Eutric Lithosols - more than 65% of the area - and Ferric Luvisols. The dominant land use consists of grain crops combined with open oak stands (*Quercus ilex* L. and *Quercus suber* L.). Harvested fields are often grazed for the stubble, and on the poorer schist hills, Mediterranean shrubs are dominant (ex. *Cistus lanadifer* L., *Arbutus unedo* L.), while plains originally formed from granite are more intensively farmed (Daveau, 1995).

Methods

In order to provide a comprehensive assessment of land use changes for Portugal, three distinct periods were identified: prior to 1900, 1900-1986, and 1986-2006. The changes in socioeconomic variables such as agricultural technology, demography, and land use policy are compared to the main land-use changes identified in the national statistics. The assessment of socioeconomic drivers and main land-use changes was based on national statistics and on a review of scientific and grey literature. We subsequently investigated land-use changes and their implication on land degradation and conservation for two research areas based on the CORINE Land Cover (CLC) obtained from satellite data (1990 and 2006) and the National Agricultural Census (NAC) obtained from survey data (1989 and 1999) (IGP, 2010; INE, 1990, 2000). CLC data cover the whole research area and NAC data cover farmland (farms with more than 1 ha of agricultural area). NAC statistics use a two-level classification of 16 categories, from which we have used the first level: 1) arable land, 2) permanent crops, 3) agro-forestry, 4) pastures, and 5) forest. CLC data use a three-level classification of 44 land-use categories, from which we have used the second and third levels: 1) arable land (Ar); 2) permanent crops (Pr); 3) pastures (Pa); 4) heterogeneous agricultural areas (Ht); 5) forest (Fo); 6) shrubs, herbaceous, and sclerophylous vegetation (Sh); 7) open forest (Of); and 8) burnt areas (Ba). For the quantification of land-use changes we used CLC data for 1990 and 2006 and, for the identification of area changes, between land-use categories, we used CLC-changes 1990-2000 and CLC-changes 2000-2006. The first dataset shows the changes greater than 25 ha and the second those greater than 5 ha (Caetano et al., 2009; Painho and Caetano, 2006).

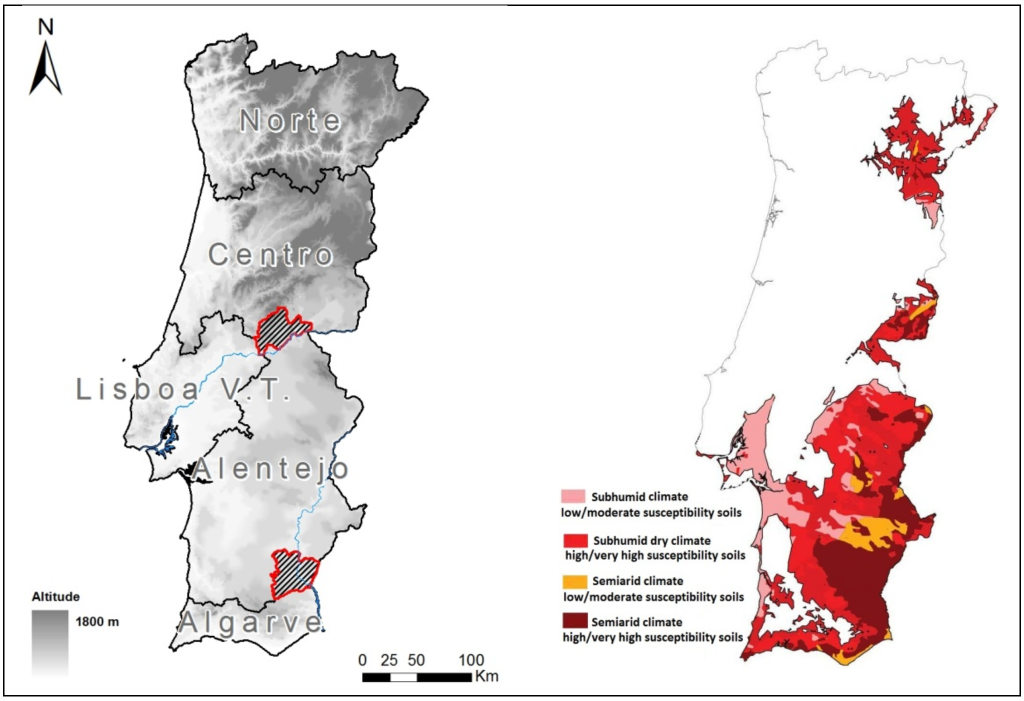

Figure 2.1 Location of the two research areas and dryland areas susceptible for soil erosion in Portugal (Source: Rosário (2004), adapted legend)

Although for the analysis of farmland changes this accuracy seems low, the fact that the conclusions are drawn at the research area scale makes it satisfactory: the Centro research area covers 112,000 ha and the Alentejo research area 128,000 ha. The implications of land-use changes on land degradation were investigated through the estimates of soil loss through the Revised Universal Soil Loss Equation (RUSLE) established by Wischmeier and Smith (1978) and revised by Renard et al. (1997). The basic form of the RUSLE model is: A = R x K x LS x C x P; where the factors are as shown in Table 2.1.

Table 2.1 Revised Universal Soil Loss Equation (RUSLE) factors

	RUSLE	Description/ Units	Value	Sources
A	Soil loss	t ha^{-1} yr^{-1}		
R	Rainfall erosivity	Annual average isoerosivity lines (25,4mm threshold) MJ mm ha^{-1} h^{-1} year^{-1}	Interpolation of isoerosivity lines	(Brandão et al., 2006) (INAG/SNIRH, 2010)
K	Soil erodibility	Correspondence with FAO soil classification t h MJ^{-1} mm^{-1}	See Table 2.9	(CNA/SROA, 1978) (Pimenta, 1998) (LNEC/Hidroprojecto, 2000)
LS	Slope and slope length	Considers length and steepness of slope Dimensionless	√(l/22.1) x 0.0065 [slope]2 + 0.0454 [slope] + 0.065	(Mitasova et al., 2000; Mitasova et al., 1996) (Morgan, 2005) (CNA, 1982)
C	Land cover	Correspondence with land cover Dimensionless	See Table 2.9	(IGP, 2010) - CORINE Land Cover (Pimenta, 1998) (LNEC/Hidroprojecto, 2000)
P	Land management	Considers the decreasing effect on soil loss of contouring, strip cropping and terracing practices Dimensionless	1 *	---

* Considering that no conservation practices are implemented.

The data for soil and climate factors of the RUSLE model were obtained from national monitoring data (CNA, 1982; CNA/SROA, 1978). The spatial analysis of the results for 1986[1] and 2006 supports the discussion of land degradation and conservation associated with the recent land-use changes. The spatial analysis was conducted on ArcGIS 9.3 ESRI software. Several studies suggest that the model overestimates erosion, mainly due to R and LS factors (Cortez and Cordeiro, 1990; Tomás and Coutinho, 1994). Tomás and Coutinho (1994) observed different adjustments of the model with slope exposure variation. Despite its limitations, RUSLE has been recently used by Santini et al. (2010) as a sub-model for water erosion to compute an Integrated Desertification Index (IDI). The hot-spot areas menaced by degradation identified through the index matched well with the in-depth examination through field visits. Taken as a comparative measure, soil losses calculated through the RUSLE model are a useful tool for the discussion of land-use change impacts on land degradation and conservation. The soil loss estimate of 10 t ha^{-1} yr^{-1} was used as the threshold to determine the area prone to erosion (Jones and Le Bissonnais, 2003).

2.3 Land use changes and drivers of change in Portugal

Historical land use changes

This section provides an historical overview of land-use changes in Portugal. Several authors support the belief that land-use patterns result from the interconnected effects of socioeconomic drivers, such as agricultural technology, demography, and policy changes (Castro-Caldas, 1991 ; Moreira et al., 2001; Pereira, 1971).

In historical times Phoenicians, Romans, Celts, and Moors gave shape to what are now the Portuguese land and its people. In the 15th century Portugal benefited from highly profitable colonial trade, which was maintained until the independence of Brazil in 1822. After 1820, sweeping liberal reforms were introduced. These reforms allowed the development of an agriculture-based economy, which was maintained by the democratic republic (1910-1926) and the dictatorship regime that followed (1926-1974). Although constrained by this last regime until 1974, the adoption of technology to agriculture was present from the 1950s on. A military coup in 1974 granted independence to all Portuguese colonies and opened the way to democracy.

Poor living conditions led nearly 2.5 million Portuguese to emigrate to Brazil and the USA (1850-1950) and Europe (1960-1970). On the other hand, nearly a million Portuguese returned after 1974 from the ex-colonies. Portugal joined the European Union in 1986. Over the next 20 years the rural and agricultural population decreased from more than 60% and 25% to less than 45% and 12%, respectively (FAOStat, 2010).

With these events in mind, the analysis of land-use changes will cover three main periods: prior to 1900, from 1900 to 1986, and from 1986 to 2006. The first two periods will be described in this section and the last period in Section 3.1. In this analysis attention will be paid to changes in agricultural technology, demography, and land-use policies.

Before 1900

In pre-Roman times agriculture was undertaken largely in the hills, while dense forested valleys were used as hunting grounds and pasture. The Roman administration (1st-5th centuries) began to cultivate the valley lands and converted the hills into *Castanea* spp. forest (Sampaio, 1979). This land-use pattern was more or less maintained until well after the collapse of the Roman Empire: during the occupation by Suevi/Visigoths (5th-8th centuries) and Moors (8th-13th centuries), and even until soon after the stabilisation of the country's borders in the 13th century.

Table 2.2 presents a summary of the main changes in the socioeconomic drivers for the period before 1900. The scarcity of land resources and the search for grains - both plausible motives for overseas explorations in the 15th century - culminated in the introduction of maize in the 17th century. Introduced as an irrigated spring crop in rotation with pasture during winter, maize allowed the intensification of farming systems through animal enclosure and the use of manure as fertiliser. Such changes were made possible by liberal reforms in land tenure during the 19th century (Castro-Caldas, 1991).

In the 19th century, liberal reforms facilitated the private appropriation of a sizable share of common land that had been kept uncultivated for free pasture and wood collection. As a result, the amount of land available for arable crops increased. This increase was particularly evident for maize, which came to account for more than 50% of grain production (Pereira, 1971). However, a lack of suitable land (either too hilly - North and Centro regions; or concentrated in large private estates - Alentejo region), constrained this expansion. Soon the increase in population led to food shortages and the administration was forced into action. Among the adopted measures, laws in support of wheat production, the impact of which was felt particularly strongly in the Alentejo, are the most important for the discussion of land degradation and conservation impacts.

From 1900 up to 1986

Implemented in 1889, the support system for wheat production included intervention prices and import barriers (Reis, 1979). In the Alentejo region the wheat production area increased based on the traditional montado system - an agro-silvo-pastoral association with cork or holm oak. Barley, oats, and fallow periods (from five to ten years) completed the rotation. Livestock grazed on the stubbles and oak acorn, as earlier in the encroached areas from which montado had evolved (Ferreira, 2001). Landowners accepted low yields of wheat and sought compensation through livestock and cork production. In the Centro region, wheat policies also favoured the conversion of flat land into arable crops, either in association with permanent crops or in rotation with other annual crops.

By the 1930s, the conversion of encroached areas in Portugal had been completed (Figure 2.2). From an estimated 4 million ha of uncultivated land in 1875, less than 1.5 million ha remained in 1934 (Basto, 1936 cit in Baptista, 1993).

Table 2.2 Main changes in socio-economic drivers of land use before 1900

Before 1900					
Technology change	**Scope of change**				**Ref date**
Maize and arable–pasture rotations (introduction)	Intensification of cropping systems. Land is used during spring and summer for maize, and in winter and autumn for pasture. This change was limited to the North and Centro regions where irrigation and land ownership were favourable (Castro-Caldas, 1991 ; Pereira, 1971) .				1600
Fertilser adoption	Capitalist and tenant farmers adopt chemical fertilisers in wine and wheat production. Subsistence farmers make use of organic fertilisers (e.g. manure and sea weed) (Castro-Caldas, 1991 ; Pereira, 1971; Reis, 1979)				1850
Extensification of wheat production systems	Due to poor edafo-climatic and market conditions, wheat farmers adopt extensified production strategies: long fallow periods (10 years), oak and pasture associations (Castro-Caldas, 1991 ; Feio, 1997; Feio, 1998; Pereira, 1971; Reis, 1982)				1870
Demography change					
Slavery abolition	Abolition of slavery and slave traffic - 1774 and 1836, respectively (Castro-Caldas, 1991 ; Pereira, 1971)				1800
Population increase	Annual population growth (%)		Population (millions)		1850
	ca. 1500-1835	0.3	1.4 – 3		
	1835-1864	1.2	3 – 4.2		
	1864-1890	0.7	4.2 – 5.1		
	1890-1911	0.8	5.1 – 6		
			(INE *in* Pereira (1971))		
Land use policy change					
Liberal reforms	Feudal land property rights are extinguished. Common and corporate land is privately appropriated (Castro-Caldas, 1991 ; Pereira, 1971)				1820
Wheat support laws	Fixed prices and import barriers are adopted to protect national production. These protective laws are extended to other sectors and colonial preferential markets are developed in Africa (Castro-Caldas, 1991 ; Pereira, 1971, 1974; Reis, 1979, 1982)				1889/ 99

Despite the scarcity of land available for clearing, wheat support policies were kept in place by the dictatorship regime (1926-1974) (Table 2.3). Under these policies further land clearing was subsidised (Baptista, 1993). Arable land continued to increase, now at the expense of more marginal areas, which by the late 1930s already revealed declining yields (Figure 2.3). After the 1950s, the use of fertilisers, selected seeds, and machinery received intensive support. The adoption of phosphorus fertilisers and selected seeds allowed the intensification of crop rotations, sustaining the yields (Feio, 1997). The use of fertilisers expanded agricultural practices into vast areas of marginal soils until 1963, when the land-clearing subsidy was suspended. Thereafter, the wheat-production area, which had nearly doubled, started to decrease (Figure 2.3). At this same time, arable land - including cultivated and fallow areas - reached its maximum extent, about 40% of the land area and 80% of agricultural land (Figure 2.2). Together agricultural and forest area represented more than 85% of the land area.

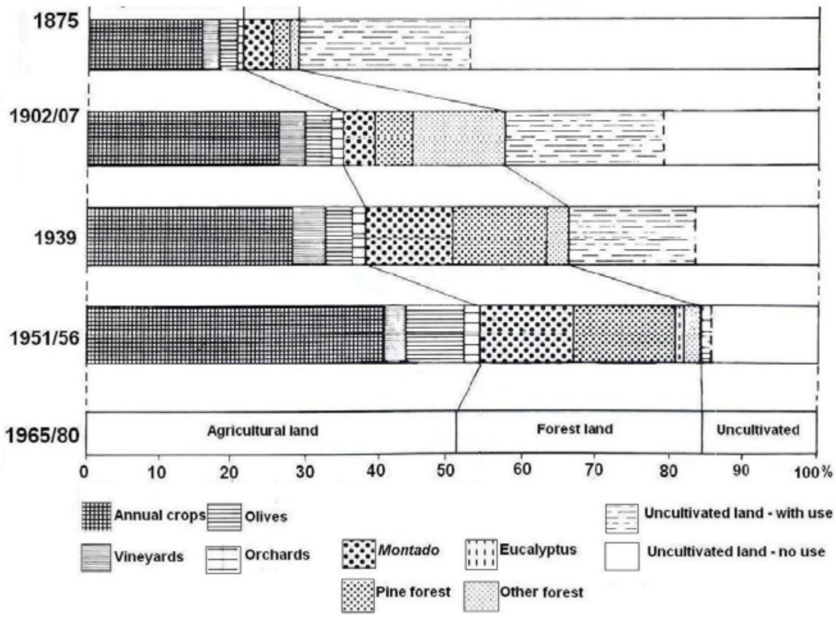

Figure 2.2 Land use change 1875-1980 – Portugal (Source: Daveau (1995); adapted legend).

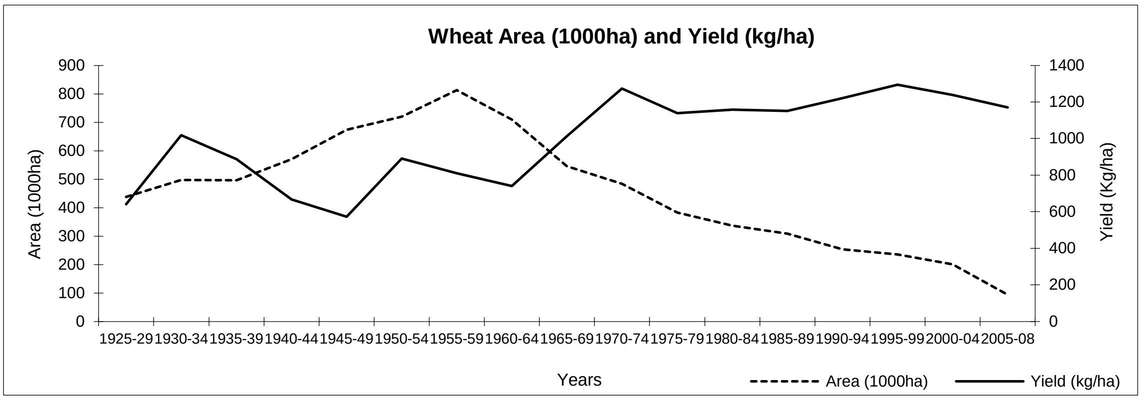

Figure 2.3 Wheat area (1000ha) and yield (Kg/ha) in Portugal – (Sources: INE *in* Baptista (1993), FAOStat (2010))

Along with the adoption of fertilisers, mechanisation was also another significant driver of agricultural land expansion. It allowed agriculturalists to reduce operation time and overcome seasonal constraints. With animal traction, tillage was earlier limited to friable soil conditions during winter (Feio, 1998) (Table 2.3).

Table 2.3 Main changes in socio-economic drivers of land use over 1900-1986 period

1900-1986			
Technology change	**Scope of change**		**Ref date**
Seed selection	Selected seeds and phosphorus fertilisers contribute to the intensification of wheat rotations however yields stay stable – between 700 and 1000 kg/ha for wheat (Feio, 1997; Pereira, 1971; Reis, 1979)		1950
Mechanisation	Tillage and harvest are mechanised. Mechanisation allows tillage to be conducted in spring, leaving the soil bare until the next cropping season. Row sowing is introduced to facilitate mechanical harvest (Feio, 1998).		1950
Demography change			
Emigration increase	Annual population growth: period - % - (population in millions): 1911-1950 – 0.9 (6 – 8.5) 1950-1974 – 0.1 (8.5-8.6) 1974-1986 – 1.2 (8.6-9.8) (INE *in Moreira (2006)*)	Annual emigration rate: (period - %) 1960-1965 – 0.5 1965-1970 – 0.9 1970-1975 – 0.5 1975-1980 – 0.2	1960
Land use policy change			
Forest framework laws	Forest area is included in four types of public management: total, compulsory, voluntary, and surveillance. Reforestation actions are conducted for public benefit on 1 419 000 ha (1931-1973) (Baptista, 1993)		1901/05
Wheat support policy	Until 1963 the support scheme includes minimum prices, land clearing and fertiliser's subsidies. From then onwards land clearing subsidy is suspended and afforestation of marginal soils is introduced (Baptista, 1993; Reis, 1979)		1930
Afforestation plan	The plan supports the afforestation of 420 000 ha, more than 50% on communal land. Effectivelly 290,673 ha are afforested (1938-1977). The favoured species is *Pinus pinaster* Aiton (maritime pine) (Baptista, 1993; Coelho, 2003; DGRF/AFN, 2006)		1938
Private afforestation policy	The support includes loans covering 50% of installation costs. Between 1965-1983 126,934 ha are afforested. The favoured species is *Eucalyptus globulus* Labill. (blue gum) (Baptista, 1993; DGRF/AFN, 2006)		1965
Wheat policy reform	The reform includes more incentive to marginal land rehabilitation through afforestation and structural SWC measures (Baptista, 1993)		1970
Increasing subsidies	After 1974 output price supports, input price subsidies, land market regulations, and agricultural credit programs are implemented. Cereals and milk/meat sectors are among the most supported (Avillez et al., 1988; Monke et al., 1986; Moreira, 1993; Pearson et al., 1987)		1980

The adoption of mechanisation was also influenced by changes in labour availability resulting from increased emigration during the 1960s. Between 1960 and 1980 more than 1 million Portuguese emigrated to France, Germany, and Luxembourg (Moreira, 2006).

Despite the evidence of production surplus and severe land degradation on marginal soils, only in the 1960s were afforestation measures introduced for the purpose of agricultural land conversion. However, the success of these measures was very limited, because the incentives were partially coupled with wheat production (Baptista, 1993). Nevertheless, a clear increase of forest area was evident before afforestation measures were included in the wheat support system (Figure 2.2). In fact, the forest area increased considerably with the implementation of the 1938 afforestation plan on the remaining common land of the North and Centro regions. Although afforestation was imposed on common-users (those making a living on shared grazing and wood collection), pine and eucalyptus forest thereafter became alternative income sources derived from the abandoned agricultural land. This was particularly true following the development of pulp industries in the 1970s (Figures 2.2 and 2.4).

After the establishment of democracy in 1974, and in spite of the support given to agriculture, the trend toward abandoning land continued. Full-employment policies were introduced with the aim of absorbing the labour force returning from the African colonies. Indeed, from 1974 to 1975 the unemployment rate increased dramatically, from 1.8% to 4.5% (ILO/FAOStat, 2010). New agricultural policies were introduced, such as output and input price subsidies, credit programmes, and real estate market interventions.

Until 1980 considerable effort was directed toward structural land reforms. Some common property was appropriated to the citizenry and large farms in the Centro and Alentejo regions were assigned to collective management (Brouwer, 1995; Laffon, 1982). Despite the suspension of the wheat-specific support scheme after 1975, the overall transfers increased thereafter. In 1980 about 37% of agriculture gross value added corresponded to support transfer (Moreira, 1993). Collective production units were managed by landless labourers whose main objective was to guarantee stable work and a reliable wage. Their farming rationale was still too closely linked with wheat production systems, and therefore both collective and privately managed farms depended on wheat production. As a result, grain production systems were still highly subsidised (Avillez et al., 1988). Overall policy transfers covered more than 40% of production costs for wheat, milk, sheep, meat, and beef production systems in 1983. And for the most common production systems those transfers greatly exceeded the private profit amount of 35-92% for wheat, more than 100% for milk and sheep meat, and 70% for beef (Monke et al., 1986).

From 1978 to 1986 forest investments were also supported by public policy. More than 130,000 ha were planted, of which more than 45% was in *Pinus pinaster*, 30% other *Pinus* spp., 14% *Eucalyptus*, and 3% cork oak (Brouwer, 1995; DGRF/AFN, 2006).

Recent land use changes

In this section the land-use changes from 1986 until the present will be analysed. Under the combined effects of policies supporting milk/meat products and afforestation during the democratisation period (1974-1986), agricultural land decreased and permanent grassland became the dominant share of agricultural land use from the 1980s on (Figure 2.4).

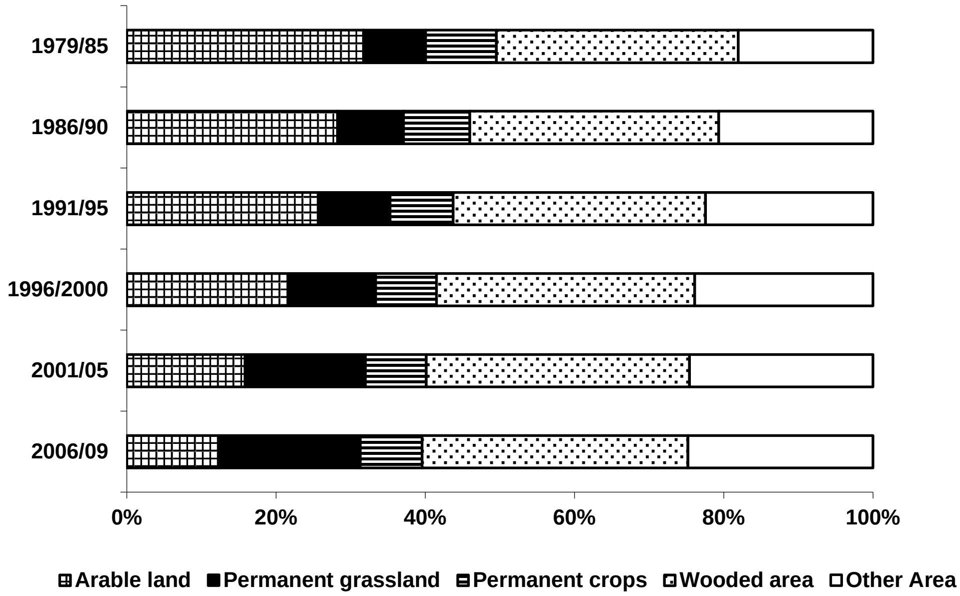

Figure 2.4 Land use change (1979-2009) – Portugal (Source: DGRF/AFN (2007); Eurostat (2009))

Some of the abandoned agricultural land has been converted into wooded areas. Between 1979-1985 and 2006-2009, agricultural land decreased from about 50% to 41% of land area, while wooded area increased from 33% to 36%. The decrease of agricultural land was due mostly to the decrease of arable land, which in the same period decreased from 64% to only 31% of agricultural land (DGRF/AFN, 2007; Eurostat, 2009). On the other hand, permanent grassland increased from 17% to 48% of agricultural land (Eurostat, 2009).

Although considered as agricultural area, permanent grassland includes transitional scrublands that can evolve into mature forests or encroached areas sparsely used as pasture for small ruminants, or constitute a rotational fallow area reclaimed for arable crop after some years. This dynamic development, which is a feature of traditional Mediterranean agro-ecosystems, has also been evolving (in some cases) into areas of recurrent fire occurrence. Demographic trends, which include persons less active in agriculture and ageing farmers, are one of the drivers for the increasing occurrence of fire (Almeida and Moura, 1992) (Table 2.4). Farm abandonment is one of the main reasons why Pelorosso et al. (2009) observed a systematic overestimation of pasture land and an underestimation of woodland in census data. Table 2.4 summarises the main changes in socioeconomic drivers from 1986 until the present.

At the time of EEC membership in 1986, low land and labour productivities were the most striking features of Portuguese agriculture, reaching before entry only 46% and 13% of EU-10 average, respectively (Mykolenko et al., 1987). These structural constraints largely reduced the potential gain at entry for the majority of Portuguese production systems. Wheat and pasture-based livestock products on poor soils were among those facing the strongest competition from other producing regions in the EU by the end of the transition period (1986-1996). During this period input subsidies had been abolished (e.g. fertilisers) and commodity prices had been brought to EU levels, generally lower than national ones with the exception of sunflower, livestock products, and tomatoes. In fact, in the absence of policy transfers, only these latest production systems were expected to have positive private profits in 1996. The improvement of pasture management through fencing and a controlled stocking rate per hectare did increase pasture productivity, but did not allow pasture-based systems to become economically viable without subsidies (Pearson et al., 1987).

Table 2.4. Main changes in socio-economic drivers of land use from 1986 until 2006

1986 until now			
Technology change	**Scope of change**		**Ref date**
Fencing pasture	Pasture management improvement through a better stocking rate per hectare, management and improvement of natural pasture through the use of new species and fertilisers (Pearson et al., 1987)		1980
Integrated management	The long term advantages of agro-ecosystem equilibrium are capitalised in terms of improved pest, nutrition and land resources management (DGDR/IDRHa, 1998, 2004)		1990
Conservation agriculture	Improvement of conservation tillage practices (minimum tillage and surface mulch) with no-till, mulch, and rotations aiming at the improvement of soil physical, biological and chemical properties (Hobbs, 2007)		2006
Demography change			
Agricultural actives	Agricultural Active Population (INE) (% on total active) 1981 – 25 1991 – 17 2001 – 12	Aging farmers (INE) (% of <35 years old on >65 years old) 1989 – 23 1999 – 11 2005 – 5	
Land use policy change			
CAP transition period	The bulk of agricultural prices are lowered in order to harmonise with EU prices. A ten years transition period is established (Mykolenko et al., 1987)		1986
Environmental Policy	Environment Basis Act sets the new policy development. Municipal spatial plans are made compulsory and protected areas are regulated. Reserves of strategic agricultural soils and ecological sensitive systems are established (Bacharel and Pinto-Correia, 1999)		1990
Agri-environmental policy and Natura 2000	Since 1992 CAP integrates follow-up measures that aim at reducing the negative impacts of agriculture and improve agro-ecosystems services. Natura 2000 is defined on the framework of EU Birds and Habitats Directives. Guadiana natural park is created in 1995 (Bacharel and Pinto-Correia, 1999)		1992
Afforestation under CAP investment	In the period 1986-2006 CAP has supported the afforestation of 781 912 ha with a total of more than 790 million Euros (DGRF/AFN, 2006)		2006

In line with Mykolenko et al. (1987) and Pearson et al. (1987), the area of arable crops decreased sharply after the 1992 and 2000 CAP revisions (Figure 2.4). Important changes were then introduced in the agriculture support system. In 1992 the main Common Market Organization's (CMO's) products, such as cereals and oilseeds, saw a reduction in their intervention prices (about 35%), and a system of direct payments per hectare was established. Set-aside was made compulsory (15% of arable land had to be left fallow) (Monke et al., 1998). In fact, the share of Common Agricultural Policy (CAP) support on agriculture gross value added has gradually decreased since EU membership:

74% in 1987; 64% in 1993; 54% in 1999 (Avillez et al., 2004). In order to compensate farmers for the reduction of direct support, follow-up measures were implemented. These included agri-environmental and afforestation measures. Among agri-environmental measures, a specific group encouraged the adoption of innovative conservation practices, such as organic agriculture, integrated management, and (more recently) conservation agriculture, too (DGDR/IDRHa, 1998, 2004). Under the CAP support from 1986 to 2006, more than 900,000 ha of forest land benefited, 217,000 ha of which corresponded to afforestation on abandoned agricultural land (DGRF/AFN, 2006).

Research by Bakker et al. (2008) and Roxo et al. (1998) suggests that the succession of forest cover supported by some agri-environmental measures has brought, in some cases, negative effects in terms of soil loss. This seems to be linked to the destruction of some beneficial covers already regenerating, as well as to the spatial distribution of afforested plots. The analysis by Caetano et al. (2005) confirms that forest land use changes rely mainly on forest categories inter-changes. This is also confirmed by Feranec et al. (2010): between 1990 and 2000, Portugal had the highest percentage of land-use change (9.8%) among 24 European countries, and presented simultaneously the highest rates of afforestation (4%) and deforestation (3.5%).

Forest represents about 35% or 3.3 million ha of the total land area 9.2 million ha. About half of this belongs to farms, and 70% of that amount is in agro-forestry. Forest ownership is 74% private non-industrial, 13% common property, 7% private industrial, and 2% public (Coelho, 2003).

2.5 Land use changes and their impact on land degradation in two research areas

Recent land use changes in Centro and Alentejo research areas

The recent land-use changes (1986-2006) are here investigated through the analysis of census statistics and satellite imagery. In this analysis we adopted land-use categories in order to find their approximate correspondence in the two datasets. Considering CLC definition of “heterogeneous agricultural areas”, this land-use category includes agro-forestry identified as such in the NAC dataset, as well as pastures with scarce tree cover, designated as “pastures” in the NAC dataset.

As described above, in the Centro research area, forest is the most important land use, whether we consider farmland area (Table 2.5) or the total territorial area (Table 2.6). Forest represented 60% of total farmland (29,000 ha of 48,000 ha) and 42% of total territorial area (47,000 ha of 112,000 ha) in 1999 and 2000, respectively (Tables 2.5 and 2.6). Agriculture represented 31% of farmland (15,000 ha of 48,000 ha) and the other 9% concerned other land use (Table 2.5). Farmland covered 43% of the total territorial area (48,000 ha of 112,000 ha) in the Centro research area (Tables 5 and 6). Both agriculture and forest areas decreased over the period 1989-99, but forest remained predominant. The CLC analysis in Table 2.6 also shows a decline of forest area during the 1990s, which continued in the 2000s (Table 2.6). However, the decrease of forest in the whole area seems to have been greater than what occurred on farms. This might indicate that forest on farms was less prone to degradation. Areas that are deforested by cutting or fire are accounted for as open forest and burnt areas. The rather low amount of burnt areas shown in Table 2.6 is due to the fact that quick regeneration has taken place, either through replanting or by natural regrowth. Because CLC considers burnt areas only when the occurrence of the fire is less than three years in the past, those areas have mostly been recorded as open forest. In fact, the open forest category corresponds to transitional woodland and combines degraded forest, clear cuts, and young plantations (Bossard et al., 2000).

Table 2.5 Land use changes on farmland in Centro and Alentejo research areas between 1989 and 1999 (1000 ha), based on National Agricultural Census (NAC) data

National Agricultural Census	Centro research area		Alentejo research area	
	1989	1999	1989	1999
Utilised Agricultural Area (UAA)	20	15	89	81
Arable land	9	3	46	39
Permanent crops	10	10	2	2
Agro-forestry	0.4	0.5	8	10
Pasture land	1	1	33	30
Forest	32	29	0.5	12
Other	8	4	1	1
Total Farm Area	60	48	90	94

Source : INE (1990, 2000)

Table 2.6 Overall land use changes in Centro and Alentejo research areas between 1990 and 2006 (1000 ha), based on CORINE Land Cover (CLC) data

CORINE Land Cover	Centro research area			Alentejo research area		
	1990	2000	2006	1990	2000	2006
Agricultural areas	31	30	30	93	83	82
Arable land (Ar)	2	2	2	41	37	36
Permanent crops (Pr)	7	7	7	0.2	1	1
Heterogeneous agricultural areas (Ht) (including pastures)	23	22	22	52	45	45
Forest (Fo)	58	47	25	4	4	3
Shrubs/ Herbaceous/ Sclerophylous vegetation (Sh)	5	2	2	29	18	14
Open forest, clear cuts and young plantations (Of)	16	31	53	1	22	28
Other (Ot)	2	2	2	1	1	1
Burnt area (Ba)	0.29	0.75	0.22	…	…	…
Total Land Area	112	112	112	128	128	128

Source: IGP (2010) - CORINE Land Cover

In the Alentejo research area, agriculture is by far the most represented land use. It represented 86% of farmland and 65% of the total territorial area in 1999 and 2000, respectively (Tables 2.5 and 2.6). Forest represented 13% of farmland (12,000 ha of 94,000 ha) and 1% concerned other land use (Table 2.5). Farmland covered 73% of the total territorial area (with 94,000 ha of 128,000 ha) in 1999 (Table 2.5). Between 1989 and 1999, the share of forest on farms increased from only 0.6% up to 13% (500 ha of 90,000 ha and 12,000 ha of 94,000 ha, respectively, see Table 2.5). The agricultural area decreased over the same period. The CLC analysis in Table 2.6 confirms that the agricultural land use is decreasing. Afforestation has taken place, also after 2000, at the expense of shrubland and agricultural land. In Table 2.6 this is reflected in the increase of open forest, clear cuts, and young plantation class. This is partly the result of the afforestation policy implemented as an accompanying measure of the 1992 CAP reform and reinforced after Agenda 2000.

The CLC analysis also allowed the identification of land-use changes between classes. Overall the share of change between 1986 and 2006 occurred in 28% of the Centro research area (31,360 ha of 112,000 ha) and 12% of the Alentejo research area (15,360 ha of 128,000 ha). Table 2.7 shows the percentage of total change that actually took place between the land-use categories in the 1990-2006 period. In the Centro research area 62% of the change (19,440 ha of 31,360 ha) was due to the transfer from forest to open forest in the 1990-2000 period. This share increased to 80% in the 2000-2006 period, due mostly to the action of fire in the last period.

Table 2.7 Area transfer (%) between CORINE Land Cover (CLC) classes in Centro research area – past 1990 – present 2006

		Present - 2000 CLC class							
	%	Ar	Pr	Ht	Fo	Sh	Of	Ba	Ot
Past - 1990 CLC class	Arable land (Ar)								
	Permanent Crops (Pr)			1					1
	Heterogeneous agriculture areas (Ht)				1		1		
	Forest (Fo)				2 *		62	3	
	Shrub land (Sh)				5		3		1
	Open forest (Of)				19				
	Burnt areas (Ba)						1		
		Present - 2006 CLC class							
	%	Ar	Pr	Ht	Fo	Sh	Of	Ba	Ot
Past – 2000 CLC class	Arable land (Ar)								
	Permanent crops (Pr)								
	Heterogeneous agriculture areas (Ht)								
	Forests (Fo)						80	1	
	Shrubs (Sh)								
	Open forests (Of)				16				
	Burnt areas (Ba)						3		

* The area change from forest towards forest in 2000 results from the change between forest sub-categories.

Legend: Ar – Arable (IR) land; Pr – Permanent crops; Ht – Heterogeneous agricultural areas; Fo – Forests; Sh – Shrubs, herbaceous and sclerophylous vegetation; Of – Open forest, clear cuts and young plantations; Ba – Burnt areas; Ot – Other.   Source: IGP (2010) - CORINE Land Cover

In fact, fire was the most important driving force of land-use change in this research area. Fire statistics reveal that before 2000, four major fires occurred (1991, 1995, 1998, and 1999) consuming 12%, 5%, 6%, and 4% of the total land area, respectively (Figure 2.5) (DGRF/AFN, 2010). After 2000, two additional main fires occurred (2003 and 2005), consuming 34% and 3% of the total research area. The magnitude of the 2003 fire damage is clearly reflected in the observed land-use changes, with the increase of open forest at the expense of forest area (62% of total change in 1990-2000, against 80% in 2000-2006 - see Table 2.7). On the other hand, some reforestation has taken place during the period, shown as an area transfer from open forest to forest, accounting respectively for 19% and 16% of the total change.

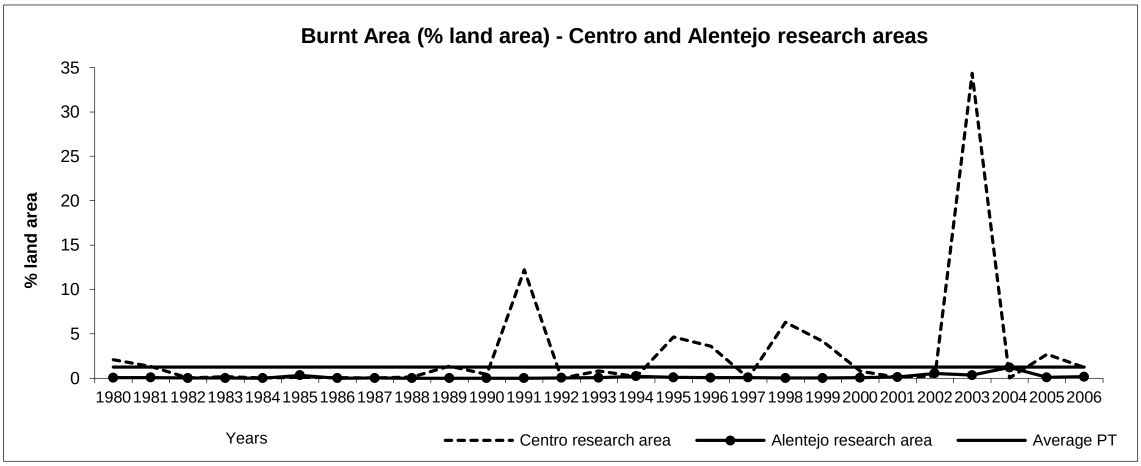

Figure 2.5 Burnt area (% of land area) in Centro and Alentejo research areas between 1980 and 2006 (Source: DGRF/AFN (2010))

Table 2.8 shows that for the Alentejo research area 54% (8290 ha of 15,360 ha) of the change until 2000 was due to area transfer from heterogeneous agricultural areas, shrub and arable land to open forest. While until 2000 the larger share of the afforestation was made at the expense of heterogeneous agricultural areas, after 2000 the major contribution came from arable crops, with 24% of total change, followed by heterogeneous agricultural areas and shrub area with equal shares (12% of total change each). The total of arable land and heterogeneous agricultural areas remained fairly constant. This results from the rotational system traditionally applied in this research area, which shows as scattered agro-forested areas during fallow years and as arable crops when cultivated. However, NAC statistics (1999) suggest that only about 20% of the heterogeneous agricultural areas were effectively agro-forestry (10,000 ha of 45,000 ha). Part of the remaining area results from the identification as heterogeneous agricultural areas of pasture land under scattered tree cover. In fact, the large area of pasture land in the NAC is not identifiable in the CLC dataset.

The afforestation effort that came into effect after the 1992 CAP reform was an “accompanying” measure. The purpose of the policy was to convert marginal agriculture land into forested area. This seems to have been successful in the Alentejo research area, with the conversion into forest of a significant part of heterogeneous agricultural areas before 2000 and of arable land after 2000, 24% and 12%, respectively (Table 2.8).

Table 2.8 Area transfer (%) between CORINE Land Cover (CLC) classes in Alentejo research area – past 1990 – present 2006

		Present - 2000 CLC class							
	%	Ar	Pr	Ht	Fo	Sh	Of	Ba	Ot
Past - 1990 CLC class	Arable land (Ar)		3	1	2	1	12		
	Permanent crops (Pr)								
	Heterogeneous agricultural areas (Ht)	11			1	10	24		
	Forests (Fo)			1					
	Shrubs (Sh)	3		11	1		18		
	Open forests (Of)			2	1				
	Burnt areas (Ba)								
		Present - 2006 CLC class							
	%	Ar	Pr	Ht	Fo	Sh	Of	Ba	Ot
Past – 2000 CLC class	Arable land (Ar)	1*	1	1		1	24		
	Permanent crops (Pr)								
	Heterogeneous agricultural areas (Ht)	12					12		
	Forests (Fo)			2			6		
	Shrubs (Sh)	3		19			12		
	Open forests (Of)	1		6					
	Burnt areas (Ba)								

* The area change from forest towards forest in 2006 results from the change between arable land sub-categories. Legend: Ar – Arable (IR) land; Pr – Permanent crops; Ht – Heterogeneous agricultural areas; Fo – Forests; Sh – Shrubs, herbaceous and sclerophylous vegetation; Of – Open forest, clear cuts and young plantations; Ba – Burnt areas; Ot – Other. Source: IGP (2010) - CORINE Land Cover

Although the occurrence of fire was not the most important driving force of land-use change in the Alentejo research area, the area affected by fire in 2003 was the largest in 24 years, and reached the national average value for this period: 1.2% of the total area (Figure 2.5).

The patterns of land-use change observed in the two research areas are largely consistent with those found in other Mediterranean regions. In Italy, Geri et al. (2010) and Pelorosso et al. (2009) observed an increase of forest areas to the detriment of semi-natural and agricultural areas since the mid-1950s. In Spain a similar trend has been reported by Serra et al. (2008) and Lasanta-Martínez et al. (2005). This trend occurred mainly in mountainous areas with a significant loss of agro-forestry ecosystems and the homogenisation of landscape patterns.

Implications of land use changes on land degradation and conservation

The comparative analysis of the land-use changes identified above and the RUSLE soil loss estimates for 1990 and 2006 contribute to the assessment of the erosion risk trend in the two research areas. Table 2.9 shows the soil erodibility factor (K) and the vegetation cover factor (C) for the land-use categories. Table 2.10 shows how land-use change has affected soil loss in the two research areas.

In the Centro research area the majority of the area is associated with soil loss classes higher than 10 t ha $^{-1}$ yr $^{-1}$ (Table 2.10). The increase of open forest at the expense of forest cover resulted in an increase of area associated with greater soil losses. Indeed, the area associated with soil loss higher than 10 t ha $^{-1}$ yr $^{-1}$ increased from 57% in 1990 to 64% in 2006. This resulted from the greater deforestation of erosion-prone areas.

Table 2.9 Erodibility factor (K) per soil type and vegetation cover factor (C) per land use class

Soil type	Factor K	Land Use	Factor C
Eutric Lihtosols	0.39	Arable land	0.3
Ferric Luvisols	0.32	Permanent crops	0.1
Hortic Luvisols	0.36	Heterogeneous agricultural areas	0.3
Dystric Cambisols	0.31	Forests	0.07
Eutric Cambisols	0.31	Herbaceous/ Shrubs/ Sclerophylous vegetation	0.02
Humic Cambisols	0.32	Open forests, clear cuts and young plantations	0.3
		Burnt areas	0.5

Source: based on Pimenta (1998); LNEC/Hidroprojecto (2000)

Table 2.10 Area distribution (% of total area) per soil loss class in Centro and Alentejo research areas in 1990 and 2006

	Centro research area - 1990								Alentejo research area – 1990							
t/ha	Ar	Pr	Ht	Fo	Sh	Of	Ot	Total	Ar	Pr	Ht	Fo	Sh	Of	Ot	Total
0-1		1	3	9	2	2		17	3		4		5		1	13
1-10		3	2	16	2	2		25	3		5	1	12			21
10-100	1	2	10	21	1	7		42	23		25	1	5	1		55
>100		1	5	6		3		15	3		7					10
	2006								2006							
0-1		1	3	4	1	8	1	18	3		4		2	2	1	12
1-10		2	2	8	1	4		17	3		4	1	6	2		16
10-100	1	2	10	9		19		41	20		22	1	2	13		58
>100		1	4	1		17		23	3		6			5		14

Legend: Ar – Arable land; Pr – Permanent crops; Ht – Heterogeneous agricultural areas; Fo – Forests; Sh – Shrubs, herbaceous and sclerophylous vegetation; Of – open forest, clear cuts and young plantations; Ba – Burnt areas; Ot – Other.

In the Alentejo research area the land-use change also resulted in a significant change of the soil loss class distribution (Table 2.10). The area associated with soil losses higher than 10 t ha $^{-1}$ yr $^{-1}$ increased from 65% in 1990 to 72% in 2006 (Table 2.10). This resulted, too, from an increase in open forest, although here the result of afforestation of marginal agricultural areas. Despite the different nature of open forest cover, post-fire regenerated pinus forest in the Centro, and oak-afforested areas in the Alentejo, we have considered that the cover provided to soil is equivalent. Therefore we have assigned the same C factor to both research areas. Future research for longer term analysis, should however consider that different susceptibility to fire might result from the two types of cover, as the findings of Nunes et al. (2005) imply. Post-fire management and afforestation techniques can also influence the amount of soil loss through the impact on the P factor, as shown by Shakesby et al. (1996) with the application of logging litter and minimum tillage. As shown by de Graaff et al. (2008a) the adoption of such soil conservation techniques is very context-specific, therefore we have considered that none of these techniques were applied. Figure 2.6 shows the increase of open forest between 1990 and 2006 in the two research areas. Considering that the white areas in the Centro area are mainly closed forest, the degradation toward open forest, resulting from forest fires, is very evident. In the Alentejo area the white areas in 1990 are mainly shrub land, and part of this and a small part of arable land have been turned into newly afforested open forest land.

2.6 Conclusions

As a result of population increase and wheat support policies, arable land use expanded in Portugal until the mid-1960s. This came at the expense of areas with rather marginal soils, and caused land degradation. After the 1960s, the incentives for the adoption of fertilisers and mechanisation favoured wheat production systems that were unsustainable in the long run. Afforestation measures were supported as well, but with little success regarding the conversion of marginal land. Instead, extensive pastures in transitional mountainous areas have been converted into Eucalyptus and Pinus forests.

During the democratisation period (1974-1986) land abandonment took place, while attention was paid to structural land reform.

Over the period 1986-2006 arable land use decreased further from about 30% of total area in 1986 to only 12% in 2006. The area under permanent crops remained constant at about 8%, and the closed and open forest area expanded slightly. Permanent grassland increased from only 7% in 1986 to about 20% in 2006. From this one might expect that land degradation would then decline, but further research in two selected areas provides evidence to the contrary. These two research areas, in the Centro and Alentejo regions, respectively, show different patterns of land-use change in the past 20 years. In the Centro area the agricultural area remained rather constant at a mere 27% of the area, despite a decrease of farmland, but the area under forest declined from 52% to only 22% of the area, mainly as a result of forest fires. This left open forest land, which in the years immediately after the fire is very susceptible to soil erosion.

In the Alentejo research area the agricultural land declined from 73% to 64% of total area, but the major change here was from miscellaneous shrub land, declining from 23% to 11%, and open forest land, increasing through afforestation from 1% to 22%.

Both of these land-use changes have resulted in a significant increase of soil loss estimates, which indicates a possible negative impact on land degradation processes. In the Centro research area soil losses higher than 10 t ha^{-1} yr^{-1} were estimated to occur in 57% of the area in 1990. As a result of closed forest degradation by fire, this share increased to 64% in 2006. In the Alentejo research area the conversion of miscellaneous shrub area into new forest plantations had the largest impact on the C factor increase, and therefore on soil loss estimates. Indeed, the soil losses higher than 10 t ha^{-1} y^{-1} occurred here in 65% of the area in 1990, rising to 72% in 2006. This confirms the findings of Roxo et al. (1998), who report the negative impact of the conversion of some areas with natural regeneration into new forest plantations. Other authors have reported the same increasing trend in land degradation as a consequence of land-use changes in Italy (Geri et al., 2010; Pelorosso et al., 2009; Salvati and Bajocco, 2011; Santini et al., 2010) and in Spain (Lasanta-Martínez et al., 2005; Serra et al., 2008).

This paper shows the complex interaction of socioeconomic drivers on land-use change and the key role of policies in particular. The results of our spatial analysis illustrate the need to articulate afforestation with other soil conservation measures in order to reach a more sustainable land-use pattern.

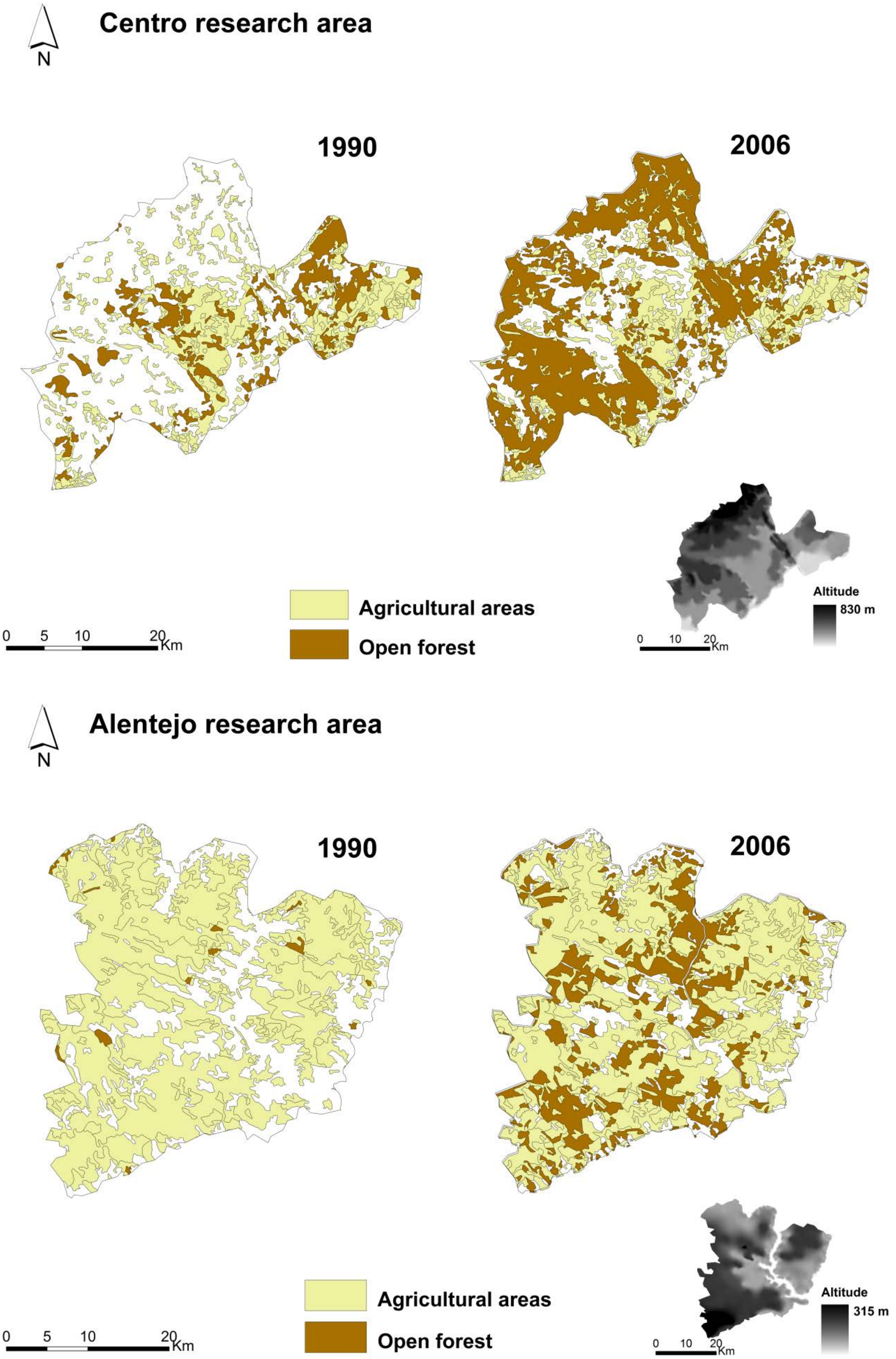

Figure 2.6 Main land use changes in Centro and Alentejo research areas for 1990 and 2006.

Chapter 3

Farming systems in two Less Favoured Areas in Portugal: their development from 1989 to 2009 and the implications for sustainable land management

Abstract

Since the late 1980s, sustainable land management is one of the objectives of the European Commission in Less Favoured Areas. In this paper, we investigate the economic and environmental sustainability of farming systems in two less favoured areas in Centro and Alentejo areas of Portugal. The specific objectives were the following: (i) to characterise the farming systems; (ii) to analyse their development over a 20-year period (1989–2009); and (iii) to investigate to what extent these farming systems contribute to sustainable land management. The diversity of the farming systems was identified through a survey and cluster analysis and compared with the Farm Accountancy Data Network classification on types of farming. Indicators on the economic and environmental sustainability were estimated, namely, farm net income, return to labour and rotation management, on the basis of a survey, Farm Accountancy Data Network database and Landsat imagery, respectively. Results indicate an increased focus on livestock in the past 20 years (1989–2009). In Centro, rotation management was not affected. The small ruminant farms have been able to retain a positive farm net income but that was only possible with a below average return to labour. In Alentejo, the increased focus on livestock, cattle in particular, led to an intensification of fodder production on certain plots. Mixed crop–livestock farms show a negative farm net income since 1995 and depend heavily on subsidies to remain viable. As other studies in southern Europe have shown, farm strategies have often been directed towards lowering labour inputs, lowering forage deficits through on-farm produced resources and acquiring subsidies.

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Farming systems in two Less Favoured Areas in Portugal: their development from 1989 to 2009 and the implications for sustainable land management

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Farming Systems in Two Less-Favoured Areas in Portugal: their development from 1989 to 2009 and the implications for sustainable land management

3.1 **Introduction**

The European Commission would like to maintain environmentally friendly farming in its less favoured areas (LFAs), because that could help to preserve habitat diversity, enhance soil fertility and allow for the maintenance of firebreaks (EC, 1997). LFAs include mountain areas, areas in danger of abandonment and areas affected by specific natural handicaps (EC, 1999). However, the farming systems in LFAs are under constant pressure to improve their productivity in order to be able to compete with more intensive systems in areas with fewer limitations (de Graaff et al., 2011). It is therefore important to assess the extent to which these systems remain sustainable. In the context of sustainable land management (SLM), sustainability has been conceptualised as a combination of technologies, policies and activities integrating socio-economic and environmental concerns in order to reach simultaneously the productivity, security, protection, economic viability and social acceptability objectives (Hurni, 2000; Smyth and Dumanski, 1993).

Until now, few studies have analysed the sustainability of Portuguese farming systems. Some have tackled the classification of farming systems (Baptista et al., 1991), whereas others have looked into the profitability of specific farm enterprises (Fleskens et al., 2009; Pearson et al., 1987). But very few have analysed specific farm types, with their integrated crop and livestock enterprises and their development over time, in order to capture the dynamics of farming systems with a focus on sustainability. In this paper, a farming systems approach has been used to characterise the past and present combinations and main features of the crop and livestock enterprises on certain farm types and to assess their productivity, economic viability and environmental sustainability.

Historically, Farming System Research has evolved from an approach focused on production economics towards a holistic approach that considers the farm as a system integrated within a broader hierarchy of systems (Byerlee et al., 1982; Norman, 2002; Ruthenberg, 1980). The striking evidence, around the 1980s, of the different degrees of success of particular innovations (e.g. mechanisation and fertilisers) in different socio-economic and biophysical settings led development practitioners to this conceptual revision (Simmonds, 1985) and to cater for the need for 'bottom-up' approaches and implementation, one also referred to Farming Systems Research and Development. In this paper, we focus on the analysis of the role of farm managers with their farming systems on SLM.

In the past two decades, a significant part of agricultural land in Portugal has been converted to open forest land, which includes shrubby vegetation resulting from land abandonment and post-fire forest regeneration and new forest areas resulting from afforestation. The outcome of this conversion seems to have led to an increase of land degradation in some LFAs (Jones et al., 2011). This leads to several questions: What land use developments at the farm level have led to this situation and which farm types have mostly contributed to this? Could the increased land

degradation be due to a higher stocking rate of cattle and/or small ruminants and as a result to shorter fallow periods?
Ruthenberg (1980) classified farming systems on the basis of such criteria as, among others: proportion of inputs produced inside the farm system (e.g. own produced animal feed), type of rotation (e.g. natural fallow systems including ley systems), and intensity of rotation, showing the extent of cropping versus fallow over the years. The rainfed crop-livestock systems are largely based on some arable and permanent cropping, some (agro) forestry, and most importantly on a combination of fodder crops and intensive and extensive grazing systems. The contribution of natural forage to the total feed consumption on a farm was used by Porqueddu (2007) to classify low-input farming systems in southern Europe. The change of these systems, with its impact on the environment, has been brought about by several strategies, ranging from pure abandonment to intensification (Abu Hammad and Tumeizi, 2012; Caballero et al., 2007; MacDonald et al., 2000; Thapa and Yila, 2012). Intensification has quite well-known effects, and abandonment can hinder the sustainability of extensive livestock systems, with socio-economic (Beaufoy et al., 1994; Caballero et al., 2007; Porqueddu, 2007) and environmental impacts (Beaufoy et al., 1994; Bento-Gonçalves et al., 2012; Moreira et al., 2005). In this paper, we hypothesised on one hand that higher stocking rates could well have reduced fallow periods and thereby increased land degradation for some farm types; whereas for others, low farm net income may soon lead to abandonment.

The objectives of this paper are therefore as follows: (i) to characterise the present farming systems as practised by specific farm types in two LFAs in Portugal; (ii) to characterise their development over time in the past two decades; and (iii) to investigate their contribution to SLM. Broader scale analysis of land-use changes across the world (Foley et al., 2005) and Europe (Bouma et al., 1998; Frost et al., 2007) have pointed out the need for small-scale detailed exploratory studies that might support sustainable land-use policy design. Ultimately, our goal is to illustrate the implications of the differential policy support of farming systems for the SLM in LFA.

3.2 Material and methods

Research areas

For this research, two areas are selected, which are part of the LFAs and are both prone to desertification risk (Jones et al., 2011). In the rest of the paper, the names Centro and Alentejo will be used to indicate these research areas. Centro includes three municipalities: Mação, Proença-a-Nova and Vila Velha de Rodão, and Alentejo includes the municipality of Mértola.

Biophysical features

Centro research area (112 kha) lies on the border of the subhumid climatic zone. Average annual rainfall ranges between 700 and 1400mm and is distributed over 50-75 days mainly between September and March (Figure 3.1). The average temperature lies between 12·5 and 15 °C. The most common soil types are eutric Lithosols and hortic Luvisols (CNA/SROA, 1978).

Alentejo research area (128 kha) lies in the semiarid climatic zone. The average annual rainfall ranges between 400 and 600 mm, distributed over 50–75 days also mainly in winter, and the average mean temperature is between 15 and 17·5 °C. The most represented soil types are eutric Lithosols and ferric Luvisols (CNA/SROA, 1978).

Socio-economic features

Centro population is about 19,000, agricultural employment is 3% and 95% of farm labour is provided by the family. Alentejo population is about 7,000, agricultural employment is 21% and 60% of farm labour is provided by the family (INE, 2011a, b). Concerning farm income, only 2% of the farms in Centro and 29% in Alentejo provide the farm household with a main source of income. In fact, most of the farms in both areas have a total output lower than €4,000/year (INE, 2010). Still, 96% of the farmers in Centro and 89% in Alentejo depend mainly on farming activities as their main source of income, next to the income from pensions and salaries. Although secondary sources of income of farm households are difficult to grasp directly from one single statistical source, more than 50% of the jobs are provided by the service sector in both areas (INE, 2011a, b). On average, only one annual work unit (AWU – work of one person full time) in Centro and 1·1 AWU in Alentejo are employed on the farm around the year (INE, 2010).

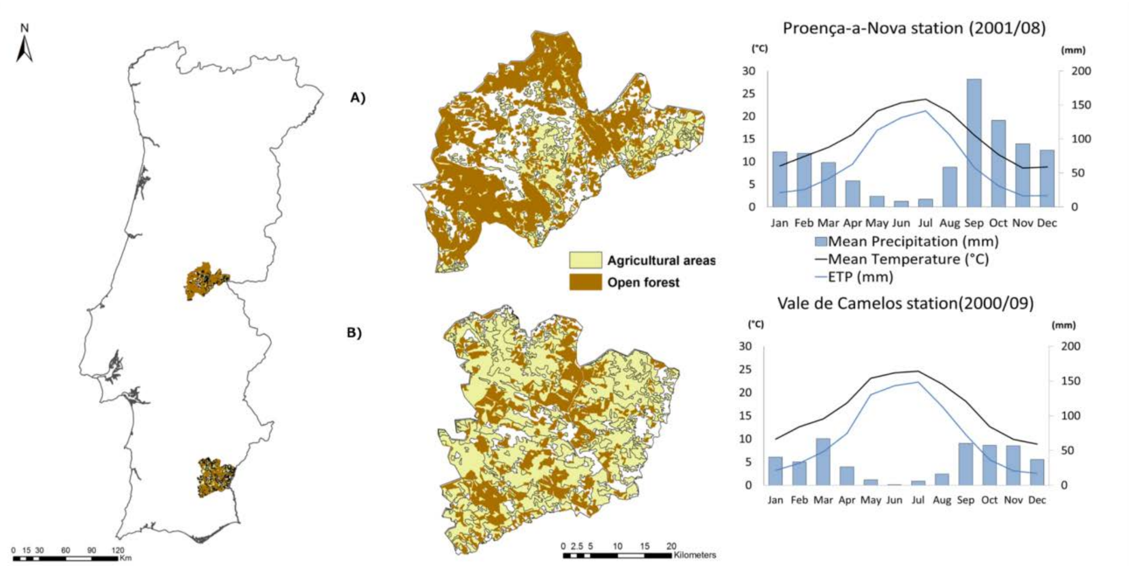

Figure 3.1 Research areas location: (A) Centro research area and (B) Alentejo research area. Mean precipitation, mean temperature and potential evapotranspiration (ETP).

Land and livestock endowments

Land and livestock endowments are quite distinct in Centro and Alentejo farms. While in Centro, about 3,000 farms manage 11·4 Mha of agricultural land with 1,000 livestock units (LUs – equivalent to one adult dairy cow producing 3,000 kg of milk annually, without additional concentrated foodstuffs); in Alentejo, about 700 farms manage 90 kha of agricultural land with 11,670 LU. Agricultural area is devoted mainly to permanent crops (55%), arable crops (25%) and permanent pastures (20%) in Centro and to permanent pastures (70%) and arable crops (30%) in Alentejo. In Centro, nearly all the livestock is composed of small ruminants; whereas in Alentejo, 35% consists of cattle (INE, 2010). Over the past two decades, livestock composition has changed significantly, likely because of market prices and common agricultural policy (CAP) subsidies. While in Centro in 1989, the goat to sheep ratio was about 3: 1; in 2009, almost all livestock is composed of sheep. In Alentejo, goats have completely disappeared and the small ruminants to cattle ratio is now 2: 1, whereas it was 10: 1 20 years ago (INE, 2010). Although land-use change has favoured the increase of permanent pastures at the expense of arable crops (Jones et al., 2011), the question remains whether the management of these pastures in terms of stocking rates and fallow periods is favourable or not for sustainability in terms of reduced land degradation.

Survey

For the analysis of the present farming systems, we used primary data collected through a farm survey. We interviewed 17 and 22 households in Centro and Alentejo, respectively, covering about 12% of the agricultural area in each research area. The survey was conducted by means of single contact interviews and covered the following topics: (i) characterisation of the farmers and their household; (ii) characterisation of the farm; (iii) soil management practices; (iv) animal production practices; (v) type of farm support schemes; and (vi) estimate of farm income.

Clustering

A cluster analysis was performed (SPSS/PASW 18, IBM Corp., New York, USA) with the information on land and livestock endowments per farm and the type of off-farm activity. Taking into account previous farming system analysis (Baptista et al., 1991; Pearson et al., 1987), we used the following criteria for the cluster analysis: arable area (ha), permanent crops (ha), forest with less than 30 years (ha), forest with more than 30 years (ha), goats (n°), sheep (n°), cattle (n°) and farmer's off-farm type of activity. Similar cases were grouped by computing the furthest squared mean distance on the standardised z-scores of the variables. Through this procedure, we ensured a stronger link of each farm case to its assigned cluster and that variables with different units could be compared (Field, 2005). Although the sample size is small, and clusters may not be very homogeneous, we think that it is useful to make some distinction between several farm types, with different characteristics and focus. Farm economic results such as farm net income and return to labour were computed for each group. Farm net income was obtained by deducting costs from the sum of output and subsidies and return to labour by dividing the sum of farm net income and labour input by amount of labour (FADN, 2010). The information on the direct aid payments per farm obtained through the survey was combined with the official public data from Instituto de Financiamento da Agricultura e Pescas (IFAP), available at http://www.ifap.min-agricultura.pt.

Farming Systems Over Time (1989–2009)

For the characterisation of the development of the farming systems over time (1989–2009), we analysed the main changes in land and farm characteristics per type of farming as classified by the Farm Accountancy Data Network (FADN). The type of farming of a farm holding is determined by the relative contribution of the standard output of the different characteristics of this holding to the total standard output of this one (EC, 2008). The type of farming reflects the characteristics of structure and management. In this paper, we will use the concept of type of farming as a proxy of farming systems in order to analyse farming systems' changes over time.

Two data sources were used: the National Agricultural Census (10-year base) and the National Accountancy Network (FADN) (annual base). The first dataset reflected the agricultural area under each type of farming at the sub-municipality level for the years of 1989, 1999 and 2009. Crop farms included among others farms specialised in arable crops and olives, livestock farms included among others farms specialised in small ruminants and mixed farming included mainly crop–livestock farms. In this way, we have obtained the main trend in the change of farming systems over the past

two decades (1989–2009). For a detailed view, we selected small ruminants and crop–livestock farms as the most significant both in terms of agricultural area and changes over this period.
The second dataset consisted of accountancy data of ten farms continuously surveyed by FADN during the period 1989–2009 in and closely to Centro and Alentejo research areas. This analysis shows the results in terms of return to labour and farm net income over the period 1989–2009 for the two main types of farming: small ruminants and crop-livestock farms.

Sustainability of Farming Systems

As rotation and fallow are the main practices used by farmers for conserving soil fertility, understanding the rotation dynamics is important to assess farming systems' sustainability. Because of different land and livestock endowments and level of farm income, farmers may use these practices differently. Therefore, we also investigated stocking rates and feed supply based on survey data and rotation management through the computation of Normalised Difference Vegetation Index (NDVI) – an indicator of vegetation greenness. The NDVI is a robust and widely used method to measure vegetation productivity (Wang et al., 2001). The index uses the reflectance of vegetation in the red and near-infrared (NIR) channels of the light spectrum. The index is equal to (NIR-RED)/(NIR +RED). Bare soil is characterised by NDVI values between -0.1 and 0.2, whereas dense vegetated surfaces show a variation between 0.5 and 0.8 (Carlson and Ripley, 1997). In the analysis, only the arable plots of Centro and Alentejo surveyed farms were selected. NDVI average values were computed for January to April images, when maximum greenness was expected. The minimum values for that average were assessed, and in view of those results, 0.3 was judged as a good determinant to distinguish cropping from fallow years.

Landsat 4–5 Thematic Mapper (TM) and Landsat Enhanced TM+ images were acquired for the two areas for the period 2001–2010. Earlier images were not available. The quality of all images was checked manually by visual interpretation, and empty data points were not taken into consideration in the analysis, that is why 2005 was not considered in Centro analysis.

Rainfall, temperature and even fallow management (e.g. Yamamoto et al., 2009) are also important for vegetation growth but not examined in great detail, as the current method was adequate to estimate the number of cropping years over the decade (2001–2010), as well as the consecutive number of fallow and cropping years. These variables were first assessed per plot, and their mode was determined over each farm group. The analysis was performed with spatial data from the land-parcel information system. Table 3.1 summarises the methodological set-up.

3.3 Results and discussion

Centro farm types

The respondents were mainly men (80%) with secondary school education, who started farming in the mid-1980s. The majority of them share the management with another member of the family: usually father and son (50%) or both spouses (30%). The household comprises on average three persons, the couple and one child who considers being successor on the farm, in case no other jobs would become available. On average, only one permanent worker was employed. Concerning land endowments, the surveyed farms ranged from 3 ha up to 628 ha, whereby fodder crops occupied from 45% to 100% of the farm land. Olives are the most significant permanent crop. The 17 surveyed farms were grouped in four clusters described in Table 3.2.

Table 3.1 Methodological set-up

Objectives	Methodological steps
Analysis of the actual farming systems	1. Grouping of surveyed farms based on land and livestock resources and enterprises, and off-farm activities; 2. Description of management characteristics per farm type;
Farming systems development over the past 20 years (1989-2009)	3. Characterisation of farm types based on census data for 1989, 1999 and 2009 (INE); 4. Characterisation of the change in farm management for each farm type, based on accountancy data (1990-2009) (FADN); 5. Determination of FADN farm types per group of farms in the sample;
Investigate farming systems contribution to sustainable land management (SLM)	6. Characterisation of rotation and fallow practices based on qualitative information from survey data and vegetation index (NDVI) trends informed by land use information per plot (IFAP).

Abbreviations: INE, Instituto Nacional de Estatistica; FADN, Farm Accountancy Data Network; NDVI, Normalised Difference Vegetation Index; IFAP, Instituto de Financiamento da Agricultura e Pescas.

The first group (C1) comprises part-time relatively old farmers, living on the farm, retired from other activities or with jobs not related to farming. The farm has on average 26 ha (±28) of agricultural land and 33 ha (±24) of forest (figures in brackets are standard deviations). Nearly three quarters of agricultural land is devoted to feed production (Table 3.2) to sustain the herd mainly composed by goats for milk production. These *small goat farmers* practice a semi-extensive husbandry that includes grazing of shrubby vegetation in areas in between the pasture fields. They also manage forest, mostly degraded maritime pine with more than 30 years of age. The second group of farmers (C2) includes full-time, relatively old, small farmers, occasionally also involved in marketing of farm products. On average, the farm includes 62 ha (±81) of agricultural land and 60 ha (±44) of forest. The agricultural area is evenly divided into arable and permanent cropping (Table 3.2). In these farms, sheep rearing is combined with permanent crops (olives) and fodder crops production, which occupy the whole arable area. The forest area comprises mainly plantations of less than 30 years of age (80%), mainly installed with the support of the afforestation measure a decade ago (EC, 1992, 1999). We will designate this group as *small sheep farmers*.

The third group (C3) integrates full-time, relatively young, medium-sized farmers, usually also involved in cheese making. On average the farm size is 205 ha (±50), all devoted to agriculture. The share of olives in the overall land use is the highest (Table 3.2). About 75% of arable area is devoted to feed production with triticale or oats occasionally harvested for grains or left for ley after hay cutting. In addition, fodder crops are also grown under the canopy of olives. Livestock mainly consists of sheep for milk production and is kept in a semiconfined system with paddocks near the shed. We refer to this group as *extensive sheep farmers*.

The fourth group of farmers (C4) includes full-time, relatively young, large farmers. On average, the farm includes 250 ha (±308) of agricultural land and 89 ha (±101) of forest. About 90% of agricultural land is used for arable cropping, with most of it used for animal feed production (Table 3.2). The remainder was used for industrial crops, such as tobacco and oil seeds. These farmers practise intensive sheep rearing for both milk and meat production. Eucalyptus spp. stands for pulp production constitute most of the forest area. Forest management is undertaken under contractual agreements with the pulp industry that pays a fixed rent to the owner. We refer to this group as *intensive sheep farmers*.

Economics of Centro farm types

Because of the relatively small farm size of the first three farm types, only intensive sheep farms (C4) seem to be highly productive with a high farm net income and a high return to labour despite the high costs (Table 3.3). In fact, if we consider the regional average annual wage of €12,000 (INE, 2011a, b), a threshold value under which farm abandonment becomes likely, only intensive sheep farms (C4) and small sheep farms (C2) are clearly viable in financial terms (Table 3.3).

Table 3.2 Farmer and farm characteristics per farm type – Centro

	C1 (N=9)	C2 (N=4)	C3 (N=2)	C4 (N=2)
Age of farmer (years) [a]	Old (61)	Old (59)	Young (44)	Young (44)
Farm activity	Part-time	Full-time	Full-time	Full-time
Live on-farm	Yes	No	--	--
Farm size (ha)	Small (59)	Small (122)	Medium (205)	Large (339)
Agricultural area : Forest area	1 : 1	1 : 1	1 : 0	3 : 1
Arable crops area : Permanent crops area	3 : 1	1 : 1	1 : 5	9 : 1
Fodder crop area (% of arable crop area)	100	100	75	90
Permanent pasture area (% fodder crop area)	5	13	4	3
Livestock (LU)	Goats (12)	Sheep (18)	Sheep (45)	Sheep (170)
Forest [b]	Degraded pine	Renewed *Montado*	--	Eucalyptus

Source: own survey November 2010.

[a]Variation coefficients are the least for the age variable (15%) and highest for arable over permanent area ratio (>100%).

[b]We have considered renewed forest stand where not less than 30% of the forest was younger than 30 years.

It is mainly thanks to the subsidies that small goat farming (C1) and extensive sheep farming (C3) become financially viable (Table 3.3).

While for small goat and sheep farmers (C1, C2), rural development payments are the most significant subsidies; for extensive and intensive sheep farmers (C3, C4), the single farm payments (submitted to cross-compliance obligations) are the most important (Table 3.3). Livestock payments represent a minor part of subsidies, but these are also partly integrated in the single farm payments as a result of the midterm CAP reform in 2003, which resulted in decoupling production from payments.

Small goat and sheep farmers (C1, C2) do not use hired labour. In order to cope with peak labour needs, small goat farmers (C1) use voluntary work from relatives often rewarded with a provision of quality products. Self-provision of quality products, pensions and other business revenues are significant for sustaining farming activity. Only two of these farmers plan to expand their activity, one with permanent pastures and the other with agro-tourism. Small sheep farmers (C2) would like to decrease their livestock activities and rely more on permanent crops. However, as stated by two of them, they should then also undertake the marketing of their products. For the other two, sheep production offers, as a secondary production activity, a positive contribution to farm image.

Table 3.3 Management results per farm type – Centro

	Part-time small goat farmers (C1; N=9)	Full-time small sheep farmers (C2; N=4)	Full-time extensive sheep farmers (C3; N=2)	Full-time intensive sheep farmers (C4; N=2)
Agricultural land (ha)	26	62	205	251
Rented land (ha)	0	0	140	0
Stocking rate (LU/ ha) [a]	0.5	0.3	0.2	0.7
Permanent labour (AWU) [b]	0.2	0.5	1.0	3.5
Total inputs (1,000€)	8	18	22	156
Total labour costs (%)	*38*	*39*	*45*	*19*
Feed costs (%)	*25*	*33*	*50*	*67*
Total output (1,000€)	13	39	38	325
Total subsidies incl. SFP (1,000€) [c]	7	18	26	126
Rural Development subsidies (%)	*57*	*83*	*4*	*2*
Livestock payments on total (%) [d]	*15*	*8*	*15*	*11*
Farm net income (1,000€)	13	39	42	298
Return to labour (1,000€ AWU^{-1})	12	30	26	73
Return to labour – without support (1,000€ AWU^{-1})	7	18	13	45

Source: own survey November 2010.

[a] Stocking rate is defined here as the ratio between total livestock units and agricultural area per agricultural holding.

[b] AWU is equivalent to the work of one person full time in an agricultural holding (Eurostat glossary).

[c] On the basis of IFAP database, rural development subsidies include afforestation, agri-environmental and less favoured areas payments.

[d] On the basis of conservative estimates of livestock payments per LU, €85 per small ruminant LU and €200 per cattle LU.

Extensive sheep farmers (C3) employ on average one permanent worker (Table 3.3). For these farmers, not labour but land seems to be the limiting factor. In order to cope with this, they establish an informal labour system based on renting land from old olive farmers. While obtaining extra land for pasture, they provide assistance to old olive farmers during harvest time. This also helps old olive farmers to comply with cross-compliance requirements. With regard to the future, extensive sheep farmers (C3) find themselves in a 'deadlock'. Because they depend on milk quantity to keep the cheese making running, they find it difficult to cope with lower yields as a result of organic farming or integrated production. Differently from small goat and sheep farmers (C1,C2) who benefit from the regional breed scheme, these extensive sheep farmers (C3) have to make use of improved breeds for milk production which activity receives less support.

Intensive sheep farms (C4) employ on average three permanent workers (Table 3.3). Although farm size allows for the internalisation of a significant part of animal feed production (Table II), feed costs represent 67% of total (Table 3.3). Similarly to the previous type of farming, the future of their farming activities will be determined by the evolution of sheep milk prices.

Livestock activities generate the highest share of output for most farm types in Centro area, except for the small sheep farms (C2) (Table 3.4). With olive output, the composition of their output corresponds to a mixed cropping type of farming as defined by FADN (EC, 2008).

Table 3.4 Total output (in 1,000 €) by farm type and enterprise - Centro

Unit = 1,000€	Part-time small goat farmers (C1; N=9)	Full-time small sheep farmers (C2; N=4)	Full-time medium sheep farmers (C3; N=2)	Full-time intensive sheep farmers (C4; N=2)
Arable cropping	1	2	0	105
Permanent crops	4	26	3	4
Livestock	6	11	35	216
Sheep	*2*	*11*	*35*	*215*
Goat	*4*	*0*	*0*	*1*
Total Output [a]	11	39	38	325
Type of farming	Small ruminants	Mixed cropping	Small ruminants	Small ruminants

Source: own survey November 2010.

[a]Forest output was not included; therefore, the total output of part-time small goat farmers is lower than in Table 3.3.

It is interesting to notice that mixed cropping allows smaller farm types (C1, C2 and C3) to obtain a sufficiently high return to labour without subsidies (Tables 3.3 and 3.4).

With regards forest revenues, only small goat farmers (C1) derived output from forest in 2009. Although owning mostly degraded pine stands, they also own eucalypts that they manage directly. Small sheep farms (C2) and intensive sheep farms (C4), who own a considerable area with eucalypts as well, have rented the area to the pulp industry and receive every 9 years the result of wood sales at a contracted price. Extensive sheep farmers (C3) do not own any forest.

Alentejo farm types

The respondents were mainly men (90%) with high school attendance who manage their farms since the mid-1980s. The household comprises also on average three persons, the couple and one child. Farm size ranged from 236 ha up to 1250 ha. Permanent cropping occupies a very limited area on all farm types and consists almost exclusively of old olive orchards with no commercial production. Fodder crops constitute from 50% up to 90% of arable land. Most of the forest area results from recent afforestation projects (less than 30 years old) (EC, 1992, 1999) mainly with stone pine (*Pinus pinea* L.), whereas the remainder consists of already established agroforestry – montado. About half the respondents managed their farm with family members. The 22 surveyed farms were grouped in five clusters described in Table 3.5.

The first farm type (A1) comprises mainly part-time farmers with an off-farm activity in the domain of agro-tourism, often living on the farm. The average farm size is 515 ha (±243), being almost exclusively devoted to arable cropping and evenly distributed between grains (triticale), fodder crops (oats and ryegrass) and area left to ley. Ley is the regrowth of fodder crops, very often the same species cultivated for grain, but cut for hay instead. The ley area is accounted for under fodder crops, which occupies about 65% of arable area (Table 3.5). With fertilisation, ley area is kept from 2 up to 5 years, being in this case accounted as permanent pasture. Although herds are usually mixed with cattle and sheep, cattle are predominant. These *part-time cattle farmers* own the smallest share of forest that is mainly renewed montado.

Table 3.5. Farmer characteristics per farm type – Alentejo

	A1 (N=5)	A2 (N=6)	A3 (N=3)	A4 (N=2)	A5 (N=6)
Age of farmer (years) [a]	Young (52)	Young (53)	Young (51)	Old (61)	Young (52)
Farm activity	Part-time	Full-time	Full-time	Full-time	Full-time
Live on-farm	Yes	--	No	--	No
Farm size (ha)	Medium (515)	Medium (437)	Medium (696)	Small (287)	Large (963)
Agricultural area : Forest area	13 : 1	6 : 1	2 : 1	1 : 9	4 : 1
Arable crops area : Permanent crops area	57 : 1	1 : 0	1 : 0	6 : 1	11 : 1
Arable crops area : Fallow area	1 : 2	1 : 3	1 : 1	--	1 : 1
Fodder crop area (% of arable crops area)	65	50	90	--	70
Permanent pasture area (% of fodder crop area)	14	41	51	--	51
Livestock (LU)	Cattle (108)	Sheep (94)	Cattle (171)	Sheep (23)	Mixed sheep + cattle (283)
Forest [b]	Renewed *Montado*	Renewed *Montado*	Old *Montado*	New pine	Renewed *Montado*

Source: own survey November 2010.

[a]Variation coefficients are the least for farm size (20%) and highest for permanent pasture over fodder area ratio (>100%).

[b]We have considered renewed forest stand where not less than 30% of the forest was younger than 30 years.

The second group (A2) consists of full-time farmers with medium-sized farms (437 ± 112 ha), of which about 85% is agricultural area evenly devoted to grain and fodder crops. About 40% of fodder area is permanent pasture. The main activity of these farms is sheep rearing for meat production combined with feed production in open oak stands (montado). Oak acorn offers also an alternative source of feed from November to February, when stubble or ley has been completely grazed and pastures installed in October are still emerging. Contrary to the traditional system, animals are kept semiconfined in paddocks. This allows a rotational management; where for each hectare used, three are left fallow. The share of fallow is the highest share among all farm types. Forest consists mainly of renewed montado. We designate this group as *sheep farmers*.

The third group (A3) includes full-time farmers who established their farming activity with the support of a young farmer project. Most live outside the farm. On average, the farm has 696 ha (±56) that includes about one third of forest (Table 3.5). About 90% of agricultural land consists of fodder crops and about half of this is permanent pasture. Fallow and cropped areas are about the same size. Although herds are usually mixed with cattle and sheep, cattle dominates. Forest area combines new and traditional oak plantations, where old montado (*Quercus rotundifolia* Lam.) is predominant. We designate these farmers as *full-time cattle farmers*.

The fourth group (A4) comprises relatively old farmers who have converted most of their farm land (287 ± 71 ha) to forest with the support of the European Union (EU) afforestation measure (EC, 1992; EC, 1999). They have no arable crops at the moment, and sheep are kept in the old montado area. They pay a forest contractor to conduct forest maintenance, an obligatory requirement in order to receive the subsidy. New oak area largely surpasses old montado area; still, stone pine is the predominant species in afforested areas. We designate these farmers as *retired farmers with new forest*.

The last group (A5) includes full-time farmers, occasionally involved in the marketing of meat products. Most of them do not live on the farm. They manage large farms (963 ± 207 ha), which include about one fifth of forest area. About 70% of agricultural land is devoted to fodder crops from which about half is permanent pasture. For each hectare of cropped area, another hectare is left to fallow. Herds are usually mixed with sheep and cattle. The forest area is dominated by renewed montado, where new oak stands represent nearly 60% of montado area. We designate these farmers as *large mixed livestock farmers*.

Economics of the Alentejo farm types

All farm types, except full-time cattle farmers (A3), manage to obtain a sustainable farm net income and return to labour, partly thanks to subsidies. Mixed livestock farms (A5) have by far the best economic results. Compared with the regional average annual wage of €10,000 (INE, 2011a, b), only part-time cattle farmers (A1) and mixed livestock farmers (A5) manage to obtain a good return to labour (Table 3.6). It is interesting to notice that these farms contract the highest amount of permanent labour.

While for part-time cattle farms (A1), rural development subsidies constitute only 7% of total subsidies; for mixed livestock farmers (A5), they represent 33%, and for forest retired farmers, even 100%. Sheep farmers (A2) and forest retired farmers (A4) depend on subsidies to make their operations viable. In fact, for sheep farmers (A2), the amount of subsidies received is about the same as total output, and forest retired farmers (A4) subsidies are almost the sole contributions to farm income. Full-time cattle farms' (A3) return to labour is just positive even with subsidies and without those it would be negative. This is due to very high feed purchases, and they cannot compensate that enough with their output. For these farms, livestock payments constitute the highest share of direct payments.

In a characterisation of extensive livestock systems in Europe by Moreira and Coelho (2010), an extensive grazing system in medium to large private farms is defined as a type of extensive grazing existing in south Iberian Peninsula that relies on an increasing substitution of labour by costly investments in fences and automatic water points. To some extent, we identify this trend in full-time cattle farms (A3), where input costs exceed largely the output, and feed costs represent 86% of the total input (Table 3.6). Despite the restricted area left to fallow (one for each cropped hectare) and the high proportion of grazing area in arable land (90%) (Table 3.5), livestock feed requirements have to be supplemented with a high amount of purchased feed. This is in part due to the higher number of cattle. Unlike sheep, cattle cannot be allowed to graze in sown pastures in late spring because of the soil disturbance they would cause; so, they have to be provided with feed. Although this is more costly in terms of feed, it avoids hiring labour to manage the herd from paddock to paddock. Beyond labour and feed requirements, livestock subsidies and market prices play a significant role in farmers' decisions to favour cattle over sheep; as a farmer explained quite clearly: 'where a cow eats, five sheep could eat instead; however, the subsidy is at least ten times more for the cow, and lamb meat prices are roughly the same as 10 years ago'. These results are in line with the research of Coelho and Reis (2009); Madeira (2008); Pearson et al. (1987).

Table 3.6 Management results per farm type – Alentejo

	Part-time cattle farmers (A1; N = 5)	Sheep farmers (A2; N = 6)	Full-time cattle farmers (A3; N = 3)	Forest retired farmers (A4; N = 2)	Mixed livestock farmers (A5; N=6)
Agricultural land (ha)	477	371	449	29	759
Rented land (ha)	10	115	0	0	284
Stocking rate (LU/ ha) [a]	0.2	0.3	0.3	0.2	0.3
Permanent labourers (AWU) [b]	0.8	0.2	0.7	0.5	4.5
Total inputs (1,000€)	37	29	188	13	141
Labour costs (%)	*24*	*7*	*4*	*7*	*35*
Feed costs (%)	*32*	*55*	*86*	--	*43*
Total output (1,000€)	76	37	125	6	269
Total subsidies (1,000€) [c]	46	35	66	42	132
Rural Development subsidies (%)	*7*	*20*	*27*	*100*	*33*
Livestock payments on total (%) [d]	*37*	*28*	*44*	--	*26*
Farm net income (1,000€)	85	43	3	34	260
Return to Labour (1,000€ AWU^{-1})	52	39	7	29	56
Return to Labour – without support (1,000€ AWU^{-1})	26	9	-33	1	32

LU, livestock unit; AWU, annual working unit.

Source: own survey November 2010.

[a] Stocking rate is defined here as the ratio between total livestock units and agricultural area per agricultural holding.

[b] AWU is equivalent to the work of one person full time in an agricultural holding (Eurostat glossary).

[c] On the bass of IFAP database, rural development subsidies include afforestation, agri-environmental and less favoured areas payments.

[d] On the basis of conservative estimates of livestock payments per LU, €85 per small ruminant LU and €200 per cattle LU.

With regard to labour, both part-time and full-time cattle farmers (A1, A3) hire one permanent worker. Part-time cattle farmers (A1) tend to have the help of relatives in cropping activities. This gives them extra time to run the agro-tourism business. Three out of five part-time cattle farmers (A1) were sheep farmers before 2008. In two cases, this change involved the conversion of grain crop area into sown pasture area. The third farmer reduced labour and land rented from others. In the present system in which high feed requirements are met with external feed sources cattle rearing is less land and labour demanding than sheep rearing. Also, two out of three full-time cattle farmers (A3) reduced sheep herds to buy cattle. They have a business attitude and do not see themselves as 'nature managers' as they claim the actual policy framework wants to make of them.

Mixed livestock farmers (A5) hire the highest number of workers, about four persons, whereas sheep farmers (A2) and forest retired farmers (A4) hire the lowest number of workers. In the case of mixed livestock farmers, more labour is needed because of large farm size and more variety of activities. Mixed livestock farmers (A5) have invested in more permanent cropping and improved permanent pastures with clover spp. However, in order to cope with high maintenance costs, two of them have partially substituted permanent pastures by sown pastures with mixed grain crops, which can be harvested as concentrates for own use or for the market when prices are profitable.

Four out of six sheep farmers (A2) have reduced their herds substantially after 2003. The only milk producer, who also owns a cheese making unit, wants to sell the farm. Part of the herd reduction is not yet reflected in direct payments.

Forest retired farmers (A4) hire forest contractors, who provide labour and technical equipment, to conduct forest maintenance operations. They have given up sheep rearing and count on the collaboration of relatives to supervise forest operations. The majority of afforestation projects are reaching maturity within 5 years and payments will then stop, which may cause problems in complying with minimum forest cleaning operations.

For most farm types, arable crops and livestock activities contribute equally to output that results in a crop livestock type of farming (e.g. A1, A2, A3) (Table 3.7). In large mixed livestock farms (A5), permanent crops contribute with a significant share to total output that results in a mixed cropping farming type. Farms with herds almost exclusively composed of cattle or sheep such as those of cattle farmers (A1, A3) and sheep farmers (A2) seem to have a lower return to labour than mixed herds such as those of mixed livestock farms (A5) (Tables 3.6 and 3.7).

Farm Types Over Time (1989–2009)

In this section, we will use the type of farming accounted in national statistics as a generalisation of farming systems. In last section, we have characterised the present farm types and we have determined the types of farming to which they were more closely associated with (Tables 3.4 and 3.7).

Table 3.7. Total farm output (in €1,000) by farm type and enterprise – Alentejo

unit = 1,000€	Part-time cattle farmers (A1; N = 5)	Sheep farmers (A2; N = 6)	Full-time cattle farmers (A3; N = 3)	Forest retired farmers (A4; N = 2)	Mixed livestock farmers (A5; N=6)
Arable cropping	31	15	65	0	45
Permanent crops	0	0	0	0	136
Livestock	42	19	61	5	86
Cattle	*33*	*3*	*52*	*0*	*42*
Sheep	*9*	*15*	*9*	*5*	*37*
Goat	*0*	*1*	*0*	*0*	*7*
Other	3	3	0	1	1
Total output	76	37	125	6	269
Type of farming	Crop-livestock	Crop-livestock	Crop-livestock	N/A	Mixed cropping

Source: own survey November 2010.

In Centro, we identified three farm types as small ruminant farms (C1, C3 and C4) and one farm type as mixed cropping farm (C2). In Alentejo, three farm types were identified as crop-livestock farms (A1, A2, A3) and one as mixed cropping (A5). For retired forest farms (A4), the concept type of farming was not applicable.

Overall, during the past two decades and in both research areas, farms specialised in livestock activities (e.g. small ruminant farms) have increased their business at the expense of farms with a mixed production pattern (e.g. crop-livestock farms).

In both research areas, small ruminant farms are the most represented among livestock farms. In Centro, they occupy 26% of agricultural area (11,363 ha) and own 78% of total LUs (1,006 LU); whereas in Alentejo, these shares are 30% (90,018 ha) and 39% (11,674 LU), respectively (INE, 2010). Since 1989, this represents more than a sevenfold increase in Centro and twofold in Alentejo in terms of area; whereas in terms of total LUs, it represents more than a twofold increase in both research areas (INE, 1990).

In contrast, crop–livestock farms that occupy 18% of the area in Centro and 15% in Alentejo; registered during the same period, a drop of more than one third in Centro and two thirds in Alentejo. In terms of total LUs, the drop was 88% and 65%, respectively (INE, 1990, 2010).

With regard to grazing, not only the share of pastures increased but also those with a permanent character increased both in small ruminant and crop–livestock farms in the two research areas (Table 3.8). Overall, this has led to a decrease of stocking rates in both areas. For example in small ruminant farms, stocking rates decreased from 0.9 to 0.3 LU/ha in Centro and from 0.4 to 0.2 LU/ha in Alentejo (Table 3.8). These trends favour SLM. The increased allocation of arable land to permanent pasture contributes to decreased soil erosion by reducing the number of tillage operations and by providing vegetation cover throughout the year.

Table 3.8. Livestock and grazing area characteristics per type of farming in Centro and Alentejo (1989-2009).

	Centro			**Alentejo**		
	1989	**1999**	**2009**	**1989**	**1999**	**2009**
Small ruminants/ Total livestock (%)						
Small ruminant farms	100	93	100	100	100	94
Crop-livestock farms	72	94	93	88	75	71
Grazing area/ Agricultural area (%) (a)						
Small ruminant farms	75	51	77	60	39	82
Crop-livestock farms	18	25	25	45	33	51
Permanent pastures/ Grazing area (%)						
Small ruminant farms	33	32	56	86	89	93
Crop-livestock farms	5	29	59	85	91	96
Stocking rate (LU/ha)						
Small ruminant farms	0.9	1.4	0.3	0.4	0.6	0.2
Crop-livestock farms	1.2	1.3	0.2	0.3	0.5	0.3

Source: INE, 1990; INE, 2000; INE, 2010.

[a]Grazing area includes permanent pastures, temporary pastures and fodder crops; agricultural area includes arable crops, permanent crops and grazing area.

Decreased stocking favours a more balanced management of pasture area, avoiding overgrazing and soil compaction.

It is important to notice that, although not shown in the table, the majority of small ruminants owned by crop–livestock farms in Centro are sheep, which to a large extent have substituted goats, particularly in the last decade. This is also a reason for the increase of permanent pasture, because sheep only graze, whereas goats also browse (on shrubs).

In Alentejo, crop–livestock farms have been replacing small ruminants for cattle. The share of small ruminants (almost exclusively sheep) has decreased from 88% in 1989 to 71% in 2009 (Table 3.8), whereas the share of cattle increased from 12% to 29%. The research of Madeira (2008) on the two livestock systems for meat production in Alentejo area shows that as result of the Agenda 2000 CAP reform, support for cattle increased from €20/ha in 1992 to €136/ha in 2004; whereas for sheep, the increase was far more modest, from €69/ha in 1992 to €72/ha in 2004. Unlike the increase in the share of permanent pasture in the total grazing area and the decrease of stocking rates, the increase of sheep over goats in Centro and the increase in cattle over small ruminants in Alentejo, although to some extent with the use of regional breeds, has a rather detrimental effect on SLM as will be shown further on this paper.

Economics of small ruminant and crop–livestock farms over time (1989–2009)

The assessment of the economics of the two main types of farming over time focused on the analysis of the return to labour and farm net income. Over the past two decades (1989–2009), small ruminant farms in Centro had in most years a return to labour (even with support) below the national minimum wage (Figure 3.2).

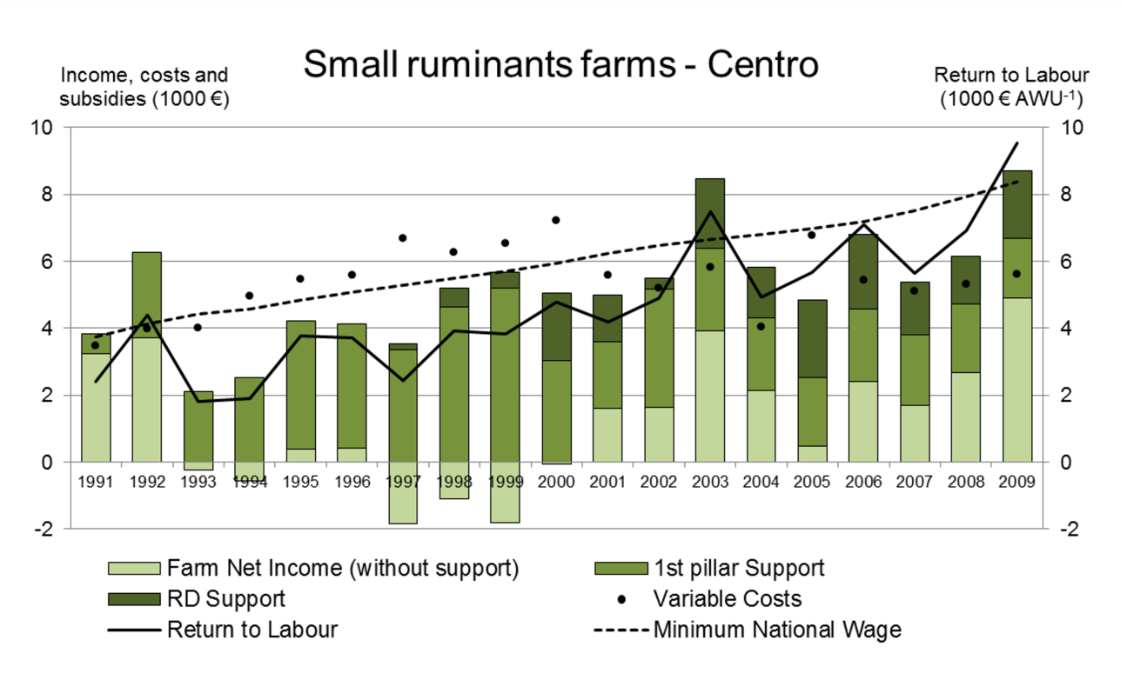

Figure 3.2 Main farm results of small ruminant farms in Centro [four farms in Farm Accountancy Data Network (FADN) sample] over the period 1991–2009 (data source: GPP/FADN database Portugal).

This has been partially sustained by labour with low opportunity cost (e.g. part-time workers and retired persons) and farming rationales other than market orientation. Nevertheless, recently, it seems that return to labour is slightly increasing, mainly as a result of a decrease in variable costs and an increase of farm income. Although the total level of support has remained nearly the same since 1992, the share of rural development payments in total payments has increased, which seems to have had a positive effect on farm net income. Recently, with the exception of 2005, which was a particularly dry year (IM, 2012), farm net income without subsidies shows an increasing trend.

In Alentejo, crop–livestock farms had on average a return to labour (with support) slightly above the national minimum wage, despite the decreasing trend in farm net income (Figure 3.3). In fact, since 1996, farm net income without subsidies has been negative. Thanks to the direct payments, these farms can continue their activities. Rural development subsidies form a minor share of direct payments for these farms, except between 2000 and 2002 when they benefited from specific agri-environmental measures mainly targeting permanent pastures. Variable costs, which during the whole period seem to have been correlated with the amount of aid, are now apparently stabilising.

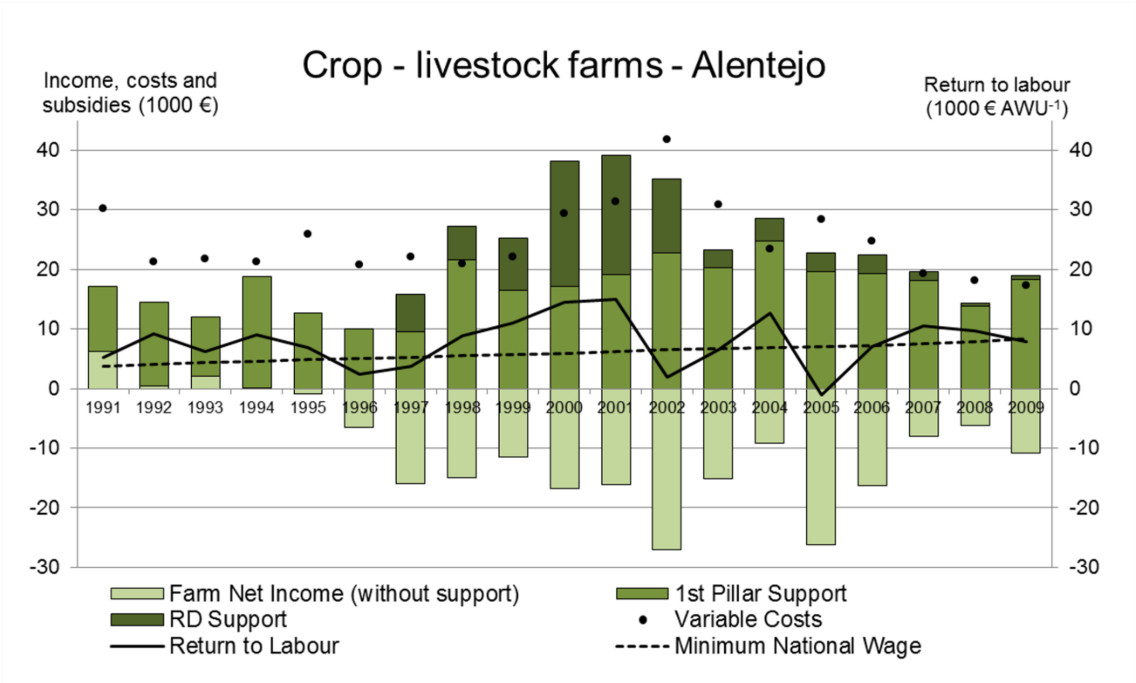

Figure 3.3 Main farm results in crop–livestock farms in Alentejo [six farms Farm Accountancy Data Network (FADN) sample] over the period 1991–2009 (data source: GPP/FADN database Portugal).

Farming Systems and Sustainable Land Management: Rotation and Fallow Practices

We have characterised earlier the different farm types in terms of their present resource endowments and management results. Small ruminants for milk production and mixed herds of sheep and cattle for meat production are the main activities of the specific farm types distinguished, respectively four in Centro and five in Alentejo. In the previous section, we characterised the change over time of these two main types of farming. In the present section, we will try to understand the rotation dynamics of the installation of fodder areas, which is a key issue for the sustainability of farming systems on the basis of livestock production in both environmental and economic terms. The analysis will focus on the farm types identified earlier.

Although the trend over the past 20 years indicates that the overall share of permanent pastures in grazing area is increasing, the different farm types are adopting distinct strategies to cope with the feeding needs of livestock. Table 3.9 shows the amount of money spent on feed purchases and the value of feed produced on-farm by the different farm types identified in Centro area.

Small goat farms (C1) and intensive sheep farms (C4) have the highest share of feed produced on-farm (34% of feed expenditure), yet they have different strategies regarding feed provision (Table 3.9). While the first manage to be highly self-sufficient by assigning a large area to each LU (4 ha/LU), the second uses land the most intensively, assigning only 1 ha/LU. With regard to fallow duration, the different intensity in land utilisation seems not to result in shorter fallow periods, as all farm types manage to leave land to fallow 3 years in a row. This is also confirmed by the analysis of satellite images through the estimates of NDVI, which identify a similar number of cultivation years for all farm types within the decade, usually 4–5 years of cultivation (Table 3.9).

On extensive sheep farms (C3), the value of feed produced on-farm represents the lowest share among Centro farm types, only 2% (Table 3.10) that matches also with the lowest share of arable land devoted to fodder crops (75%) (Table 3.2). Small sheep farmers (C2) manage to produce on-farm about 20% of feed requirements, half of them by organic and integrated production methods. These farmers devote the largest share of fodder crops to permanent pastures (13%, Table 3.2).

In Alentejo, the identified farm types use the land more intensively than in Centro. In order to provide feed for one LU all farm types use less than 3 ha. Understandably, cattle farmers have the largest area per LU, 2.6 ha/LU on full-time cattle farms (A3) and 1.7 ha/LU on part-time cattle farms (A1) (Table 3.10). However, with the larger area per LU, full-time cattle farmers (A3) provide the lower value of feed, 27% against 67% on part-time cattle farms (A1). Although one might conclude that full-time cattle farms (A3) are less intensive than part-time cattle farms (A1), it is not the case; because within the last decade (2001-2011), the whole plots showed to have been cultivated for 6 years against only 4 years on part-time farms (Table 3.10). In the sheep farms (A2), the area devoted to each LU is the lowest among all farm types (1.1 ha/LU). Still, they manage to provide about half the feed expenditure with on-farm production while leaving to fallow the highest share of land (3 ha for each cropped hectare, Table 3.5). This seems to indicate a higher suitability of sheep to land and climate conditions.

All farm types manage to include 3 years of fallow in their rotations. In fact, the mode of the maximum number of consecutive years of fallow identified within the decade (2001–2011) is 3 years for all farm types. Within the decade, full-time cattle farmers (A3) and mixed livestock farmers (A5) seem to use land more intensively as the total number of cropping years is 6 and 7 years, respectively (Table 3.10).

Our research on the respective farm types in two areas in Portugal and their economic and environmental sustainability brought to light the narrow margin of their economic viability in terms of return to labour, their strong dependence on public handouts and their trend towards specialisation in detriment of mixed farming systems while preserving extensive features. Porqueddu (2007) shows similar trends in extensive grassland farming systems in southern Europe and Caballero et al. (2007) do so for LFAs in Europe. These authors consider that these systems result from traditional systems that made modifications to overcome the socioeconomic and environmental constraints, mostly related to labour and forage deficit.

The adopted strategies to overcome such constraints have been to lower labour inputs (Caballero, 2001), to lower forage deficit with on-farm produced resources (Porqueddu, 2007) and to acquire subsidies (Caballero et al., 2007).

Traditional grassland farming systems have been changing through the replacement of grazing by hay cutting (Caballero, 2001; MacDonald et al., 2000) and fencing (Caballero et al., 2007; Moreira and Coelho, 2010). This translates into changing grazing patterns with localised concentration of livestock around farmsteads and intensification of forage production on better quality plots, whereas others are being abandoned (MacDonald et al., 2000). Our results are not conclusive with regard to grazing patterns, but through the assessment of the number of cultivation years within the decade 2001–2011, we were able to identify localised intensification at the farm level at least for two farm types in Alentejo: full-time cattle farmers (A3) and mixed livestock farmers (A5). Although the sequence of images was not complete for Centro, the results seem to indicate that there is no localised intensification.

Table 3.9 Sustainability indicators regarding feed consumption and fodder area per livestock unit - Centro

	Part-time small goat farmers (C1; N=9)	Full-time small sheep farmers (C2; N=4)	Full-time extensive sheep farmers (C3; N=2)	Full-time intensive sheep farmers (C4; N=2)
Feed produced on-farm (a) (1000 € per farm)	1	2	0	54
Feed purchased (1000 € per farm)	2	6	11	104
Feed self-sufficiency (% in value)	34	23	2	34
ha LU^{-1} (b)	4	3	9	1
Average fallow years	3	3	3	3
No. Cultivation years (in 9) (c)	4	5	--	5

Sources: Own survey 2010/11; Landsat images 2001-2011

Notes: (a) The value of the feed produced on-farm does not include the value of the grass consumed fresh (grazing); (b) Includes Montado area and arable crops without fallow area; (c) It was not possible to obtain an image for 2005.

The distortion effect of livestock payments in extensive grassland farming systems has been widely reported (Beaufoy et al., 1994; Caballero et al., 2007; Madeira, 2008). Our results illustrate that situation quite well. On the one hand, small goat and sheep farmers (C1, A2) represent the most traditional systems that make good use of poor pasture resources, which are common on idle land in Centro and on heavily degraded soils in Alentejo. On the other hand of the intensification «spectrum» are intensive sheep farmers and full-time cattle farmers (C4, A3) who rely mainly on purchased feed. These farm types depend mainly on first pillar CAP payments and on the strategy followed by farmers for maximising these subsidies. Somewhere in between are the other farm types either adjusting feed production with more ley (C3, A1), feed requirements with less cattle (A5) or investing in supplementary activities (e.g. quality olive oil) with the support of rural development payments (C2). We have shown that these strategies have not the same value in terms of SLM.

In Centro, it seems important to maintain grazing practices of poor pasture resources for vegetation control in order to avoid wildfires; the replacement of goats for sheep and the increased focus on specialised livestock farming seems to contradict that expectation.

Extensive grazing, particularly with goats, contributes to a well-managed forest-pasture mosaic in depopulated mountainous areas where shrub encroachment is the trigger of recurrent fire events (e.g. Álvarez-Martínez et al., 2013). Álvarez-Martínez et al. (2013) found that in Spanish Cantabrian Mountains, most benefits were perceived from extensive grazing in combination with other practices (e.g. trimming and prescribed fires). Other solutions have been tried out for the immediate intervention after fire occurrence such as the application of hydromulching – a mixture of seeds, wood fibbers, a surfactant, nutrients, a natural biostimulant and a green colourant (Prats et al., 2013). In Centro, although the intervention proved effective at the plot level, it is expensive and not yet completely established for large areas (Prats et al., 2013). Such interventions might be justified for the control of flood risk that can be an issue for pine and eucalypt forests after fire when the already existing soil water repellence seems to increase (e.g. Santos et al., 2013; Stoof et al., 2011). Therefore, providing subsidies for the maintenance of extensive grazing farms can be cost-effective for safeguarding landscape production and regulation services at stake.

Table 3.10 Sustainability indicators regarding feed consumption and grazing area per livestock unit - Alentejo

	Part-time cattle farmers (A1; N = 5)	Sheep farmers (A2; N = 6)	Full-time cattle farmers (A3; N = 3)	Forest retired farmers (A4; N = 2)	Mixed livestock farmers (A5; N=6)
Feed produced on-farm (a) (1000€ per farm)	24	15	61	--	45
Feed purchased (1000€ per farm)	12	16	162	--	60
Feed self-sufficiency (% in value)	67	47	27	--	43
ha LU^{-1} (b)	1.7	1.1	2.6	--	1.3
Average fallow years	3	4	3	--	4
No. Cultivation years (in 10) (c)	4	4	6	--	7
No. Consecutive Fallow Years	3	3	3	--	3
No. Consecutive Cultivation Years	3	1	3	--	3

Sources: Own survey 2010/11; Landsat images 2001-2011

Notes: (a) The value of the feed produced on-farm does not include the value of the grass consumed fresh (grazing); (b) Includes montado area and arable crops without fallow area; (c) One part-time cattle farm and two sheep farms were not located and therefore not considered in NDVI analysis.

In Alentejo, although the maintenance of permanent pasture is positive to protect the already degraded soils, its association with high feed requirements such as those of cattle farms might cause an over-intensification on other plots of the farm if the feed value of these pastures is not properly targeted.

For crop-livestock farms in Nigeria, Thapa and Yila (2012) also showed that farmers tended to choose management practices that they perceived as bringing the highest return to labour. Although it could be desirable to have more livestock in order to have a larger pool of manure to integrate into the soils, the lack of labour might be a constraint to do so. An alternative intensification path is needed for these traditional systems that are still operating.

The need to redirect subsidies to the support of sensible management alternatives that might render these systems more sustainable in the future is also a recurrent recommendation (Beaufoy et al., 1994; Caballero et al., 2007). A good example is the improvement of self-sown legume-based pastures, which constitutes a long-term lowering cost strategy (Porqueddu, 2007) and an opportunity for the rehabilitation of degraded land (Porqueddu et al., 2013). This recommendation could be of use for farm types where pasture efficiency was not at its best, for example, in the case of extensive sheep farmers in Centro (C3) and full-time cattle farmers in Alentejo (A3). At the EU level, a number of agri-environmental measures were designed to support beneficial traditional practices (e.g. the upkeep of permanent pastures), which have been abandoned over the years in the course of intensification biassed policies (Barbayiannis et al., 2011; Calatrava et al., 2011; Prager et al., 2011; Prosperi et al., 2011). Although the design of these incentive-based measures potentially delivers the desired benefits, a better target at the farm level management needs to be put into practice in order to deliver the intended benefits (Louwagie et al., 2011; Posthumus et al., 2011). A measure for the improvement of permanent pastures would have a high initial cost and would have to be well articulated with livestock payments and cross-compliance measures. This recommendation stems also from the research of Kutter et al. (2011) on the EU-27 policy measures with a soil conservation focus.

3.4 Conclusions

This paper focused on the analysis of land management at the farm level in order to find out whether land degradation was due to higher stocking rates and shorter fallow periods. The analysis shows that in spite of an increased focus on livestock activities at the expense of mixed farming stocking rates decreased and the share of permanent pastures increased. Livestock payments in particular for cattle seem to have encouraged high expenditures on external inputs (e.g. full-time cattle farmers, A3), whereas rural development payments seem to have encouraged more sustainable strategies such as the improvement of yields of mixed farming systems (e.g. small sheep farmers, C2, and mixed livestock farmers, A5). This is also perceived from the trend of farm net income composition over time (1989–2009) constructed with the national FADN data.

In Centro, goat and extensive sheep farms (C1, C3) showed to have lower returns to labour and goat farms (C1) were in fact unsustainable without subsidies. Intensive sheep rearing (C4) showed to be viable on large farms managing to internalise feed production costs. Permanent cropping with olives contributes to the higher returns to labour and farm net income of mixed cropping farms (C2). In these farms, about 20% of the total amount spent on feed is met with on-farm production. For each LU, 3 ha is available and about 13% of the area devoted to fodder crops is maintained with permanent pastures.

In Alentejo, all farm types manage to remunerate labour above regional average annual wage, except full-time cattle farms (A3) that present a negative return to labour (€ -33,000/AWU) depending on subsidies to stay viable. Mixed herds of sheep and cattle were responsible for the higher returns to labour and farm net income of mixed cropping farms (A5). In these farms, about 40% of the amount spent on feed is produced on-farm. About 1.5 ha is devoted to each LU, and about 51% of fodder crops area is maintained with permanent pastures.

While in Centro, the change from perennial to arable crops (for animal feed) seems not to have affected the rotation management; in Alentejo, the increased focus on cattle did lead to a higher number of cultivation years and hence seems to indicate a trend towards less sustainable land use. In order to support economically viable and environmentally sustainable farming systems, future policy design should take into consideration the suitability of livestock and pasture associations. In the past 20-year period (1989–2009), the most economically viable and environmentally sustainable systems in Centro and Alentejo seem to have been associated with mixed cropping farming types.

Chapter 4

The role of EU agri-environmental measures preserving extensive grazing in two Less-Favoured Areas in Portugal

Abstract

Since 1992 agri-environmental issues have gained attention by reforms of the CAP. For instance by supporting environmentally friendly land use, such as permanent pastures in less-favoured areas (LFA) that are only marginally suitable for alternative farming practices. In the last two decades a significant part of agricultural land in Portugal has been converted to permanent pastures. The question is what role the EU agri-environmental measures (AEM) have played in that development.

This paper assesses to which extent AEM have been effective in preserving and promoting permanent pastures and extensive animal production. We investigated two AEM in two research areas: Traditional Mixed Farming (TMF) in Centro and Extensive Grassland (EG) in Alentejo for the implementation period 2005-2009. Spatial information was analysed to link plot and farm characteristics with performance (result and impact) indicators such as stocking rate and soil cover (assessed through the normalised difference vegetation index (NDVI)). These indicators have been recognized as valuable indicators of AEM effects, and are therefore used in this research. A comparison was made between farms with certain AEMs and farms without, yet eligible, for these specific AEMs. The results indicate that the participation in TMF and EG in preserving permanent pastures has been rather low in both regions. Nevertheless these measures contributed to the upkeep of extensive livestock production with about 65% of participant farms achieving the expected policy result (maintenance or intensification of livestock keeping), although the effect was only significant in Centro. TMF and EG measures were effective in preserving the number of grazing livestock (goats and sheep, in Centro and Alentejo respectively). These effects on livestock appeared to be associated with increased vegetation cover on participant farms in Centro, and with a tendency towards maintaining the pre-existing vegetation cover in Alentejo. Our results suggest that although AEM were effective in preserving grazing livestock, changes in grazing practices have not led to a significant improvement of the conditions to reduce the risk of wildfire and soil erosion. This should be taken into account in the design of new AEMs.

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The role of EU agri-environmental measures in preserving extensive grazing in two Less Favoured Areas in Portugal

Land Use Policy

The role of EU agri-environmental measures preserving extensive grazing in two Less-Favoured Areas in Portugal

4.1 Introduction

Background

In Portugal, as in other countries in the European Union, small farmers in dry and mountainous zones have since the 1960s lost the competition with large scale mechanized farms elsewhere in Europe. They gradually abandoned farming and migrated to the cities. In several areas in Portugal the abandoned agricultural land was subsequently converted to forest either through afforestation or invasion of shrubs, and appeared very vulnerable to forest fires (Baptista, 1996, 2011; Lopes et al., 2013). After repeated fires the soils and their stock of seeds become exhausted, and the resulting bare soils become exposed to soil erosion. In the worst case the whole ecosystem degrades and the remaining farmers can no longer earn a living from the land and the forest, and may have to leave the area (Carreiras et al., 2014; IGP, 2004).

To try to combat such trends the EC has earmarked so-called Less-favoured Areas (LFA) and Agri-environmental Measures (AEM) in its policy framework for special assistance. Most of the northern part of Portugal falls under Article 18 of Regulation (EC) 1257/99: Mountain-hill areas, and most of southern Portugal falls under Article 19 of the same regulation: Areas in danger of abandonment of land use (EC, 1999). Altogether more than 50% of Portugal's agricultural area falls into LFA (Agro.Ges, 2009).

Between 1986, when Portugal joined the EU, and 2006 the area under arable land use has declined from about 30 % of total area to only 12 %, whereas permanent grassland has increased from only 7 % to 20 % (Jones et al., 2011). In the context of abandoned farmland and increasing shrub land vulnerable to forest fires, the conservation of permanent grassland and extensive livestock grazing through AEM could have the dual advantage of reducing forest fire and erosion hazards and retaining a source of income for farmers.

This paper therefore investigates what role certain EU agri-environmental measures (AEM) have played to date in preserving permanent pastures and extensive livestock rearing in Less-favoured areas (LFA), with the aim to reduce soil erosion and wildfire risk. The paper focuses on the LFA Centro and Alentejo, in which an increased focus on livestock has been observed (Jones et al., 2014).

The agri-environmental measures of the Common Agricultural Policy in Portugal

The first time environmental issues were approached by the EU Common Agricultural Policy (CAP) was in 1985 under Article 19 of the Reg. (EC) 797/85, that defined incentives-based instruments for farmers who voluntarily adopted agricultural practices favouring nature/countryside conservation (Baldock and Lowe, 1996; Facchini, 1999). Such instruments were voluntary both for farmers and Member States, and therefore their implementation was rather limited (Baldock and Lowe, 1996; Buller, 2000). In Portugal, Article 19 was not even translated into national law (Rodrigo, 2001).

Only in the 1992 CAP reform, agri-environmental measures (Regulation (EC) 2078/92) emerged as a mandatory policy response of all Member States (MS) to prevent a further imbalance of the agriculture-environment relationship. And to contribute also to support farmers' income, reduce production and favour market equilibrium (Oréade-Brèche, 2005). Since the Agenda 2000, AEM were integrated in the CAP Pillar 2. During the recent public debate on CAP reform launched by the European Commission, many stakeholders agreed that policy should deliver diversified farming systems and public goods across Europe, particularly in remote areas. However two main opinions can be distinguished on how this should be achieved. Some consider that farmers should receive subsidies for income support as agricultural income continues to be much lower than income in other economic sectors, and for providing public goods that are not sufficiently rewarded by the market. Others think that farmers should only be supported in cases where public goods are being delivered, contributing to territorial cohesion and enhancing the vitality of rural areas (EC, 2013).

Taking both opinions into consideration, a new CAP should secure food provision while safeguarding the resources and providing a harmonised territorial development (GPP, 2011). This will involve a reinforcement of the rural development pillar (CAP pillar 2), under which the AEM fall, a “greening” of the direct income support for farmers (CAP pillar 1) or both. In any case a better linkage of the payments with the delivery of public goods will be required, which could be achieved by improved spatial targeting of the measures and by ensuring that the most environmentally friendly forms of farming are supported (EC, 2013).

Evaluation of policy measures

Several evaluations of AEM have been conducted in Portugal (Agro.Ges, 2009; Pinto-Correia, 2000; Rodrigo and Veiga, 2008). Those evaluations focus on the extent of farmers’ participation or “uptake” (number of beneficiaries, and area under agreement) as indicator of policy performance. Primdahl et al. (2003; 2010) refer to policy performance and Moxey et al. (1998) to policy outputs, as the effects of policy on farming practices and the first step for the appraisal of AEM effectiveness. We consider this type of analysis also as the first step in the evaluation of policy measures. So far, the effects of policy implementation were documented for measures with a territorial base of implementation (Marta-Pedroso et al., 2007; Moreira, 1999). These evaluations suggest that AEM have been more effective as income support for farmers than as effective conservation of the countryside. Such a conclusion is not exclusive to Portugal (see for example Hodge and Reader, 2010; Parissaki et al., 2012).

The second step in the evaluation of policy measures would be to focus on the physical impact of the AEM on the environment (with livestock density and soil cover as indicators), and this could then be followed by translating the physical effects into financial and economic effects (Figure 4.1).

The EU makes now use of the Common Monitoring and Evaluation Framework (CMEF) (EU, 2015). According to that framework, the uptake of AEM would be considered as an output indicator, the upkeep of livestock numbers as a result indicator and the eventual vegetation cover as impact indicator.

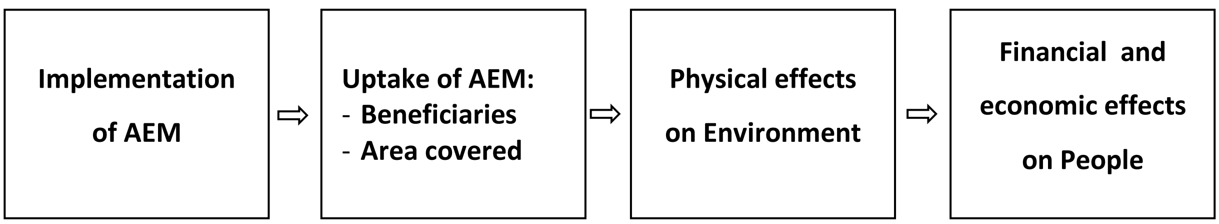

Figure 4.1 Evaluation framework

In this paper we will analyse two AEM that both aim at the preservation of permanent pastures and extensive livestock production, with the ultimate environmental goal of reducing soil erosion and wildfire. The broad objective of the paper is to assess first the uptake of these two AEMs in two selected LFA areas and secondly to assess their physical effects in preserving permanent pastures and extensive livestock production. The financial effects will be considered in another publication.

4.2 Material and methods

Research areas

Centro research area (112,000 ha) and Alentejo research area (128,000 ha) represent two types of LFA (Figure 2). Centro falls under “mountainous areas” and Alentejo under “areas where biophysical constraints from the land result in higher production costs and may lead to abandonment” (EC, 1999). The two research areas differ considerably in terms of climate, land use, farm size and livestock ownership (Jones et al., 2014).

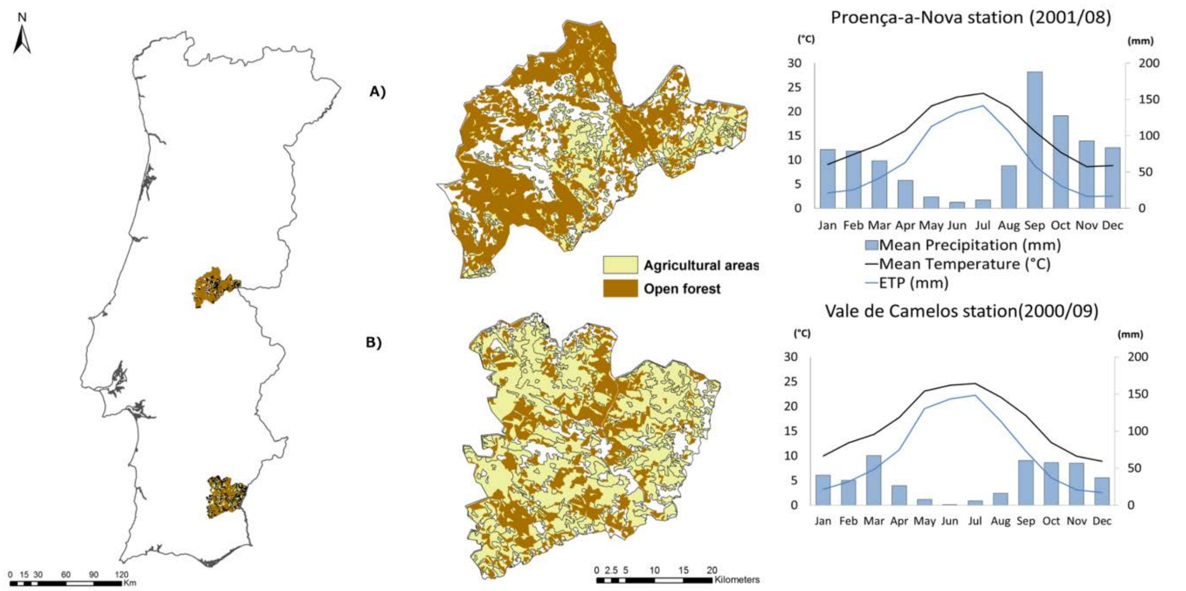

Figure 4.2 Research areas location map: A) Centro research area and B) Alentejo research area. Mean precipitation, mean temperature and potential evapotranspiration (ETP).

Centro covers a transition zone from semi-arid to sub-humid climate, with annual rainfall ranging from 700-1400 mm. The most common soil types are eutric Lithosols and hortic Luvisols (CNA/SROA, 1978). Most land is under forest or shrub land and the agricultural area is with 30,000 ha (27% of total area) very limited. The forested area declined, mainly as result of 6 major forest fires during the period 1990-2006, and permanent crops and pastures are more important than arable crops (Jones et al., 2011, based on CORINE LC data).

Alentejo lies in the semi-arid climatic zone, with annual rainfall ranging from 400-600 mm. The most common soil types are ferric Luvisols (CNA/SROA, 1978). Agricultural land is with 82,000 ha (or 64 % of total area) the largest land use. There was a considerable increase of land under forest land between 1990 and 2006 – from 1,000 ha to 28,000 ha, at the expense of shrub land and ‘heterogeneous agricultural land’, which consists largely of pasture land under scattered trees (Jones et al., 2011, based on CORINE LC data). Agricultural land is managed in a rotational system, including arable land, fallow and agroforestry land.

Farm size and livestock endowments are quite different in both research areas. In Centro there is a predominance of very small farms (ranging from 4-10 ha on non-specialised farms and on specialised sheep/goats farms) with few sheep (ranging from 0.3 - 3 Livestock Units (LU)/ farm). By contrast, in Alentejo medium to large farms (ranging from 127-395 ha on non-specialised farms and on mixed cattle/sheep farms) with many sheep and/or cattle (26 – 109 LU/ farm) prevail (INE, 2010).

These distinct farm structures have been changing, which has led to different impacts on land use. In Centro a change towards more specialised farming in detriment of mixed farming has been observed, whereas in Alentejo the most striking change has been the increase in cattle numbers (INE, 2010). In Centro, farm abandonment and less use of poor pastures favoured the increase of an already large area of shrub land (Jones et al., 2014), where fire occurrence tends to be higher (Pereira et al., 2006). Meanwhile in Alentejo, the conversion of resown pastures into permanent ones on some farm plots has favoured the intensification of pasture renewal on some other plots, questioning the overall environmental benefit of the practice (Jones et al., 2014).

The two selected AEM: Traditional Mixed Farming and Extensive Grassland.

AEM have been designed to support the adoption of beneficial practices to address environmental problems, such as the preservation and improvement of permanent grasslands to reduce soil erosion and wildfire risk. Conventionally in Portugal farmers re-sow pastures to obtain more palatable swards (Belo et al., 2007), constituting a form of ley farming (rotation of crops with legume or grass pastures). Sometimes fire is also used to eliminate shrubs and obtain re-sprouts (Carmo et al., 2011; Pereira et al., 2006). Both tillage and fire have damaging effects on soil structure and fertility. Evidence of that is shown in several studies (e.g. Esteves et al., 2012; Lammerding et al., 2011; Shakesby et al., 2013; Stoof et al., 2011). Therefore reducing pasture renewal interventions can bring significant environmental benefits.

During the second agri-environmental program (2000-2006) Traditional Mixed Farming (TMF) and Extensive Grassland (EG) measures supported permanent pastures. Permanent pasture is herein defined as “*land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or longer*” (EC, 2004, art 2 n. 2). This definition excludes ley, but includes a large array of permanent pastures from poor semi-natural grasslands to improved pastures with clover species.

A five-year agreement assured farmers’ participation in both schemes. In 2006 these measures were reformed, but the agreements already concluded with farmers remained. Other AEM included among others organic farming and traditional olive orchards in Centro, and rainfed grain production and a territorial measure for habitat conservation “Plano Zonal de Castro Verde” in Alentejo.

Table 4.1 summarizes the objectives, obligations and incentives of TMF and EG. The TMF measure was designed with the objective to keep extensive animal production within a permanent and arable cropping mosaic, with the ultimate objective to avoid forest fires. The mosaic landscape combining arable land, permanent crop land, open pasture land and forests has been the traditional landscape in several areas in Portugal (Firmino, 1999). In such landscapes the misuse of fire for the renewal of pastures has been at the origin of recurrent fire events. A diversified landscape could avoid frequent fires and this could be reinforced by improving the quality of permanent pastures by other means than fire (e.g. leguminous species). Table 4.1 shows the farmer's obligations under the TMF measure, such as keeping stocking rates below 2 livestock units per hectare. Incentives were given to areas up to 10 ha in payments gradually declining from 260 down to 135 € per ha of potentially eligible area (IDRHa, 2004).

The Extensive Grassland (EG) measure was designed with the objective to increase the area of permanent grassland and maintain low stocking rates in order to mitigate erosion processes. Table 4.1 shows again the various obligations, among others related to soil cover and stocking rate. The incentive was given in the framework of five-year agreements to areas up to 500 ha, with amount of support gradually declining from 109 € down to 44 € per ha of potentially eligible area (IDRHa, 2004).

Table 4.1 Main objectives, obligations and incentives of Traditional Mixed Farming (TMF) and Extensive Grassland (EG) schemes, in Portugal.

Traditional Mixed Farming scheme (TMF)	
Stated objectives	**Most important agreement obligations**
- Maintain traditional mixed farming (mosaic of permanent and arable crops) - Decrease farm abandonment in order to mitigate fire risk - Conservation of terraces and traditional irrigation systems if present	- **Maintain permanent pastures**, controlling the encroachment of unwanted vegetation - Pruning and harvest of permanent crops - **Maintain the stocking rate under 2 LU ha^{-1}** (particularly for goat keeping) - Recover the abandoned area and preserve the terrace infrastructure if present.
Distribution of payment (max. 10 ha)	**Incentive (€/ha)**
First 2 ha	260
Next 3 ha	180
Next 5 ha	135
Extensive Grassland scheme (EG)	
Stated objectives	**Agreement obligations (among others)**
- Reduce soil erosion maintaining vegetal cover and avoiding tillage - Maintain rainfed permanent pastures - Maintain and enhance grassland quality - Decrease stocking rates higher than the carrying capacity at the farm level - Support the reduction of herds in small farms	- **Maintain 90% of soil covered between November – March** - Minimum tillage with no inversion of top soil, except for permanent pasture installation - Control encroachment of unwanted vegetation - Hay cutting forbidden during the nesting period - Maintain the tree cover if present - **Maintain stocking rate between 0.15 and 2 Livestock Units (LU) per hectare**
Distribution of payment (max. 500 ha)	**Incentive (€/ha)**
First 10 ha	109
Next 10 ha	87
Next 30 ha	71
Next 50 ha	54
Next 400 ha	44

Source: based on (IDRHa, 2004)

With the TMF measure in Centro permanent pastures would be preserved, vegetation encroachment prevented, and livestock maintained under extensive management which would contribute to the control of soil erosion and fire hazard. With the EG measure in Alentejo permanent pastures would be preserved, tillage reduced and overgrazing prevented, contributing to the control of soil erosion. Both schemes (TMF and EG) thus considered the preservation of permanent pastures as one of the required practices. In order to assess the extent of the compliance of the measures we used stocking rate and soil cover as physical performance indicators.

Analytical framework

We evaluate the effectiveness of the AEM in the two research areas following the two steps mentioned in Section 1.3. We first assess the uptake of the two measures, using number of beneficiaries and area covered as indicators, and thereafter the physical effects of the measures on the environment. We focus on analysis of the short term performance of policy rather than the long term outcomes on the environment. Considering the agreement obligations of these two AEMs (see Table 4.1), we will thereto make use of two specific performance indicators: soil cover and stocking rate. By preserving permanent pastures and ensuring appropriate stocking rates, the AEMs aimed to reduce fuel load while preserving soil cover in order to reduce the risk of wildfire and soil erosion.

The selected output, result and impact indicators: uptake of AEM, stocking rate and soil cover are also considered in the EU agri-environmental indicator system (EC, 2001). Although stocking rate and soil cover preservation have been recognized as valuable indicators of AEM effect, their use is constrained by challenges in generating and accessing the necessary data (EEA, 2005). This research shows an approach to compute these indicators – which was applied in the two LFAs of Centro and Alentejo.

Uptake of agri-environmental measures

Data from the Land Parcel Information System (LPIS) were used to spatially link the statistical information concerning each farm (e.g. participation in agri-environmental schemes). In order to get an impression of the relative importance or uptake of AEM in the two research areas, we first sought to obtain – based on (IFAP, 2012) – an overview of all farms (registered in LPIS), all farms eligible for TMF and EG measures, and how many were actually involved. Eligible in the sense that they complied with the stocking rate and available land criteria required for applying for the measures in 2005: for both areas, farms with more than 0.5 ha and with stocking rates under 2 LU/ha.

Among the eligible farms we considered three groups of farms: farms with no AEM, farms with other AEM (not supporting permanent pasture cover), and farms with TMF or EG measures. Using the same IFAP database we compared the resource endowments of these three groups of farms in 2005 and 2009.

Performance indicators (result and impact)

For the assessment of stocking rate changes we classified the trend between 2005 and 2009 into four categories: abandonment (no livestock anymore), extensification (more than 30% decrease in stocking rate), no change (changes between -30% and +30%), and intensification (more than 30% increase). Stocking rate was defined as the number of livestock units per agricultural area, including arable and pasture land and permanent crops (i.e. land under olive trees also used for livestock). We considered the following standard definitions of Livestock Units (LU): cattle = 1; sheep = 0.15 and goats = 0.15 (MADRP, 2008).

For the assessment of soil cover changes on arable land we first looked at the changes of land use at farm level and thereafter at changes in soil cover on arable plots. Hereto we estimated the area with no change in NDVI (Normalised Difference Vegetation Index) between 2005 and 2009 as an approximate measure of permanent pasture cover. At the farm level, we considered three levels of the share of permanent pasture on arable farmland: less than 30%, between 30% and 60%, and more than 60%. These percentages correspond with common rotation systems, as well as with the shares of agricultural area under AEM contract at the farm level (Table 4.2). The NDVI is an appropriate indicator for land uses covering less than 100% of soil surface, which is generally the case in rainfed Mediterranean pastures (Carlson and Ripley, 1997). The available data for the estimation of the soil cover indicator corresponded to more than 40% and 90% of the eligible arable area in Centro and Alentejo respectively.

For stocking rate and soil cover performance indicators we investigated the significance of the effect of AEM participation through a Chi-square test and we quantified the effects through Kendall's rank order coefficient (Saunders et al., 2009). We also investigated the differences in resource endowments among the three groups of farms and tested the significance of changes between 2005 and 2009 through ANOVA. For the statistical analysis we used IBM-SPSS 19.

4.3 Results

Uptake of agri-environmental measures

TMF and EG were among the most popular AEM, accounting for over 30,000 AEM agreements in Portugal, covering 30% of the total area under AEM agreement (655,274 ha) and about the same share of total AEM budget (386 million €) (Agro.Ges, 2009).

Farms in the two research areas differed greatly in terms of their access to subsidies. While in Centro only 23% of the farms registered in LPIS received subsidies in 2005 (about 3,000 farms), in Alentejo the share was 56% (about 500 farms in LPIS). Overall the ten main AEMs involved 221 farmers in Centro and 102 in Alentejo research areas, covering about 2,000 ha and 15,000 ha respectively which corresponded to about 50% of the agricultural area of the farms involved (IFAP, 2012). Farms with TMF/EG were larger than the average farm in the area (Table 4.2). This resulted partially from the eligibility criteria on farm land (≥ 0.5 ha agricultural area) (IDRHa, 2004).

A very small share of farms was actually involved in the two selected AEM. In Centro 622 farms were eligible for TMF with 7,497 ha farmland (2005), of which 132 were actually involved in the measure with a total of 993 ha. In Alentejo we considered 265 eligible farms for EG with 53,465 ha and of which 20 were actually involved in the measure with 1,841 ha (IFAP, 2012). This corresponded to 13% of the eligible area for TMF measure in Centro, and 3% of eligible area for EG in Alentejo.

In both research areas AEM farms featured more marginal conditions for farming than average farms (in terms of slope, number of plots, and distance to main roads). It is interesting to note that smaller eligible farms with few animals and steep land but with a slightly less scattered structure (less plots and shorter distance to main roads), considered that AEM were not worthwhile (Table 4.2). It is also remarkable that although stocking rates were similar (0.4 LU/ha) livestock composition of no AEM farms differed from the other groups of eligible farms. In fact on TMF/EG farms the ratio of grazing livestock over livestock mainly fed from troughs (goats:sheep in Centro, and sheep:cattle in Alentejo) was close to one, whereas on no AEM farms it was close to three (sheep in Centro, and cattle in Alentejo). On TMF farms there were more goats than on other eligible farms (2.2 LU, opposed to 1.3 LU and 1.7 LU; Table 4.2).

In Alentejo non-eligible farms had a much more intensive livestock production than similar farms in Centro. While in Centro the stocking rate on non-eligible farms was about twenty times higher than on eligible farms, in Alentejo it was fifty times more (Table 4.2).

Table 4.2 Resource endowments and AEM uptake for the different groups of farmers in the two research areas in 2005.

	Eligible farms (n=622)			Not eligible	Total
Centro	No AEM n = 410	Other AEM n =80	TMF farms n = 132	n = 56	n = 678
Arable area (ha) [a]	4.5	17.7	13.5	2.1	7.6
Permanent crops area (ha) [a]	2.2	12.1	4.5	1.2	3.7
Forest (ha) [b]	2.1	5	8	1.1	3.5
Farm size (ha)	6.7	29.8	18	3.2	11.3
Arable area with slope above 15% (%)	40.5	41.1	35.5	21.1	38
Number of agricultural plots	18.0	22.6	28.6	5.2	19.6
Distance of plots to main road (km)	19.7	46.4	42	7.4	26.2
Area under TMF (% arable area)	_	_	62.6	_	12.2
Area under AEM (% agricultural area)	_	28.0	64.3	4.8	16.2
Sheep (LU, 1 sheep = 0.15 LU)	0.5	5.2	2.7	5.6	1.9
Goats (LU, 1 goat = 0.15 LU)	1.3	1.7	2.2	3.3	1.7
Stocking Rate (LU/ha) [c]	0.4	0.4	0.4	8.9	1.1
	Eligible farms (n=265)			Not eligible	Total
Alentejo	No AEM n = 168	Other AEM n =77	EG farms n = 20	n = 33	n = 298
Arable area (ha) [a]	149	291	274	15.9	179
Permanent crops area (ha) [a]	0.8	1.7	13.5	.3	1.8
Forest (ha) [b]	13.2	35.1	22.3	21.3	20.4
Farm size (ha)	163	328	310	37.5	202
Arable area with slope above 15% (%)	33.1	14.6	26.2	24.1	26.9
Number agricultural plots	15.3	25.1	27.5	3.2	17.3
Distance plots to main road (km)	57.3	81.4	85.2	12.2	60.4
Area under EG (% arable area)	_	_	40.8	.0	2.8
Area under AEM (% agricultural area)	_	52.5	56.9	21.9	19.8
Cattle (LU, 1 cow = 1 LU)	8.5	21.5	54.7	63.8	21.1
Sheep (LU, 1 sheep = 0.15 LU)	26.6	60.1	51.8	56.0	40.2
Stocking Rate (LU/ha) [c]	0.4	0.5	0.4	19.9	2.6

Source: IFAP, 2012

Notes: a) Arable area includes pasture area; b) includes afforested and reforested areas between 1994 and 2006; c) for stocking rate computation we considered the whole agricultural area.

In this section we present the results about the effects or physical impact of the two agri-environmental measures on stocking rate and soil cover.

Stocking rate

According to the objectives of TMF and EG measures with regard to stocking rate, one would expect that participant farms would belong to those that maintain their livestock herd and less so to those that abandon livestock.

Over the period 2005-2009 slight changes occurred in livestock densities, resulting in similar stocking rates for all the groups of eligible farms in both research areas (0.5 LU/ha in Centro and 0.4 LU/ha in Alentejo) (Table 4.3). Livestock numbers decreased in all groups of farms, except on TMF and EG farms where a slight increase was observed, mainly for sheep in Centro (0.7 LU) and for cattle in Alentejo (8.2 LU). Therefore, expectations regarding livestock upkeep were met. Livestock densities were in compliance with the thresholds required by TMF and EG measures (less or equal to 2 LU/ha). In Alentejo non-eligible farms reduced their large herds and thus their stocking rates considerably. This effect was mainly due to the CAP 2003 reform, which resulted in a partial decoupling of livestock subsidies from production.

Table 4.3 Stocking rate and stocking rate changes between 2005-2009 for the different groups of farms in the two research areas.

	Eligible farms (n=622)			F statistics [a]	Not eligible
Centro research area	No AEM	Other AEM	TMF farms		(n = 56)
	n = 410	n =80	n = 132		
Stocking Rate 2005 (LU/ha) [b]	0.4	0.4	0.4	1.2	8.9
Stocking Rate 2009 (LU/ha)	0.5	0.5	0.5	0.05	9.2
Change in sheep numbers (LU, 1 sheep = 0.15 LU)	-0.1	-1.3	0.7	3.7**	0.02
Change in goats numbers (LU, 1 goat = 0.15 LU)	-0.4	-0.7	-0.4	1.5	-1.3
	Eligible farms (n=265)			F statistics [a]	Not eligible
Alentejo research area	No AEM	Other AEM	EG farms		(n = 33)
	n = 168	n =77	n = 20		
Stocking Rate 2005 (LU/ha) [b]	0.4	0.5	0.4	0.5	19.9
Stocking Rate 2009 (LU/ha)	0.4	0.4	0.3	0.2	5.8
Change in sheep numbers (LU, 1 sheep = 0.15 LU)	-7.6	-10.0	0.4	1.3	-30.8
Change in cattle numbers (LU, 1 cow = 1 LU)	0.3	3.1	8.2	0.8	-39.6

Source: IFAP, 2012

Notes: a) The homogeneity of variances was checked for all the variables and the assumption was not rejected (p<0.01) for all variables. Significant differences between groups are denoted by *** = p<0.01; ** = p<0.05; * = p<0.1; b) for stocking rate computation we considered the whole agricultural area.

Table 4.4 shows that similar stocking rates actually resulted from different trends towards livestock activity. In Centro we found for example that 37% of TMF farms favoured intensification. The stocking rate trend was significantly linked with AEM participation (X^2 = 20.74, df = 6, p <0.01), although the effect was very weak (Kendall's tau = 0.106, p < 0.05). The positive effect suggests a link between the ranked variable 'stocking rate trend' and 'AEM participation', both showing increasing values.

In Alentejo, "no change" and "intensification" trends were also predominant among EG farms (representing together 65% of participant farms) (Table 4.4). Because the "no change trend" was also predominant among the other groups of eligible farms, the effect of AEM participation appeared to be not significant. The largest share of abandonment occurred among not eligible farms (64%), unlike in Centro where the largest share of abandonment occurred among eligible farms with no AEM (26%).

Table 4.4 Share of farms with different stocking rate trends, by type of farm and by research area during the period 2005-2009.

Stocking rate trends 2005-2009	Centro (n = 622)				Alentejo (n = 265)			
	No AEM n = 410	Other AEM n =80	TMF farms n = 132	Not eligible n = 56	No AEM n = 168	Other AEM n = 77	EG farms n = 20	Not eligible n = 33
Abandonment	26	23	21	11	19	16	20	64
Extensification	15	17	14	27	20	14	15	21
No change	38	25	28	43	43	52	35	6
Intensification [a]	21	35	37	19	18	18	30	9
Total (%)	100	100	100	100	100	100	100	100
Pearson Chi-Square [b] = 20.742, df = 6, p = 0.002 Kendall's tau = 0.106, p = 0.036					Pearson Chi-Square [b] = 4.084, df = 6,p = 0.665			

Codes: Abandonment (0) : stocking rate is 0 in 2009; Extensification (1) : stocking rate 2009 is less than 30% of stocking rate 2005; No change (2) : stocking rate 2009 is between -30% and +30% of stocking rate 2005; and Intensification (3) : stocking rate 2009 is more than 30% stocking rate 2005; No AEM (0) = no agri-environmental agreements; Other AEM (1) = AEM other than TMF and EG; TMF and EG farms (2).

Notes: a) Some farms followed an intensification trend leading to stocking rates above 2LU/ha. In Centro 4% for No AEM and Other AEM farms; 5% for TMF farms, and 20% for non-eligible farms; in Alentejo 2% for no AEM; 1% for other AEM; 0% for EG farms; and 9% for non-eligible farms, b) Chi-square test was performed considering only the categories associated with eligible farms.

Soil cover at farm level

In view of the TMF and EG objectives, one would expect that participant farms show less abandonment of farm land than non-participants, and that they would have preserved more permanent pasture area. AEM participation seems not to have stopped land abandonment, since a decrease of agricultural land was found among all participant farms. Nevertheless AEM participation appears associated with a significantly higher share of permanent pastures on farmland (Table 4.5). AEM farms compensated the loss of arable area with forest in Centro and more permanent crops in Alentejo, whereby trends on TMF and EG farms did not differ much from farms with other AEM.

In order to test whether the differences in permanent pasture area were only an expression of larger farm size we built a ranked variable associated with increasing shares of permanent pastures on arable land. The participation in AEM had no significant effect on the share of permanent pasture among the three groups of eligible farms (Table 4.6), so indeed the significantly larger permanent pastures area in Table 4.5 resulted from larger farm sizes. Table 4.6 shows that high shares of permanent pastures were observed in particular in the EG farms group.

Table 4.5 Average farm level changes of soil cover between 2005 and 2009, by type of farm and by research area.

Centro research area	Eligible farms (n=622)			F statistics [a]	Not eligible
	No AEM n = 410	Other AEM n =80	TMF farms n = 132		n = 56
Arable area change (ha)	-2.5	-9.3	-6.2	25.2***	-0.8
Permanent crop change (ha)	1.0	0.9	0.4	0.2	-0.2
Forest change (ha)	0.9	3.2	2.5	8.6***	0.7
Permanent pasture area (ha) [b]	1.1	4.4	3.1	16.1***	0.4
Alentejo research area	Eligible farms (n=265)			F statistics [a]	Not eligible
	No AEM n = 168	Other AEM n =77	EG farms n = 20		n = 33
Arable area change (ha)	-25.0	-48.2	-20.0	0.9	49.8
Permanent crop change (ha)	8.1	38.9	21.2	4.8***	3.2
Forest change (ha)	12.3	5.8	0	0.5	-1.3
Permanent pasture area (ha) [b]	72.6	140.9	141.0	5.5***	41.3

Notes: a) Significant differences between groups are denoted by *** = p<0.01; ** = p<0.05; * = p<0.1;
b) Sum of the area of plots where the trend of the average NDVI between 2005 and 2009 was identified as having no change (trend line slopes between -0.5 and 0.5). Only the plots maintaining arable land cover between 2005 and 2009 were included.

Table 4.6 Share of farms with different extent of permanent pastures during period 2005-2009, by type of farm and by research area.

Permanent Pasture (% arable land)	**Centro (n = 464)** [a]				**Alentejo (n = 260)** [a]			
	No AEM n = 286	Other AEM n = 70	TMF farms n = 108	Not eligible n = 16	No AEM n = 164	Other AEM n = 76	EG farms n = 20	Not eligible n = 24
0%	39	26	35	63	15	10	10	21
< 30%	37	43	49	25	25	32	25	0
30-60	16	26	13	_	26	37	45	17
>60%	8	5	3	12	34	21	20	62
Total (%)	100	100	100	100	100	100	100	100
Pearson Chi-Square [b] = 9.967, df = 4, p = 0.041 Kendall's tau-b = 0.01, p = 0.807					Pearson Chi-Square [b] = 7.223, df = 4, p = 0.125			

Codes: Permanent pastures <30% arable area (0); Permanent pasture between 30% and 60% arable area (1); Permanent pasture above 60% arable area (2).
Notes: a) considering only farms with plots with NDVI > 0.1 and no change trend; b) considering only eligible farms, and three categories of permanent pasture share: the last two categories together for Centro, and the first two for Alentejo. This avoided the occurrence of cells with low expected counts which invalidate Chi-square.

Soil cover at plot level

Considering EG/TMF obligations we expected to find a lower share of bare plots and a higher share of plots with permanent pastures among EG/TMF plots compared to plots not eligible, not involved, or under other AEM. Moreover we expected to find a negative effect between increasing vegetation cover and livestock intensification. Overall we observed that bare plots represented similar shares in Centro and Alentejo (20% and 30%), and that they were evenly distributed among the groups of plots. Looking at the vegetated plots only, we observed an increasing NDVI trend on the majority of the plots in Centro suggesting a more dense vegetation. In Alentejo the majority of the plots demonstrated stable vegetation cover, suggesting the presence of permanent pastures ('no change' trend; Table 4.7). Although the above identified trends appeared more clearly on plots associated with AEM, the effect was non-significant.

From the interactions between stocking rate and soil cover trends, we concluded that in Centro there was no interaction between the two, whereas in Alentejo the intensification of livestock was significantly associated with higher shares of permanent pastures ($X^2 = 15.139$, df = 3, $p < 0.01$; Table 4.8).

Overall, although the effects of AEM participation were not statistically significant the measures appeared to be associated with the reinforcement of vegetation cover in Centro and the conservation of permanent pastures in Alentejo.

Table 4.7 Share of plots with different soil cover trends during the period 2005-2009, by type of farm and by research area.

AEM participation vs Soil cover [a]	**Centro (n = 1,656)**				**Alentejo (n = 3,011)**			
	No AEM n = 1,311	Other AEM n = 54	TMF plots n = 291	Not eligible n = 40	No AEM n = 2,554	Other AEM n = 374	EG plots n = 83	Not eligible n = 137
Decreasing	3	2	3	5	36	33	25	17
No change	39	28	35	22	64	67	75	83
Increasing	58	70	62	73	_	_	_	_
Total (%)	100	100	100	100	100	100	100	100
Pearson Chi-Square [b] = 4.678, df = 2, p = 0.096 Kendall's tau-b = 0.045, p = 0.066					Pearson Chi-Square [b] = 5.361, df = 2, p = 0.069			

Note: a) considering eligible arable plots with vegetation; b) considering only the two main categories of soil cover trend: no change and increasing for Centro; and decreasing and no change for Alentejo.

Table 4.8 Share of plots with different soil cover trends by stocking rate trend for the two research areas.

Stocking rate vs Soil cover [a]	**Centro (n = 1,656)**				**Alentejo (n = 3,011)**			
	Abandon-ment n = 292	Extensifi-cation n =361	No change n = 579	Intensifi-cation n = 424	Abandon-ment n = 252	Extensifi-cation n = 476	No change n = 1,676	Intensifi-cation n = 607
Decreasing	3	3	3	3	43	34	37	30
No change	42	38	35	39	57	66	63	70
Increasing	55	59	62	58	--	--	--	--
Total (%)	100	100	100	100				
Pearson Chi-Square [b] = 4.733, df = 3, p = 0.192					Pearson Chi-Square [b] = 15.139, df = 3, p = 0.002; Kendall's tau-b = 0.05, p = 0.003			

Note: a) considering eligible arable plots with vegetation; b) considering only the two main categories of soil cover trend: no change and increasing for Centro; and decreasing and no change for Alentejo.

4.4 Discussion

To assess the performance of the two measures at farm level, first the uptake in the period 2005-2009 was analysed. Thereafter the physical effects were investigated, in terms of soil cover and stocking rates, through a comparison between farms with and without TMF or EG. By comparing participant with non-participant farms we considered the additional benefit of AEM, with non-participant farms being a proxy for a counterfactual situation (Pearce, 2005).

Uptake of AEM

The uptake of both measures was rather low when considering the total eligible area, with respectively 13% and 3% under EG/TMF agreement in Centro and Alentejo. However the eligible area was quite large, covering 66% of the agricultural area in Centro and 60% in Alentejo. For a targeted share of 15% of agricultural area under AEM – as stated in ENRD (2013) for the 2007-2013 period - TMF ensured 60% of the objective for Centro while EG only met 14% of the objective for Alentejo. It should be noted that AEM uptake was constrained by budget restrictions from 2005 onwards (Agro.Ges, 2009).

Farms with AEM were generally larger and had steeper slopes, a more fragmented farm structure and longer distances to main. However smaller marginal farms with a less scattered structure found AEM apparently less interesting.

Performance indicators: stocking rate and soil cover

Stocking rate showed similar changes among all the farm groups. This has been the consequence of a decrease in both agricultural land area and livestock numbers, with the exception of TMF/EG farms where an increase of livestock numbers was observed. On TMF farms the increase in sheep numbers compensated for the decrease in goats (0.7 LU vs -0.4 LU), whereas on EG farms the increase in cattle numbers largely surpassed that of sheep (8.2 LU vs 0.4 LU) (see Table 4.3). This indicates that despite the increase in livestock numbers, the replacement of grazing livestock (goats in Centro and sheep in Alentejo) with livestock fed mainly from troughs (sheep in Centro and cattle in Alentejo) also occurred on TMF and EG farms. Nevertheless, the measures may have kept the loss of grazing livestock to a minimum. A large decrease in livestock numbers was observed on non-eligible farms. Due to the reduction of livestock subsidies coupled to production, which resulted from the CAP 2003 reform, most farmers reassessed their herds. Because non-eligible farms were smaller they could not internalize the costs previously spent on off-farm feed for maintaining the large herds. As shown by Poux (2007) the positive reversion of high- towards low-intensity farming systems through decoupled payments is happening elsewhere in Europe. The positive effects tend to be out shadowed by competition mechanisms in the absence of targeted support for low-intensity farming systems (Poux, 2007).

In Centro, AEM participation influenced significantly the stocking rate. Farms with no AEM appeared to be more prone to abandon livestock activities than those participating in the AEM. In Alentejo the relation between AEM participation and stocking rate was not statistically significant with similar shares of no change in all the farm groups. This means that with stocking rate as an indicator we were able to identify a positive effect from TMF in Centro and a fair compliance with EG stocking rate obligations in Alentejo.

With regard to soil cover at farm level, the area of permanent pastures was larger on AEM farms, however no significant effect was identified on the influence of AEM participation (Tables 4.5

and 4.6). Participation in TMF respectively EG was not able to prevent land abandonment as the decrease of arable land observed was equivalent to or larger than on farms with no AEM (Table 4.5). In Centro the decrease in arable area was partially compensated (ca. 30%) by an increase in forest area, whereas in Alentejo the area seemed to have been reallocated to permanent crops. These results point to a risk of agricultural abandonment in Centro, where arable land continues to be converted to forest, and to a trend towards diversification of farm activities in Alentejo. Our findings for Alentejo are in agreement with results reported by Ribeiro et al. (2014). Our results suggest that AEM participation has to some extent prevented the full conversion of arable land to forest in both areas, favouring in Alentejo a more or less complete conversion of the abandoned arable land to permanent crops (e.g. olives).

At the plot level, the effect of AEM on the trend of the vegetation index was not significant in both research areas. Nevertheless the plots under AEM agreement in Centro were mainly associated with an increasing vegetation trend, suggesting a vegetation build-up that is probably due to reduced grazing practice. By contrast, the plots under EG agreement in Alentejo appeared to be more associated with the preservation of permanent pastures (Table 4.7). Despite the lack of significant results, the assessment with the soil cover indicator showed the compliance of participant farms with TMF/EG obligations and revealed diverging trends in grazing practices among the different groups of farms according to AEM participation.

In both research areas the decrease in arable area (which includes pasture land) was associated with a change in livestock composition favouring animals fed from troughs instead of grazing animals. In Centro we found that the group with the highest share of grazing livestock ('no AEM'; goats versus sheep in Table 4.2) also shows the lowest share of plots with an 'increasing' NDVI trend (58% against 70% and 62%; Table 4.7). In Alentejo the highest share of grazing livestock (sheep versus cattle) also appeared to be associated with the group of 'no AEM' (Table 4.2), and it also corresponded to the lowest soil cover (lowest percentage of plots with permanent pastures - 64% against 67% and 75%; Table 4.7). In the absence of AEM obligations, farmers tend to renovate part of the pastures with the installation of winter cereals (e.g. oats and barley) left for ley for two or more years in a row. In marginal areas, because of the very low yields, the cereal crop is mainly justified for obtaining stubble and forage the first year, and for regrowth on the remaining years of the rotation (Belo et al., 2007). It is likely that for farms with a higher share of grazing livestock, securing the existence of good quality ley is preferable to preserving poor quality permanent pastures resulting from longer fallow periods with no particular yield improvement.

Our results show that the EG measure supporting extensification of ley systems led in fact to an increase of permanent pastures on farms where livestock was increasingly fed from troughs. Additional benefits derived from further extensification of such systems is questioned by several authors (e.g. Beaufoy et al., 2011a; Horrocks et al., 2014) on the basis of limited environmental gain and increased pressure on farm abandonment. Instead these systems would possibly benefit from AEM schemes targeting the whole farm (Parissaki et al., 2012), and more flexible rules for cross-compliance targeting the improvement of pasture quality on the longer term (Beaufoy et al., 2011a).

The upcoming CAP reform is expected to lead to further land abandonment, particularly on grazing livestock farms with low profitability in marginal areas (Hanley et al., 2012; Renwick et al., 2013). This is because farm income will decrease under globalized markets, in particular in these areas. Corbelle-Rico and Crecente-Maseda (2014) also refer to low farm income and remoteness as key drivers for land abandonment in Galicia, Spain. This is likely to bring encroachment of shrubby vegetation on arable/ley plots. With regards to erosion this seems beneficial provided that wildfire risk does not increase. Although over-grazing issues have been a more classic concern of desertification monitoring in the Mediterranean region (e.g. Oldeman, 1992; Runnstrom, 2003), under-grazing in the sub-humid area of this region has been also a reported issue (Álvarez-Martínez et al., 2013; Lasanta-Martínez et al., 2005). Therefore, ensuring the presence of livestock is an essential but not sufficient condition to reach a sustainable management of these landscapes. Past TMF measure has been effective in preventing the abandonment of grazing livestock but has fallen short with regards to soil cover improvements, although the majority of participant farms complied with TMF obligations. Farms with 'no AEM' featured a lower share of plots with increasing NDVI trends, and therefore seem to preserve grazing practice more effectively.

The two strategies followed by Centro and Alentejo farmers were in accordance with the objectives of both TMF and EG with regard to preservation of permanent pasture and extensive livestock, but one could argue about the real effects on the conservation of agricultural land. The research of Oltmer et al. (2000) and Primdahl et al. (2003) on the effects of AEM across Europe also identified a more explicit effect on preserving extensive livestock production than on grassland conservation.

4.5 Conclusions

The TMF and EG measures were, in 2005, two of the most important agri-environmental measures in the two research areas. Their ultimate goals were respectively to create a mosaic of land use and avoid land abandonment in order to reduce fire risk (of major importance in Centro) and to maintain vegetation cover and reduce soil erosion (important in Alentejo). Both AEM therefore focused on permanent pastures preservation and on the control of stocking rates.

Despite the relative popularity of the two measures, the uptake was rather modest. In Centro area 21 % of the eligible farms were involved in TMF and in Alentejo only 8 % of eligible farms were involved in EG. The eligible farms generally have much larger farms than the farms that (often because of their high stocking rate) are not eligible. It was also noticed that farms with AEM generally had more marginal conditions with regard to slope, to farm structure with scattered plots, and to distances to main roads.

Over the period 2005-2009 livestock numbers decreased in all groups of farms, except on TMF and EG farms, where a slight increase was observed, mainly for sheep in Centro and for cattle in Alentejo. But the livestock densities still complied with the thresholds required for the two measures.

The largest share of abandonment occurred among non-eligible farms in Alentejo and among eligible farms with no AEM in Centro. AEM participation seems in general not to have been able to stop the decrease of agricultural land use, but it seems to have led to a significantly higher share of pastures on farmland. And the analysis of soil cover on plot level showed that the AEM measures appeared to be associated with the reinforcement of vegetation cover in Centro and to the conservation of permanent pastures in Alentejo.

Preserving extensive livestock grazing in less favoured areas (LFA) could have the potential to both reduce forest fire and erosion hazards and retain a source of income for farmers. AEM implemented in LFA have aimed to achieve such results. However, evaluation of the effectiveness of these efforts has been difficult. This research shows an approach to compute stocking rate and soil cover preservation – both valuable indicators for AEM assessment but constrained by challenges in generating and accessing the necessary data (EEA, 2005). The outcome provided useful insight into the impact of AEM over a period of five years (2005-2009) in these areas. In light of the ever tightening budgetary constraints on CAP at multiple levels, it is more important than ever to develop measures that are effective. Our results suggest that although AEM were effective in preserving grazing livestock, changes in grazing practices in both regions did not lead to a significant improvement of the conditions to reduce the risk of soil erosion in Alentejo and wildfire in Centro. This should be taken into account in the design of new AEMs. Our results suggest that in order to maintain in place the most sustainable grazing livestock production, future AEM should target yield improvement of permanent pastures. The effects of past AEM should not be overlooked when developing new ones, as lessons from the past can be a wise way to approach the future.

Appendix I

NDVI is defined as (NIR-RED)/(NIR+RED), where NIR and RED are the reflectances averaged over wavelengths in the near infrared and red region of the light spectrum, respectively obtained from band 4 and 3 of Landsat 5 TM and Landsat 7 ETM+ images.

A time-series of images was acquired from United States Geological Survey website (http://earthexplorer.usgs.gov) for the period January 2005 - December 2009. The quality of all images was checked by visual interpretation and empty data points were not taken into consideration. For each plot with arable and pasture land cover (LPIS database), a trend analysis was conducted using linear least square regression over the standardized sums of NDVI averages for each year. We considered only plots with vegetation to ensure that “no change in NDVI” would refer to the presence of permanent pastures and not to the prevalence of bare soil. For each farm we estimated the arable area with “no change in NDVI” (trend line slopes between -0.5 and 0.5). This technique has been used in desertification research (e.g. Helldén and Tottrup, 2008) for being a robust way to reveal long-term trends of data originally built from annual fluctuations. For the computation of NDVI we used ArcGIS 10 software.

Chapter 5

Financial incentives through agri-environmental measures for preserving extensive grazing in two Less Favoured Areas in Portugal

Abstract

In the last two decades a significant part of agricultural land in Portugal has been converted to rangeland. Part of this can be classified into permanent pasture which includes natural or sown grass forage that has not been included in the crop rotation of the farm for five years or longer. The pasture area increase has been associated with an increased farm specialization on livestock activities. This chapter assesses to which extent the financial incentives offered through two specific agri-environmental measures (AEM) have indeed fostered the development of permanent pastures and extensive animal production systems in the period 2005-2009. We investigated the financial effects at the farm level by comparing the net benefit – investment (N/K) ratio of two management options for AEM implementation (improved permanent pasture and long duration ley) and one option corresponding to non-implementation (short ley). We also assessed the cost-effectiveness of the two AEM at the regional level through a composite index based on stocking rate and soil cover indicators. At the farm level the results showed that AEM implementation with improved permanent pastures was financially more attractive than ley options. However when time preference for money was considered, the long duration ley option showed to be the most attractive option. The permanent pasture option then only appeared the most attractive for longer periods of analysis (10 and 12 years) and when higher yields were considered. The implementation of AEM with longer duration leys showed to generate extra costs, which were amply compensated in most years. So these payments had a clear incentive effect, yet the short duration of the contracts (5 years) was not in favour of a change towards more environmentally friendly permanent pastures. At the regional level our results showed that AEM actually achieved the intended objectives at a ‘fair price’ when compared with two more targeted options, showing that a more targeted AEM will not be achieved ‘by design’, but would also need a locally defined targeting strategy.

Financial incentives through agri-environmental measures for preserving extensive grazing in two Less Favoured Areas in Portugal

5.1 Introduction

In order to try to stop or even reverse the agricultural abandonment trend the EU has earmarked so-called Less-favoured Areas (LFA) and Agri-environmental Measures (AEM) in its policy framework for special assistance. Most of the northern part of Portugal falls under Article 32(a) of Regulation (EC) 1305/2013: Mountain areas, and most of southern Portugal falls under Article 32(b) of the same regulation: other areas facing significant natural constraints (EU, 2013b). Although the "less favoured area (LFA)" designation has been now re-labelled as "area facing natural constraint (ANC)", we will hereafter hold to the first designation.

CORINE Land Cover data show that in Portugal the area under arable land use declined from about 30 % of total area in 1986, when Portugal joined the EU, to only 12 % in 2006, whereas permanent grassland increased from only 7 % in 1987 to 20 % in 2006 (Jones et al., 2011). Agricultural census data show even a more spectacular increase of permanent pastures on farmland - a slightly broader category including both agriculturally-improved pastures and rough grazing areas. Rough grazing had a three-fold increase between 1989 and 2009 mainly as a result of agricultural land conversion from cereal cropping to extensive pastures (Avillez, 2014). Much of this conversion to extensive livestock production resulted in environmental benefits in areas where soils are of marginal quality or heavily degraded. Yet in other areas prone to abandonment, the conversion of agricultural areas to shrub land, vulnerable to forest fires, poses a problem. The extension of permanent grassland and a certain focus on livestock (without overgrazing) could have the dual advantage of reducing the forest fire (e.g. Moreira et al., 2011) and erosion hazards and retaining a source of income to farmers.

This chapter will investigate what role the financial incentives provided by two specific EU agri-environmental measures (AEM) have played in preserving and expanding permanent pastures and extensive livestock rearing in less favoured areas. The chapter focuses on two less favoured areas in the Centro and Alentejo regions, in which an increased focus on livestock has been observed in the period 1989-2009 (Jones et al., 2014).

Agri-environmental measures (AEM) have been a central feature of EU-wide agricultural policy since Regulation 2078/92 was implemented for the period 1994-1999 as part of the McSharry reforms (1992). This policy framework provided for the following main actions:

- Input reduction schemes, including organic farming
- Extensification of production, including conversion of arable land to permanent grassland
- Reduced stocking rates for livestock
- Preservation of rare breeds
- Establishment and maintenance of woodlands
- Long-term set-aside
- Public access to farmland
- Training and advice to improve environmental performance.

Payments were mainly based on per hectare or per number of animals, which were calculated according to costs of compliance with scheme requirements, income forgone and (initially at least) a financial incentive to participate. The agri-environmental programmes could be implemented in different forms in each member state (and in regions within states) and were co-financed by the EU and member states according to fixed rules. As a result a very wide range of schemes and payment rates can be found across the EU (FAO, 2010).

Schrijver et al. (2008) state that agri-environmental measures are required to provide the necessary payments to preserve pastoral landscapes in Europe. At present large areas of pastoral land are not eligible for CAP support, because of the EU rules and their interpretation, thus increasing the risk of abandonment of farming. In the past decade the share of pillar 2 in the total agricultural budget has increased from 10 % in the period 2000-2006 to 19 % in the period 2007-2013. Schrijver et al. (2008) wonder whether this budget is sufficient to keep landscapes open and whether the pillar 2 budget is spent in agreement with environmental goals. A considerable shift is expected from payments targeting the reduction of intensity towards those avoiding abandonment. This will increase the focus of AEM towards less productive land, likely to be located in less favoured areas (Hodge, 2013). Although this shift is expected to improve the effectiveness of agri-environmental policy (e.g. ECA, 2011; Matzdorf et al., 2008), the mobilization of effective solutions for extensive livestock systems will depend on the presence of strong local political commitment (Beaufoy and Poux, 2014).

We would like to get an impression of the impact of AEM on the environment and the economic situation of farmers. In an earlier chapter, we have shown that the two selected AEM in Portugal appeared to a certain extent effective in preserving stocking rates within the prescribed range and in preserving sufficient soil cover (Jones et al., under review; Chapter 4). In this chapter we focus on the issues whether the measures were also cost-effective and to which extent future targeting could benefit from these results.

5.2 Materials and methods

The position of TMF and EG farms in the two research areas

Centro research area (112,000 ha) and Alentejo research area (128,000 ha) represent two types of LFA (Figure 5.1). Centro is a mountainous area and Alentejo falls under the designation of 'areas, other than mountainous areas, facing significant natural constraints' (EU, 2013b).

Centro has a semi-arid to sub-humid climate (700-1400 mm; 15-16ºC), and the most common soil types are eutric Lithosols and hortic Luvisols (CNA/SROA, 1978). Most land is under forest or shrub and the agricultural area is very limited (27% of total area). There is a predominance of very small farms (average 4 ha) with on average only 0.3 Livestock Units (LU)/farm (INE, 2010) . A sheep = 0.15 LU and a goat = 0.15 LU (MADRP, 2008b).

Alentejo lies in the semi-arid climatic zone (400-600 mm; 16-17.5ºC), and soils are mostly ferric Luvisols (CNA/SROA, 1978). Agricultural land is the largest land use (64 % of total area), and the average farm size is 127 ha with about 17 LU/farm (INE, 2010).The husbandry of goats in Centro and sheep in Alentejo is conducted with the highest shares of grazed feed.

Since 2005 more specialised farming has been favoured in detriment of mixed farming which resulted in a higher share of farm income generated from livestock activities (INE, 2010). In Centro, farm abandonment decreased the use of rangelands as pasture favouring the enlargement of shrub land (Jones et al., 2014), where fire occurrence tends to be higher (Pereira et al., 2006). Meanwhile in Alentejo, the conversion of resown pastures into permanent ones on some farm plots has favoured the intensification of pasture renewal on some other plots, questioning the overall environmental benefit of the practice (Jones et al., 2014).

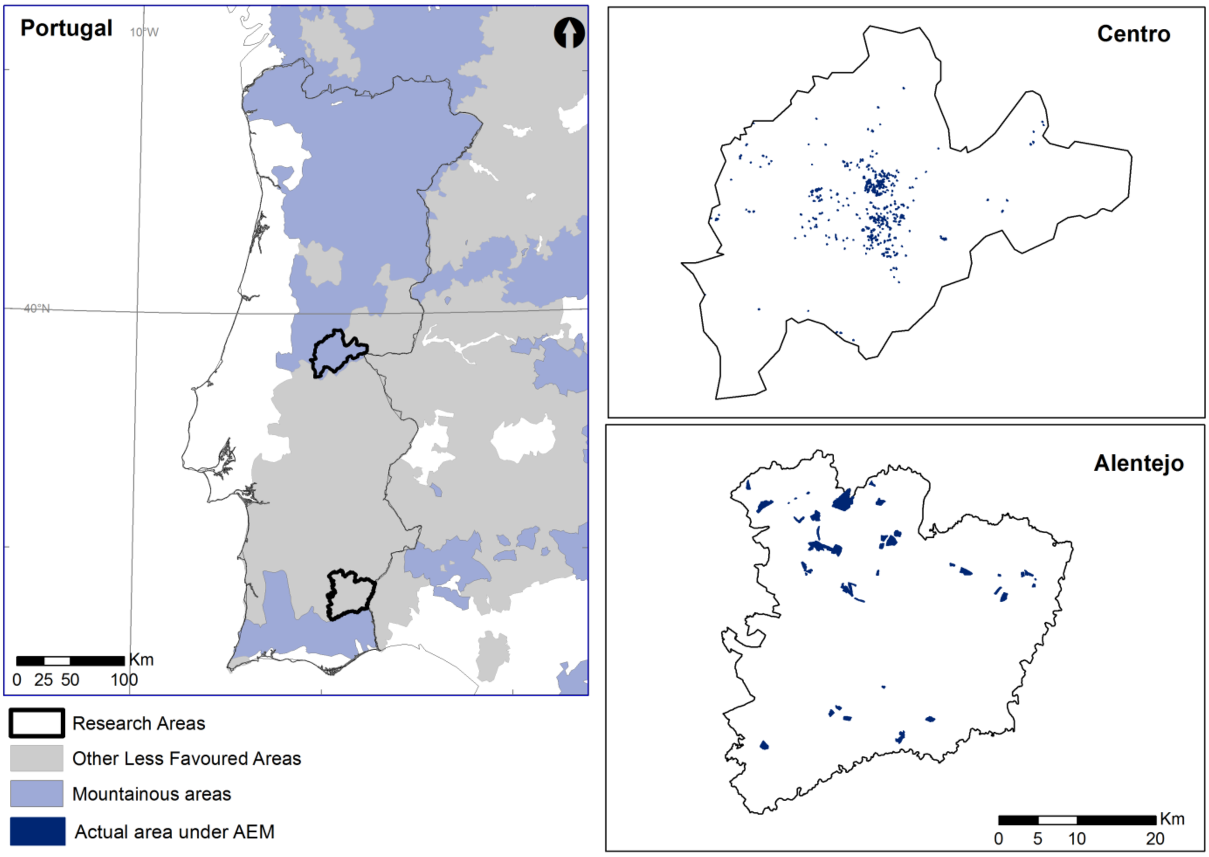

Figure 5.1 Location of LFA in Portugal, location of research areas with the area under selected AEM in 2005-2009.

Some AEM have been designed for the preservation of extensive livestock production contributing to the upkeep of permanent grasslands. Conventionally in Portugal farmers re-sow pastures to obtain more palatable swards (Belo et al., 2007), constituting a form of ley farming. Tillage has damaging effects on soil structure and fertility (e.g. Lammerding et al., 2011). Therefore reducing pasture renewal interventions and securing the appropriate level of grazing can bring significant environmental benefits. Traditional Mixed Farming (TMF) and Extensive Grassland (EG) agri-environmental measures were designed with such objectives, delivering permanent pasture coverage and the upkeep of grazing livestock within appropriate stocking rates. Important factors in the effective delivery of such objectives are the slope of the terrain (affecting soil erosion), and the type of livestock present on the farm. TMF and EG were among the most popular AEM, accounting for over 30,000 AEM agreements in Portugal, covering 30% of the total area under AEM agreement and about the same share of the total AEM budget (Agro.Ges, 2009). TMF was particularly important in Centro with 993 ha (Figure 5.1), covering about 50% of the area under AEM, and EG in Alentejo with 1,841 ha covering about 12% of AEM area (IFAP, 2012).

Although the definition of permanent pastures presently also considers shrub vegetation used as forage (EU, 2013c), the definition at the time of TMF and EG implementation only considered natural and sown grasses that had not been included in the crop rotation of the farm for five years or longer (EC, 2004, art 2 n. 2). This definition excludes ley resown every three years, the most common situation of pasture management, but it includes a large array of permanent pastures from poor semi-natural grasslands to improved pastures with clover species. We then considered that farmers participating in TMF and EG could choose from two distinct management options: postponing pasture renewal or establishing improved swards with self-seeding legume species (e.g. subterranean clover). Non-participant farmers would then keep the management of short duration ley systems (e.g. mixed oats x ryegrass swards), while participant farmers would manage long duration ley systems, or improved permanent pastures (e.g. mixed ryegrass x clover), hereafter also designated as Ley 1, Ley 2, and PP. The adoption of AEM with improved permanent pastures (PP) would result in a more beneficial situation both in terms of the durability of the effects of soil cover and avoided tillage operations.

A five-year agreement assured farmers' participation in both measures. Farmers' obligations also included keeping stocking rates below 2 livestock units per hectare. TMF incentives were given to areas up to 10 ha in payments gradually declining from 260 € down to 135 € per ha of potentially eligible area (IDRHa, 2004). EG incentives were given to areas up to 500 ha, with the amount of support gradually declining from 109 € down to 44 € per ha of potentially eligible area (IDRHa, 2004).

To obtain an impression of the uptake of the two selected AEM in the research areas, we have first obtained – based on (IFAP, 2012) - an overview of all farms (registered in LPIS), and all farms eligible. Eligible in the sense that they complied with the criteria for stocking rate and farmland area: more than 0.5 ha and stocking rates under 2 LU/ha. Among the eligible farms we considered three groups of farms: farms with no AEM, farms with other AEM (not supporting permanent pasture cover), and farms with TMF or EG measures. Using the same IFAP database we compared the resource endowments and subsequently the importance of pillar 1 and pillar 2 subsidy payments of these three groups of farms in 2005 and 2009.

Financial effects of TMF and EG Measures at the farm level

When capital budget is not sufficient to implement immediately all investment options, decision-makers need to rank these options. The net benefit – investment ratio (N/K ratio) is a reliable measure to rank projects in the order they should be prioritized, granting maximum return per unit of available investment (Gittinger, 1982). When presented with the decision to participate in AEM, farmers make an investment decision between keeping 'business as usual' or changing their management practices. In the present case the decision would be to choose among short ley, long ley, or permanent pasture. To illustrate that decision and also consider time preference for money, we estimated the net benefit – investment ratio which is the present worth of the net benefits divided by the present worth of the investment. We built the cash-flow of net benefits over a period of 6 years based on the activity budgets of the Ministry of Agriculture for similar pasture options (GPP, 2011a), using survey information for updating prices and practices (2010/2011 - 40 farmers) and secondary information and expert knowledge on permanent pasture installation and maintenance (Crespo, 2009). We considered a 6-years period in order to include two complete rotations of the short ley option. In this assessment we compared the non-discounted and discounted cash-flows of costs and benefits in order to test the influence of discounting on the ranking of pasture options. We used the same 4% discount rate for all options - the average rate recommended by EU DG Competition in 2005 (COM, 2014).

We assessed the output of each pasture option by estimating the yield in forage units of the French energy system: Unité Fourragère (UF) (McDonald, 1996) and using its equivalence to 1kg of standard barley to value the production at the market price of 0.16 €/kg (Survey information, 2011).

Table 5.1 Management operation and (low and high) yields of pasture options: short duration ley, long duration ley, and permanent pasture.

	Ley 1 – No AEM Oats x Ryegrass		**Ley 2 – AEM Oats x Ryegrass**		**PP – AEM Ryegrass x clover**	
Year	**Operations**	**Yield (UF/ha)**	**Operations**	**Yield (UF/ha)**	**Operations**	**Yield (UF/ha)**
1	Harrowing (i) Fertilisation (i) Sowing (i) Fertilisation Cutting	1,040 – 1,200	Harrowing (i) Fertilisation (i) Sowing (i) Fertilisation Cutting	1,040 – 1,200	Harrowing (i) Liming (i) Fertilisation (i) Sowing (i) Grazing	360 – 450
2	Fertilisation Grazing	830 – 960	Fertilisation Grazing	830 – 960	Fertilisation Grazing	720 – 900
3	Harrowing Grazing	830 – 960	Harrowing Grazing	830 – 960	Fertilisation Harrowing Liming Grazing	1,080 – 1,350
4	Harrowing (i) Fertilisation (i) Sowing (i) Fertilisation Cutting	1,040 – 1,200	Fertilisation Grazing	620 - 720	Fertilisation Grazing	1,200 – 1,500
5	Fertilisation Grazing	830 - 960	Harrowing Grazing	620 - 720	Fertilisation Grazing	1,200 – 1,500
6	Harrowing Grazing	830 - 960	Grazing	410 - 480	Fertilisation Grazing	1,200 – 1,500
Total		5,400 – 6,240		4,350 – 5,040		5,760 – 7,200

Sources: based on (GPP, 2011a), (GPP, 2011b), (Crespo, 2009) and own survey 2010/11
(i) investment in establishment operation of pasture.
Note: Pasture production is expressed in forage units (UF) of the French energy system, which builds on the equivalence of any feed stuff to the energy provided by a kilo of standard barley 1820 Kcal (de Freitas, 2010; McDonald, 1996).

Table 5.1 summarizes the operations and yields of the three management options. We considered that management of Ley 1 and 2 was similar for the first three years. However in order to comply with AEM obligations, the renovation of pasture would not be performed in year 4 for Ley 2 and for the remaining years farmers would have to cope with lower yields. For PP we assumed that the maximum yield would only be reached in year 4, as clover and grasses benefit from grazing and soil management operations performed in the first three years. For the three types of cover we have considered a range of yields to account for production fluctuations.

Financial effects at the research area level

Thereafter, with the objective to assess to which extent TMF and EG had reached the enounced objectives with regard to stocking rate and soil cover we built a composite goal achievement index:

$G = \sum$ [0.5 x (plot area/ arable farm area) x i + 0.5 x (plot area/arable farm area) x f], whereby i and f are assumed to be binary values, being 1 whenever the desired effect was observed, respectively with the stocking rate trend and permanent pasture presence between 2005 and 2009. If both effects were observed on all plots of the farm G equals 1. Stocking rate was defined as the number of livestock units per agricultural area, including arable, pasture land and permanent crops (i.e. mostly olive trees with pasture understorey). We considered the following standard definitions of Livestock Units (LU): cattle = 1; sheep = 0.15 and goats = 0.15 (MADRP, 2008a). Soil cover was assessed using NDVI (Normalised Difference Vegetation Index) trends and the area with no change as an approximate measure of permanent pasture cover. The NDVI is an appropriate indicator for land uses covering less than 100% of soil surface, which is generally the case in rainfed Mediterranean pastures (Carlson and Ripley, 1997).

The actual AEM implementation was then compared with two more targeted situations: one that we designated 'most suitable area' where AEM would have been targeted to areas with steep slope (≥ 15%) and a majority of grazing animals (farms with ≥40% grazing animals), and another 'high performance area' corresponding to a restriction of the previous area to only those farms where positive effects were actually observed. For the accounting of the goal achievement index (G), we assumed that participant farms with positive effects that would cease to participate would no longer provide the positive effects, and that a non-participant with negative effects that would in turn change to be participant would provide the desired positive effects. For the remainder we considered that the provision of effects would be the same as in the actual AEM implementation. The payments of TMF and EG were considered the same in all three situations. The 'most suitable area' situation approximates a situation where the targeting strategy would be restricted to a change in the eligibility criteria and the 'high performance area' to an extension of that strategy allowing the enrolment of the most cost-effective areas from the farmer's perspective. For this we assumed that because the actual AEM implementation was conducted while considering all plots as eligible regardless their slope, the actual location of the effects reflects the most cost-effective option from farmer's perspective.

5.3 Results and discussion

The relative importance of TMF and EG measures in the research areas, resource endowments, and subsidies for the respective farms groups

To obtain an idea how TMF and EG farms compare with other farms in the two regions, we show the resource endowments of the respective farms. Generally the farms in Alentejo are much larger than the farms in Centro and farms eligible for the two AEM are in both areas much larger than those that are for various reasons not eligible (among others because of their very high stocking rate). Among the three categories of eligible farms stocking rates are quite comparable in both areas (0.4 LU/ha), and clearly lower than required (Table 5.2). TMF and EG farms are those with more livestock. TMF farms in Centro have on average only about 5 Livestock Units (LU), consisting of both sheep and goats, while the EG farms in Alentejo have on average more than 100 LU, almost equally divided among cattle and sheep.

With regard to the area under AEM management, despite being smaller than farms with other AEM, TMF and EG farms had a higher share of agricultural area under AEM agreement (64% against 28% for TMF farms, and 57% against 53% for EG farms) (Table 5.2).

Table 5.2 Average resource endowments and AEM uptake per group of farms in 2005

Centro	Eligible farms (n=622)			Not eligible
	No AEM n = 410	Other AEM n =80	TMF farms n = 132	n = 56
Farm size (ha)	6.7	29.8	18.0	3.2
Of which arable area (ha) (1)	4.5	17.7	13.5	2.1
Arable area with slope above 15% (%)	40.5	41.1	35.5	21.1
Area under TMF (% arable area)	_	_	62.6	_
Area under AEM (% agricultural area)	_	28.0	64.3	4.8
Sheep (LU, 1 sheep = 0.15 LU)	0.5	5.2	2.7	5.6
Goats (LU, 1 goat = 0.15 LU)	1.3	1.7	2.2	3.3
Stocking Rate (LU/ha) (3)	0.4	0.4	0.4	8.9
Alentejo	**Eligible farms (n=265)**			**Not eligible**
	No AEM n = 168	**Other AEM n =77**	**EG farms n = 20**	**n = 33**
Farm size (ha)	163	328	310	37.5
Of which arable area (ha) (1)	149	291	274	15.9
Arable area with slope above 15% (%)	33.1	14.6	26.2	24.1
Area under EG (% arable area)	_	_	40.8	.0
Area under AEM (% agricultural area)	_	52.5	56.9	21.9
Cattle (LU, 1 cow = 1 LU)	8.5	21.5	54.7	63.8
Sheep (LU, 1 sheep = 0.15 LU)	26.6	60.1	51.8	56.0
Stocking Rate (LU/ha) (2)	0.4	0.5	0.4	19.9

Source: IFAP, 2012

Notes: (1) Arable area includes pasture area; (2) for stocking rate computation we considered the whole agricultural area.

Before embarking on the analysis of the financial effects of the two TMF and EG measures, we show the amounts of pillar 1 and pillar 2 subsidies to the different farm groups and the changes in subsidy flows between 2005 and 2009.

In Centro TMF farms showed the highest increase in total payments (+25% of total payments) (Table 5.3). This change was mainly due to the fact that lower pillar 2 payments were more than compensated by higher payments from pillar 1 (animal payments and Single Farm Payment (SFP)). In Alentejo all the groups of farms suffered a decrease in total payments, due to lower pillar 2 payments and to the decreased contribution of animal payments. Yet, EG farms were among those where the decrease was less severe, thanks to the compensation by pillar 1 (SFP) payments. This change is already illustrating the effect of the change introduced in CAP design that aims at rewarding with pillar 1 funds the ecosystem services already provided by extensive livestock systems as they are commonly practiced, and saving pillar 2 funds for rewarding services that go beyond those resulting from common good practice. Moreover, TMF and EG farmers could well belong to those group of farmers who are most well informed and therefore sometimes also switch easiest from one subsidy to another.

Table 5.3 AEM and other CAP payments in 2005, and changes in payment amounts (2009 vs 2005) for groups of farms differently involved in AEM (in Euro per farm).

	Eligible farms (n=622)			
Centro – Pillar 2 (AEM&LFA) and Pillar 1 (Animal & SFP) payments (in € per farm)	No AEM n = 410	Other AEM n =80	TMF farms n = 132	Not eligible n = 56
AEM	-	1,105	1,118	91
LFA	731	1,691	1,153	576
Change in pillar 2 in 2005-09	*- 88*	*- 797*	*- 859*	*75*
Animal payments	114	839	382	1,190
SFP	133	927	552	1,283
Change in pillar 1 in 2005-09	*266*	*705*	*1669*	*160*
Total subsidies in 2005	978	4,562	3,205	3,140
Total percentage change (%)	*18*	*- 2*	*25*	*7*

	Eligible farms (n=265)			
Alentejo - Pillar 2 (AEM&LFA) and Pillar 1 (Animal & SFP) payments (in € per farm)	No AEM n = 168	Other AEM n =77	EG farms n = 20	Not eligible n = 33
AEM	--	2,797	5,364	592
LFA	864	667	536	1,402
Change in pillar 2 in 2005-09	*- 407*	*- 2,681*	*- 3,840*	*- 1,597*
Animal payments	3,905	8,696	13,974	14,693
SFP	6,145	19,848	21,672	30,890
Change in pillar 1 in 2005-09	*- 538*	*- 1,473*	*1,806*	*- 2,984*
Total subsidies in 2005	10,914	32,008	41,456	47,577
Total percentage change (%)	*- 9*	*- 13*	*- 5*	*- 10*

Source: IFAP, 2012

Compared with farms with other AEM, TMF farms received less pillar 1 payments in 2005, including Single Farm Payment (SFP) and animal payments. The reason for that is not entirely explained by the smaller area, and may result from more marginal conditions and consequently lower yields accounted for the estimation of SFP. Total AEM payments were about the same for both groups of AEM farms due to the contribution of other AEM such as organic farming and traditional olive orchards. LFA payments were particularly important for farms with no AEM agreements, which happened to be also smaller in size (see Table 5.2).

AEM payments were higher on EG farms when compared with other AEM farms. Other AEM measures included the support to rainfed grain production and a territorial measure (Plano Zonal de Castro Verde). But the largest share of CAP payments was by far from SFP and animal payments, and EG farms were the highest net receivers of these payments. For EG farms a high SFP corresponded with larger farm and herd sizes, which was not the case for small non-eligible farms which also received high payments from SFP, possibly incorporating part of the decoupled aid for animals (e.g. 50% sheep subsidies). LFA payments represented a rather small amount for all groups of farms, probably since most farms surpass the maximum economic size unit threshold (40 European Size Units, ESU) for LFA support (MADRP, 2008b).

Table 5.4 Costs and benefits of short ley (Ley 1), long ley (Ley 2), and permanent pasture (PP), over a 6 year period.

		Ley 1 – No AEM		Ley 2 – AEM		PP – AEM	
		Low yield	**High yield**	**Low yield**	**High yield**	**Low yield**	**High yield**
year 1	Yield (UF/ha)	1040	1200	1040	1200	360	450
	Revenue 'equivalent UF' (€/ha)	166	192	166	192	58	72
	Establishment operations	Harrowing, fertilisation, sowing		Harrowing, fertilisation, sowing		Harrowing, liming, fertilisation, sowing	
	Establishment cost (€/ha)	232	232	232	232	460	460
	Maintenance operations	Fertilisation, cutting		Fertilisation, cutting		Grazing	
	Maintenance cost (€/ha)	123	123	195	195	17	17
	Total costs (€/ha)	355	355	427	427	476	476
	Net benefit (€/ha)	-188	-163	-260	-235	-419	-404
	Cost per UF (€/UF)	0.34	0.30	0.41	0.36	1.32	1.06
year 2	Yield (UF/ha)	830	960	830	960	720	900
	Revenue 'equivalent UF'(€/ha)	133	154	133	154	115	144
	Maintenance operations	Fertilisation, grazing		Fertilisation, grazing		Fertilisation, grazing	
	Maintenance cost (€/ha)	53	53	53	53	61	61
	Net benefit (€)	80	100	80	100	54	83
	Cost per UF (€/UF)	0.06	0.06	0.06	0.06	0.09	0.07
year 3	Yield (UF/ha)	830	960	830	960	1080	1350
	Revenue 'equivalent UF'(€/ha)	133	154	133	154	173	216
	Maintenance operations	Harrowing, grazing		Harrowing, grazing		Harrowing, liming, fertilisation, grazing	
	Maintenance cost (€/ha)	34	34	34	34	86	86
	Net benefit (€/ha)	99	120	99	120	87	130
	Cost per UF (€/UF)	0.04	0.04	0.04	0.04	0.08	0.06
year 4	Yield (UF/ha)	1040	1200	620	720	1200	1500
	Revenue 'equivalent UF'(€/ha)	166	192	99	115	192	240
	Establishment operations	Harrowing, fertilisation, sowing		---	---	---	---
	Establishment cost (€/ha)	232	232	---	---	---	---
	Maintenance operations	Fertilisation, cutting		Fertilisation, grazing		Fertilisation, grazing	
	Maintenance cost (€/ha)	123	123	53	53	61	61
	Total costs (€/ha)	355	355	53	53	61	61
	Net benefit (€)	-188	-163	46	62	131	179
	Cost per UF (€/UF)	0.34	0.30	0.09	0.07	0.05	0.04
year 5	Yield (UF/ha)	830	960	620	720	1200	1500
	Revenue 'equivalent UF'(€/ha)	133	154	99	115	192	240
	Maintenance operations	Fertilisation, grazing		Harrowing, grazing		Fertilisation, grazing	
	Maintenance cost (€/year)	53	53	34	34	61	61
	Net margin (€/ha year)	80	100	66	82	131	179
	Cost per UF (€/UF)	0.06	0.06	0.05	0.05	0.05	0.04
year 6	Yield (UF/ha)	830	960	410	480	1200	1500
	Revenue 'equivalent UF'(€/ha)	133	154	66	77	192	240
	Maintenance operations	Harrowing, grazing		Grazing		Fertilisation, grazing	
	Maintenance cost (€/ha)	31	31	17	17	78	78
	Net margin (€/ha)	102	122	49	60	114	162
	Cost per UF (€/UF)	0.04	0.03	0.04	0.04	0.07	0.05
Total	Revenue 'equivalent UF'(€/ha)	864	1000	696	807	922	1152
	Establishment cost (€/ha)	464	464	232	232	460	460
	Maintenance cost (€/ha)	417	417	385	385	365	365
	Total costs (€/ha)	881	881	617	617	825	825
	Total output (€/ha)	864	998	696	806	922	1152
	Net benefit (€/ha)	-17	117	79	189	97	327
	Cost per UF (€/UF)	0.16	0.14	0.14	0.12	0.14	0.11

Sources: based on (GPP, 2011a) (GPP, 2011b), (Crespo, 2009) and own survey 2010/11

Financial effects at the farm level

In this section we investigate to which extent the adoption of TMF and EG has led farmers to incur extra costs and whether these were sufficiently compensated. We refer here to the management options laid down in Table 5.1: Ley 1 for no AEM farms, Ley 2 and PP for AEM farms. For that purpose we first show in Table 5.4 the results of the net benefits of each management option without discounting.

The undiscounted total net benefits indicate that permanent pasture is the option that over the 6-year period contributes the most to the recovery and remuneration of capital. However the stream of cash-flows is quite different between the options (Table 5.4). While for short duration ley (Ley 1) the investment (establishment) costs (464 €/ha) are more evenly distributed over the years, for PP option these costs (460 €/ha) are concentrated in the first year which leads to a quite negative net benefit and high cost per forage unit. In fact the cost per forage unit is almost four times higher (0.34 €/UF) than the one generated from short ley systems, and almost eight times higher when considering the equivalent barley market price (0.16 €/UF).

For farmers with lower access to capital this is an important constraint for the adoption of permanent pastures, particularly when one has to consider the risk factor of yield failure and the need to make capital available for buying feed to support the existing herd. For those the short ley option is indeed the wiser, which allows them to distribute the investment costs more evenly for each year although incurring in the end a slightly higher cost per forage unit. The time value of money plays here an important role, and in consequence we have considered that in Table 5.5 through discounting.

As stated earlier the net benefit – investment ratio gives a measure of how well the investment is remunerated. Table 5.5 shows the discounted version of this measure for the three pasture options. The higher the discount rate the higher the preference for money in the present, and therefore it is understandable that with discounting long duration ley (Ley 2) is still preferred to permanent pasture (PP) in areas with lower yield (N/K=1.17 against 0.9 and 1.08). As already referred to PP – AEM farmers incur much higher costs per forage unit in the first year. The N/K ratio of long duration ley (Ley 2) and permanent pasture options only becomes equivalent in high yield areas (N/K= 1.6), or for longer periods of analysis also in lower yield areas (N/K= 1.18). This indicates that the adoption of AEM with the most beneficial option PP would be first adopted by farmers with not so marginal soils and with longer term investment plans. With regard to the quality of the soils, the adoption of AEM by farmers operating on very marginal soils would also be an option, but they would have to incur much higher costs than their neighbours. When considering the duration of the investment, one should realise that the farmers in these marginal areas are rather old, and that 12-years investments would only make sense if the succession of the farms is in some way secured.

On some of the farms the adoption of AEM does not result in extra costs and in most of the cases where it does, the subsidy largely compensates farmers for the extra costs incurred. In fact for the 6-years period none of the AEM management options (Ley 2, PP) resulted in extra costs, although that was the case for establishment and renewal years on all management options. Considering TMF and EG payments, which at their best paid 260 €/ha, Ley 2 farmers would already be fully compensated in the second year while PP farmers would have to wait for the third year.

The apparent overcompensation is due to the fact that horizontal measures such as TMF and EG required high uptake rates to deliver the public environmental benefits and therefore included a considerable incentive element to ensure that. That high uptake was in fact realised neither in Centro nor in Alentejo, where respectively only 13 and 3% of the eligible area was covered (Jones et al., under review). This rather disappointing result illustrated both the budgetary constraints at the Programme level from 2005 onwards (Agro.Ges, 2009), but also the fact that in some cases lower yields and higher discount rates might in fact have led to more negative net present values than the ones reported in Table 5.5.

Table 5.5 Net benefit – investment ratio for the three pasture options with discounting, over periods of 6 and 12 years (discount rate i = 0.04)

		Ley 1 – No AEM		Ley 2 - AEM		PP – AEM	
year	**$(1+i)^{-n}$**	**Low yield**	**High yield**	**Low yield**	**High yield**	**Low yield**	**High yield**
1	0.962	-181	-157	-250	-226	-403	-389
2	0.925	74	93	74	93	50	76
3	0.889	88	107	88	107	77	116
4	0.855	-161	-139	39	53	112	153
5	0.822	65	82	54	67	107	147
6	0.790	80	97	39	47	90	128
7	0.760	-139	-120	-194	-175	-316	-305
8	0.731	58	74	58	74	40	61
9	0.703	70	85	70	85	62	92
10	0.676	-124	-107	31	42	88	121
11	0.650	52	65	43	53	85	116
12	0.625	64	77	30	37	82	112
N/K ratio (6 years)		0.90	1.3	**1.17**	**1.6**	1.08	**1.6**
Net Present Value		-35	83	43	141	33	230
N/K ratio (12 years)		0.91	1.3	**1.18**	**1.6**	**1.18**	**1.6**
Net Present Value		-54	157	82	257	74	427

Financial effects at the research area level

Often enough horizontal AEM such as TMF and EG, with low requirements and quite generous payments, have been accused of delivering few benefits at a rather high price because farmers prefer to adopt those since it is easy for them to agree with the requirements of the measure. This trade-off between low requirements and generous benefits is, to a large extent, explained by the fact that Portuguese policy-makers, as other Southern MS, tend to use AEM more as a farmers' income supplement than as an environmental incentive (Rodrigo, 2001). A recurrent suggestion for the improvement of the effectiveness of such measures is their combination with more targeted measures (de Graaff et al., 2011). In order to assess to which extent TMF and EG incentives resulted in payments with the desired effect, we have further analysed the cost-effectiveness of TMF and EG using a goal index combining stocking rate and soil cover indicators. The amount of spending per index unit represents how much was paid to an ideal 'perfect' farmer who delivered both effects: preserving the grazing livestock and managing all arable land as a permanent pasture cover (considering that such cover is best in order to reduce erosion and fire hazard). The actual AEM implementation was compared with two more targeted situations of AEM payments. Table 5.6 shows the results of that comparison.

Table 5.6 Spending and coverage of TMF and EG measures (5-years agreements) in Centro and Alentejo research areas in three scenarios of implementation, in € per ha and € per goal achievement index, expressing the performance of AEM.

	Centro			Alentejo		
	Actual	Most suitable (a)	High performance (b)	Actual	Most suitable	High performance
Goal Achievement index- Stocking Rate	144	151	117	86	95	82
Goal Achievement index - Soil cover	74	103	63	66	74	64
Goal Achievement index – total (c)	218	254	180	152	169	145
Area under AEM (ha)	375	521	92	1,844	6,773	2,429
Area under AEM/ goal index (ha/index)	2	2	0.5	12	40	17
Spending in AEM (€/ha)	902	1,039	1,158	322	322	334
Spending / goal index (€/index)	1,556	2,130	588	3,912	12,893	5,584
Total AEM spending (€)	338,250	541,319	106,536	593,768	2,180,906	811,286

Note: (a) slope ≥ 15% and farms with more than 40% of grazing animals (goats in Centro and sheep in Alentejo);

(b) Stocking rate trend no change and soil cover with permanent pasture;

(c). G = ∑ [0.5 x (plot area/ arable farm area) x i + 0.5 x (plot area/arable farm area) x f], whereby i and f are binary values, 1 if the desired effect is observed, respectively with regards stocking rate trend and permanent pasture presence. G equals 1 when both effects are present.

It is interesting to observe that the actual implementation of AEM, when compared with the two more targeted situations, corresponded to an intermediate amount spent per 'perfect' farm in both research areas. The actual situation also led in Centro to an intermediate total AEM spending, whereas in Alentejo the actual situation was the least expensive one. The actual spending per hectare was the lowest for both areas. Yet in an ideal situation of AEM implementation, with a perfect control system able to guarantee payments only to farmers with a majority of grazing animals and managing all their steepest land as permanent pastures, more complete effects would have been obtained. That is what the results of the most suitable situation illustrate, where the composite implementation of AEM would have resulted in the equivalent presence in the research area of 254 and 169 'perfect' farmers in Centro and Alentejo, respectively. That is also depicted in Figure 5.2 showing the largest area covered in the most suitable situation in comparison with the actual AEM implementation. Targeting the most suitable area would result in the highest spending both at the farm level and in the overall spending.

Conceiving an improvement of that targeting situation would be to restrict payments to those 'real' farmers that actually delivered the desired effects on stocking rate and soil cover. That is what the results of the 'high performance' situation reflect. In Table 5.6 we see that in comparison with the previous option, this targeting strategy results in a significant decrease of total spending. However this is conducted at the expense of a significant loss of effect, illustrated by the smaller area under management and total index achieved.

Both these 'ideal' situations explore two possible strategies for targeting AEM payments, based on the actual delivery of the effects achieved with past AEM. Optimistic assumptions were made with regard to the generation of effects and the same level of payments was considered. In fact the whole context of past AEM implementation was taken as unchangeable, also with regard to the fact that non-beneficiaries with positive effects in the past would remain doing so in the future. Yet, by considering these past effects the analysis retains also those that were provided the most cost-effectively. We assumed a top-down approach with a targeting strategy led 'by design', which shows a very poor performance with regard to the gains in cost-effectiveness. Considering the results of our analysis of the adoption of improved permanent pastures, future AEM focusing on extensive livestock production in less favoured areas, should probably aim at those "high performance" farmers. Those farmers, located in the most relevant areas and willing to produce positive environmental effects, could then reach higher impact levels with more demanding AEM.

However 'finding' those farmers will require local partnerships to effectively implement such measures. Although the change in CAP payments seems to favour the compensation of lower pillar 2 with higher pillar 1 payments in order to avoid abandonment, this will be detrimental for the adoption of more demanding AEM. Moreover, since pillar 1 payments are made annually farmers will not be committed to long-term strategies and that is likely to negatively affect the adoption of improved permanent pastures.

5.4 Conclusions

This chapter focuses on the role of the financial incentives provided by two EU agri-environmental measures (AEM) in the preservation and expansion of permanent pastures and extensive livestock keeping in less favoured areas. These two AEM, Traditional Mixed Farming (TMF) and Extensive Grassland (EG), were designed to provide a broad spectrum of benefits, among which permanent pasture coverage and to retain livestock numbers within appropriate stocking rates. Attention was first paid to the characterisation and the assessment of the actual uptake of the two AEM in the two research areas, whereby a distinction was made between non-eligible and eligible farms, and among the latter between no-AEM, other AEM and TMF/EG farms.

TMF was particularly important in Centro covering about 50% of the area under AEM, and EG was important in Alentejo covering about 12% of the AEM area. TMF farms and to a less extent EG farms were smaller than farms with other AEM, but had a higher share of agricultural land under AEM.

It appeared that TMF and EG farms had been able to compensate the declining pillar 2 payments in the period 2005-2009 with higher pillar 1 payments, which for TMF farms in Centro resulted even in a 25 % increase of total CAP payments. Two of the reasons for that might be that these farmers are among those best informed about subsidies and that they were able to gain most from the fact that Single Farm Payments had become fixed on the historical payments to the farm (the 2000-2002 reference period for SFP). LFA payments were also an important part of pillar 2 payments, being particularly important for farms with no AEM for which they represented the main share of total payments. These farms with no AEM are actually smaller than the average eligible farms.

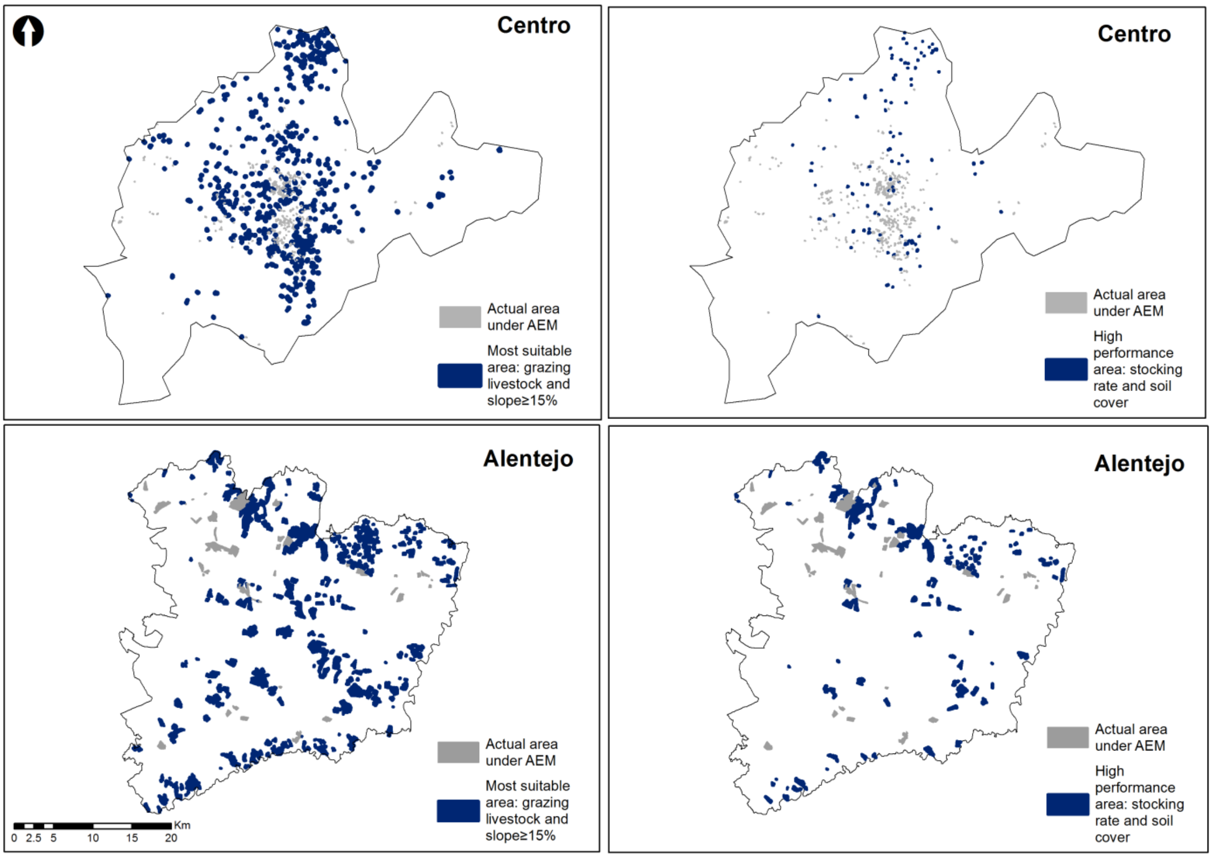

Figure 5.2 Areas under AEM in three implementation situations: the actual one (light shaded), AEM targeted to most suitable area in terms of slope and presence of grazing animals (dark shaded on the left), and AEM targeted at the area that achieved the highest performance in the actual situation (dark shaded on the right).

An assessment was thereafter made about the financial effects of the two AEM on the farm level. A distinction was thereby made between the traditionally applied three year ley system, the extended (6 year) ley system and the permanent pastures, which respectively corresponded to a situation of no participation in AEM, and two management options for AEM participants. Since these systems differ in the stream of costs and benefits over the years, discounting was applied. The net benefit-investment ratio revealed that adopting AEM with permanent pasture (PP) was only favourable in financial terms when yields were higher or when a longer period (12 instead of 6 years) was considered. Negative net margins were in most cases amply compensated by AEM payments, and already after the second or third year of pasture establishment. This overcompensation could be justified on the grounds that it also concerns public environmental benefits. A better targeting of such horizontal measures could be a point of improvement instead of increasing the payments of AEM.

Subsequently the focus was on the effects of the AEM incentives on permanent pastures in the two research areas, for which use was made of a combined index with stocking rate and soil cover indicators. The results showed that the actual implementation of AEM offers an intermediate «price» per unit of goal achievement when compared with two more targeted situations: 1) steep arable farmland with grazing livestock ("most suitable areas"), and 2) steep arable farmland with grazing livestock, located on farms, which actually achieved the desired environmental effects ("high performance areas"). Future AEM focusing on extensive livestock production in less favoured areas, should probably be aimed at those “high performance” farmers, which were the most cost-effective deliverers of positive effects either as a result of AEM or not.

Although the AEMs analysed in this chapter may not anymore be implemented as such in the future policy framework, the support for permanent pastures tends to assume an increasing relevance, either by means of cross-compliance (within pillar 1) or through new agri-environmental measures. The establishment of improved permanent pastures benefits from longer term investment plans and better soils, yet the higher delivery of environmental benefits is more likely to be obtained in more marginal areas by those farmers with more ‘traditional’ farming practices such as grazing. Whether more targeted pillar 2 measures will be able to aim at those ‘traditional’ yet ‘high performance’ farmers will be interesting to see.

Chapter 6

Targeting the impact of agri-environmental policy - future scenarios in two less favoured areas in Portugal

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6.1 Introduction

Mainstreaming the delivery of environmental public goods within the instruments of the European Commission's Common Agricultural Policy (CAP) is one of the objectives of the recent reform (COM, 2011). Many have urged the need for more targeted spending in order to improve the effectiveness of agri-environmental policy (e.g. Matzdorf *et al.*, 2008; de Graaff *et al.*, 2011; ECA, 2011). Targeting refers here to the definition of measurable objectives which makes it possible to assess the delivery of environmental goods (COM, 2006). So far, in the EU targeting has been operationalized through the definition of designated areas for support, the number of beneficiaries, and the size of area under management (Finn & O hUallachain, 2012). However at the local level and with the geographical data acquired by the administration (e.g. Land Parcel Information System) enhanced targeting of policies should be possible both at the design (Primdahl *et al.*, 2003; Rossing *et al.*, 2007; Zander *et al.*, 2008; Uthes & Matzdorf, 2013) and implementation stages (Paar *et al.*, 2008; Enengel *et al.*, 2011).

Agri-environmental measures (AEM) have been criticised for lack of targeting (Kleijn *et al.*, 2006; Uthes *et al.*, 2010; Parissaki *et al.*, 2012). Some AEM with simple obligations require large uptake rates to reach spatial significance to deliver the aimed effects (e.g. extensive grassland measures) (Uthes *et al.*, 2010; Parissaki *et al.*, 2012), while other more targeted AEM fail due to poor target definition (Kleijn *et al.*, 2006). Whereas improving spatial targeting can lead to gains of effectiveness of AEM, interactions between measures may lead to over expenditure at the programme level or under-achievement of some objectives (Uthes *et al.*, 2010). Such effects may be remedied by improving the efficiency of policy mixes, as demonstrated by Schader *et al.* (2014) for the case of organic farming AEM. Future AEM effectiveness will thus rely on setting appropriate targets associated with suitable spatial translation of their effects.

In line with these concerns, the European Court of Auditors (ECA, 2011) recommended that future agri-environmental programmes should consider a clear distinction between simple and more targeted AEM. Moreover, AEM should be aligned with other CAP payments in order to deliver environmental public goods and avoid double subsidisation (COM, 2011; EU, 2013b). This is particularly important for AEM and Less Favoured Areas (LFA) payments, which may have overlapping objectives such as avoiding abandonment. Moreover, it is likely that the present CAP reform will bring a shift of resources from payments targeting the reduction of intensity towards payments with the purpose to avoid abandonment (Hodge, 2013). This is expected to shift the focus of AEM towards less productive land, likely to be located in less favoured grazing areas, emphasizing the importance of looking at these policies in an integrative way (Hodge, 2013). A better articulation between CAP instruments can eventually decrease policy costs as shown by Schuler & Sattler (2010) for intensive farming systems in Germany.

Existing research so far fails to provide a holistic view for policy design at the relevant farm or regional level, neglecting often the role of the available budget for AEM spending (Uthes & Matzdorf, 2013). Van der Horst (2006) refers to a general neglect of spatial heterogeneity of costs and benefits in past environmental policies. In Portugal the impact of CAP payments has been shown for specific

farming systems (Jorge *et al.*, 2010; Agro.Ges, 2011; Fragoso *et al.*, 2011), but there is a lack of focus on the spatial translation of the effects at the local level. Moreover, it is on extensive farming systems operating in LFAs that the impact of the changes in CAP (2014-2020) is deemed to be highest (Renwick *et al.*, 2013). Conflicting results on the success of past territorial targeting strategies have been reported, with some studies giving positive feedback on the targeting of AEM e.g. within specific nature conservation sites in Scotland (Yang *et al.*, 2014), but also negative results e.g. differentiated levels of AEM payments per municipality in Czech Republic (Pelucha *et al.*, 2013).
The impact of farm abandonment in LFAs in Portugal, as in other countries in the European Union, has been threatening farmers in dry and mountainous zones. Since the 1960s their farming systems based on low-input crop-livestock associations have lost the competition with specialised farms in more suitable agricultural areas. In several areas the abandoned agricultural land was subsequently converted to forest either through afforestation or invasion of shrubs, and it appeared very vulnerable to forest fires (Baptista, 1996; Baptista, 2011; Lopes *et al.*, 2013). After repeated fires the soils and their stock of seeds become exhausted, and the resulting bare soils become exposed to soil erosion (IGP, 2004; Carreiras *et al.*, 2014).

For the farms still operating in those marginal areas, policies have partially supported the specialisation of some crop-livestock farming systems (Poux, 2007), but this trend has not been associated with an improvement strategy of pasture areas (Caballero, 2007; Caballero *et al.*, 2008). The improvement of poor pasture areas through forage legumes could lead to a win-win situation where the carrying capacity could be enhanced alongside the delivery of environmental benefits such as water and soil protection, and carbon sequestration (Porqueddu, 2007; Porqueddu *et al.*, 2013). Moreover, targeting support policies such as AEM to the preservation of a viable livestock production in marginal areas might contribute to the reduction of fire hazard and erosion risk.

In this chapter we assess the impacts of several combined measures of the CAP for two case studies in Portugal, both located in marginal areas, using a scenario modelling approach. The objectives of the chapter are: 1) to assess cost-effectiveness of reducing erosion and fire risk by preserving extensive livestock production; 2) to determine the added value of using a spatial targeting strategy based on slope and fire risk criteria.

6.2 Policy environment: targeting agri-environmental expenditure

Changes in Pillar 1 and Pillar 2 of the CAP

The CAP includes two main types of payments to farmers: i) payments linked to past production and cross-compliance with minimum management requirements, and ii) payments linked with the delivery of environmental public goods. These two types of payments are also designated as Pillar 1 and 2 of the CAP. Single Farm Payment (SFP) based on past production together with livestock coupled payments compose the bulk of Pillar 1, whereas AEM together with LFA payments compose the main part of Pillar 2.

The CAP reform for the period 2014-2020 intends to phase out the link of SFP to past production levels while adding a second level of environmental compliance called 'Greening'. This second level of environmental compliance can be met through one of three 'Greening' options: crop diversification, permanent grassland, and ecological focus areas (Hart & Little, 2012; EU, 2013c). Of special interest for marginal areas with extensive livestock production is the option to meet the 'Greening' objective through the preservation of permanent grassland.

About 70% of sheep and goats in the EU is located in LFAs (EC, 2011). Some EU countries, among which Portugal, have kept a partial link of livestock payments with production. Although in the CAP reform remaining coupled payments for livestock were to be discontinued to achieve total decoupling, an exception was made for situations where they could be maintained for economically vulnerable areas or specific quality systems (EC, 2011). The latter has been the case for Portugal (Avillez, 2014) (Table 6.1). As a result support should be carefully targeted both geographically and to specific production systems (EC, 2011).

In the framework of CAP reform, criteria for LFAs were also revised. Eliasson *et al.* (2010) provide some recommendations on common biophysical criteria for LFA delimitation to be adopted, e.g. slope higher than 15%. LFA payments were defined to compensate farmers operating in areas with limitative agronomic conditions, such as mountainous areas prone to abandonment and other LFAs facing natural handicaps such as shallow soils (EC, 1999). Altogether, more than 50% of Portugal's agricultural area falls into LFAs (Agro.Ges, 2009), with payments targeting farms with a standard gross margin below 48,000 Euros.

The preservation of livestock production in LFAs is important in order to preserve permanent pastures which in return deliver environmental public goods such as: reduced fire risk avoiding subsequent carbon release and soil erosion, open landscapes valued by tourists, and maintaining biodiverse habitats (Keenleyside *et al.*, 2011; EFNCP, 2012). However, preserving grazing livestock may not be enough to preserve grazing practices (Jones et al., under review). As most animal production systems rely on concentrates, conserved forage and grazing land, a combination of these sources of feed is needed that serves both objectives: the viability of farms, and the delivery of environmental public goods. In this chapter we will look at the delivery of reduced fire and erosion risks.

Agri-environmental policy scenarios for LFAs

The process of CAP reform should culminate in 2020 with a convergence of direct payments per hectare among EU regions (COM, 2011). The main components of the reformed CAP direct payments should lead to stacking of:

- a basic payment - in return for minimum management requirements,
- a 'greening' payment - in return for extra environmental compliance;
- a LFA payment - in return for operating in limitative farming conditions;
- and agri-environmental payments - in return for specific management requirements.

With regard to the transfers between Pillar 1 and 2 and the existence of coupled payments, the study from Agro.Ges (2011) assesses the impact of three possible policy combinations for the agricultural sector in Portugal: i) without transfers and without coupled payments; ii) without transfers and with coupled payments; and iii) with transfers and with coupled payments. They conclude that in any of these scenarios extensive livestock farms in the Centre and South regions will gain from the redistribution of subsidies. Because the objective of Agro.Ges (2011) was to assess the impacts at the national level they assumed that no major changes would happen with regard to AEM and LFA payments. The options for the changes of AEM and LFA components are the main focus of this chapter. With respect to greening payments we will consider the decisions already contemplated in the regulation of the policy (EU, 2013b; EU, 2013c).

In the context of a much more targeted Pillar 1, the objectives of Pillar 2 payments would have to provide for a much higher level of delivery of environmental public goods (Allen *et al.*, 2012; Hodge, 2013). Hodge (2013) states that in a context of higher commodity prices, agri-environmental policy can even become unaffordable for certain governments as it would become impossible to compensate for the amount of income forgone. In view of these limitations the definition of a clear impact model able to provide a link between measures and environmental outcomes is essential to provide a learning path for policy evaluation (Primdahl *et al.*, 2010). Zander *et al.* (2008) suggest the use of supply-based approaches for the evaluation of trade-off functions between the provision of commodity and non-commodity outputs.

Although extensive livestock production is likely to become an overall winner in terms of Pillar 1 redistribution (Agro.Ges, 2011), there is a risk that not enough effort is made at the national level in developing Pillar 2 (namely with AEM and LFA payments) to bring these farms to a more environmentally friendly intensification pathway. For the particular case of marginal areas in Portugal, this means that because farm abandonment is likely to be mitigated with Pillar 1 payments, measures for higher provision of environmental public goods would have less chance of being adopted. Hart and Little (2012) also identify this watering down effect with regard to the greening options and suggest some solutions, e.g. ‘conditional greening’, where the greening component would only be accessible to those with AEM; and ‘extended ecological focus areas’ with the adoption of a wide mix of management practices (e.g. use of clover in intensive grassland).

In this chapter we hypothesize that the delivery of environmental public goods, notably with regard to the reduction of fire hazard and erosion risk in Portuguese LFAs, could be enhanced through a certain policy mix favouring best practices such as the improvement of permanent grasslands and grazing. Ultimately the objective of the chapter is to assess to which extent more targeted agri-environmental payments can contribute to environmental public goods delivery in LFAs.

6.3 Materials and methods

Research areas

Two research areas in Portugal were considered, one in Centro with 112,000 ha and another in Alentejo with 128,000 ha (Figure 6.1). Centro falls under the mountainous LFAs (EC, 1999), and is just within the sub-humid climatic zone with annual rainfall ranging from 700-1400 mm. The most common soil types are eutric Lithosols and hortic Luvisols (CNA/SROA, 1978). Most of the area is under forest or shrub while the agricultural area constitutes 27 % of the territory. The predominant farms are very small (ca. 4 ha) with few sheep (0.3 Livestock Units (LU)/ farm). Alentejo falls under the intermediate LFAs “where biophysical constraints from the land result in higher production costs and may lead to abandonment” (EC, 1999), in the semi-arid climatic zone with annual rainfall ranging from 400-600 mm. The most common soil types are ferric Luvisols and eutric Lithosols (CNA/SROA, 1978). Agriculture is the largest land use (64 % of total), but thanks to afforestation efforts ‘open and new forest’ land increased to 22 % in 2006 mainly at the expense of ‘heterogeneous agricultural land’, which consists largely of pasture land under scattered trees (Jones *et al.*, 2011, based on CORINE LC data). The farms are predominantly medium to large-sized (ca. 127 ha) with many sheep and/or cattle (26 LU/ farm) (INE, 2010).

Changes towards more specialised farming and farm abandonment in Centro, and increase of cattle in Alentejo have been leading to a lower use of pastures (Jones *et al.*, 2013). In Centro this trend is adding to the already large area of shrubs more prone to fire occurrence (Pereira *et al.*, 2006), while in Alentejo the conversion of ley area into permanent pasture through longer fallow periods has favoured intensification of pasture renewal on the remaining farm land. Therefore the future benefits of permanent pasture preservation seem to be strongly related with the spatial targeting of incentives to support that practice.

We consider the year of 2009 as the base year for our analysis. In that base year, from a total of 687 farms in Centro and 303 in Alentejo, 86% benefited from SFP. With regard to the other CAP components, 44% and 74% benefited from livestock payments, 30% and 17% from AEM, and 84% and 34% from LFA payments in 2009, respectively in Centro and Alentejo (IFAP, 2012).

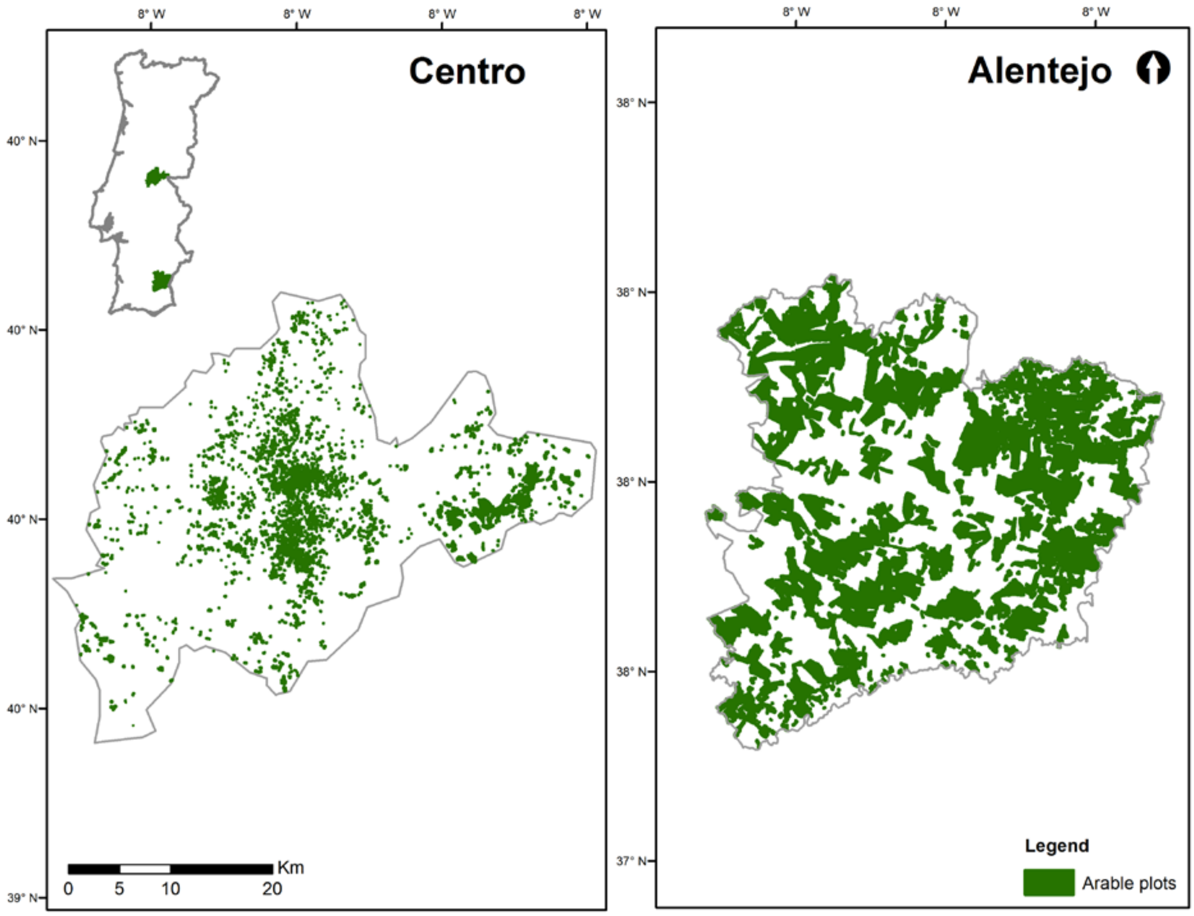

Figure 6.1 Research areas and arable area for land use change

Analytical framework

The analytical framework is summarised in Figure 6.2. We used a spatially-explicit mixed integer programming (MIP) optimisation model to allocate options of pasture management or abandonment among the available arable area. Two options of pasture management were considered: a ley farming system renewed every 3 years representing wide-spread current practice, and a permanent pasture with a minimum duration of 5 years. For the estimation of costs and feed value we assumed that ley cover consisted of a combination of oats with ryegrass, and that permanent pasture consisted of a combination of clover species with ryegrass. We assumed that plot delimitation of 2009 provided by the Land Parcel Information System (LPIS) does not change over the period of optimisation (2010-2030). Moreover, we assumed that land under permanent crops and forest will not be converted into pasture.

From a societal perspective, permanent pasture is the most desirable management option for steeper arable plots because it: i) requires fewer tillage operations minimizing erosion; and ii) preserves the open landscape which favours forest discontinuity and therefore higher resilience to fire risk. Ultimately if the preservation of grazing practices becomes too expensive for the farmer, grazing is abandoned and the plot becomes forest which is beneficial in terms of erosion but less attractive in terms of fire risk and farm income.

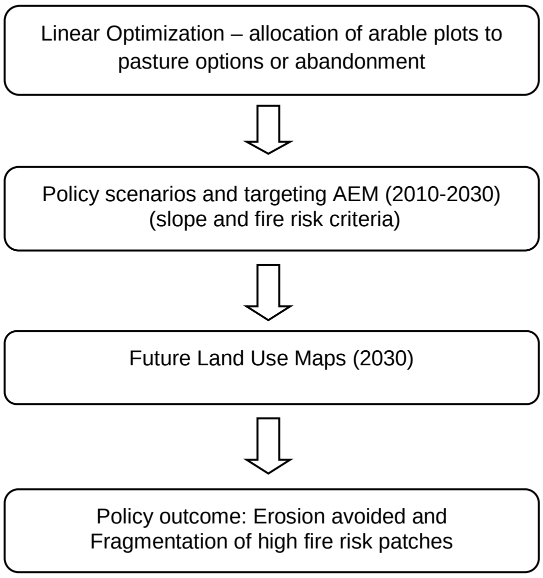

Figure 6.2 Analytical framework

We assumed that ley was the initial management option for all farms. The model was validated with past CAP payments verifying whether past changes observed between 2005 and 2009 were fairly reproduced by the model. We assessed the past trends on the change of the number of animals, arable area, and stocking rate of 622 farms in Centro and 295 in Alentejo. As the MIP model only takes the income effect in consideration, we did not expect a complete reproduction of those trends. The effect of other bio-physical and socio-economic variables has been widely documented (e.g. Pinto-Correia et al., 2006a; Van Doorn & Bakker, 2007). With regard to the number of animals and stocking rate, the model was able to reproduce the direction of change in 50 % of the cases in Centro and 60 % in Alentejo. The model was 'right' on the direction of change of arable area in about 40 % of the cases. Although the model is limited in that it only considers the maximization of income, it has the strength to locate the plots where pasture management options or abandonment will take place. Moreover, it is expected that younger farmers are more income-driven and therefore this MIP model is deemed to be an appropriate tool to assess changes in land and animal production within a future-oriented scenario analysis framework.

CAP scenarios

The allocation of pasture management options was studied under different scenarios for CAP payments, more particularly with regard to AEM payments. The main objective was to assess whether targeting AEM to specific plot conditions was better than 'broad brush' implementation of AEM or not. Table 6.1 gives a summary of the scenarios considered in this chapter. Altogether we considered three scenarios (Table 6.1):

- Basic – with base, greening and less favoured area CAP payments;
- AEM – with all the basic scenario components plus AEM and livestock coupled payments;

- Targeted AEM – with all the basic components plus targeted AEM and livestock coupled payments.

From a separate run with the past policies we obtained the validation of the model, and from the comparison of AEM and Targeted AEM scenarios with the Basic scenario we obtained the value added of implementing AEM with and without a spatial targeting strategy.

Table 6.1 Description of policy scenarios

Policy scenario	**Components**	**Obligations/ requirements**	**Payment (€ / ha or LU)**	**Source**
Basic	Base payment	GAEC	DP $_{farm}$/ ha < 110 €/ha = 110 €/ha; DP $_{farm}$/ ha >165 €/ha = 165 €/ha (1)	(Avillez, 2014)
	Greening payment	Greening condition (crop diversification; permanent pasture; ecological focus areas)		
	LFA	Standard total output < 50,000 € 0.15 LU/ha < Stocking rate < 2 LU/ha	Mountain areas (Centro): ≤ 3ha = 260 €/ha; 3-10 ha = 190 €/ha; 10-30 = 60 €/ha; 30-150 ha = 20 €/ha; Other areas (Alentejo): ≤ 3ha = 130 €/ha; 3-10 ha = 95 €/ha; 10-30 = 25 €/ha; 30-150 = 10 €/ha	(GPP, 2014)
	Livestock payment	Sheep-Goats Cattle	19 €/ animal (1 a = 0.15 LU) 120 €/ animal (1 a = 1 LU)	(Avillez, 2014)
AEM	Basic scenario + AEM	All arable plots	Centro: < 2ha = 112 €/ha; 2-5 ha = 80 €/ha; 5-10 = 64 €/ha; Alentejo: < 10ha = 120 €/ha; 10-20 ha = 96 €/ha; 20-50 =80 €/ha; 50-100 ha =64 €/ha; 100-500 ha = 48 €/ha	(own calculation and past AEM tiers)
Targeted AEM	Basic scenario + AEM + Targeting AEM	Only arable plots with slopes 15-45% (IQFP 3 and 4), and high susceptibility to fire (within 250m buffer of high fire risk vegetation patches)		

Note: (1) DP $_{farm}$ – farm direct payment in 2009 (our last updated information) equals SFP + livestock payments; Greening fixed payment equals 30% National Envelope (566 million €)/ 3.0858 million eligible ha = 55€/ha. To calculate the average national single farm payment we used 2013 average: 566 million €/ 3.0858 million eligible ha = 183.4 €/ha (Avillez, 2014). GAEC – Good Agricultural and Environmental Conditions; LFA – Less favoured Areas; AEM – Agri-environmental measures; PP – Permanent pastures.

The spatial targeting strategy for the Targeted AEM scenario consisted in designating plots that were simultaneously more prone to erosion and in the vicinity of fire risk vegetation patches as eligible for AEM. Slope and fire susceptibility classifications were obtained from the LPIS database and fire susceptibility from a national fire risk map (IGEO, 2011; IFAP, 2012). In this targeting strategy we did not consider the transaction and administration costs of implementing AEM on selected plots.

For CAP future scenarios we considered the information already made available (EU, 2013b; EU, 2013c; GPP, 2013a). For Pillar 1 payments we considered the average national SFP for 2013 (566 million € / 3.0858 million eligible ha = 183.4 €/ha) (Avillez, 2014). As greening payment is accessible without any extra requirements to farms complying with one of the following conditions: more than 75 % of forest cover, more than 5 % of permanent crops, more than 75 % of permanent pastures or grasses for forage production, we assumed that all farms would have access to both components of Pillar 1 in both research areas. This is a fair assumption based on previous land use assessments (Jones *et al.*, 2011). Greening fixed payment equals 30% of National Envelope (566 million €) / 3.0858 million eligible ha = 55 €/ha). In all three CAP scenarios a special regime for small farms will be in place: all farms with direct payments under 500€ will receive that amount without being constrained by greening obligations (and will have access to AEM and LFA). We assumed that the small farm status does not change within the period considered for the runs of the model. The area that was subject to change was respectively 2.3 % of total area (ca. 1,125km^2) in Centro and 36.4 % of total area (ca. 1,293km^2) in Alentejo (Figure 6.1). The share of the area in Centro may seem small but has wider significance through the link of farming activity with active forestry management (e.g. Novais & Canadas, 2010).

Indicators for impact assessment

We assessed resource, output, result, and impact indicators of each scenario (COM, 2004). As a resource indicator we assessed policy spending (€), as output indicators we considered net farm income (€), and on-farm feed provision (% of total), as result indicators we estimated the arable land not abandoned (% initial arable area), the area of permanent pasture (% targeted area), and the share of grazing livestock (% of total), and finally, as impact indicators we considered the erosion avoided (t/ha) and the fragmentation of high fire risk patches in the landscape (effective mesh density). The erosion avoided was assessed through PESERA (Kirkby et al., 2008) within a subsequent analysis of the outputs and not in an embedded modelling approach as in Fleskens et al. (2014) for the assessment of SLM technologies The main difference between ley and permanent pastures, frequency of tillage operations, was considered through calculating potential erosion over a period of 5 years where soil cover and soil disturbance in installation years was equivalent to annual crops and ley years were equivalent to grassland. The fragmentation of high fire risk patches in the landscape was assessed through the estimation of effective mesh density (s_{eff}). The effective mesh density indicates structural differences between two landscapes based on the probability that two points chosen randomly in an area are connected and are not separated by any barriers (EEA, 2011): $s_{eff} = A_{total} / \sum (A_{patch})^2$, where A_{total} indicates the total area, and A_{patch} indicates the area of each patch. If fragmentation increases the effective mesh density also increases (EEA, 2011). For both impact indicators we compared the 2010 and 2030 land use maps. All indicators were reported for three groups of farms: very marginal, marginal, and less marginal, according to their distance to main road, and slope. Farms with a majority of area located more than 3 km from main roads and with slopes steeper than 15 % were considered very marginal, those with none of these conditions were considered less marginal, and those with at least one of these conditions were considered marginal.

MIP model description

The objective function maximises farm income at the farm level, subject to constraints on: external feed purchase, plot area, and fixed labour and capital availability (Eq 1). We expected a single management option per plot, and therefore the optimisation was conducted using a mixed integer linear programming solver. Three pasture management options (i) are allocated among the available arable plots (p) producing the amount of feed X_i. The farmer maximizes farm net income Z which results from the revenue of livestock (l) production Y_l plus subsidies on land (AEM, SFP and LFA) and livestock ($subsidy_l$) minus the costs from pasture ($cost_i$) and livestock management ($cost_l$). AEM is linked to pasture management options and plot targeting criteria, whereas SFP and LFA subsidies are considered in function of farm size. X_i and Y_l are accounted annually and all costs and benefits are discounted at 3% over the time horizon modelled (2010-2030). The solutions are constrained by the amount of resource available (labour, capital, and land), the carrying capacity of each pasture option, the possibilities of interchanges between pasture management options, and the distance of each plot.

$$Z = \max \sum_{jl} Y_{jl} \cdot \left(revenue_l - cost_l + subsidy_l \right) + \sum_{ijp} X_{ijp} \cdot \left(AEM_i \cdot target_p + SFP + LFA - cost_i \right)$$

s.t.

$$\sum_{ip} X_{ijp} \cdot cost_i + \sum_{l} Y_{jl} \cdot cost_l \leq \sum_{p} resourceavailable_p \qquad (1)$$

$$Y_{jl} = \sum_{ilp} X_{ijp} \cdot carryingcapacity_{il}$$

$$\sum_{ip} X_{ijp} = area_p$$

6.4 Results

Policy scenarios are compared based on resource, output, result and impact indicators, displayed by groups of farms with a different marginality condition (Tables 6.2 – 6.7). Policy spending (excluding all transaction and administrative costs) was considered as the resource indicator. By multiplying the average amount of payments received per farm with the number of active farms we obtained the total policy spending and concluded quite expectably that the basic scenario results in the lowest policy spending, followed by targeted AEM and AEM scenarios. Respectively in Centro and Alentejo: 309 k€, and 3,259 k€; 455 k€, and 4,482 k€; 467 k€, and 4,927 k€.

We subsequently assessed to what extent increased policy spending in the AEM and targeted AEM scenarios leads to enhanced performance indicators. We found the most favourable scenario by considering the most desirable outcome for each indicator attributing equal importance to each one of them. Thereby we took into account the following optimisation factors: 1) lower policy spending, 2) higher share of Pillar 2 on total amount of subsidies, 3) higher gross farm income, 4) higher share of on-farm feed provision, 5) higher number of livestock, while keeping stocking rate under 2 LU/ha, 6) higher share of abandonment avoided on initial arable area of the farm, 7) higher share of permanent pasture on target area, 8) higher share of grazing livestock on total, 9) higher share of erosion avoided, and 10) higher landscape fragmentation with high fragmentation of forest patches associated to low fragmentation of pasture patches.

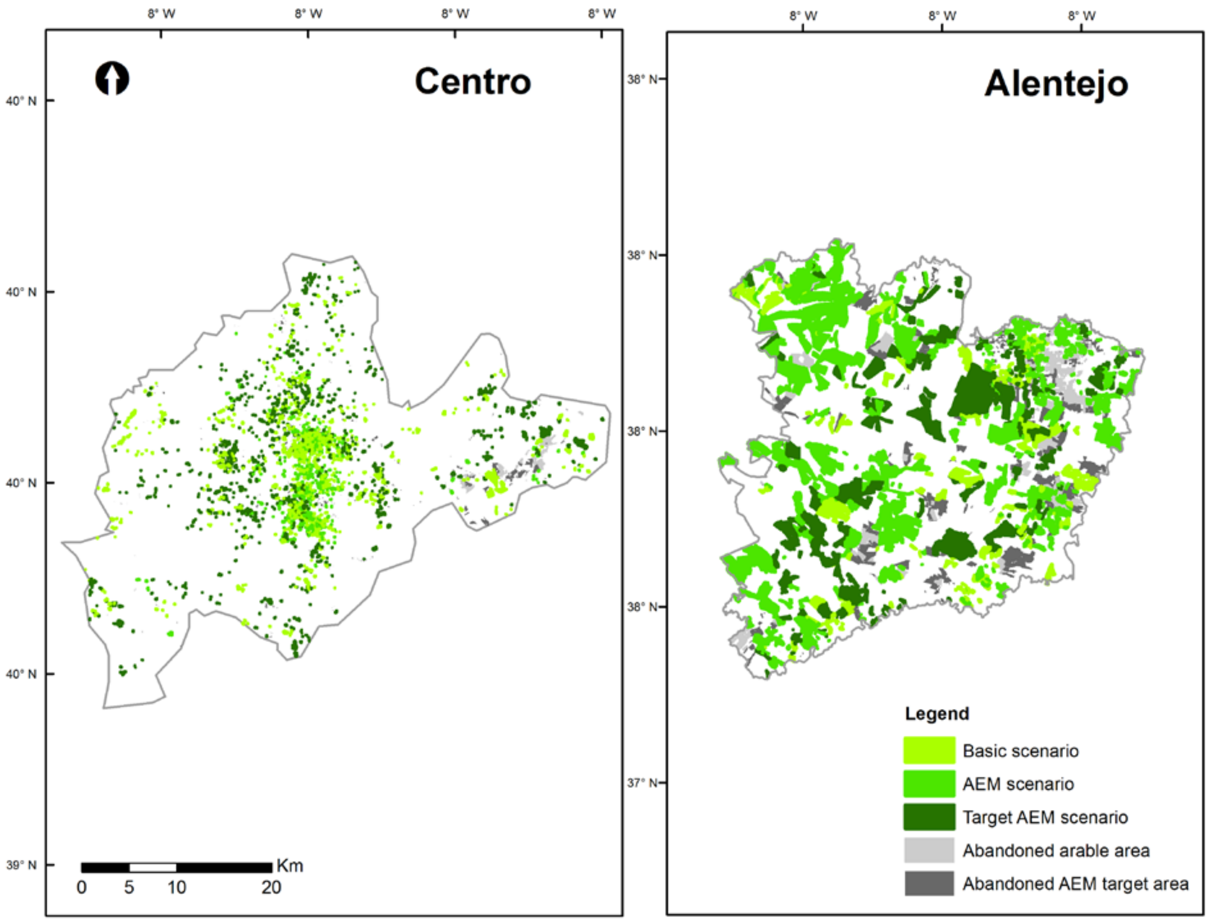

Figure 6.3 Scenarios with the best performance at the farm level for Centro and Alentejo

The first ranking scenario is represented in Figure 6.3, and Table 6.2 shows the respective arable area and number of farms. Because the only aim of the MIP model is to maximize farm income within each scenario's constraints, this analysis completes the policy scenario assessment from a policy planner point of view of simultaneously maximizing policy outcome while minimizing costs of policy both from a social perspective (minimizing policy spending at the state budget level) and a private perspective (maximizing income at the farm level).

With regard to the whole set of desirable effects targeted AEM and AEM showed the best outcome for the majority of the farms and area in Centro and Alentejo, respectively. This concerned 181 and 88 farms covering 672 and 17,880 ha (Figure 6.3, Table 6.2). The area abandoned is different in all scenarios, yet there are farms that in all three scenarios always end up going out of farming. They correspond to about 40 % of the arable area in Centro and 30 % in Alentejo.

When considering the subsets of resource and output indicators on one hand, and result and impact indicators on the other hand, we obtained that AEM was the most favourable scenario in both subsets in Alentejo, whereas basic and targeted AEM granted the best performance for each subset respectively in Centro (Tables 6.3 and 6.4). While this result confirms AEM as the best performing scenario in Alentejo, in Centro it shows that AEM and targeted AEM do not bring improvement in the performance of resource and output indicators and basic scenario offers the best outcome. For result and impact indicators targeted AEM shows a pronounced improvement, in particular for very marginal farms.

Table 6.2 Scenarios with the best performance – all indicators

Best ranked scenario (all indicators)		Centro				Alentejo			
		Very Marginal	Margi-nal	Less Marginal	Total	Very Marginal	Margi-nal	Less Marginal	Total
Basic	Arable area (ha)	62	297	311	670	594	1,649	1,567	3,810
	No. farms	19	60	47	126	8	24	13	45
AEM	Arable area (ha)	25	163	71	260	1,979	**8,458**	**7,443**	**17,880**
	No. farms	4	31	20	55	11	**44**	**33**	**88**
Target ed AEM	Arable area (ha)	**73**	**369**	230	**672**	2,879	2,384	4,280	9,543
	No. farms	**41**	**84**	56	**181**	9	18	16	43
Aban-doned	Target area (ha)	38	320	261	619	609	3,857	2,632	7,099
	Non-target area (ha)	0	212	159	371	127	1,599	2,583	4,309
	No. farms	37	44	37	118	9	20	19	48
Total	Arable area (ha)	198	1,361	1,032	2,592	6,188	17,947	18,506	42,640
	No. farms	101	219	160	480	37	106	81	224

Note: Values in bold correspond to the best outcome.

Table 6.3 Scenarios with the best performance - resource and output indicators

Best ranked scenario (resource and output indicators)		Centro				Alentejo			
		Very Marginal	Margi-nal	Less Marginal	Total	Very Marginal	Margi-nal	Less Marginal	Total
Basic	Arable area (ha)	88	**475**	**425**	**988**	**3,810**	4,548	3,199	11,557
	No. farms	27	**94**	**68**	**189**	**13**	34	19	66
AEM	Arable area (ha)	20	183	62	264	666	**6,733**	**7,232**	**14,632**
	No. farms	4	28	19	51	5	**35**	**29**	**69**
Targeted AEM	Arable area (ha)	53	172	125	350	976	1,210	2,858	5,043
	No. farms	33	53	36	122	10	17	14	41

Note: Values in bold correspond to the best outcome. Abandoned and total areas are identical to the ones reported in Table 6.2.

Table 6.4 Scenarios with the best performance - result and impact indicators

Best ranked scenario (result and impact indicators)		Centro				Alentejo			
		Very Marginal	Margi -nal	Less Marginal	Total	Very Marginal	Margi-nal	Less Marginal	Total
Basic	Arable area (ha)	13	162	124	299	660	1,841	1,910	4,411
	No. farms	3	21	25	49	9	25	15	49
AEM	Arable area (ha)	24	232	126	382	2,063	**8,494**	**7,896**	**18,453**
	No. farms	2	38	26	66	12	**46**	**31**	**89**
Targeted AEM	Arable area (ha)	**123**	**436**	**362**	**921**	2,729	2,155	3,484	8,369
	No. farms	**59**	**116**	**72**	**247**	7	15	16	38

Note: Values in bold correspond to the best outcome. Abandoned and total areas are identical to the ones reported in Table 6.2.

Moreover, when assessing each indicator individually, AEM scores better in both research areas (Tables 6.5 and 6.6). Concerning landscape fragmentation (Table 6.7) Centro and Alentejo differ in terms of the preferred scenario. In Centro only the fragmentation of pasture patches shows some change between the scenarios, with targeted AEM granting the most desirable effect (Table 6.7) (s_{eff} = 139), which is yet very far off from the minimum fragmentation which would be obtained in the event of the whole area being preserved into pasture land use (s_{eff} = 31). In Alentejo there is a small effect on the pattern of forest patches fragmentation, with the targeted AEM giving the best outcome whereas for pasture the best outcome is obtained with AEM.

While AEM thus performs best for farm level optimisation of the whole set of indicators in Alentejo, AEM could in Centro lead to the worse situation where only 55 farms and 260 ha reach the best outcome (Table 6.2). In order to rank AEM and targeted AEM scenarios with regard to a common 'yardstick', cost-benefit analysis taking basic scenario as a baseline would be the best approach. However because benefits were not measured in monetary terms we applied the second-best appraisal methodology: cost-effectiveness analysis (CEA) (OECD, 2005). The lowest cost-effectiveness ratio using the basic scenario as a baseline indicates which option provides the additional unit of result and impact indicator at the lowest cost - in this case translated into cost per ha of avoided abandonment, per ha of permanent pasture, per ton of eroded soil avoided, and per ha of effective mesh size. We considered that Pillar 1 would be significant for the delivery of avoided abandonment, Pillar 2 for the delivery of permanent pasture establishment, and that both payments would be significant for the delivery of erosion and landscape fragmentation.

In Centro, and concerning the main issues of abandonment and fire hazard, targeted AEM offers the most cost-effective solution, whereas AEM is slightly more cost-effective with regard to permanent pasture establishment and erosion avoided (Table 6.8). In Alentejo where the improvement of pastures and the rehabilitation of highly eroded land are the main issues, targeted AEM is also the most cost-effective solution. Yet, one might argue on this rank based on the share of farms and area where best results would be obtained: 9,543 ha compared to 17,880 ha with AEM

(Table 6.2). Additionally as we have considered unlimited budget and no restrictions on AEM adoption at the farm level, the benefits accounted at the regional level are quite optimistic. There are scale effects of the cost-effectiveness ratio as can be checked in Table 6.9 showing cost-effectiveness ratios but here computed at the farm level and therefore independent from the benefits on other farms. Most results do not alter much compared to Table 6.8, except for abandonment and erosion avoided in Alentejo where now targeted AEM and AEM deliver the best outcome respectively.

6.5 Discussion

The main idea of spatial targeting is that by applying conservation measures on the most suitable land parcels, environmental effects are provided at lower costs than if conducted elsewhere (Uthes *et al.*, 2010). Suitability can however be defined over several criteria, and from different stakeholders' perspectives. Our approach, built on that idea, considers first of all the maximization of farm income, from a farmer perspective, and then assesses the possibilities for the provision of a more resilient landscape with regard to erosion and fire hazard mitigation, from a societal perspective (planners and taxpayers included). Within the approaches for cost-effective conservation listed by Duke *et al.* (2013) ours fits between the description provided for *benefit targeting with cost adjustment*, which scores cost as a non-monetary benefit measure; and *benefit-cost targeting*, which selects the highest benefit-cost ratio. We assumed an unconstrained budgetary provision, AEM payment indexed to the annualized establishment costs of a permanent pasture (5 years - 80€/ha) and contemplated an increase and a decrease for small and large areas of enrolment, respectively. For that purpose we assumed the same shares of area of past AEM (traditional mixed farming in Centro, and extensive grasslands in Alentejo).

Based on a set of assumptions over the desirability of effects we were able to rank AEM and targeted AEM scenarios. We computed several resource, output, result, and impact indicators, as well as cost-effectiveness ratios. The results show that an AEM for permanent pastures would be more cost-effective for erosion and fire hazard mitigation if implemented within a spatial targeting framework. However when cost-effectiveness is weighed with other criteria, non-targeted AEM implementation delivers the best outcome in Alentejo, whereas in Centro the 'doing nothing' option delivers the best outcome when resource/output are more appreciated than result/impact. These results are in line with Uthes *et al.* (2010) findings on spatial targeting at measure and programme levels. They conclude that spatial targeting should only be performed in areas in which the targeting objective is either the only objective or of higher priority than other objectives. In our analysis, erosion and fire hazard mitigation objectives were considered in equal terms. Fire hazard appears of capital importance in Centro based on recent fire regime analysis (e.g. Fernandes *et al.*, 2014), and possibly in Alentejo due to forest and scrubland increase (Moreira *et al.*, 2011). Soil losses are within a tolerable range 0.3 – 1.4 t/ha but these values still entail a loss of 2 – 30 cm in soil depth in the next 100 years (Verheijen *et al.*, 2009), which undermines future soil productivity of shallow soils (≤ 30 cm) common in LFAs. Restoration and rehabilitation measures, such as improved pastures with legume species and the reintegration of fragmented landscapes, are increasingly viewed as a tangible alternative to standard conservation measures in Mediterranean ecosystems where certain functions have been damaged or blocked by abandonment or technological change (Blondel & Aronson, 1999).

Table 6.5 Resource and output indicators for Centro and Alentejo research areas (last five years averages per farm group)

			Basic policy scenario						AEM policy scenario						Targeted AEM policy scenario					
	Type of farm	Total farms	Active farms (n)	Pillar I (€/farm)	Pillar II (€/farm)	Net Farm Income (€/farm)	On-farm feed (%)	Live-stock (LU / farm)	Active farms (n)	Pillar I (€/farm)	Pillar II (€/farm)	Net Farm Income (€/farm)	On-farm feed (%)	Live-stock (LU / farm)	Active farms (n)	Pillar I (€/farm)	Pillar II (€/farm)	Net Farm Income (€/farm)	On-farm feed (%)	Live-stock (LU / farm)
Centro	VM	101	50	620	101	717	90	1.3	64	604	**325**	**795**	90	1.6	64	604	322	791	90	1.6
	M	219	153	**880**	156	996	91	1.7	172	904	**463**	**1,164**	91	**2.2**	171	900	445	1,132	91	2.1
	LM	160	100	978	163	1,120	92	1.9	121	**937**	**484**	**1,232**	92	**2.3**	117	944	469	1,212	92	2.2
	Total	480	303	869	149	991	91	1.7	357	861	**446**	**1,121**	91	2.1	352	861	431	1,097	91	2.1
Alentejo	VM	37	23	26,274	1382	15,507	55	58	26	24,287	**4,415**	**18,765**	56	58	26	**24,237**	4,300	18,359	**57**	**57**
	M	106	68	**18,977**	1358	13,018	54	45	81	21,386	**4,370**	**17,749**	**57**	46	75	20,494	3,814	16,440	56	46
	LM	81	42	**28,132**	1407	18,080	54	**66**	62	28,987	**4,798**	**22,778**	56	61	57	29,738	3,900	21,551	56	62
	Total	224	133	**23,130**	1378	15,047	54	54	169	24,621	**4,534**	**19,750**	**57**	54	158	24,445	3,925	18,600	56	54

Note: Values in bold correspond to the best outcome. VM = Very Marginal, M = Marginal and LM = Less Marginal

Table 6.6 Result and impact indicators for Centro and Alentejo research areas (last five years averages per farm group)

			Basic policy scenario						AEM policy scenario						Targeted AEM policy scenario					
	Type of farm	Arable area (ha)	Aband. evaded (% arable area)	Perm. past. (% arable area)	Graz. live-stock (% total)	Stock. rate (LU/ ha)	Erosion 2010 (t/ha)	Erosion evaded (t/ha)	AEM farms	Aband. evaded (% arable area)	Perm. past. (% arable area)	Graz. live-stock (% total)	Stock. rate (LU/ ha)	Erosion evaded (t/ha)	AEM farms	Aband. evaded (% arable area)	Perm. past. (% arable area)	Graz. live-stock (% total)	Stock. rate (LU/ ha)	Erosion evaded (t/ha)
Centro	VM	198	49	2.8	19	0.5	1.1	0.014	64	63	**96**	24	0.7	**0.261**	64	63	95	24	0.7	0.259
	M	1361	69	1.1	38	0.4	0.7	0.010	172	**78**	**85**	**41**	0.6	**0.202**	166	78	75	40	0.6	0.184
	LM	1032	62	0.3	46	0.4	0.6	0.008	121	**75**	**79**	45	0.6	**0.171**	117	73	67	45	0.5	0.146
	Total	2592	62	1.1	38	0.4	0.7	0.010	357	**74**	**85**	**40**	0.6	**0.202**	347	73	76	39	0.6	0.184
Alentejo	VM	6188	61	30	6	0.8	0.11	0.017	26	**76**	**60**	8	0.8	0.034	26	75	58	8	0.8	0.034
	M	17947	63	22	9	0.9	0.14	0.018	81	**77**	**54**	**11**	0.8	**0.038**	69	71	50	10	0.9	0.036
	LM	18506	51	22	11	0.9	0.13	0.016	62	**72**	**48**	11	0.7	**0.038**	51	66	38	11	0.8	0.026
	Total	42640	58	24	9	0.9	0.13	0.017	169	**75**	**53**	**11**	0.8	**0.035**	146	69	47	10	0.8	0.032

Note: Values in bold correspond to the best outcome. VM = Very Marginal, M = Marginal and LM = Less Marginal; Aband. = Abandonment; Perm. past. = Permanent pasture; Graz. = grazing; Stock. rate = stocking rate.

Table 6.7 Impact indicator – landscape fragmentation – for Centro and Alentejo research areas (last five years averages per farm group)

		Basic policy scenario			AEM policy scenario			Targeted AEM policy scenario			Current situation (all plots pasture)		
		Forest	Pasture	Landscape	Forest	Pasture	Landscape	Forest	Pasture	Landscape	Forest	Pasture	Landscape
Centro	Number of patches	651	1,889		518	2,142		532	2,135		168	2,644	
	Effective mesh size (ha)	41,790	6.7	40,994	41,817	7.1	40,948	41,813	**7.2**	40,947	42,275	32	40,821
	Effective mesh density (mesh/1000 ha)	0.02	150	0.02	0.02	141	0.02	0.02	139	0.02	0.02	31	0.02
Alentejo	Number of patches	262	498		214			245			115		
	Effective mesh size (ha)	5,925	413	4,487	5,069	**568**	3,420	4,870	458	3,383	4,224	1,146	2,631
	Effective mesh density (mesh/1000 ha)	0.17	2.42	0.22	0.2	1.76	0.29	0.21	2.18	0.30	0.24	0.87	0.38

Note: Values in bold correspond to the best outcome.

Table 6.8 Cost-effectiveness of policy spending taking basic scenario as baseline (at regional level)

		AEM policy scenario				Targeted AEM policy scenario			
		Pillar 1 €/ha abandonment avoided	Pillar 2 €/ha permanent pasture	Pillar 1 and 2 €/t erosion avoided	Pillar 1 and 2 €/ha effective mesh size	Pillar 1 €/ha abandonment avoided	Pillar 2 €/ha permanent pasture	Pillar 1 and 2 €/t erosion avoided	Pillar 1 and 2 €/ha effective mesh size
Centro	Very Marginal	277	116	479		277	115	479	
	Marginal	166	90	293		163	95	304	
	Less Marginal	111	95	343		110	102	359	
	Total	146	**94**	**318**	307	**144**	97	325	**285**
Alentejo	Very Marginal	30	59	1,061		29	62	1,019	
	Marginal	178	88	1,986		175	76	1,243	
	Less Marginal	160	117	2,075		187	130	1,644	
	Total	**155**	91	2,229	**41**	163	**86**	**1,635**	70

Note: Values in bold correspond to the best outcome.

Table 6.9 Cost-effectiveness of policy spending taking basic scenario as baseline (at farm level)

		AEM policy scenario				Targeted AEM policy scenario			
		Pillar 1 €/ha abandonment avoided	Pillar 2 €/ha permanent pasture	Pillar 1 and 2 €/t erosion avoided	Pillar 1 and 2 €/ha effective mesh size	Pillar 1 €/ha abandonment avoided	Pillar 2 €/ha permanent pasture	Pillar 1 and 2 €/t erosion avoided	Pillar 1 and 2 €/ha effective mesh size
Centro	Very Marginal	758	382	2,152		402	382	2,170	
	Marginal	144	479	3,265		135	591	4,028	
	Less Marginal	142	507	4,194		113	755	5,512	
	Total	273	**468**	**3,340**	---	**184**	602	4,132	---
Alentejo	Very Marginal	318	4,142	15,167		293	2,169	11,802	
	Marginal	1,632	2,124	10,249		1,100	1,220	14,435	
	Less Marginal	1,318	957	8,288		289	799	5,723	
	Total	1,302	2,035	**10,352**	---	**673**	**1,225**	10,850	---

Note: Values in bold correspond to the best outcome.

The final ranking of AEM objectives with regard to erosion and fire would need further assessment in each LFA for a consistent targeting strategy. However, past policies reveal substantial budgetary provisions for similar AEM in the past - (0.3 M€ in Centro, 0.4 M€ in 2005 in Alentejo (IFAP, 2012)) – and the investment in fuel breaks – roughly 2.7 M€ for one municipality, considering a cost of about 1,560€/ha and 4% coverage (Schwilch *et al.*, 2012). For fire hazard control only this seems quite a large amount. Considering the actual AEM spending of about 2M€ (IFAP, 2015), the budgetary provision is enough to enable AEM and targeted AEM scenarios in Centro but not in Alentejo, at least when considering the assumptions of homogeneous uptake by farmers and their income driven farming activity. The CEA employed can however not answer the question from a farmer perspective whether an AEM should be adopted or not. Yet, because we also considered cost-effectiveness with other criteria, namely with result and impact indicators in a simplified multicriteria analysis (Table 6.2, Figure 6.2), we were able to also value the option of 'doing nothing' or 'not applying AEM' which was represented by the basic scenario. Our results can be viewed in a utilitarian perspective to contribute to building a benefit ranking map to inform planners against adverse selection.

Our results also highlight the divergence between cost-effectiveness ratios determined at the farm and regional levels. This is due to added heterogeneity on the spatial distribution of costs at the farm level when farm size distribution and land fragmentation are taken into account. While benefits are tied up to landscape diversity, which does not change between the farm and regional levels, costs are linked with farm-level policy payments, and therefore dependent on farm structures and farmer behaviour. When simplistic assumptions are made on both those parameters, the heterogeneity of the spatial variation of benefits tends to be higher than the one of costs. In such cases benefit targeting tends to deliver better results than cost targeting (van der Horst, 2007). In our case, all scenarios give the same outcome for the on-farm share on total feed provision and little change in stocking rate, which seems to indicate that no significant change of farming system intensity occurs. As budgetary provisions are in Alentejo also limitative of targeted AEM, one solution might be to target for the enrolment of more cost-effective farms first, less marginal in Alentejo and very marginal in Centro, until the budget is exhausted.

A final note is warranted regarding the synergic effect of policy instruments. Pillar 1 and 2 payments have interconnected objectives, namely to avoid abandonment and promote the provision of environmental goods. Our analysis considers that interconnected action and concludes that when benefits are more important (conveyed by result and impact indicators), targeted AEM offers the best outcome. This is in line with the EC (2007) study on the environmental consequences of sheep and goat farming, which concludes that general mechanisms (cross-compliance) can set the extremes of acceptable grazing pressure, but that there is a clear need to provide targeted measures in order to promote the most appropriate grazing patterns within these limits. Moreover there are important synergies to collect at the landscape level provided that a higher overall cost-effectiveness regarding the sum of all policy targets is met (Schader *et al.*, 2014). As in other studies taking such an approach, e.g. considering scrubland clearing for the reclamation of abandoned land and fuel break establishment in La Rioja – Spain (Lasanta *et al.*, 2009; Lasanta *et al.*, 2015), our results confirm the scope for landscape level synergies, but in addition also show that variations in farm structure and farm-level adoption of AEM play an important, potentially counteracting role.

6.7 Conclusions

This chapter has applied a scenario modelling approach to target the impact of agri-environmental policy. We set out to assess cost-effectiveness of reducing erosion and fire risk by preserving extensive livestock production in two LFAs in Portugal, and determine the added value of using spatial targeting of AEM. Thereto we computed several resource, output, result, and impact indicators, as well as cost-effectiveness ratios. The results show that an AEM for permanent pastures would be more cost-effective for erosion and fire hazard mitigation if implemented within a spatial targeting framework. However when cost-effectiveness is weighed with other criteria, non-targeted AEM implementation delivers the best outcome in Alentejo, whereas in Centro the 'doing nothing' option delivers the best outcome when resource/output are more appreciated than result/impact.

Targeted AEM scenario seems to give a slightly better cost-effectiveness than the AEM scenario with regard to the cost per ton of avoided erosion. It should be remarked however that concerning erosion avoided we do not account for areas that are converted to shrubs and for which no incentives are paid. Despite the subsidies more than 20% of the farms in Centro and Alentejo will abandon farming in all the policy scenarios, which represents nearly 40 % of the arable area in Centro and 30 % in Alentejo. The AEM tends to favour farms in less marginal conditions whereas the targeted AEM performs well on very marginal farms, particularly on small farms of Centro region. In Centro spatial targeting beyond LFA brings more benefits than in Alentejo due to higher heterogeneity of the Centro landscape, which reflects higher spatial heterogeneity of benefits and therefore an higher gain from policy instruments able to capitalise on those higher gains.

Chapter 7

Synthesis

Synthesis

7.1 Introduction

This thesis research had as its aim the development of a means for evaluation of the impacts, both physical and financial, of agricultural policies involving agri-environmental measures (AEM) in less favoured areas (LFA) of Portugal.

Since Portugal joined the EU in 1986, a number of programs and measures have supported agriculture in LFA across the EU. Since the early 1980's the Common Agricultural Policy (CAP) has been undergoing reform in order to better meet the needs of a downsizing agricultural sector and increasing environmental demands. One of the most profound changes in recent years has been the decoupling of payments from production levels and re-coupling them to the provision of environmental goods and services. This has solved many of the trade conflicts and eliminated food mountains, but has not solved the unequal distribution of payments among farmers and the important support role these payments represent to farm income (Baldwin and Wyplosz, 2009). The most recent CAP reform makes an attempt to address these issues which are particularly relevant for agriculture in LFA.

Both abandonment and intensification are bringing new features to farmland management in LFA. Abandonment of agricultural land leads to encroachment of forest and shrubs bringing with it increased risk of erosion and forest fire. Intensification of livestock production often involves overstocking which also contributes to soil degradation. Rangelands, not yet abandoned land used for extensive grazing and sometimes overexploited by more frequent pasture renewal, are at this crossroad.

Rangeland is in fact the largest land use in the Mediterranean (128 Mha) (Zdruli, 2014), and extensive in Portugal. Specific AEM within the CAP framework are intended to support more sustainable management of these extensive lands, with the aim of strengthening their multi-functionality and achieving both production and environmental objectives. Two of the key environmental objectives on Mediterranean LFA in general and Portugal's LFA in particular, are reduction of and resilience to fire hazard and land degradation. Establishing or maintaining more landscape mosaic and forest discontinuity can contribute to these goals.

The benefits of AEM to improve LFA rangeland management, are by nature not confined chronologically nor geographically (Brouwer and Lowe, 2000). This is a major reason that their evaluation is difficult. For instance, the cross-scale effects of grazing management are still not completely understood (Asner et al., 2004). Additionally the AEM component of CAP should be aligned with the regulatory instruments enforcing a minimum standard and enhanced advisory measures (e.g. Fleskens and Graaff, 2010; Verspecht et al., 2011). A spatial approach to AEM assessment could inform the linkage of payments with the actual delivery of public goods and address some of the distributional issue of CAP mentioned above (EC, 2013). A spatial focus makes case study research particularly relevant for the identification of response structures and the understanding of policy implementation patterns (Piorr et al., 2009).

In Portugal, more than 85% of the agricultural area falls into LFA, and about 25% into mountainous areas (GPP, 2013b). AEM for the support of extensive grazing are in place, but the spatial distribution of both their physical and financial effects is not well known. In the context of increasing scrutiny of these policies we developed and applied an approach for assessment of both physical and financial impacts of AEM and AEM policy through two case studies: one located in Centro and the other in Alentejo. (Further details on the case study sites and the general methodology can be found in Section 1.8 of this thesis).

7.2 Brief answers to the four research questions

The overall aim of the research was addressed through four main questions. In this section each of these questions will be briefly answered, with reference to the respective chapters.

1) What land use changes have occurred in the past 20 years and what implications did those changes have for land degradation and conservation?

The main transition in land use was made from arable land to permanent grassland, which was just 7% in 1986 and increased to about 20% in 2006 (Chapter 2). Forest increased slightly, from 33% to 36%. From this one might expect that land degradation would then decline, but further research in the two selected areas provides evidence to the contrary. The conversion of forest to shrub in Centro and shrub to open forest in Alentejo resulted in an overall increase in soil loss estimates. The area with potential soil loss higher than 10 t ha^{-1} y^{-1} increased from 57% to 64% in Centro, and from 65% to 72% in Alentejo.

2) How have the farming systems developed during that period and what has been their contribution to sustainable land management?

Despite an increased specialisation on livestock production, stocking rates decreased, and the share of permanent pastures increased, which overall favoured sustainable land management (Chapter 3). Livestock on specialised farms increased more than twofold but stocking rates decreased from 0.9 to 0.3 LU ha^{-1} in Centro and from 0.4 to 0.2 LU ha^{-1} in Alentejo (INE, 1990, 2010). The extent of fallow was not affected (on average 3 years). High livestock payments, in particular for cattle, have encouraged high expenditures on external inputs, whereas rural development payments seem to have encouraged more sustainable strategies. On some farm types where cattle predominates, a higher number of pasture renewal operations was practiced in order to compensate the forage deficit.

3) What have been the physical and financial effects of past AEM policies supporting permanent pastures and extensive livestock production?

AEM contributed to the upkeep of extensive livestock production and were effective in preserving the number of grazing livestock (goats and sheep, in Centro and Alentejo respectively) (Chapter 4). These effects were associated with increased vegetation cover on participant farms in Centro, and maintenance of pre-existing vegetation cover in Alentejo. Our results suggest that although AEM were effective in preserving grazing livestock, changes in grazing practices have not led to any significant improvement in conditions that would reduce fire hazard and soil erosion.

With regard to the financial effects, the implementation of AEM involving improved permanent pastures seemed most attractive. Improved permanent pasture is the best option for longer periods of analysis (10 and 12 years) and for higher yields. However our findings show that long duration ley has the advantage of earlier benefits and allow farmers to mitigate the risk of adoption and of a bad cropping year (Chapter 5). The costs of AEM implementation are amply compensated, resulting in payments having a clear incentive effect.

4) What will be the future effects of alternative policy measures regarding pasture and extensive livestock development on production and on the environment?
Objective analysis showed that AEM for permanent pastures applied to reduce erosion and fire hazard would be more cost-effectively implemented within a spatial targeting framework. However when cost-effectiveness is weighed with other criteria different results are achieved. For example, when resource/output indicators are more appreciated than result/impact indicators, non-targeted AEM delivers the best outcome in Alentejo, whereas in Centro the 'doing nothing' option delivers the best outcome.

As hypothesized, targeted AEM results in lower policy spending than non-targeted AEM. Still, considering that budgetary provisions may be limiting, the preferential enrolment of the most cost-effective farms may be the best approach. In the case of Centro those were located on very marginal areas, whereas in Alentejo they were located in less marginal areas (Chapter 6).

7.3 Emerging issues

As this research and thesis evolved, a number of emerging issues became obvious. The most important ones are described below.

Global trends - implications for livestock farming systems (LFS)
Agriculture and forestry are facing three main challenges: securing viable food production to meet a growing demand for food; ensuring sustainable management of natural resources and climate action; and balanced territorial development (EC, 2015). Although global population and the demand for meat products continue to grow, in Europe the trends have been rather stagnant with an aging population and a change in food consumption patterns that favours lower consumption of meat (Godfray, 2013). Policies have been co-evolving in response to this driver. This has also been the case in North and South Mediterranean countries (CIHEAM, 2014). Yet, the global trend of increasing urban-population and income are pushing overall meat consumption forward (Sedlacko et al., 2013). Although policies for the reduction of meat consumption should be in place, no short term effect could be expected. (Sedlacko et al., 2013).

The availability of resources needed for increases in meat production is limited. Thus sustainable use of the existing resources is of extreme importance if the EU's Horizon 2020 vision of smart, sustainable, and inclusive growth is to be achieved. The EU encompasses a wide range of farming conditions, however more than 57% of the agricultural area (91 million hectares) can be characterized as LFA (Eliasson et al., 2010). Important environmental values, e.g. reduced vulnerability to desertification and forest fires, are associated with these areas and the low-input farming practiced on them (Eliasson et al., 2010). Therefore, In order for farming to remain viable in these marginal areas and be part of meeting the global demand for meat, sustainable intensification is vital. Sustainable intensification means simultaneously improving the productivity and the environmental management of agricultural land (Buckwell et al., 2014). This challenge makes effective AEM policy for LFA as important as ever.

EU policy development
Mixed crop-livestock farming is regaining interest worldwide as a way to reduce environmental problems while allowing productive and economically viable agriculture. However, in Europe, production has become more concentrated on specialised and enlarged farms (Ryschawy et al.,

2014). In Portuguese LFA the transformation of farming systems is also following a trend of specialisation (Jones et al., 2014). Livestock farming systems (LFS), mainly pasture-based, can satisfy societal demands for public goods and are less vulnerable to market changes. However they are not paid for the environmental services they deliver (Bernués et al., 2011). In this thesis we provide evidence from that in Chapter 5 where non-participant farms provide benefits from permanent pasture conservation.

In dryland environments the improvement of pastures with legumes is not a new restoration practice (e.g. Floret and Pontanier, 1982, in Tunisia; Crespo, 1995, in Portugal; and Caballero, 2007, in Spain). On degraded pastures and when grazing exclusion is not sufficient, the reintroduction of palatable legume species is considered. The benefits are to improve the forage deficit with on-farm inputs, while improving vegetation soil cover. In drylands, permanent soil cover is not only important for avoiding soil loss by reducing the impact of rainfall, it is also important for improving water use efficiency by avoiding evaporative water loss that does not benefit any plants (Stroosnijder et al., 2012).

The paradigm shift in CAP, towards a market determined price system with compensation for greater respect for the environment and animal welfare, has been reinforcing to AEM. These measures started off as a structural policy providing an incentive for farming practices favourable to the environment, then they included compensation for income foregone, and they are now evolving toward payments for ecosystem services (PES). PES could be defined as "incentives offered to farmers or landowners in exchange for managing their land to provide some sort of ecological service". The last two reforms were undertaken within the framework of a decreasing budget.

The expected reductions in Single Farm Payments (SFP) imply a need to shift resources from payments for the reduction of intensity to payments to prevent abandonment (Hodge, 2013). Because SFP are a part of private returns, their overall reduction implies that less money is needed to compensate farmers' loss on good quality land, but also that more is needed on low quality land to bring farming intensity to higher levels. This also implies that a part of the 'intermediate quality' land previously receiving payments to de-intensify will now be candidate to claim payments for intensification to avoid abandonment. In a lower budget context this will bring extra competition for the very marginal land areas.

Evaluation framework – Physical and financial effects of AEM

For better monitoring and evaluation much attention is paid to the choice of adequate indicators. Perhaps, even more importantly this information could also be used by local stakeholders for land use decisions to improve their management. Several systems of indicators on sustainable land management have been established (e.g. IRENA, UNCCD) (EEA, 2005; COP9, 2009).

Following OECD guidelines, the EC (2001) states that agri-environmental indicators should be policy-relevant (address the key environmental issues), responsive (change sufficiently quickly in response to action), analytically sound (based on sound science), measurable (feasible in terms of current or planned data availability), easy to interpret (communicate essential information in a way that is unambiguous and easy to understand), and cost effective (costs in proportion to the value of information derived) (EC, 2001).

Important guidelines with regard to monitoring and evaluation are stated in the legal acts regulating the present Rural Development Policy (EU, 2013a; EU, 2013b). Recently the Common Monitoring Evaluation Framework (CMEF) has been laid down by the Commission to guide the reporting responsibilities of each member state and define the relationship between the different categories of indicators considered: context, output, result, and impact (EU, 2015). The analysis conducted in this thesis was based on the indicator systems for land degradation already in use as is referenced in the respective chapters. In Chapter 6 the references to output, result, and impact indicators, are applied at the measure level and not at differential levels (measure – pillar – CAP) as suggested (EU 2015).

A great variety of indicators have been proposed for the assessment of desertification and a set of key impact indicators has been suggested, including change in land use and land cover status (COP9, 2009). Kosmas et al. (2014b) concluded that only a small set of indicators are relevant for each land degradation process. For instance farm subsidies and rainfall seasonality were the most relevant indicators for risk of water erosion on pastures, land abandonment and land fragmentation were the most explanatory for overgrazing, and grazing control was the most relevant variable for forest fire risk hinting at the interconnectedness between these two (Kosmas et al., 2014b).

The farm level scale is the most relevant scale for land degradation indicators because management decisions by individual land users are taken at this level (Kosmas et al., 2014b). In this thesis farm level indicators were used to determine physical and financial effects of AEM. The spatial translation of those effects at more aggregated levels was investigated on different groups of farms (e.g. AEM participant versus non-participant). In such a way it was possible to assess the link between the economics of farm management and its translation into physical effects on the landscape.

Targeting payments for ecosystems services (PES)

AEM are increasingly approached as Payments for Ecosystems services (PES). PES has become an important integrating concept for a range of research disciplines and disparate interest groups (Fleskens and Hubacek, 2013). Both AEM and PES rely on the principle of correction of a market failure. However, PES is a wider designation which considers the possibility of innovative arrangements between providers and buyers of ecosystem services, thus going beyond the current AEM formulation of farmers and central administration (Schomers and Matzdorf, 2013).

In the United States, where payments are more targeted than in the EU, the opportunity cost for the provision of a certain ecosystem service is taken into account (Baylis et al., 2008). Because the focus there is almost entirely on reducing agriculture's negative externalities, such as soil erosion, the assessment of ecosystem services is more straightforward. By contrast, in the EU AEM have wider objectives and use agriculture as a driver for rural development, which is achieved by compensating farmers for the private delivery of positive public goods. This different focus presents challenges in how to assess or value the ecosystem services.

Stressing the place based approach is a way to truly combine the natural and the socio-economic factors and therefore address change and its management in accordance to each particular context (Antrop et al., 2013).

7.4 Contribution to science

In this thesis a systematic evaluation of some EU policy measures was undertaken. After an overview of land use developments in the two research areas over the last twenty years, an assessment was made of the uptake of the two most relevant AEM in the areas. We then conducted a detailed evaluation of the physical effects of the measures on the environment using two basic criteria (soil cover and stocking rate), followed by an analysis of the financial effects of these measures.

Alternative scenarios for the possible targeted implementation of AEM in LFA in Portugal were also considered and analysed.

The two particular case study sites, associated with a mountainous and an intermediate LFA, allowed investigation of the link between farming systems and ecosystem service provision aimed at reducing erosion and fire hazard. Within this framework insights were gained regarding the choice of indicators for a more integrated monitoring and evaluation system of value to both administrators and land-users. Future targeting and effectiveness of agri-environmental policy will depend strongly on having information that is actually connected to and affected by management choices. The approaches used in the two case studies to transform data into information provide new and valuable insights for future establishment of local partnerships for that purpose. With regard to rangelands characterization and the link with the several permanent pasture management options, some relevant insights were also gained.

7.5 Reflections

Review of the results of this research project as a whole brings a number of points to light. Especially issues related to farm management options are of interest as the scientific evidence gathered in this thesis is meant to improve the livelihood of Mediterranean farmers in LFA in general and in Portuguese LFA in particular.

Regarding land use changes and land degradation

To avoid major damaging fires in mountainous LFA it is important to ensure that large forest patches are compartmentalized by fire breaks. Improved permanent pasture between patches of forest can help target that goal with the plus of obviating the origin of many pastoral fires, which occur with pasture renewal (Catry et al., 2010).

In intermediate LFA, afforestation projects can bring benefits with regard to the renewal of agro-forestry systems (established more than 200 years ago, as a diversifying source of feed for livestock) if reintegrated with livestock activities. At this point these are either substitutes for farming activity by abandoning farmers, or a source of income for those diversifying their core business with agro-tourism and/or hunting activities (Chapters 2 and 3). As well, pasture improvement would lower the potential for over-intensification on the remaining plots, with the plus of maintaining livestock yields and rebuilding soil fertility, which has been so depleted by consecutive grain cropping in the far and recent past. Furthermore, in Alentejo such improvement would guarantee the open fields needed for the great bustard, an bird species that is endangered at the European level (Moreira et al., 2012). Table 7.1 shows the main categories of rangelands and highlights those most prone to degradation due to poor and absent management.

Crop-livestock systems are threatened by the overexploitation of forage resources, the insufficiency of high-protein feedstuff, and the increasing costs of agricultural inputs (Melis et al., 2014). To minimize the impact of such threats, low-input systems in LFA have been favouring the reduction of grazing, the concentration of livestock on better grassland areas, and the simplification of practices with single species flocks (MacDonald et al., 2000). Legumes and cereals mixtures are a requirement for producing high-quality meat and milk while reducing the environmental footprint of grassland agriculture (Boelt et al., 2014), and are of particular interest for boosting fodder protein content as well (Melis et al., 2014). Therefore improvement of permanent pastures with legumes would constitute an alternative and sustainable change path for low-input farming systems in marginal areas. Due to disruptions of certain ecosystem functions, some of these systems may already be less sustainable than the traditional system from which they evolved. Examples of those transformations are also provided by the analysis conducted in this thesis.

Table 7.1 Rangelands main characteristics – grey highlight: rangelands prone to degradation

<table>
<tr><td colspan="2" rowspan="2">Land cover</td><td rowspan="2">Land use</td><td colspan="2">Duration</td><td rowspan="2">Management practices</td></tr>
<tr><td>< 5 years</td><td>≥ 5 years</td></tr>
<tr><td rowspan="3">Arable</td><td rowspan="2">Semi-natural grasslands</td><td rowspan="5">Rangelands</td><td rowspan="3">Ley *</td><td>Long ley</td><td rowspan="3">Cutting and/or grazing
+
Pasture renewal (fertilization, sowing)</td></tr>
<tr><td rowspan="2">Improved permanent pastures</td></tr>
<tr><td rowspan="2">Agro-forest</td></tr>
<tr><td rowspan="2">Scrub</td><td rowspan="2"></td><td rowspan="2">Degraded arable
Degraded forest</td><td rowspan="2">Cutting and/or grazing
(pasture renewal with fire)</td></tr>
<tr><td>Shrubs</td></tr>
</table>

* Rotations of fodder crops followed by a variable number of fallow years.

For many botanically impoverished rangelands extensification (reduced intensity in terms of the level of inputs) is not enough to recover their fertility status. In fact the results of Jeangros and Troxler (2008) in mountainous areas in Switzerland show that the characteristics of meadows and pastures did not change a lot, despite the abandonment of mineral fertilizers, and that increasing botanical diversity by only reducing management intensity is difficult. Horrocks et al. (2014) also question the effectiveness of extensification approaches in UK grasslands, under the argument that the legacy of intensive management on soils is likely to limit ecosystem service provision from former intensively managed sites for many decades. It is key to determine whether the benefits delivered by soils outweigh the costs in terms of loss of production.

The EU has incorporated in its Common Agricultural Policy (CAP) measures to support ruminants farming with special premiums coupled to production, such as the suckler cow premium or the ewe premium with two objectives: food production and maintenance of the rural fabric. Questions regarding the coupling of such payments under World Trade Organization (WTO) agreements have pushed policy makers within the EU to look for other incentive measures to maintain these forms of farming in LFA (CIHEAM, 2014).

Effects of alternative AEM on production and environment

Livestock farming systems are getting less pasture-based and more concentrated feed-based. This transformation is mainly linked to labour constraints for farming operations and also to meat and milk yields. In the researched LFA, despite the increased focus on concentrated feed-based livestock production, permanent pastures increased (Chapter 3). Some farms were actually intensifying forage production with more consecutive years of cropping in order to feed the livestock, mainly cattle. This was partially incentivized by livestock payments favouring cattle ownership to the detriment of small ruminants. Despite that, the length of fallow was not affected and the stocking rate did not increase. This indicates that fallow is considered a key fertility rebuilding practice, or is the result of set-aside compliance, or both.

The unbalanced livestock payments were revised, so overgrazing problems are now even less likely to appear in Centro and Alentejo. Indeed overgrazing is a recognised cause of desertification in other Mediterranean LFA (Kosmas et al., 2014b; Kairis et al., 2015) and a trigger for land degradation in other LFA of the EU (e.g. Beaufoy et al., 2011b, in Scotland). When land is capable of recovering by anytime during the next growing season it is not considered to be overgrazed (Beaufoy et al., 2011b). And in fact in many Mediterranean LFA undergrazing seems to be the problem with detrimental effects on vegetation encroachment, forest fire frequency, and loss of biodiversity (Moreira et al., 2011; Lasanta et al., 2015). The findings of Carmona et al. (2013) confirm that moderate stocking rates help to improve species diversity, with the threshold stocking rate being dependent on water and nutrient availability. Lasanta (2015) reports that grazing associated with vegetation control in the La Rioja mountains bring dual benefits of pasture restoration and forest fires control. Future AEM that aim at building a more resilient landscape to fire hazard and erosion in LFA should take these results into consideration.

Our results show that although past AEM were effective in maintaining grazing livestock numbers they did not achieve the more ambitious final goal of a landscape more resilient to fire hazard and erosion (Chapter 4). Among other things the aging farmer population and the lack of advisory services within AEM administration were contributing factors to this. This confirms the need for a more integrated AEM monitoring and evaluation system able to inform administration and decision-makers equally of the steps necessary to reorient farm practices in real time for the provision of the ecosystems services needed and being demanded.

In Portugal a centralized culture for AEM governance is not in favour of this change (Pinto-Correia et al., 2006b). However efforts for more participatory tools in landscape management are under way, as shown by the example of the Index of Function Suitability (IFS) expressing the gap between the current landscape and the preferred landscape from different users' perspectives (Pinto-Correia et al., 2013). Because past AEM participation has been lower among smaller and less marginal farms (Table 4.2, Chapter 4), it is important to take this pattern into account in the future AEM governance strategies.

It has been suggested that pastoral activities, regulated and adapted to the real potentialities of the natural pastures within forest areas, could be a valuable in the prevention of forest fires, involving farmers in the prevention plans of the area (Franca et al., 2012). Our research supports this idea for areas like the Centro LFA where fires have increased the shrub area at the expense of the agriculture/closed forest mosaic area (Chapter 2). Rebuilding of such a mosaic landscape could be accomplished through AEM that provides specific support to improved permanent pastures able to support higher livestock yields per active farm. At the same time in an intermediate LFA such as Alentejo, with a long history of land degradation by successive grain production, a similar AEM could maintain more desirable extensive grazing with reasonable yields by improvement using legume species instead of focusing on frequent pasture renewal which creates higher erosion risk (Chapters 2 and 3).

The present Rural Development Programme 2014-2020 includes 12 AEM and a budgetary provision at the national level of 668 M€, which represents an increase of 36% when compared with the previous period 2007-2013 (Avillez, 2014). Two of the AEM concern rangelands and extensive grazing, but with no focus on improvement of pasture quality. Such practices are included under another priority area dedicated to competitiveness and production organization and are considered farm investments (GPP, 2014). Our findings suggest that inclusion of management practices for pasture improvement in future AEM concerning rangeland and grazing areas would increase the effectiveness of AEM aimed at these areas.

Physical and financial effects of AEM

AEM aiming at the preservation of extensive grazing were among the most popular AEM of the 2000-2005 programming period at the national level. Nevertheless the participation in the studied LFA was rather low, particularly among smaller and less marginal farms (Chapter 4). Comparing participant with non-participant farms for the achievement of the expected effects on livestock upkeep, a significant number of participant farms achieved better results than non-participant farms. However, the expected effects on the preservation of permanent pastures were less clear. In Centro despite the upkeep of grazing livestock there was a vegetation build up, indicating a decrease of effective grazing practices and a consequent lower resilience to fire hazard. In Alentejo participant farms did not differ significantly from non-participant farms, although permanent pastures were more frequent on plots where AEM was implemented. Overall and as previously noted, although the general effects of the studied AEM were delivered by the farmers, these effects did not lead to the greater desired outcome: a landscape more resilient to erosion and fire hazard. This leads to the conclusion that there is scope for better targeting of future AEM supporting extensive grazing in ways that will achieve the greater landscape goal.

With regard to financial effects, AEM compensated the extra costs of adoption (Chapter 5). The AEM could be adopted under two options: 1) permanent pastures improved with legume species (e.g. clover), or 2) long duration ley (oats x ryegrass). Our analysis showed that the first, with higher environmental benefits, was financially more attractive for long periods of analysis (e.g. 10 years) or with high yields, whereas the second minimized the risk with regard to the uncertainty of a bad cropping year. Both options complied with AEM obligations. Present AEM programmes are generally 5-year agreements, while some can be extended to 7-years agreements (GPP, 2014). Considering that yields in LFA tend to be low, our research findings lead to the conclusion that longer agreements could be an option for stimulating more AEM participation.

Targeting erosion and fire hazard reduction with sustainable intensification

The transfer of SFP resources to CAP pillar 2 (rural development) measures, by lowering private returns, opens the opportunity to transfer resources towards measures to increase intensification (and avoid abandonment) on lower quality land (Hodge, 2013). This opportunity for change might however be constrained by large increases in SFP and a poor offering of sustainable intensification measures for lower quality land. Missing this opportunity would have a particularly negative impact for mountainous LFA, the most marginal among the LFA, where SFP increases alone would not be enough to avoid abandonment. Strategies for targeting AEM should take both these aspects into consideration: 1) the scope for the design of sustainable intensification measures, and 2) the spatial targeting to the most marginal areas.

Through improved targeting of AEM in LFA, the upkeep of extensive livestock keeping can be supported which will ensure the conservation of the landscape mosaic and forest discontinuity, which ultimately contributes to avoid large forest fires (Moreira et al., 2011). In Portugal between 2002 and 2007, pastoral activity was responsible for 20% of the wildfires and 11% of the area burned (Catry et al., 2010). This could be reduced with strategically targeted AEM. Moreover, the improvement of poor pasture areas through forage legumes could lead to a win-win situation whereby the carrying capacity of the pastures could be enhanced alongside the delivery of environmental benefits such as water and soil protection, and carbon sequestration (Porqueddu, 2007; Porqueddu et al., 2013).

In Chapter 6 the targeting of a hypothetical AEM for the improvement of permanent pastures is tested for the Centro mountainous LFA and Alentejo intermediate LFA. The aim of this AEM was the reduction of erosion and fire hazard, and a spatially targeted option was tested against a non-targeted one. The results confirmed that such an AEM would be more cost-effectively applied if implemented within a spatial targeting framework. When resource/output indicators are more appreciated than result/impact indicators, non-targeted AEM delivers the best outcome in Alentejo, whereas in Centro the 'doing nothing' option delivers the best outcome. This indicates that costs are still seen as more important than the benefits. Targeted AEM resulted in lower policy spending than non-targeted, still budgetary provisions may be limitative making the claim for the preferential enrolment of more cost-effective farms (with regard to erosion and fire hazard reduction). In the case of Centro those were located on very marginal areas, whereas in Alentejo they were located in less marginal areas.

Although the budget provision for AEM in the 2014-2020 period has an increase of 36% when compared to the previous period 2007-2013 (Avillez, 2014), more farms from the 'intermediate quality' land will be seeking to compensate losses in pillar 1 payments with receipt of pillar 2 payments. This will bring increased competition for AEM and the possible loss of low-input farming systems on the very marginal land, unless sustainable intensification AEM are offered. Hodge (2013) suggests the introduction of 'Higher Level Stewardship' measures, which are aimed to provide environmental benefits through more targeted schemes within identified priorities and whereby applicants are selected on a basis of good value for money. Our results indicate that a similar approach could be effective in areas like Centro, provided that the assumptions made on the desirability of the outcomes for erosion and fire hazard reduction are indeed confirmed. In Alentejo a targeted AEM was not identified as the best option, but still the tested AEM was better than none.

Non-targeted scenarios of AEM implementation seem to be preferable when cost-effectiveness is weighed among other criteria and in a context of larger farms which is the case for Alentejo. On larger farms very marginal land gets more chance of being balanced with less marginal areas, where farmers get to internalize the costs of lower yields. Moreover, in Alentejo a lower heterogeneity of the landscape when compared with Centro, reflects a lower spatial heterogeneity of benefits making targeted policy instruments somewhat redundant.

As suggested by van der Horst (2007) targeting has two components: on the one hand, the criteria for ranking the eligible applicants (either benefits only, costs only or cost-benefit ratio), and on the other hand, the type of 'optimum' (either value for money where the best ranked applicants are chosen until a cost constraint is reached, or a cost-effectiveness approach whereby the best ranked are selected until a benefit target is reached). For a consistent targeted AEM strategy in LFA a clear definition of both components is needed. Although not tested, insights from the research indicate to us that the value for money path is a viable way forward. Indeed in the light of present CAP distribution and equity concerns, where budgets will be adjusted to respond to those concerns, that seems a useful approach for the local agents in a 'budget-taker' position.

Under such an approach a cost constraint to AEM adoption would be set and it would be necessary to confirm that the benefits of landscape fragmentation are still there. Investigation of a threshold for that would also be advisable before implementation. And of course implementation of such targeted AEM would need the intervention of local agents to manage AEM adoption. This is particularly the case in Centro where adverse selection from less marginal farms could undermine the aggregate cost-effectiveness of the scheme (Chapter 6). The implementation of advisory measures under the priority action 'Innovation and knowledge' of the rural development plan 2014-

2020 (GPP, 2014), are extremely important for stimulating the participation of farmers in such targeted AEM and their effectiveness. This is particularly important with regard to information on monitoring and evaluation so that both administrators and land users can be informed about and accountable for best management practices for bringing ecosystem services into reality. Although aging farmers may not be the perfect setting for such measures, innovation on LFA farming can bring a new interest to farming in those areas. Not only new farmers, but also new expertise and increased participation of those not previously involved.

Hart et al. (2011) state that under targeted AEM, despite the smaller area and fewer farmers that will be involved, the demands on those farmers will be greater as will be the level of commitment required. Although the overall cost of payments might be lower under this approach, the support costs falling on public administration regarding research, preparation, targeting, advice and information, monitoring and feedback would be greater. In order to minimize those costs the approach is particularly suited to schemes where a more universal setting of targets is possible, such as widespread problems of soil erosion and loss of soil organic matter (Hart et al., 2011).

A last reflection on employment is also pertinent in the Portuguese context of 15% total, and 37% youth unemployment (GPP, 2014). Within a continued trend of increasing demand and prices for meat products (OECD, 2014), it is likely that the focus of policies will be on keeping domestic prices low (Josling, 2015). An AEM targeting the sustainable intensification of livestock production in LFA – 85% of agricultural land in Portugal - would bring an important local supply to internal markets, with lower transportation costs, and anchoring employment. Moreover, because the implementation of targeted AEM would require more expertise with regard to monitoring and evaluation to inform both administration and land users, new opportunities for research and knowledge transfer could open offering qualified employment for youth.

7.6 Limitations of the study

Data were collected from primary sources during interviews, as well as from secondary sources, e.g. the IFAP database and detailed NAC 2009 with regard to farm technical orientation, which were made available after request. Administration officials were very cooperative within the limitations of their busy functions. Because there is no link between the spatial and the statistical data on farms in the IFAP database, the link had to be made with an inside coding which was not always straight forward. But finally all the data needed were provided.

Despite the complex nature of the IFAP database, we are today more convinced about its value for informing local management. Issues regarding the disclosure and ownership of the data should be framed under clear terms. In my view such a framework should give special attention to the role of farmers, the primary providers of the data, and most interested end-users of the information produced with it. In the course of this research, authorisation was granted during the interviews and when the whole set of farms was considered, an effort was made to communicate the results in such a way that the link between spatial and statistical information was not disclosed for any specific farm in particular.

The uncertainty around the assumptions made in the analysis of future AEM scenarios was not tested. However, since on the one hand conservative estimates were made for yields, prices, and labour costs, and on the other hand rather optimistic AEM participation was assumed, we feel the outcomes are none the less valid. With more computational expertise however, quicker and more integrated formats of outputs could be obtained, allowing more suitable assessment of uncertainty.

7.7 Recommendations for further research and future policies

Land use changes

In Mediterranean mountainous LFA such as Centro, and intermediate LFA such as Alentejo, land use policies should favour changes that move toward agro-forest mosaics, a form of landscape more resilient to erosion and fire hazard. Such change should mainly target the improvement of arable rangeland.

Farming systems development

Stocking rates are an informative indicator of the general trend in the livestock farming systems, yet more attention should be paid to the link between feed inputs and the spatial translation of pasture endowments at the farm level. The appraisal of such dynamics at the regional level are key for ecosystem services delivery.

AEM policies focusing on permanent pastures and extensive grazing

Smaller farmers in less marginal conditions within the studied LFA were less involved in AEM in the past. More research is needed to unveil the reasons for this. Despite the conservation of satisfactory stocking rates for grazing livestock by AEM, the observed effects on soil cover revealed no improvement. Future AEM should consider the improvement of the quality of permanent pastures over the longer term.

Future effects of alternative AEM

In view of the main environmental issues and considering cost-effectiveness criteria, a targeted AEM for the improvement of permanent pastures should be considered. While our results indicated that targeted implementation is less pertinent when weighed with/against other criteria, in mountainous LFA such as Centro the more heterogeneous distribution of the benefits through the landscape seems to be well suited to the use of more targeted policy instruments. Smaller farm sizes and high land fragmentation also seem to favour the pertinence of such instruments. The relationship to other CAP payments revealed a positive outcome since AEM scenarios always ranked better than the one with no AEM. The indications from our research are areas for further consideration – both verifying the findings and considering them in policy development.

As previously noted, policy spending was lower within the framework of a targeted AEM, still budgetary provisions may be limitative making the claim for the preferential enrolment of the more cost-effective farms (with regard erosion and fire hazard reduction). In the case of Centro those were located in very marginal areas, whereas in Alentejo they were located in less marginal areas. Consistent targeting of such AEM should validate the criteria used for ranking and set a threshold budget or a benefit target, respectively, in the case of a 'cost-effectiveness' or a 'good value for money' type of optimum.

Because landscape aggregated benefits are only capitalised with certain levels of AEM uptake, more research should be conducted on the appraisal of AEM at the landscape level paying particular attention to the different uptake rates among smaller and larger farms, and among more marginal and less marginal farms. The cost-effectiveness of more targeted implementation of past AEM revealed weak results, suggesting that more targeted AEM will not be achieved exclusively 'by design'. Since targeting 'by design' is not likely to be successful, more ground rooted approaches that are anchored in sound science and local partnerships for co-learning strategies are needed. Within this, focus on advisory measures capable of guiding AEM implementation at the landscape level will be key to effectiveness and ultimate achievement of landscape level goals.

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Summary

In the past decades there have been significant land use changes in Portugal. After the integration of Portugal in the EU, farmers have been able to benefit from EU policy measures, which were initially mainly aimed at supporting farmer's income. It soon became apparent that these land use changes led to both intensification and abandonment of land, which were detrimental to the environment in various ways, in particular to higher soil erosion hazards and to an increased incidence of wildfire. In response, EU policies have over the years paid increasing attention to sustainable rural development, among others through cross-compliance and agri-environmental schemes. In this thesis an analysis is made of agri-environmental measures aimed at reducing erosion and wildfire risks in two selected research areas. Both of these areas are situated in so-called Less Favoured Areas (LFA) where environmental impacts have been greatest. One research area falls under the "Mountain-hill areas" and the other under the "Areas in danger of abandonment".

The introductory Chapter 1 delineates the problem statement, objectives, state of the art, evaluation framework and research questions, and it provides the outline of the thesis. The main research questions relate to the past land use changes and their environmental implications, the development of the farming systems over the past 20 years, the physical and financial effects of Agri-Environmental Measures (AEM) supporting permanent pastures and extensive livestock production, and the future effects of alternative policy measures in that domain on production and on the environment.

Chapter 2 provides an historical review of land use changes in Portugal and their implications for land degradation and conservation, with a focus on Centro and Alentejo regions. The objective of this chapter is twofold: 1) to clarify in which way socio-economic drivers have influenced land use change, and 2) to investigate the implications of land use changes on land degradation. The paper shows that arable land in Portugal decreased from about 30 % of the total area in 1986 to only 12 % in 2006. The area under permanent crops and various types of forest remained roughly the same, while grassland or rangeland increased from 7 % in 1986 to about 20 % in 2006. In the two research areas arable land was still of major importance, and often combined with livestock activities. In Centro arable land remained stable at 27 %, but forest area declined from 52 % to only 22 % of the area, as a result of forest fires. In Alentejo arable land still occupied 64 % in 2006, but much shrub land had been afforested in the period 1986-2006. In both areas land use changes and grazing activities led to an increase of soil erosion.

Chapter 3 is looking at the various farming systems in the two research areas in Portugal and at the implications of their development for sustainable land management. The objectives of this chapter are: 1) to characterise the present farming systems as practised by specific farm types in two less favoured areas in Portugal; 2) to characterise their development over time in the period 1989-2009; and 3) to investigate their contribution to sustainable land management. Confirming findings of Chapter 2, the farm level analysis showed an increasing focus on livestock and rangeland activities among the respective farm types. In Centro three types of small ruminant farms (goats and/or sheep) and one mixed cropping farm type were distinguished, while in Alentejo three crop-livestock farm types, one mixed cropping farm type and one forest farm type were identified. In Alentejo there appeared to be an increased focus on cattle rearing. We postulate that on the one hand and for some farm types higher stocking rates would reduce fallow periods and thereby increase land degradation,

while on the other hand the low net farm income of some other farm types (e.g. small goat farms in Centro) may soon lead to abandonment.

Chapter 4 analyses the role of EU agri-environmental measures that preserve extensive grazing in these two Less-Favoured Area in Portugal. In this chapter two AEM are analysed that both aim at the preservation of permanent pastures and extensive livestock production, with the ultimate environmental goal of reducing soil erosion and wildfire: Traditional Mixed Farming (TMF), and Extensive Grassland (EG). The objective is to assess first the uptake of these two AEM in two selected LFA areas and secondly to assess their physical effects in preserving permanent pastures and extensive livestock production. TMF and EG appeared to be of major importance in Centro and Alentejo respectively. The uptake of these two measures was rather low, but for a targeted share of 15 % of the agricultural area under AEM, TMF ensured 60 % of this objective for Centro. On the other hand EG only met 14 % of the objective for Alentejo. The analysis shows that these two AEM are to a certain extent effective in preserving stocking rates within the prescribed range, while on the other hand preserving sufficient soil cover.

Chapter 5 looks at the effectiveness of the financial incentives offered through these same two agri-environmental measures for preserving extensive grazing in the two research areas. Attention is paid first to the amounts of Pillar 1 (income support) and Pillar 2 (rural development) subsidies that the different farm groups receive and the changes of these subsidy flows over the period 2005 to 2009. TMF farms in Centro received rather low amounts of Pillar 1 subsidies in 2005, but this had increased by 2009, while the Pillar 2 subsidies declined. This trend also holds for EG farms in Alentejo, but being much larger, they received in total ten times as much as the TMF farms in Centro. The two measures generally lead to a change from a short (3 years) ley system (rotation of crops with legumes/grassland) to a longer rotation ley system (6 years) or to a permanent pasture system. In both areas the adoption of AEM with permanent pasture appears often financially more attractive than with the long ley, and in most cases the subsidy largely compensates farmers for the extra costs incurred, also when discounting is applied. At the regional level the cost-effectiveness of TMF and EG was assessed using a goal index combining stocking rate and soil cover indicators. Future AEM in LFA would be most effective, when focusing on farms which can achieve best the desired environmental effects.

Chapter 6 assesses the future effects of alternative combined policy measures for pastures and extensive livestock development on production and on the environment. It is a normative analysis whereby attention is paid to spatial targeting. The objectives of the chapter are: 1) to assess cost-effectiveness of reducing erosion and fire risk by preserving extensive livestock production; 2) to determine the added value of using a spatial targeting strategy based on slope and fire risk criteria. An AEM for the improvement of permanent pastures would be more cost-effective for erosion and fire hazard mitigation if implemented within a spatial targeting framework. However when cost-effectiveness is weighed with other criteria, non-targeted AEM implementation delivers the best outcome in Alentejo, whereas in Centro the 'doing nothing' option delivers the best outcome when resource/output indicators are higher valued than result/impact indicators. Analyses confirm scope for harmonising landscape level synergies of policy impact, but also show that variations in farm structure and farm-level adoption of AEM play an important, potentially counteracting role.

Finally, Chapter 7 provides an overall synthesis of the thesis. It briefly summarizes answers to the research questions, discusses emerging issues, provides reflections about the topics of study and subsequently indicates some contributions to science, limitations of the study and recommendations for further research and future policy design.

Samenvatting

In de afgelopen decennia hebben er aanzienlijke landgebruiksveranderingen plaatsgevonden in Portugal. Na de integratie van Portugal in de EU, konden boeren baat hebben van de EU beleidsmaatregelen, die aanvankelijk vooral bedoeld waren om het inkomen van boeren te ondersteunen. Het werd snel duidelijk dat deze landgebruiksveranderingen zowel tot intensivering als tot het opgeven van land leidden, wat het milieu op verschillende manieren schade berokkende, in het bijzonder vanwege de grotere kans op bodemerosie en meer brandgevaar. Als reactie daarop, heeft het EU beleid in de jaren daarna steeds meer aandacht besteed aan duurzame plattelandsontwikkeling, onder andere door middel van "cross-compliance" en "agri-environmental schemes". In dit proefschrift worden landbouw-milieu beleidsmaatregelen geanalyseerd, die gericht zijn op het verminderen van erosie en brandgevaar in twee geselecteerde onderzoekgebieden. Beide gebieden bevinden zich in zogenaamde "Less Favoured Areas (LFA)", waar de milieu effecten het grootst zijn. Het ene gebied valt onder de "Berg en heuvel-gebieden" en het andere onder de "Gebieden die verlaten worden".

Het inleidende hoofdstuk 1 geeft de probleem beschrijving, de doelstellingen, de huidige situatie, het evaluatie raamwerk en de onderzoekvragen weer, en het toont de indeling van het proefschrift. De belangrijkste onderzoekvragen gaan over de landgebruiksveranderingen in het verleden en hun milieueffecten, de ontwikkeling van landbouwbedrijfssystemen in de afgelopen 20 jaar, de fysische en financiële effecten van landbouwmilieu beleidsmaatregelen die permanent grasland en extensieve veeteelt ondersteunen, en de toekomstige effecten van alternatieve beleidsmaatregelen in die sector op productie en op het milieu.

Hoofdstuk 2 geeft een historisch overzicht van landgebruiksveranderingen in Portugal en de gevolgen daarvan voor land degradatie en –conservering, en gericht op de gebieden "Centro" en "Alentejo". De doelstelling van dit hoofdstuk is tweeledig: 1) om na te gaan op welke manier sociaaleconomische factoren landgebruiksveranderingen beïnvloed hebben, en 2) om de effecten van landgebruiksveranderingen op land degradatie te onderzoeken. Het hoofdstuk laat zien dat bouwland in Portugal afnam van 30 % van het totale areaal in 1986 tot slechts 12 % in 2006. Het areaal met meerjarige gewassen en diverse types bos bleef ongeveer hetzelfde, terwijl grasland en weidegrond toenam van 7 % in 1986 tot ongeveer 20 % in 2006. In de twee onderzoekgebieden bleef bouwland nog van groot belang, en werd vaak gecombineerd met veeteelt activiteiten. In Centra bleef bouwland stabiel met 27 %, maar het bosareaal nam af van 52 % tot slechts 22 % van het gebied, als gevolg van bosbranden. In Alentejo nam bouwland in 2006 nog 64 % van gebied in beslag, maar veel struikgewas was bebost in de periode 1986-2006. In beide gebieden zorgde landgebruiksveranderingen en begrazing tot een toename van bodem erosie.

Hoofdstuk 3 geeft inzicht in de diverse landbouwbedrijfssystemen in de twee onderzoek-gebieden in Portugal en de gevolgen van hun ontwikkeling voor duurzaam landbeheer. De doelstellingen van dit hoofdstuk zijn: 1) om de huidige bedrijfssystemen weer te geven, zoals ze toegepast worden door specifieke bedrijfstypes in twee LFA's in Portugal; 2) om hun ontwikkeling te beschrijven over de periode 1989-2012; en 3) om hun bijdrage aan duurzaam landbeheer te onderzoeken. Conform de bevindingen in hoofdstuk 2, toont het bedrijfsonderzoek een toenemende aandacht voor veeteelt en weide activiteiten onder de respectievelijke bedrijfstypes. In Centro werden drie type bedrijven met kleinvee (geiten en/of schapen) en één gemengd bedrijfstype onderscheiden, en in Alentejo werden drie gewas-veeteelt bedrijfstypes, één type met diverse

gewassen en één bosbedrijf type geïdentificeerd. In Alentejo bleek er een toenemende aandacht voor het houden van koeien te zijn. We hebben aangenomen dat enerzijds en voor bepaalde bedrijfstypes een grotere vee dichtheid de braakperiodes zal verkorten en tot meer landdegradatie zal leiden, en dat anderzijds de lage netto inkomsten van sommige bedrijfstypes (bijvoorbeeld van geitenbedrijfjes in Centro) spoedig tot bedrijfsbeëindiging zal leiden.

Hoofdstuk 4 analyseert de rol van EU “agri-environmental measures (AEM)”, die de extensieve begrazing in deze twee LFA’s in Portugal in stand houden. In dit hoofdstuk worden twee AEMs geanalyseerd, die beide gericht zijn op het in stand houden van permanente weides en extensieve veeteelt, met het uiteindelijke doel om bodemerosie en branden te verminderen: “Traditional Mixed Farming (TMF)” en “Extensive Grassland (EG)”. De doelstelling is om eerst het gebruik maken van deze twee AEM in twee geselecteerde LFA gebieden te onderzoeken, en ten tweede de fysische effecten van het in stand houden van permanente weides en extensieve veeteelt te beoordelen. TMF en EG bleken van groot belang in respectievelijk Centro en Alentejo. Er werd niet veel gebruik gemaakt van deze twee beleidsmaatregelen, maar gegeven de doelstelling dat 15 % van het landbouw areaal onder AEM zou vallen, neemt TMF wel 60 % van deze doelstelling voor haar rekening in Centro. Daarentegen is in Alentejo de bijdrage van EG aan deze doelstelling slechts 14 %. De analyse laat zien dat deze AEM tot op zekere hoogte effectief zijn in het in stand houden van de vee dichtheid, en aan de andere kant zorgen voor een afdoende bodembedekking.

Hoofdstuk 5 gaat over de efficiency van de financiële stimuleringseffecten van deze twee beleidsmatregelen om de extensieve begrazing in deze twee onderzoekgebieden te behouden. Eerst wordt een overzicht gegeven van de hoeveelheid “Pillar 1” (inkomenssteun) en “Pillar 2” (plattelandsontwikkeling) subsidies die de verschillende bedrijfstypen ontvingen en van de veranderingen in deze subsidie stromen over de periode 2005 tot 2009. TMF bedrijven ontvingen vrij weinig “Pillar 1” subsidie in 2005, maar dat was toegenomen in 2009, terwijl de “Pillar 2” subsidies afnamen. Dezelfde trend gold voor EG bedrijven in Alentejo, maar omdat de bedrijven daar aanzienlijk groter waren, ontvingen zij in totaal ongeveer tien keer zoveel als in Centro. De twee AEM leidden in het algemeen tot een overgang van een kort 3 jarig “ley” systeem (rotatie van gewassen met leguminosen/grasland) tot een langer “ley” systeem (van 6 jaar) of tot een permanent weide systeem. In beide gebieden was de adoptie van AEM met permanente weide financieel aantrekkelijker dan dat met een lange “ley”, en in de meeste gevallen compenseerde de subsidie ruimschoots de extra kosten die de boeren maakten, ook wanneer gebruik gemaakt werd van verdisconteren. Op regionaal niveau is de kosten effectiviteit van TMF en EC beoordeeld met behulp van een doelstellingsindex, gebruikmakend van vee dichtheid en bodem bedekking indicatoren. Toekomstige AEM in LFA zullen effectiever zijn, wanneer ze gericht zijn op bedrijven, die het beste in staat zijn om de gewenste milieu effecten te bereiken.

Hoofdstuk 6 richt zich op de toekomstige effecten van alternatieve gecombineerde beleidsmaatregelen voor beweiding en extensieve veeteelt op de productie en op het milieu.
Het betreft een normatieve analyse, met speciale aandacht voor ruimtelijke targeting. De doelstellingen van het hoofdstuk zijn: 1) om de kosteneffectiviteit te beoordelen van het verminderen van erosie en brandgevaar door het in stand houden van extensieve veeteelt productie; 2) om de toegevoegde waarde te bepalen van het gebruik van een ruimtelijke targeting strategie, gebaseerd op helling en brandgevaar criteria. Een AEM ter verbetering van permanente weides zal kosteneffectiever zijn voor de vermindering van erosie en brandgevaar, wanneer het uitgevoerd wordt binnen een ruimtelijk targeting kader. Wanneer kosteneffectiviteit echter gewogen wordt met andere criteria, geeft AEM uitvoering zonder targets het beste resultaat in Alentejo, terwijl in Centro

de optie om “niets te doen” de beste uitkomst geeft, wanneer de input en output indicatoren hoger gewaardeerd worden dan de resultaat en impact indicatoren. Analyses bevestigen dat het mogelijk is om landschappelijke synergiën van beleidseffecten te harmoniseren, maar ze tonen ook aan dat verschillen in bedrijfsstructuur en adoptie van AEM op bedrijfsniveau vaak een belangrijke en potentieel tegenstrijdige rol spelen.

Hoofdstuk 7 geeft tenslotte een algehele synthese van de dissertatie. Het vat kort de antwoorden samen op de onderzoeksvragen, het bespreekt de problemen die nu aan de orde zijn, en na verdere beschouwingen ten aanzien van het onderwerp toont het een aantal bijdragen aan de wetenschap, beperkingen van de studie en aanbevelingen voor verder onderzoek en voor het ontwerpen van toekomstig beleidsmaatregelen.

PE&RC Training and Education Statement

With the training and education activities listed below the PhD candidate has complied with the requirements set by the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PE&RC) which comprises of a minimum total of 32 ECTS (= 22 weeks of activities)

Review of literature (6 ECTS)

- The impact of land use policies on agro-ecosystem goods and services, desertification and rural livelihoods in Portugal (2008)

Writing of project proposal (4.5 ECTS)

- The impact of land use policies on agro-ecosystem goods and services, desertification and rural livelihoods in Portugal (2008)

Post-graduate courses (9 ECTS)

- Biodiversity and ecosystem services in a sustainable world; PE&RC (2008)
- Introduction to R for statistical analysis; PE&RC (2008)
- I-GIS; PE&RC (2011)
- IALE PhD Advanced course: agricultural landscapes responding to multiple drivers – challenges for landscape ecology in Europe; Évora, Portugal (2012)

Laboratory training and working visits (4.5 ECTS)

- Linear programming with GAMS; Leeds University – School of Earth & Environment (2012)

Deficiency, refresh, brush-up courses (6 ECTS)

- Theories and models on environmental economics (2008)
- Research methodology (2008)
- Integrated environmental/ecosystem assessment – in regional management (2010)
- IELTS Certification / preparation (2011)

Competence strengthening / skills courses (4.5 ECTS)

- Techniques for writing and presenting a scientific paper; WGS (2008)
- Scientific writing; Language Centre (2010)

PE&RC Annual meetings, seminars and the PE&RC weekend (1.2 ECTS)

- PE&RC PhD Weekend (2008)
- PE&RC Day (2013)

Discussion groups / local seminars / other scientific meetings (4.5 ECTS)

- Cape Verde 2nd desire project meeting (2008)
- Workshop: desenho de estratégias financeiras integradas ; Seminário TCP FAO/CPLP, São Domingos de Rana (2009)

- Participation on desertwatch-E endusers meeting; Lisboa (2010)
- Meetings with local stakeholders in the research areas (2010-2011)

International symposia, workshops and conferences (8.7 ECTS)

- DeSurvey 1st workshop – assessing and monitoring of desertification and land use systems vulnerability; Saragossa (2009)
- Desire PhD meeting; poster presentation; Enschede (2010)
- IALE PhD Advanced course: agricultural Landscapes responding to to multiple drivers - challenges for landscape ecology in Europe; Évora, Portugal (2012)
- Geospatial forum; Lisboa (2015)

Curriculum vitae

Nádia Manuela Jones was born in Paris 18th district, France on 4 March 1974. For her primary and secondary education she went to: École Paul Bert Primary School in Paris 12nd district, Escola Primária de Amora no. 3, Paulo da Gama and Amora High Schools in Seixal district. Nadia graduated from the Technical University of Lisbon with a B.Sc. in Agriculture, with a specialization in Tropical Agriculture in 1998.

Soon after her undergraduate studies she was awarded a junior research grant at her University, working one year in the optimisation of analytical methods for the extraction of tobacco alkaloids. After that she worked for private companies involved in the forest inventory, the cadastral record of olive orchards and the control of CAP payments for arable crops in semi-arid and sub-humid regions (e.g. Silviconsultores/Terracarta/Geometral/ERENA). In 2000 she started studies for the M.Sc. degree in Agricultural Economics and Rural studies at Technical University of Lisbon, earning a FCT scholarship for field work in S.Tomé and Príncipe which she completed in 2001. After that, she worked as a researcher for Centro de Estudos Africanos ISCTE and for PARTEX consulting for database development. Under these jobs her duties included: optimization of laboratory protocols, project management, farm surveys, and satellite image visual interpretation.

During her tenure at Centro de Estudos Africanos – ISCTE Nadia was trained in participatory rural appraisals, attended a two week workshop for Socio-economic and Gender Analysis (SEAGA/FAO - Rome), and extension training visits to EMBRAPA/Brasil. She implemented these techniques during the assessment of small and medium cocoa farms in S. Tomé and Príncipe training enumerators and analysing the link between farm types and incentives. The title of her M.Sc. thesis is: *Os Médios Empresários Agrícolas em São Tomé e Príncipe: Identidades Sociais (Medium scale farm business in São Tomé and Príncipe: Social Identities)*.

In 2003 she started as a researcher for the EU-project OLIVERO. She actively participated in the four project meetings (Granada, Wageningen, Basilicata, and Lisboa), producing methodological guidelines and results within the socio-economic analysis working packages of the project, and she became aware of the opportunity to study for a PhD with Professor Leo Stroosnijder and Dr Ir. Jan de Graaff. Between the end of the project in 2006 and the beginning of her PhD in 2009, she worked in order to ensure funding for PhD, preparing the proposal, taking lecturer jobs in East Timor and Cape Verde on behalf of the Technical University of Lisbon bilateral cooperation, delivering subjects such as farm economics and participatory methods, and conducting research in two national projects in the field of sustainable olive production. She also received training in ArcGIS ESRI software.

In 2008 she was awarded a PhD scholarship by the EU-project DESIRE and FCT, to embark on her PhD program in July 2009. During her PhD Nadia developed interest in the spatial analysis of the effects of agri-environmental policies and in the link between bio-physical processes and socio-economic aspects of land use decisions.

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Publications

Journal articles

Jones, N., de Graaff, J., Rodrigo, I., and Duarte, F. (2014). Farming systems in two Less Favoured Areas in Portugal: their development from 1989-2009 and the implications for sustainable land management. *Land Degradation & Development*, 25: 29-44.

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Jones, N., Fleskens, L., Stroosnijder, L. Targeting the impact of agri-environmental pollicy – future scenarios in two Less Favoured Areas in Portugal.
Submited to *Journal of Environmental Management*

Jones, N., Duarte, F., Rodrigo, I., van Doorn, A., and de Graaff, J. The role of EU agri-environmental measures preserving extensive grazing in Less-Favoured Areas in Portugal.
Submited to *Land Use Policy* (under review)

Jones, N. (2012) Impact assessment of land use policies on agro-ecosystem goods and services in Portugal, "Agricultural landscapes responding to multiple drivers - Challenges for landscape ecology in Europe" PhD Advanced Course, 24th to 29th of June 2012 , IALE Europe, Évora, Portugal.

Jones, N. (2010) Land use changes and land degradation: case study in Portugal, *Programme DESIRE – PhD conference "Advances in land degradation research: integrating different approaches"*, ITC Enschede 18-21 May 2010.

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Jones, N.M. (2006), *Os Médios Empresários Agrícolas em São Tomé e Príncipe: Identidades Sociais*, M.Sc. thesis, Universidade Técnica de Lisboa.

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