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

Nadia Jones, Soil Physics and Land Management Group, Wageningen University, PO Box 47, Wageningen, The Netherlands, nadiamanuelajones@gmail.com

Luuk Fleskens, Soil Physics and Land Management, Wageningen University, PO Box 47, Wageningen, Tel.: +31 317 485467, The Netherlands, luuk.fleskens@wur.nl

Leo Stroosnijder, Soil Physics and Land Management Group, Wageningen University, PO Box 47, Wageningen, The Netherlands, leo.stroosnijder@wur.nl

Abstract

Targeting agri-environmental measures (AEM) improves their effectiveness in the delivery of public goods, provided the necessary coordination with other incentives. In less favoured areas (LFA) measures focusing on the conservation of extensive farming contribute to sustainable land management in these areas. In this paper we investigate the implementation of a possible AEM supporting the improvement of permanent pastures coordinated with the extensive livestock and single farm payments actually in place. Through applying a spatially-explicit mixed integer optimisation model we simulate future land use scenarios for two less favoured areas in Portugal (Centro and Alentejo) considering two policy scenarios: a 'targeted AEM', and a 'non-targeted AEM'. We then compare the results with a 'basic policy' option (reflecting a situation without AEM). This is done with regard to landscape-scale effects on the reduction of fire hazard and erosion risk, as well as effects on farm income. The results show that an AEM for permanent pastures would be more cost-effective for erosion and fire hazard mitigation if implemented within a spatially targeted framework. However when cost-effectiveness is assessed with other indicators (e.g. net farm income and share of grazing livestock) 'non-targeted AEM' implementation delivers the best outcome in Alentejo. In Centro the implementation of an AEM involves important losses of income compared to the 'basic policy'. 'Targeted AEM' tends to favour farms in very marginal conditions, i.e. targeting is demonstrated to perform best in landscapes where spatial heterogeneity is higher. The results also show the risk of farm abandonment in the two studied less favoured areas: in all three scenarios more than 30% of arable land is deemed to be abandoned.

Keywords: Mediterranean ecosystem; benefit-cost targeting; afforestation; forest discontinuity; improved pastures; landscape fragmentation.

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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). 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). 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 (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, 2013a). This is particularly important for AEM and Less Favoured Areas (LFA) payments, which may have overlapping objectives such as avoiding abandonment. Farmland abandonment has, next to structural socio-economic changes, been associated with increased erosion (García-Ruiz & Lana-Renault, 2011) and fire risk (Carreiras et al., 2014), and mixed impacts on biodiversity (Keenleyside et al., 2011; Queiroz et al., 2014). It is however not clear how AEM can be designed to achieve desired environmental outcomes when farming systems, landscape configurations, and priorities differ across regions (Jones et al., 2016).

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). Indeed, the impact of the changes in CAP (2014-2020) will likely be highest on extensive farming systems operating in LFAs (Renwick et al., 2013). Whereas policies have partially supported the specialisation of some crop-livestock farming systems in marginal areas (Poux, 2007), 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).

In Portugal, as in other countries in the European Union, farm abandonment has been threatening farmers in dry and mountainous zones classified as LFAs. 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. 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). Although impacts of CAP payments have been shown for specific farming systems (Jorge et al., 2010; Agro.Ges, 2011; Fragoso et al., 2011), these have not been focused on the spatial translation of the effects at the local level.

As payments influence individual farmer decisions but seek to promote wider environmental benefits, better understanding is needed on how policy leads to environmental benefits in heterogeneous landscapes under patterns of aggregate decisions, and at what cost. 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. Better coordination between CAP instruments can eventually decrease policy costs as shown by Schuler & Sattler (2010) for intensive farming systems in Germany.

In this paper we therefore 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. We particularly test the hypothesis that targeting AEM support to the preservation of a viable livestock production in marginal areas contributes to the reduction of fire hazard and erosion risk (Jones et al., 2016). The objectives of the paper are: 1) to assess cost-effectiveness of reducing erosion and fire risk by avoiding abandonment through preserving extensive livestock production in two Portuguese LFA's – Centro and Alentejo; 2) to determine the added value of using a spatial targeting strategy.

2. Policy environment: targeting agri-environmental expenditure

2.1. 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, 2013b). Of special interest for marginal areas with extensive livestock production is the option to meet the 'Greening' objective through the preservation of permanent grassland.

LFAs cater for a large share of EU sheep and goat production (about 70%) (EC, 2011). Although the CAP reform aimed at total decoupling of payments, an exception was made for economically vulnerable areas or specific quality systems (EC, 2011). The latter has been the case for Portugal (Avillez, 2014) (Table 1). 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, 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, 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., 2016). 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 paper we will look at the delivery of reduced fire and erosion risks.

2.2. 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 paper. With respect to greening payments we will consider the decisions already contemplated in the regulation of the policy (EU, 2013a; EU, 2013b).

Under 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 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).

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).

From a societal perspective, permanent pasture is the most desirable management option for the steep arable plots common in marginal areas 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 negatively affects fire risk and farm income.

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

3. Materials and methods

3.1. Research areas and farm samples

Two research areas in Portugal were considered, one in Centro with 112,000 ha and another in Alentejo with 128,000 ha (Fig 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 agricultural land 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). The farms are predominantly medium to large-sized (ca. 127 ha) with many sheep and/or cattle (26 LU/ farm) (INE, 2010).

More specialised farming and farm abandonment 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.

We consider the year of 2010 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, respectively in Centro and Alentejo (IFAP, 2012). We classified all farmland in three categories based on distance to main road and slope: very marginal, marginal, and less marginal. 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 (Fig 1).

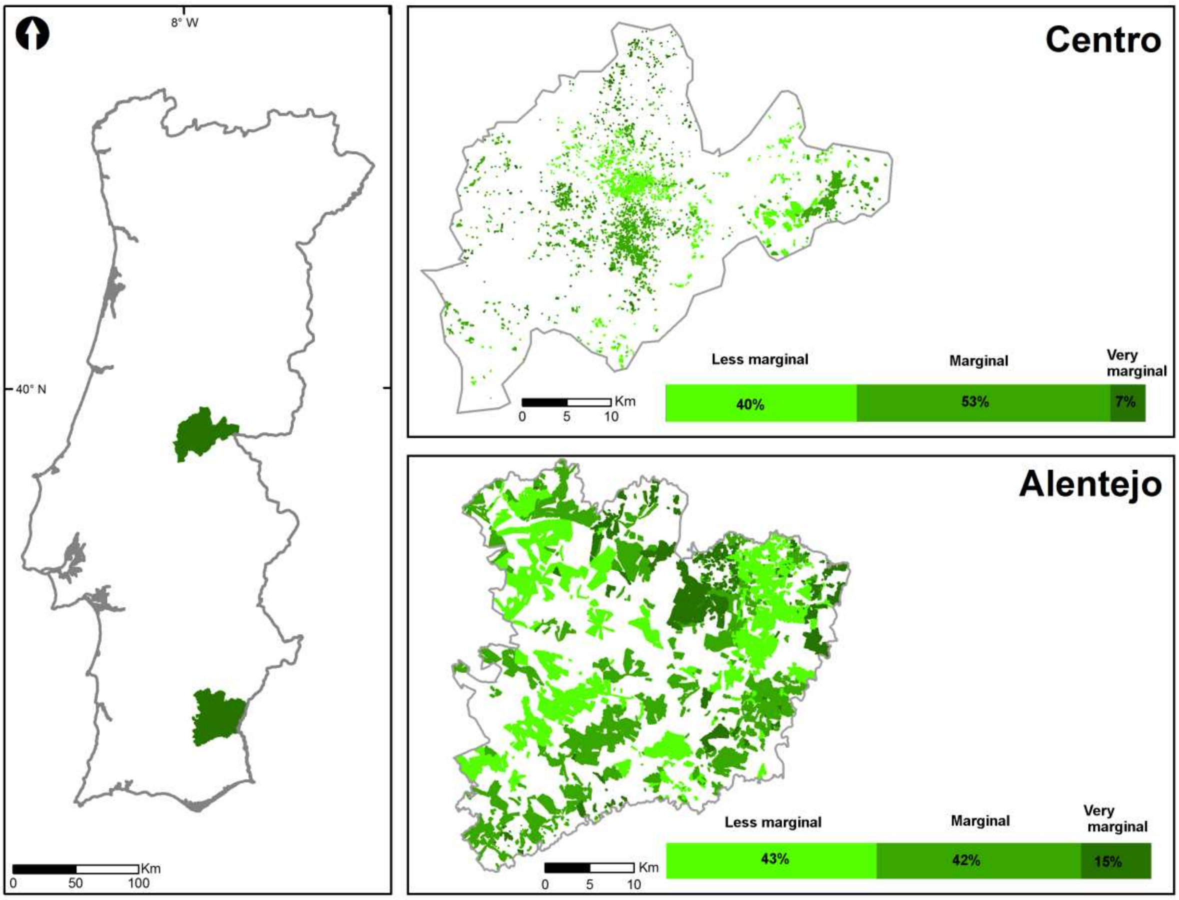

Fig. 1 Research areas: arable area and marginality categories

3.2. Methods

Analytical framework

The analytical framework is summarised in Fig. 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. Three policy scenarios were used to produce model outputs: 'basic policy' (reflecting the absence of AEM), 'AEM' (broad brush AEM), and 'targeted AEM' (spatially targeted AEM). A set of indicators was assessed separately, and entered into a multi-criteria analysis to inform on the best policy scenario for each research area. We established some assumptions, which are summarized in Fig. 2 as sources of uncertainties.

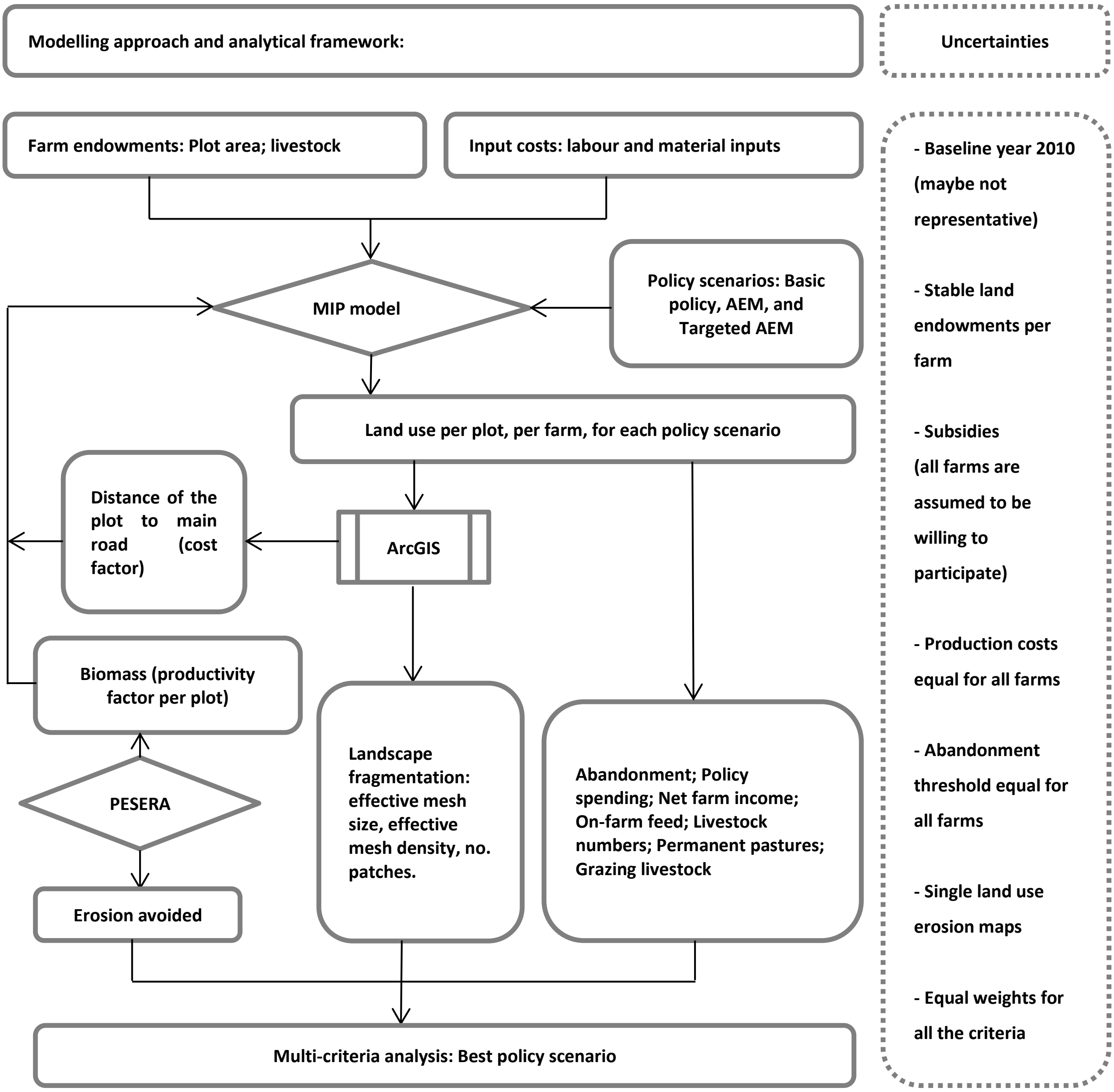

Fig. 2 Analytical framework, and sources of uncertainties

MIP model description

The MIP model's objective function maximises farm income (Z) given land (X) and livestock (Y) endowments of livestock types (l) (cattle and sheep for meat production, and sheep and goats for milk production), under some constraints concerning labour, and capital availability (Eq 1). We expected a single management option (i) per plot (p), and therefore the optimisation was conducted using a mixed integer linear programming solver. Three pasture management options are considered: a ley farming system renewed every 3 years representing widespread current practice (combination of oats with ryegrass), a permanent pasture with a minimum duration of 5 years (combination of clover species with ryegrass), and abandonment. For each plot, travel distance and productivity effects were taken into account. We assumed that land under permanent crops and forest would not be converted into pasture. We established the ley system as the initial management option for all plots of the farm.

Pillar I subsidies (SFP and livestock) were considered as part of net farm income. We took 2010 as our baseline year for land and livestock endowments. All costs and benefits were accounted annually (j) and discounted at 3% over the time horizon modelled (2010-2030).

$$Z = \max \sum_{jl} Y_{jl} \cdot \left(\text{revenue}_l - \text{cost}_l + \text{subsidy}_l\right) + \sum_{ijp} X_{ijp} \cdot \left(\text{AEM}_i \cdot \text{target}_p + \text{SFP} + \text{LFA} - \text{cost}_i\right)$$

s.t.

$$\sum_{ip} X_{ijp} \cdot \text{cost}_i + \sum_{l} Y_{jl} \cdot \text{cost}_l \le \sum_{p} \text{resourceavailable}_p \qquad (1)$$

$$Y_{jl} = \sum_{ilp} X_{ijp} \cdot \text{carryingcapacity}_{il}$$

$$\sum_{ip} X_{ijp} = \text{area}_p$$

For each farm an optimal combination of plots with ley, permanent pasture, and abandonment was found without buying or selling land, but allowing alterations in livestock numbers and types. For example, a farm with goats for milk production and little labour available would start to concentrate ley production on the nearest plots, and undergo some conversion to permanent pasture and abandonment on the furthest ones in order to minimize distance costs. Still when return to labour becomes too low, the farmer can replace goats by sheep, which are less labour demanding. Such strategy is however constrained by the availability of capital to buy off-farm feed, and by the need to provide a certain share of on-farm feed. A certain number of goats would then be still kept, to use up the available labour. Payments for permanent pastures and goats (varying under different scenarios considered) can change the equilibrium solution.

The model validation indicated that past changes (2005 – 2009) were fairly reproduced by the model. The direction of change in the number of animals and stocking rate was correctly predicted in 50% of the cases in Centro and 60% in Alentejo, and for arable area in 40% of cases in both study areas. 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., 2006; Van Doorn & Bakker, 2007). Despite the narrow model focus on maximization of income, it has the strength to locate the plots where pasture management options or abandonment will take place.

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 1 gives a summary of the scenarios considered in this paper. Altogether we considered three scenarios (Table 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 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 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 < 2LU/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 (GPP, 2013; EU, 2013a; EU, 2013b). 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). 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). 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 (Fig. 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 simulations with PESERA (Kirkby et al., 2008) for all pasture management options. 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, and the opposite happens with the effective mesh size m_{eff} (1,000 ha/ s_{eff}) (EEA, 2011). We computed those measures for pasture and forest land use categories separately, and together for the whole landscape measure.

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). Results are presented both at the farm and regional levels. The lowest cost-effectiveness ratio indicates which option provides an 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.

For all the indicators computed at the farm level we compared the significance of the differences between scenarios and between categories of farmland marginality by performing one-way ANOVA with SPSS.

Multi-criteria analysis

By maximizing farm income, the MIP model focuses on a farmer perspective. A multi-criteria analysis of the whole set of indicators was conducted by simultaneously maximizing policy outcome while minimizing the costs of policy. Costs of policy were considered from a social (minimizing policy spending at the state budget level) as well as private perspective (maximizing income at the farm level).

In the multi-criteria analysis the most desirable outcome was considered: 1) lower policy spending, 2) higher share of Pillar 2 on total amount of subsidies, 3) higher net 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. Criteria 1-5 represent resource and output indicators, and 6-10 result and impact indicators. Results will be discussed aggregated across all indicators, as well as separately for the sets of resource/output and result/impact indicators. Differences between the two research areas Centro and Alentejo will be examined.

4. Results

The multi-criteria analysis, simultaneously reflecting the policy planner's point of view at the regional level and the farmer's point view at the farm level, showed that the first ranking scenario was Targeted AEM in Centro and AEM in Alentejo (Fig. 3). Table 2 shows the respective arable area and number of farms. The area abandoned is different for each scenario, yet some farms were abandoned regardless the policy scenario they were operating in. They correspond to about 40% of the arable area in Centro and 30% in Alentejo (Fig. 3, Table 2).

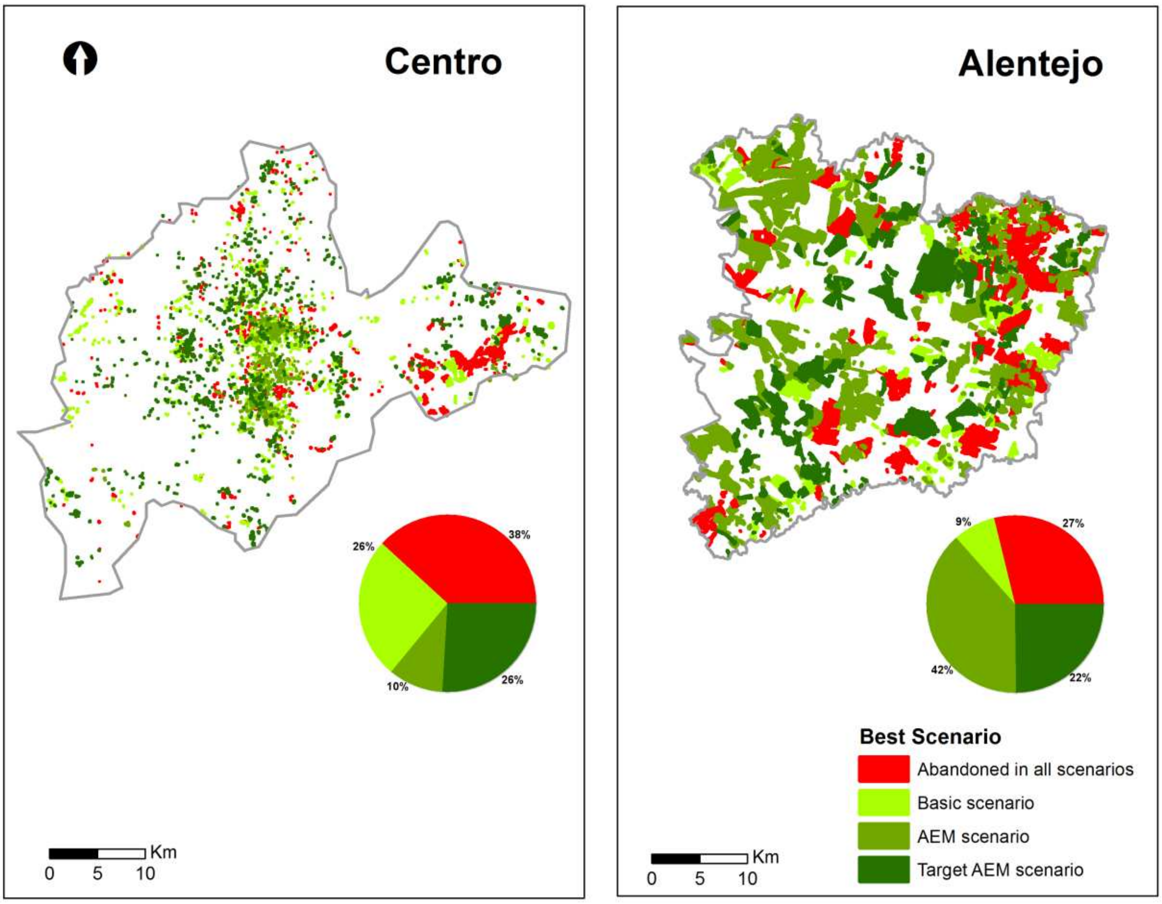

Fig. 3 Best performing scenario at the farm level for Centro and Alentejo

Table 2. Scenarios with the best performance – all indicators

Best ranked scenario (all indicators)		Centro				Alentejo			
		Very Marginal	Marginal	Less Marginal	Total	Very Marginal	Marginal	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**
Targeted 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
Abandoned	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.

4.1. Centro

In Centro, targeted AEM showed the best outcome. This concerned a large share of farms, 181 out of 480 covering 672 ha (Table 2, Fig. 3). When considering the subset of resource and output indicators, which are a proxy of the costs of the policy, we obtained that the Basic scenario performed better than any of the other. This result concerned about 40% of the farms (Table 3). Losses of income are an important part of the costs of the policy. Indeed when implementing an AEM, more than 50% of the farm land shows losses of income either within a spatially targeted framework or not (Fig. 4).

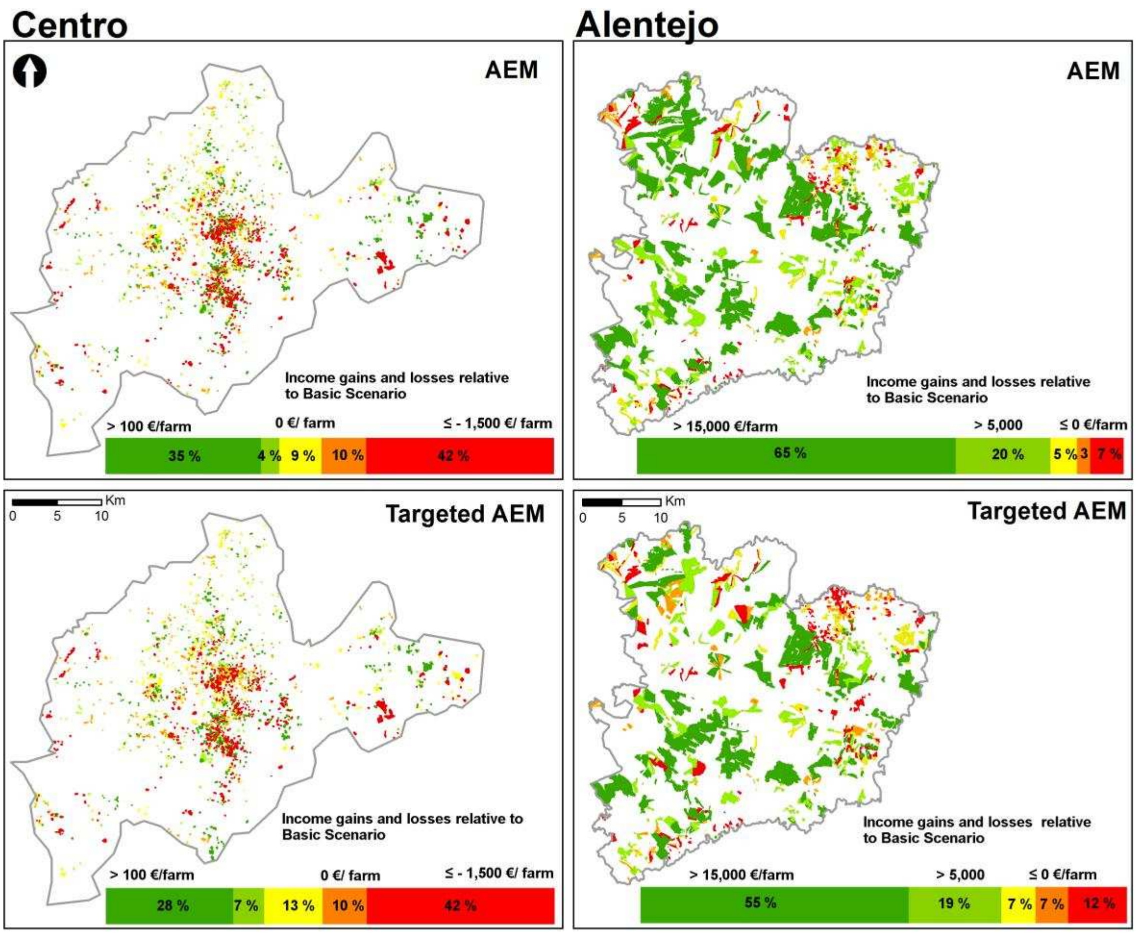

Fig. 4 Income gains and losses of AEM and target AEM scenarios with regard basic scenario

Considering the subset of result and impact indicators, or the benefits of the policy, Targeted AEM shows to be most favourable, particularly in very marginal farmland. In fact more than 60% of the concerned area performs best under this scenario (123 ha out of 198 ha, Tables 2 and 4). When assessing indicators individually, AEM and Targeted AEM scenarios performed significantly better (0.05 level) than Basic scenario for Pillar 2 spending, permanent pasture share, stocking rate, and erosion avoided (Tables 5 and 6). AEM significantly differed from Targeted AEM only for the share of permanent pasture share (85% against 76% - i.e. AEM outperformed Targeted AEM, Table 6). Very marginal farms differed (0.05 level) from marginal and less marginal ones for most indicators, with the exception of livestock numbers and share of abandonment (Tables 5 and 6). The outcome was always to the disadvantage of very marginal farms, with the exception of permanent pasture share and erosion avoided (Table 6). Forest continuity showed little changes between scenarios (s_{eff} = 0.02 for all scenarios), including the current land use with all plots being devoted to pasture. Pasture patches' highest continuity was obtained under Targeted AEM (Table 7, m_{eff} = 7.2 ha). This can be observed in Fig. 5 as a slightly less scattered distribution of permanent pastures patches under Targeted AEM than under AEM scenario.

4.2. Alentejo

In Alentejo, multi-criteria analysis revealed that AEM scenario was the best performing scenario for the majority of the farms and area. This result concerned 88 out of 224 farms, and 17,880 ha out of 42,640 ha (Fig. 3, and Table 2). When assessing the subsets of indicators, the AEM scenario was also the best performing one (Tables 3 and 4). When assessing indicators individually, AEM and target AEM scenarios performed significantly better (0.05 level) than the Basic scenario for Pillar 2 spending, net farm income, permanent pasture share, and erosion avoided (Tables 5 and 6). The AEM and Targeted AEM scenarios did not differ from each other significantly (0.05 level) for any of the indicators considered (Table 6). There were also no significant differences (0.05 level) between categories of farmland marginality for the majority of the indicators (Tables 5 and 6). With regard to landscape fragmentation, pasture patches exhibited the highest continuity under AEM scenario (Table 7, m_{eff} = 568 ha), while forest continuity was lowest under Targeted AEM (Table 7, m_{eff} = 4,870 ha). Although not readily observable from the distribution of land use categories, this outcome was reached with a lower pasture area (65% of the available area, against 71%, Fig. 5).

Table 3. Scenarios with the best performance - resource and output indicators

Best ranked scenario (resource and output indicators)		Centro				Alentejo			
		Very Marginal	Marginal	Less Marginal	Total	Very Marginal	Marginal	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 2.

Table 4. Scenarios with the best performance - result and impact indicators

Best ranked scenario (result and impact indicators)		Centro				Alentejo			
		Very Marginal	Marginal	Less Marginal	Total	Very Marginal	Marginal	Less Marginal	Total
Basic	Arable area (ha)	13	162	124	299	660	1,841	1,910	4411
	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 2.

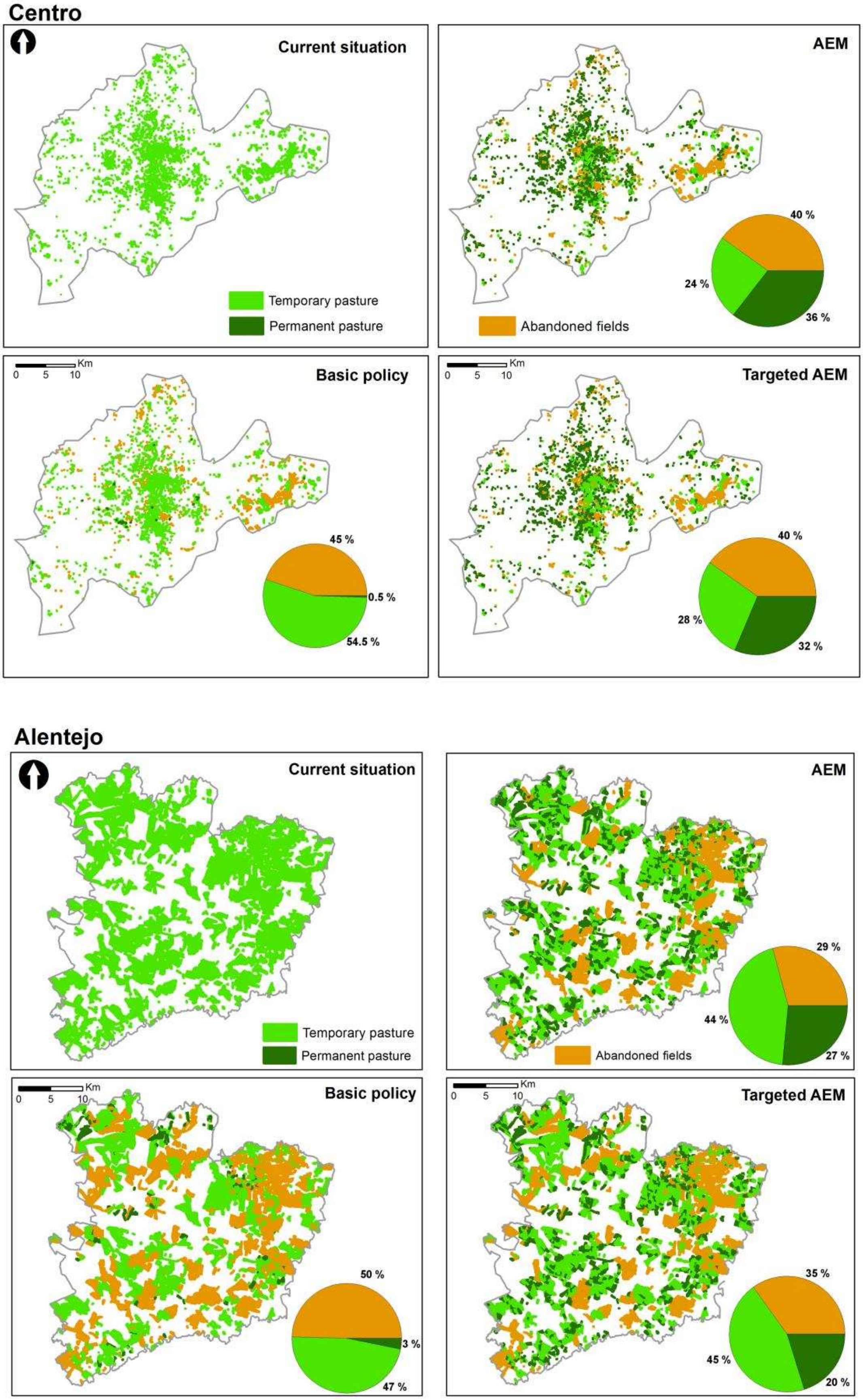

Fig. 5 Land use maps per policy scenario, and current situation

4.3. Combined regional assessment

Multi-criteria and individual indicator assessments point to important trade-offs to be considered in a choice between policy scenario options. These involve important income losses in Centro, and decreasing landscape fragmentation in both research areas. The multi-criteria analysis does not take into consideration the cost-effectiveness of policy options at the regional level.

Table 8 presents cost-effectiveness indicators at the regional level. Having in mind the main issues in Centro and Alentejo, on the one hand abandonment and fire hazard, and on the other the improvement of pastures and the rehabilitation of highly eroded land, we found that Targeted AEM offers the most cost-effective solution in both research areas. (Table 8). Since 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. Nonetheless, for both regions, implementing Targeted AEM involves a lower budget than AEM scenario. By multiplying the average amount of payments received per farm with the number of active farms we respectively obtained for Targeted AEM and AEM scenarios in Centro and Alentejo: 455 k€, and 4,482 k€; 467 k€, and 4,927 k€.

There are scale effects of the cost-effectiveness ratio as can be checked in Table 9, showing cost-effectiveness ratios computed at the farm level, and therefore independent from the benefits on other farms. Most results do not contradict the results of Table 8. However, expenditure on permanent pastures in Centro differs significantly (0.05 level) between AEM and Targeted AEM scenarios. The area involving the highest cost per ha of permanent pasture was 26% under Targeted AEM, against only 18% under AEM scenario (Fig. 6).

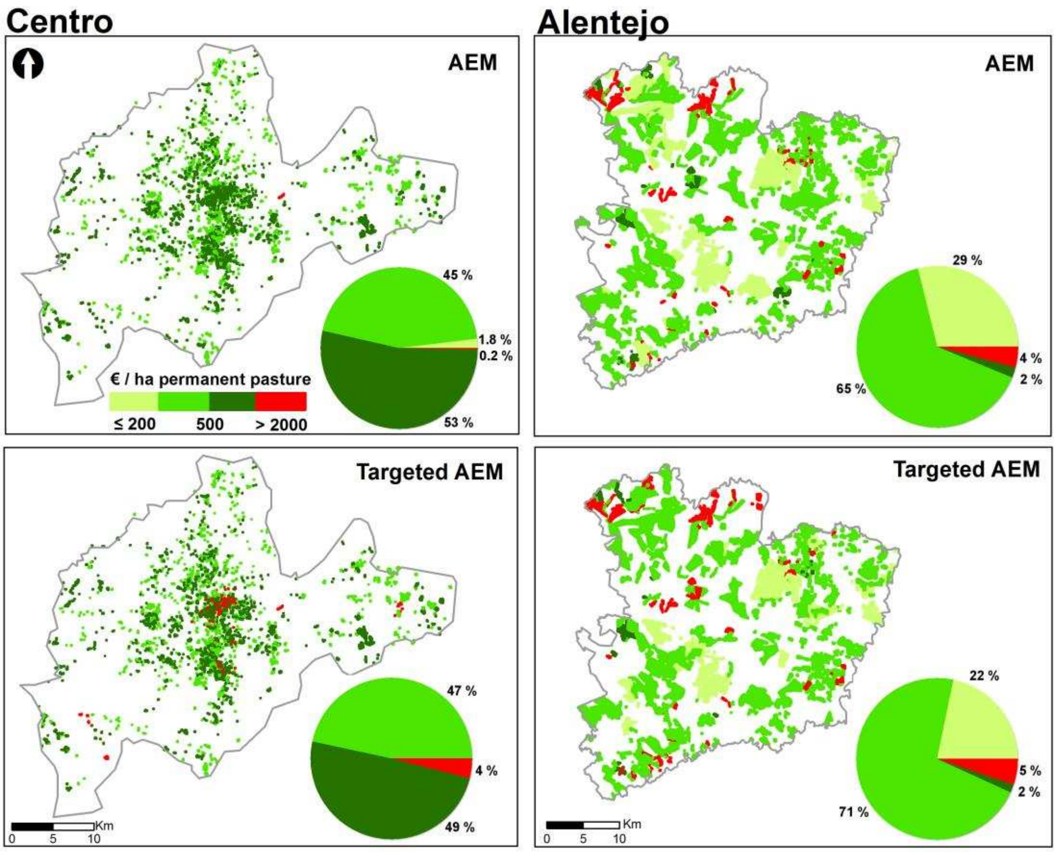

Fig. 6 Cost-effectiveness at the farm level (€/ ha permanent pastures)

Table 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					
		Total farms	Active farms (n)	Policy Spending_I (€/farm)	Policy Spending_II (€/farm)	Net Farm Income (€/farm)	On-farm feed (% on total feed)	Livestock numbers (LU/farm)	n	Policy Spending_I (€/farm)	Policy Spending_II (€/farm)	Net Farm Income (€/farm)	On-farm feed (% on total feed)	Livestock numbers (LU/farm)	n	Policy Spending_I (€/farm)	Policy Spending_II (€/farm)	Net Farm Income (€/farm)	On-farm feed (% on total feed)	Livestock numbers (LU/farm)
Centro	Very Marginal	101	50	620^{a}	101^{a}	717^{a}	90^{a}	1.3^{a}	64	604^{a}	325^{a}	795^{a}	90^{a}	1.6^{a}	64	604^{a}	322^{a}	791^{a}	90^{a}	1.6^{a}
	Marginal	219	153	880^{b}	156^{a}	996^{b}	91^{b}	1.7^{a}	172	904^{b}	463^{b}	1,164^{b}	91^{b}	2.2^{a}	171	900^{b}	445^{b}	1,132^{b}	91^{b}	2.1^{a}
	Less Marginal	160	100	978^{b}	163^{a}	1,120^{b}	92^{b}	1.9^{a}	121	937^{b}	484^{b}	1,232^{b}	92^{b}	2.3^{a}	117	944^{b}	469^{b}	1,212^{b}	92^{b}	2.2^{a}
	Total	480	303	869^{A}	149^{A}	991^{A}	91^{A}	1.7^{A}	357	861^{A}	**446^{B}**	1,121^{A}	91^{A}	2.1^{A}	352	861^{A}	**431^{B}**	1,097^{A}	91^{A}	2.1^{A}
Alentejo	Very Marginal	37	23	26,274^{a}	1,382^{a}	15,507^{a}	55^{a}	58^{a}	26	24,287^{a}	4,415^{a}	18,765^{a}	56^{a}	58^{a}	26	24,237^{a}	4,300^{a}	18,359^{a}	57^{a}	57^{a}
	Marginal	106	68	18,977^{a}	1,358^{a}	13,018^{a}	54^{a}	45^{a}	81	21,386^{a}	4,370^{a}	17,749^{a}	57^{a}	46^{a}	75	20,494^{a}	3,814^{a}	16,440^{a}	56^{a}	46^{a}
	Less Marginal	81	42	28,132^{a}	1,407^{a}	18,080^{a}	54^{a}	66^{a}	62	28,987^{a}	4,798^{a}	22,778^{a}	56^{a}	61^{a}	57	29,738^{a}	3,900^{a}	21,551^{a}	56^{a}	62^{a}
	Total	224	133	23,130^{A}	1,378^{A}	15,047^{A}	54^{A}	54^{A}	169	24,621^{A}	**4,534^{B}**	**19,750^{B}**	57^{A}	54^{A}	158	24,445^{A}	**3,925^{B}**	**18,600^{B}**	56^{A}	54^{A}

Note: a, b, c correspond to mean differences significant at 0.05 level between marginality groups; and A, B, C for the comparison between scenarios.

Table 6. Result and impact indicators for Centro and Alentejo research areas (last five years averages per farm group) (cont.)

		Basic policy scenario							AEM policy scenario						Targeted AEM policy scenario					
		Arable area (ha)	Abandonment avoided (% arable area)	Permanent pasture (% arable area)	Grazing livestock (% total)	Stocking rate (LU/ha)	Erosion 2010 (t/ha)	Erosion avoided (t/ha)	AEM farms	Abandonment avoided (% arable area)	Permanent pasture (% arable area)	Grazing livestock (% total)	Stocking rate (LU/ha)	Erosion avoided (t/ha)	AEM farms	Abandonment avoided (% arable area)	Permanent pasture (% arable area)	Grazing livestock (% total)	Stocking rate (LU/ha)	Erosion avoided (t/ha)
Centro	Very Marginal	198	49^{a}	2.8^{a}	19^{a}	0.5^{a}	1.1	0.014^{a}	64	63^{a}	96^{a}	24^{a}	0.7^{a}	0.261^{a}	64	63^{a}	95^{a}	24^{a}	0.7^{a}	0.259^{a}
	Marginal	1361	69^{a}	1.1^{a}	38^{b}	0.4^{b}	0.7	0.010^{a}	172	78^{a}	85^{b}	41^{b}	0.6^{b}	0.202^{b}	166	78^{a}	75^{b}	40^{b}	0.6^{b}	0.184
	Less Marginal	1032	62^{a}	0.3^{a}	46^{b}	0.4^{b}	0.6	0.008^{a}	121	75^{a}	79^{b}	45^{b}	0.6^{b}	0.171^{b}	117	73^{a}	67^{b}	45^{b}	0.5^{b}	0.146
	Total	2592	62^{A}	1.1^{A}	38^{A}	0.4^{A}	0.7	0.010^{A}	357	74^{A}	**85^{B}**	40^{A}	**0.6^{B}**	**0.202^{B}**	347	73^{A}	**76^{C}**	39^{A}	**0.6^{B}**	**0.184^{B}**
Alentejo	Very Marginal	6188	61^{a}	30^{a}	6^{a}	0.8^{a}	0.11	0.017^{a}	26	76^{a}	60^{a}	8^{a}	0.8^{a}	0.034^{a}	26	75^{a}	58^{a}	8^{a}	0.8^{a}	0.034^{ba}
	Marginal	17947	63^{a}	22^{a}	9^{a}	0.9^{a}	0.14	0.018^{a}	81	77^{a}	54^{a}	11^{a}	0.8^{a}	0.038^{a}	69	71^{a}	50^{ba}	10^{a}	0.9^{a}	0.036^{a}
	Less Marginal	18506	51^{a}	22^{a}	11^{a}	0.9^{a}	0.13	0.016^{a}	62	72^{a}	48^{a}	11^{a}	0.7^{a}	0.038^{a}	51	66^{a}	38^{b}	11^{a}	0.8^{a}	0.026^{b}
	Total	42640	58^{A}	24^{A}	9^{A}	0.9^{A}	0.13	0.017^{A}	169	75^{A}	**53^{B}**	11^{A}	0.8^{A}	**0.035^{B}**	146	69^{A}	**47^{B}**	10^{A}	0.8^{A}	**0.032^{B}**

Note: a, b, c correspond to mean differences significant at 0.05 level between marginality groups; and A, B, C for the comparison between scenarios.

Table 7. Impact indicator – landscape fragmentation – for Centro and Alentejo research areas(last five years averages per farm group) (cont.)

		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 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	Pilar 2 €/ha permanent pasture	Pillar 1 and 2 €/t erosion avoided	Pillar 1 and 2 €/ha effective mesh size	Pillar 1 €/ha abandonment avoided	Pilar 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 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	Pilar 2 €/ha permanent pasture	Pillar 1 and 2 €/t erosion avoided	Pillar 1 and 2 €/ha effective mesh size	Pillar 1 €/ha abandonment avoided	Pilar 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 [a]	**468** [a]	3,340 [a]	---	184[a]	602 [b]	4,132 [a]	---
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 [a]	2,035 [a]	10,352 [a]	---	673 [a]	1,225 [a]	10,850 [a]	---

Note: a, b, c correspond to mean differences significant at 0.05 level between scenarios; all the mean differences between marginality groups are not significant at 0.05 level.

5. Discussion

The main idea of spatial targeting is that by applying conservation measures on the most suitable land parcels, environmental benefits are provided at lower costs than if conducted elsewhere (Uthes et al., 2010). Suitability can however be defined based on several criteria, and from different stakeholders' perspectives. In our model we built on that idea, considering from a farmer perspective the maximization of farm income, and from a societal perspective (planners and taxpayers) the possibilities for the provision of a more resilient landscape with regard to erosion and fire hazard mitigation. Within the approaches for cost-effective conservation listed by Duke et al. (2013) ours fits between 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. Indeed, we have conducted a multi-criteria analysis, where the minimum cost was considered a non-monetary benefit, and we have conducted a cost-effectiveness analysis, where the highest benefit-cost ratio was selected. The first approach was relevant for the choice of the best performing scenario combining both farmer and policy planner perspectives, and the second to assess cost-effectiveness at the regional level.

The results at the regional level 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 (Table 8). However when cost-effectiveness is weighed with other criteria, non-targeted AEM implementation delivers the best outcome in Alentejo, whereas in Centro the Basic policy option delivers the best outcome due to important income losses in both AEM and Targeted AEM scenarios.

In the past substantial budgetary provisions have been given to similar AEM – (0.3 M€ in Centro, 0.4 M€ in 2005 in Alentejo (IFAP, 2012)) – as well as for implementing fire 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, implying high societal demand for that objective alone. 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. Our results can contribute to build a benefit ranking map to inform policy planners against adverse selection and allow the selection of the best performing areas.

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).

A final note 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 (Table 8). This is in line with the EC (2007) study on the environmental consequences of sheep and goat farming. They conclude that cross-compliance can set the limits of acceptable grazing pressure, but there is a clear need to provide targeted measures to promote the most appropriate grazing patterns within the set limits. Moreover, there are important synergies to collect at the landscape level provided that overall cost-effectiveness of all policy targets is met (Schader et al., 2014). As in other studies taking a landscape 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. In addition we also show that variations in farm structure and farm-level adoption of AEM play an important, potentially counteracting role.

6. Conclusions

This paper 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 other criteria are valued, non-targeted AEM implementation delivers the best outcome in Alentejo. In Centro the ‘Basic policy’ option delivers the best outcome when resource/output are more appreciated than result/impact. It should be remarked 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 regardless the policy scenario that is implemented, which represents nearly 40% of the arable area in Centro and 30% in Alentejo. 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 a higher gain from policy instruments able to capitalise on those higher gains.

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