Farmland Abandonment in the EU: an Assessment of Trends and Prospects

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A report for WWF Netherlands by

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GLOSSARY

CAP	Common Agricultural Policy
CAPRI	Common Agricultural Policy Regional Impact assessment
CLC	CORINE Land Cover
CLUE	Conversion of Land Use Change and its Effects [model]
CORINE	CO-oRdination of INformation on the Environment
CMEF	Common Monitoring and Evaluation Framework
EAFRD	European Agricultural Fund for Rural Development
EEA	European Environment Agency
EU	European Union
EU-12	Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia
EU-15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom
EU-25	EU-27 other than Romania and Bulgaria
EU-27	All 27 Member States of the European Union
FADN	Farm Accountancy Data Network
FSS	Farm Structure Survey
GAEC	Good Agricultural and Environmental Condition
HNV	High Nature Value
IMAGE	Integrated Model to Assess the Global Environment
IPCC	Intergovernmental Panel on Climate Change
IRENA	Indicator Reporting on the Integration of Environmental concerns into Agriculture
JRC	Joint Research Centre
LAU	Local Administrative Unit
LCF	Land Cover Flow
LEAC	Land and Ecosystem Accounts
LFA	Less Favoured Area
LU	Livestock Unit
LUCAS	Land Use/Cover Area frame statistical Survey
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PLCM	Pan-European Land Cover database
RDP	Rural Development Programme
SFP	Single Farm Payment
SPS	Single Payment Scheme
SMR	Statutory Management Requirements
SRES	Special Report on Emission Scenarios (IPCC, 2000)
UAA	Utilised Agricultural Area

FARMLAND ABANDONMENT IN THE EU: AN ASSESSMENT OF TRENDS AND PROSPECTS

EXCUTIVE SUMMARY

Background and aims of study

Over recent decades substantial areas of the EU have been affected by agricultural abandonment, defined here as the complete withdrawal of agricultural management such that natural succession processes are able to progress. This is largely a result of declines in the viability of extensive (low input) and small-scale agriculture systems. The nature conservation impacts of long-term abandonment vary according to their context. In many circumstances abandonment may be damaging as it will threaten a range of semi-natural habitats and associated species of nature conservation importance, many of which are concentrated in Natura 2000 sites and other High Nature Value (HNV) farmland. But in some locations abandonment could be highly beneficial, particularly in highly fragmented landscapes and where it could provide the opportunity for significant large-scale restoration of non-agricultural habitats (eg re-wilding).

Whether or not abandonment has negative or positive biodiversity impacts, it is clear that it would be useful to know the likely scale and location of abandonment, so that necessary conservation interventions can be identified. However, predicting the extent and location of future abandonment is a challenge, as it can be a complex and gradual process that can lead to semi-abandonment (where agricultural production ceases, but the land is maintained as agricultural land), and various forms of permanent or transitional abandonment. Abandonment is therefore difficult to define, measure and study. Furthermore, data on past abandonment are relatively sparse and mostly out-of-date, the drivers of abandonment are changing over time and the results of land use modelling studies are difficult to interpret and vary according to their socio-economic and policy assumptions.

This study was carried out by the Institute for European Environmental policy (IEEP) for WWF Netherlands with the aim of assessing the likelihood of large-scale agricultural abandonment in the EU (and as far as data allow, other European countries) over the next 20-30 years, and its likely extent and location.

Extent and location of recent abandonment

From a review of the evidence over the last few decades it is clear that that there have been significant but variable levels of farmland abandonment in Europe, primarily in areas where agriculture is less productive, particularly in remote and mountainous regions and areas with poors soils and harsh climates. For example, annual losses of Utilised Agricultural Land of 0.17% in France and 0.8% in Spain were recorded from the late 1980s to the end of the 1990s, though some of this land may have been converted to forestry rather than merely abandoned (Pointereau *et al,* 2008). In eastern Europe widespread abandonment occurred as a result of the political changes at the end of the 1980s, with abandonment estimates of 15-20% of cropland in Slovakia, Poland and Ukraine. However, some anecdotal observations suggest that significant areas of recently abandoned land have since been returned to agricultural production in the EU-12.

There are, however, insufficient representative sample data to attempt an EU-wide estimation of past abandonment.

Drivers of abandonment

Examination of case studies indicates that many of the contributory causes of land abandonment are locally specific (eg relating to soil fertility) and some may be temporary (eg as a result of land restructuring). Nevertheless, past land abandonment and consideration of current institutional as well as physical factors, points to a number of drivers that could be expected to lead to marginalisation of agricultural production and increase the risk of abandonment. These are primarily factors that reduce the profitability of farming enterprises, including physical factors that limit yields and/or increase the costs of farming (eg poor soils) and economic factors such as low commodity prices and the availability of agricultural support payments. Secondary drivers may include the impacts of rural depopulation and institutional factors such as land ownership patterns and tax regimes.

Although trends in the drivers of abandonment are uncertain, most are expected to remain, and some key drivers are expected to intensify, in particular as a result of increasing exposure to global agricultural markets. This is likely to sustain the recent trend towards specialisation and achieving greater economies of scale in most agricultural sectors, and will further reduce the viability of marginal livestock systems. The economic pressures on some farming systems are also likely to be exacerbated by ongoing soil erosion and degradation over large areas of Europe as well as widespread rural depopulation. In the long-term, further abandonment may be driven by climate change, especially in south-west, southern-central and south-east Europe, where declines in yield are expected, as result of droughts and high temperatures.

Land abandonment is mitigated to some extent by Common Agricultural Policy (CAP) policies, including environmental measures that aim to support environmentally beneficial farming practices and rural communities in marginal/less productive farming areas, such as through Less Favoured Area and agri-environment payments. Cross-compliance measures also reduce the risks of complete abandonment by requiring landowners to maintain agricultural land in 'good agricultural and environmental condition' in order to receive CAP payments (eg by grazing or occasional cutting). Support for marginal/less productive farming systems may increase as a result of the forthcoming reform of the CAP, if support becomes more focused on the provision of public goods and the delivery of a range of environmental, social and economic needs. This could result in increased support for HNV farming systems, especially where they can provide multiple benefits in terms of ecosystems services (eg carbon sequestration and storage and water resources). But the degree and impacts of such changes are uncertain.

Model projections of farmland abandonment

Given the combined impact of the multiple interactions amongst the different drivers and their spatial variability, it is difficult to predict the magnitude and location of future abandonment without the use of complex, spatially-explicit computer models. Consequently, a number of studies have used such models to forecast projections of land

use change across Europe according to a range of socio-economic scenarios (which typically vary according to two key axes: the degree of globalisation and the degree of regulation).

The results of all of the recent modelling studies suggest that there is likely to be significant levels of farmland abandonment in Europe over the next 20-30 years. However, the projected levels of abandonment vary significantly, both within and between model scenarios, ranging from 0.7% of land area by 2020 (Scenar 2020 Regionalisation Scenario; Nowicki *et al*, 2006) to 6.7% by 2030 (EURURALIS Global Cooperation Scenario). There is a tendency for the highest projected levels of abandonment to result for scenarios that anticipate high levels of global competition in agriculture, and low levels of CAP support for extensive farming. However, significant abandonment is also projected under scenarios with reduced global competitiveness, high levels of support for agriculture and the environment and strong regulations. This suggests that abandonment trends may be tempered to a certain extent by the effect of CAP measures, but it is likely that many low-intensity grazing systems will not survive, and those that do will require significant long-term public funding. Furthermore, projections from a scenario with ambitious widespread measures that aim to protect semi-natural habitats associated with HNV farming appear to have little impact on abandonment.

Abandonment projections appear to be considerably reduced in scenarios that incorporate high levels of biofuel production in the EU. However, although obligations under the EU Renewable Energy Directive has stimulated demand for biofuels, it is expected that a significant proportion of production to meet this demand will occur outside Europe. Furthermore, the Directive's sustainability criteria (which aim to protect forests, species-rich grasslands and protected areas) and other EU environmental legislation (such as the Habitats Directive) do not appear to have been fully taken into account in the models, as the projections include substantial losses of forests and other semi-natural habitats, especially in eastern Europe. Thus the projections from scenarios with high biofuel production in Europe appear to be unrealistic.

The models are fairly consistent in their indications that the areas most at risk from abandonment will be in Finland and Sweden, the Pyrenees, north-western Spain and Portugal, the Massif Central (France), Apennines (Italy), Alps, other uplands areas of Germany and the border area of the Czech Republic and, to a lesser extent, the Carpathian Mountains. Most of these areas are mountainous, hilly or in northern latitudes and are likely to include a large proportion of HNV farmland. Consequently, projections from one study (IEEP and Alterra, 2010) suggest that 19.8% of arable farmland and 28.1% of grassland within areas that have been mapped as HNV farmland (Paraccchini *et al*, 2008) could be abandoned by 2030. However, within these high risk areas there are likely to be complex smaller scale patterns of abandonment.

The modelled projections do, however, need to be considered with caution, as they are constrained by available data, lags in policy assumptions and uncertainty over future socio-economic developments and policy decisions. In particular, the projections of very high levels of abandonment may be exaggerated because their scenarios assume levels of market liberalisation and weak environmental regulation that are probably unrealistic. The models are also deterministic and assume that land owners take decisions primarily on the basis of economic signals with little time lag. In reality it is evident that landowners will often

continue uneconomic farming (by supplementing incomes in others way) for a variety of social and cultural reasons. On the other hand, some factors may result in the models underestimating abandonment, such as the inclusion of set-aside obligations in some scenarios (even though compulsory set-aside was abolished in 2008) and the effects of ongoing soil erosion, rural depopulation and climate change, which are factors that are not directly included in the scenarios.

Conclusion

In conclusion, there is reasonable evidence from expected trends in the key drivers of abandonment that there will be significant farmland abandonment in Europe over the next few decades, particularly of extensively grazed areas (where there will also be widespread semi-abandonment). This is supported by modelling results, but projected levels of abandonment vary significantly, particularly with respect to their underlying socio-economic and policy measure scenarios. Abandonment projections therefore need to be treated with considerable caution as there is considerable uncertainty over future socio-economic conditions and policy responses, and some of the adopted scenarios are probably unrealistic. Taking these factors into account it is suggested that a mid-range estimate of farmland abandonment of 3-4% of total land area by 2030 is most plausible, which would amount to 126,000 – 168,000 km^2. However, the magnitude of abandonment will undoubtedly vary considerably from place to place according to local circumstances.

The impacts of abandonment will also vary according to their context. Nevertheless, it is clear that large areas of semi-natural habitats of high conservation concern are likely to be at risk, especially where it relates to HNV farmland. On the other hand, some abandonment may provide opportunities for beneficial restoration of non agricultural habitats. However, a substantial proportion of abandoned land may be intentionally converted to forestry plantations or used for other purposes, which would significantly reduce its biodiversity value and the potential for habitat restoration and re-wilding.

FARMLAND ABANDONMENT IN THE EU: AN ASSESSMENT OF TRENDS AND PROSPECTS

1 INTRODUCTION

1.1 Background

Substantial areas of the EU have been affected by agricultural abandonment and progressive loss of management over recent decades mainly as a result of declines in the viability of extensive (low input) and small-scale agriculture systems (Baldock *et al,* 1996; IEEP and Veen, 2005). The impacts of such abandonment on biodiversity will vary according to circumstances, in particular the relative importance of the existing habitat and its contribution to landscape diversity (IEEP and Veen, 2005; Stoate et al., 2009; IEEP and Alterra, 2010). As extensively managed farmland in mountains and on poor soils is most vulnerable to abandonment then many areas of semi-natural habitat and their associated species will at risk. Many such habitats and species are of European importance according to the EU Birds and Habitats Directives, and are consequently protected in Natura 2000 sites, but large areas of other High Nature Value farmland outside the Natura network may have little protection unless they lie within other designated landscape or nature areas (IEEP and Veen, 2005). Abandonment may therefore have significant impacts on EU and national nature conservation objectives.

On the other hand, in intensive farming (and in many extensive ones too) landscapes small-scale abandonment, even on a temporary basis, can be very beneficial (though it is relatively scarce). Variations in the landscape and patches of more natural habitat can be valuable, as was demonstrated by the now terminated arable set aside scheme. More importantly, in some locations large-scale abandonment could provide the opportunity for significant landscape-scale conservation benefits (eg rewilding). Such large-scale habitats may be more resilient to climate change and may also help to reverse the impacts of fragmentation, by creating/joining up large blocks of undisturbed habitat. This can provide the large areas of high quality habitat (and perhaps wilderness) that are essential for some species of very high conservation importance (eg top-level predators).

Whether or not abandonment has negative and positive biodiversity impacts, it is clear that it would be useful to know the likely scale and location of abandonment, so that necessary conservation interventions can be prepared for. For example, strategic planning and policy measures could help guide abandonment to areas where it could be most beneficial whilst protecting High Nature Value (HNV) farmland habitats. Furthermore, well targeted proactive habitat restoration and management (eg to overcome the impacts of long-term nutrient enrichment, impoverishment of seed banks and invasive species) could increase the likelihood that habitats of high nature conservation value develop following abandonment.

However, predicting the extent and location of future abandonment is a challenge. Abandonment often is a complex and gradual process, starting with progressive marginalisation (i.e. withdrawal of management) that leads initially to a reduction in farming intensity (eg lower stocking rates, withdrawal of grazing from the margins and infrequent cultivations). This can lead to various forms of permanent or transitional abandonment,

often influenced by specific local factors, including institutional factors. Furthermore, existing data on abandonment tends to be inconsistent, incomplete and out-of-date. It is therefore difficult to define and measure existing abandonment, and in turn understand the drivers of abandonment. Nevertheless, a number of modelling studies have indicated that widespread large-scale abandonment may occur in the EU in future. However, in some cases it is difficult to determine if the projections relate to actual land abandonment and some of the scenarios on which the projections are based may not be realistic given current trends in key drivers of abandonment and policy responses. Furthermore, there is some concern that the models are too deterministic and assume that land owners take decisions primarily on the basis of economic signals with little time lag. In reality it appears that farmers will continue farming even economic losses (by supplementing incomes in others way) for a variety of social and cultural reasons.

There is therefore a need for a critical review of the evidence for future agricultural abandonment and its likely extent and location.

1.2   Objectives of this assessment

The overall aim of this study has been to ascertain the likelihood of large-scale agricultural abandonment in the EU (and as far as data allow, other European countries) over the next 20-30 years, and its likely extent and locations. In particular through an examination of evidence of past abandonment, and trends in drivers of abandonment and results of modelled based studies, we:

- Summarise the extent and location of recent farmland abandonment, according to case studies and land use data.
- Indentify the proximate and ultimate drivers of abandonment, and examines their expected trends over the next 20-30 years. This includes an examination of the possible impacts of likely revisions to the Common Agricultural Policy (CAP), interactions with biofuel and biomass production policies and afforestation programmes in the EU, on abandonment.
- Review existing projections of land use change and abandonment in the EU from modelling studies, in terms of their extent and location, and examine their consistency and sensitivity with respect to model type, variables and scenario assumptions.
- Draw overall conclusions from the analysis of the available information on the likely scale and location of abandonment in the EU over the next 20-30 years.

2   DEFINING AND MEASURING FARMLAND ABANDONMENT

This chapter firstly defines farmland abandonment[1] and then provides an introduction to the main economic and environmental EU datasets which contribute to assessments of the location and extent of farmland abandonment in the EU (CORINE, LUCAS, FSS and FADN). These data sets are also used in a number of economic models that have been developed to

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[1] This study focuses on farmland abandonment (agricultural abandonment), rather than broadening the study to include, for example, abandoned forest land. Therefore, for the sake of brevity the terms *abandonment* or *land abandonment* in this study refer to *farmland abandonment* unless otherwise explicitly stated.

explore possible future land use changes in the EU. These models and their use of these datasets are described in Chapter 4, together with their results.

We then consider the evidence that these datasets provide on recent farmland abandonment in the EU-27, and the significance of the differences in extent, location and type of abandonment. This is followed by a short discussion of the apparent variability in abandonment at a range of spatial and temporal scales, and the effect of this and the scarcity of data on efforts to estimate recent abandonment and model risks of future abandonment.

2.1   Defining farmland abandonment

Farmland abandonment can be a complex and gradual process, starting with progressive marginalisation (i.e. withdrawal of management) that leads initially to a reduction in farming intensity (eg lower stocking rates or concentration of management in a reduced area of the farm or infrequent cultivations). Thus it can be difficult to define and recognise abandonment of various degrees, especially since it can also be temporary, transitional or permanent. In this study we recognise the following forms of farmland abandonment, (IEEP and Veen, 2005; Pointereau, 2008).

- Where the farmland is not used at all it can be characterised as **actual abandonment**. The vegetation may change through natural succession into tall herb, bush and forest ecosystems after a period, depending on climatic and soil conditions etc. On rich and wet soils the outcome is likely to be forest ecosystems but, in contrast, on poor dry soils in southeast Europe it can be a 'steppe' like grassland vegetation which is able to survive for many years without any active management by mowing or grazing.
- Where the land is used by the farmer but with a very low level of management, it can be described as **semi-abandonment or hidden abandonment**. The land is not formally abandoned and is subject to some form of management, which might be simply to keep it available for future use, for example for tourism. Such land may also be subject to the minimum management necessary to meet cross-compliance requirements (i.e. certain environmental conditions that must be met) by all those claiming direct payments so that the single farm payments and other CAP payments can be claimed. Very extensive or intermittent farming operations may also fall into this category, not least on semi-subsistence farms. Such extensive farming is generally associated with very low or zero direct economic returns, but may be continued for social reasons, to support other farm income streams (eg from hunting and tourism) or for nature and landscape conservation.
- **Transitional abandonment** has been observed particularly in EU-12 as a result of restructuring and land reforms, and in EU-15 as a result of compulsory set-aside (until this was abolished in 2008), or as a result of land use change.

Fallow land is not to be confused with abandoned farmland, and is included as a specific category in some agricultural datasets[2].

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[2] Fallowing is the management practice of leaving arable land in an uncropped state for a period of time prior to sowing another crop. Its purpose is to allow for the accumulation and retention of water and mineralised nutrients in the soil, and generally to also allow for weed control (OECD, 2001, glossary, pages 389-391).

To a certain extent these definitions reflect several different attitudes to farmland abandonment. In economic terms farmland abandonment may represent unused assets, but in socio-cultural terms abandoned land maybe a consequence of other pressures, such as in Germany in 1956, when the expression *Sozialbrache* ("social fallow") appeared, referring to farmland which is no longer agriculturally used due to social and structural change[3] (Moravec and Zemeckis, 2007). One possible new definition of farmland abandonment that has been discussed at the JRC (Joint Research Centre) is 'a significant decrease in management which leads to undesirable changes in ecosystem services' but although this deals with the different types of abandonment it also implies a somewhat subjective value judgement about the *impact* of farmland abandonment (in this case on ecosystem services).

The most important EU level data sets used in studies of land abandonment are described briefly below, their key characteristics and uses are summarised in Table 2.2, and a more detailed description is provided in Annex 1. Although it is beyond the scope of this study to assess and describe relevant national and sub-national land use datasets in detail, some are referred to below where they provide evidence of abandonment (eg the TERUTI land use survey in France).

2.1.1   CORINE Land Cover (CLC)

The EU established CORINE 25 years ago to create pan-European databases on land cover, biotopes (habitats), soil maps and acidification impacts. CORINE Land Cover (CLC) maps are based on satellite imagery and provide comparable digital maps of land cover for most countries of Europe at a 1:100 000 scale. The 44 standard CLC land cover classes have remained the same for the three CORINE inventories: CLC1990, CLC2000 and the current CLC2006. The agricultural land cover classes identified in CLC data are shown in Table 2.1, although some other land classes (for example, natural grasslands, moors and heathlands) may also be used for extensive pastoral farming. CLC is the only data source which provides information about the flows between the different land uses, estimating the withdrawal of land from farming and the conversion of farmland to artificial surfaces (Pointereau *et al,* 2008). By early 2010 the most recent CLC2006 coverage was complete for 25 of the EU-27 Member States.

There are problems of image interpretation in CORINE, for example in distinguishing between temporary, permanent and natural or abandoned grasslands and between pasture and meadows (EEA, 2006). The EEA validated CLC2000 data and found that although total reliability in this regard was 87%, there was subjectivity of photo interpretation in 18% of the samples. There were misclassifications between 'agriculture' and 'forest and semi-natural' and, at a more detailed level, there was subjectivity in several land cover classes potentially associated with land abandonment, for example 'agriculture with significant amount of natural vegetation', 'transitional woodland', 'shrub' and 'complex cultivation patterns', which cover transitional vegetation associated with land abandonment. CORINE has the additional problem that landscape features below a certain size are either attributed to neighbouring larger land cover features or shown as mixed classes (Nol et al., 2008, quoted in Britz *et al,* 2010).

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[3] For example, agricultural land near to the cities was abandoned as a result of the stronger income potential of city employment.

Table 2.1. CORINE Land Cover classes for agriculture

CORINE Land cover classes for agriculture
2.1   **Arable land**
2.1.1 Non-irrigated arable land
2.1.2 Permanently irrigated land
2.1.3 Rice fields
2.2   **Permanent crops**
2.2.1 Vineyards
2.2.2 Fruit trees and berry plantations
2.2.3 Olive groves
2.3   **Pastures**
2.3.1 Pastures
2.4   **Heterogeneous agricultural areas**
2.4.1 Annual crops associated with permanent crops
2.4.2 Complex cultivation patterns
2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation
2.4.4 Agro-forestry areas

2.1.2   *LUCAS (Land Use/Cover Area frame statistical Survey)*

LUCAS is a Eurostat field survey programme initially developed to estimate annual European crop areas, but is now used to gather statistics on land use and land cover in the EU, and ground evidence for calibration of satellite images. LUCAS data collection is based on ground observations by surveyors at sample points, using the same methodology and definitions across Europe (photographs are also taken). A new LUCAS survey began in 2008/09, using 230 000 survey points in 25 EU Member States, intended to provide results reliable at EU level down to NUTS 2 and NUTS 3 level. For the first time, soil samples are being collected to assess soil organic carbon and to update the European soil map, and in future other specific modules will be added to the survey – for example relating to biodiversity (Eurostat, 2010).

2.1.3   *FSS (Farm Structural Survey)*

The main purpose of the FSS is to follow structural trends in EU agriculture. A census of individual farm holdings is conducted every 10 years in all EU Member States, with three intermediate sample surveys in between. Information about land use, livestock numbers, rural development, management and farm labour input is collected at farm level, then aggregated at different geographic levels for publication by Eurostat. The FSS census only captures holdings above a certain threshold size, and it does not identify all land at risk of abandonment. For example, it includes fallow land[4] but excludes common grazing land (EEA, 2005). The latest FSS data are from 2007, but changes in threshold values for data collection have diminished the comparability of historic 1990 and 2000 data.

2.1.4   *FADN (Farm Accountancy Data Network)*

FADN is the only harmonised micro-economic EU database combining data on farm structure, input use and economic variables. The individual Member States collect accountancy data every year through a sample survey of their 'commercial' farms above a

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[4] The FSS defines fallow land as 'bare land bearing no crops at all, land with spontaneous natural growth (the normal weeds that grow on any land), which may be used as feed or ploughed in, or land sown exclusively for the production of green manure (green fallow)'

certain economic threshold, which varies from one country to another according to their agricultural structures.

FADN is statistically representative at NUTS 0, 1 and 2 levels[5], tends to under-represent the smallest farms, and provides data only on the total value of expenditure on certain inputs (such as fertilisers, pesticides, feedstuff, energy, water, etc.) for the holding as a whole, rather than recording the volumes of inputs used in specific production activities. The EEA (2006) suggested that the survey could be broadened to record the input volumes alongside the expenditure on inputs, and in some Member States, some input data are already available in the national FADN data sets. Despite these limitations, the combination of variables in one data set is helpful in linking different issues, and FADN has been used in the past for exploring general trends in intensification/extensification and in identifying high nature value (farmland) areas (IRENA indicators). More recently FADN data have been used in applications of the CAPRI models and will be used in the development of new agri-environment indicators.

Table 2.2 Characteristics and uses of EU data sets relevant to land abandonment

Data set	Coverage, scale, source, frequency, and type of data	Uses relevant to land abandonment
CORINE Land cover	EU-27 1:100 000 scale Satellite imagery (interpreted) 1990, 2000 and 2006 Maps and data sets of 44 land cover types (11 agricultural) Land flow data	• IRENA indicators (until 2005, for EU-15) • CLUE and other economic and environmental models (see below) • for a new agri-environment indicator of land abandonment (see Section 3.7.2 for details)
LUCAS Land use and land cover	EU-25 (excluding CY and MT) NUTS 2 and 3 Ground observations at sample points From 2008-09 Land use, land cover, photographs, physical samples (eg of soil)	• calibration of satellite imagery • update European soil map • possible future ground observations of land cover and land flows
FSS Farm structure	EU-27 Individual holding, aggregated from NUTS 5 to 0 Information supplied by farmers to Member States Every 10 years (1990, 2000 …), plus intermediate sample surveys Land use, livestock, labour	• JRC analysis of farmland abandonment (Pointereau, 2008) • CAPRI-Spat (see below)
FADN Farm economics	EU-27 NUTS 1 and 2 Sample of 'commercial' farms Accountancy data collected by Member States Annually	• IRENA indicators (until 2005, for EU-15) • CAPRI models (see below) • for a new agri-environment indicator of land abandonment (see Section 3.7.2 for details)

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[5] http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction

2.2   Evidence of recent farmland abandonment

There is relatively little literature on recent farmland abandonment, and no EU wide studies, but it is clear from smaller studies that the causes and extent of abandonment are not the same across Europe (Moravec and Zemeckis, 2007), and vary both temporally and spatially.

This is illustrated by studies of land use changes in countries of the former Soviet Union over the past 20 years, as they adjusted to a market-based economy and EU membership. The post-Soviet land restitution process in many EU-12 countries has been burdened with structural issues, and in many cases the small scale and fragmented land ownership has taken extreme forms. Land abandonment became a major problem, accelerated by the collapse of many collective farms, the retirement of an older generation of more traditional farmers and by the migration of young people to urban areas (Pasakarmis and Maliene, 2009). Using remote sensing images for 1986, 1988 and 2000, Keummerle et al (2008) found substantial differences between countries in the proportion of abandoned agricultural land, with 20.7% abandoned in Slovakia and 13.9% in Poland. Within Poland, cropland abandonment rates were twice as high on previously collectivised land than in areas that had remained in private ownership. In Romania, in Argeş County 21% of the 1990 cropland had been abandoned by 2005, with isolated cropland patches and rougher terrain most at risk, as a result of market forces affecting the profitability of cultivation (Muller and Kuemmerle, 2009). Such institutional changes are exceptional and much of the abandonment will be transitional but substantial areas have not returned to production. Even in the more stable economy of Switzerland, studies of alpine land abandonment have shown how difficult it is to predict causes and patterns of land use change (Gellerich *et al,* 2007; Gellerich and Zimmermann, 2006).

In developing a methodology to quantify abandonment in the EU and assess the drivers of land abandonment, the constraints on data availability led Pointereau et al (2008) to use a data-driven definition of abandonment as 'the loss of UAA in rural areas between FSS surveys, excluding farmland converted to artificial areas'. The study acknowledges the shortcomings of this definition. Although FSS provided data at a sufficiently small scale (although it can be difficult to access at LAU 2[6] level), the time-delay of 10 years between full FSS surveys meant that the most recent data they could compare for the three Member States studied in detail (France, Spain and Poland) was for the 1990s, pre-dating the two most recent reforms of the CAP and EU enlargement. FSS data excludes common land (possibly at significant risk of abandonment) and cannot be used to identify how much of the UAA loss is farmland converted to forestry; including plantations (and forestry data are not available at a sufficiently detailed scale). This means that the estimates of abandoned farmland in this study will be an overestimation because they include land which was not abandoned, but afforested. On the other hand the net loss of UAA calculation tends to underestimate the extent of farmland abandonment in another respect because it masks the flow of land use change. Some abandoned or unused farmland will not be included in the calculation, because it had been converted to artificial surfaces during the survey period. The extent of land flows is illustrated in Figure 2.1 with data from the more detailed national TERUTI land use survey in France.

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[6] ie Local Administrative Unit level 2 (formerly NUTS level 5) consists of municipalities or equivalent units in the 27 EU Member States.

Figure 2.1. The main land use flows in France during 1992-2003 (source: TERUTI, in Pointereau, 2008)
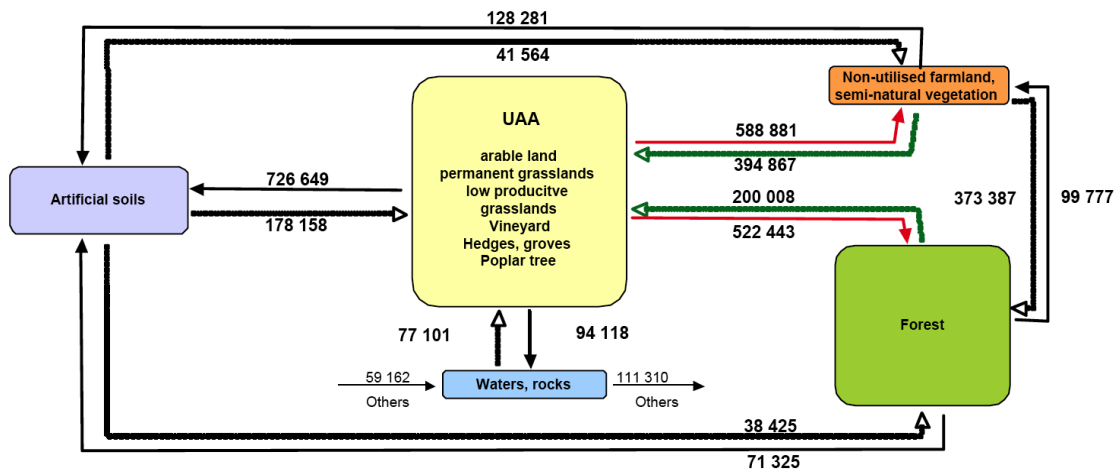
Pointereau et al (2008) illustrate very clearly the advantages of using small scale LAU2 data (and the risks of using larger scale NUTS 2 data) by comparing maps of changes in UAA in Spain between 1989 and 1999 (Figure 2.2). In both maps the red areas indicate the areas with the greatest loss of UAA, but the smaller scale map shows clearly that the losses of UAA are unevenly distributed within each NUTS 2 area, and that they vary in severity from less than 5% in some municipalities to more than 50% in others.

Figure 2.2. Comparison of representations of changes in UAA at LAU2 and NUTS 2 (Pointereau *et al,* 2008)
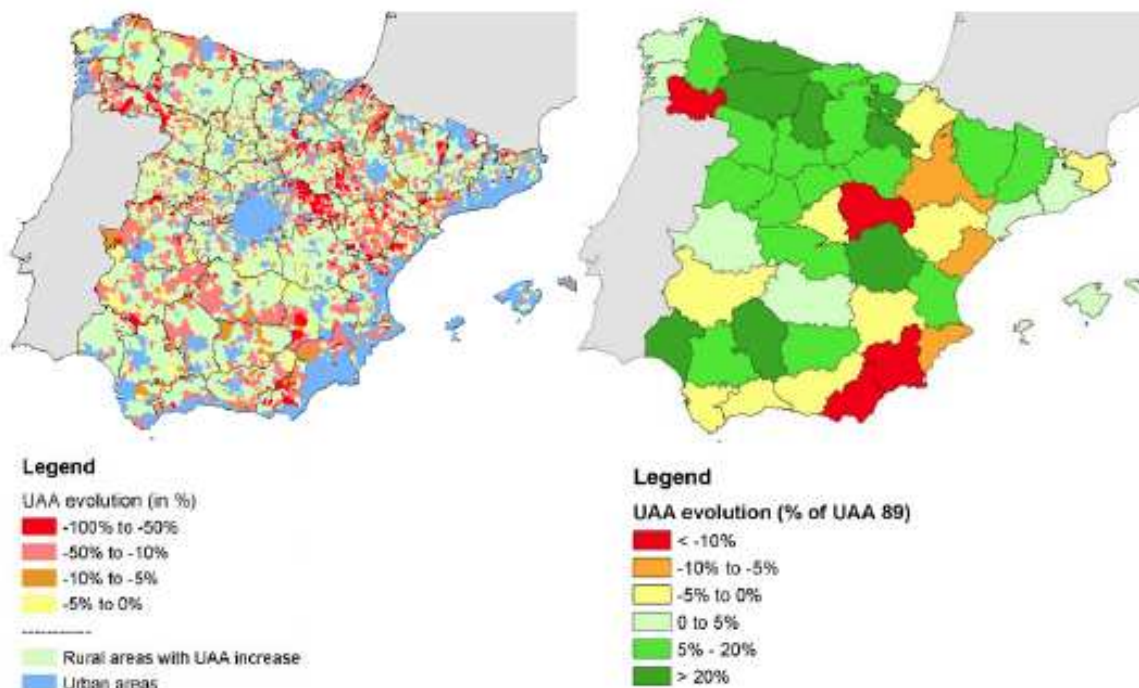
Pointereau argues that the process of farmland abandonment should only be studied at a regional level with detailed agricultural data available at municipality level (LAU 1 and LAU 2 levels), and that FSS data should be made publicly available at LAU 2 level. The study concluded that farmland abandonment – in terms of UAA loss - for the periods considered[7] represented a total surface of 3.3 million ha for the 3 countries, with 2% of the total UAA lost in France (0.17% per year), 4% in Poland (0.66% per year) and 8% in Spain (0.8% per year).

Farmland abandonment and an increase in the UAA were observed to happen simultaneously in Spain, pointing to a relocation of production, and confirming the view that net UAA change is not sufficient to identify the extent of farmland abandonment. To obtain a more accurate picture it is necessary to consider the flow of land between different uses, and at present the only available data on this is from CLC assessments (see Section 2.2.1 above). Feranec et al (2010) used CLC data to quantify agricultural intensification / extensification and changes from one land use to another (ie flows of change) in 24 European countries for the period 1990–2000. The overall land cover flow was around 88,000 km^2, equivalent to 2.5% of the total area, but there were striking differences between countries both in the overall flow and the driving processes. The greatest changes in land cover were found in Portugal, with 9.85% of the total country's area changing, followed by Ireland at 7.91% and the Czech Republic at 6.43%. In contrast Austria, Slovenia, Bulgaria and Poland showed land cover changes of less than 1% of the total area. Different processes appear to be driving the changes in different parts of the EU. Urbanisation was most conspicuous in the Netherlands (2.1% of the total area), intensification of agriculture in Ireland (3.3%), extensification of agriculture in the Czech Republic (over 3.5%), both afforestation and deforestation in Portugal (more than 4% and 3.5% respectively) and the construction of water bodies in the Netherlands and Slovakia (over 0.1%).

The same CORINE data sets were used in another study to map areas of land abandonment (Figure 2.3), but IEEP and Alterra (2010) comment that areas of land use change within the CLC 1990-2000 land cover change dataset do not correspond with reported 'hot-spots' of change from case studies. In a small number of countries the 'hot-spots' of land abandonment on the land cover map correspond to areas frequently cited as facing abandonment (for example, the Italian mountain areas (Falcucci *et al,* 2007)).

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[7] 1988-2000 for France, 1989-1999 for Spain and 1996-2002 for Poland
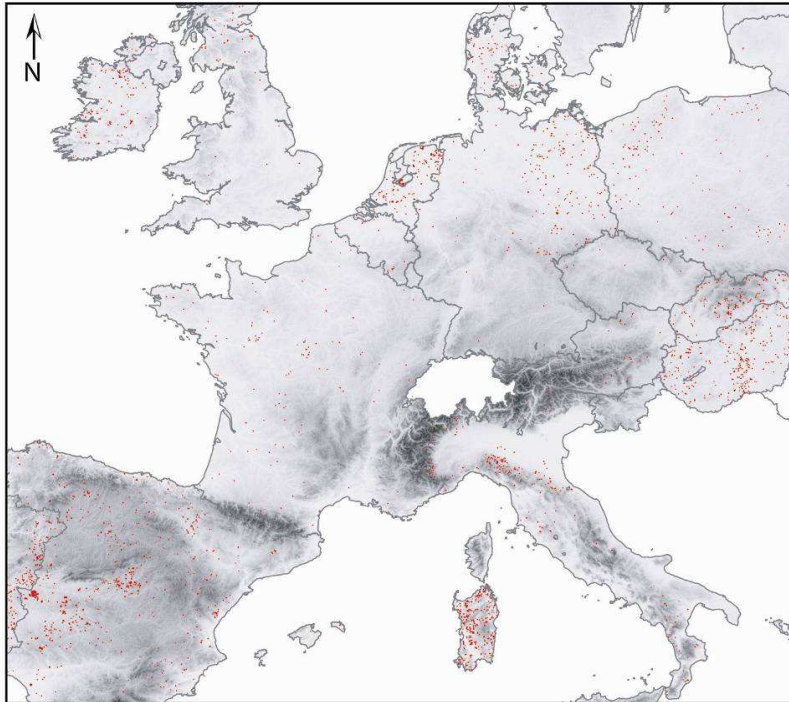
Figure 2.3. Areas of land abandonment (red) according to the CLC1990-2000 dataset (IEEP and Alterra, 2010, derived from remote sensing interpretation of the CORINE database (EEA, 2005; Haines-Young and Weber, 2006)).

However, other mountain areas that are mentioned in literature as 'hot-spots' of agricultural abandonment do not appear in this map for the larger part of Europe (for example, the Pyrenees, the Massif Central area of France, the Austrian alps, the mountain areas of Germany, and most of the 24 mountain areas reported by MacDonald et al (2000). These large apparent discrepancies between CLC and case study data can partly be attributed to the problems of interpreting land cover from satellite images, and to other land use/land cover discrepancies (IEEP and Alterra, 2010). Verburg and Overmars (2009) also note that it is difficult to distinguish abandoned farmland from CLC data due to its spectral resemblance to grassland. In addition alternative uses of former agricultural land as for hobby farming cannot be distinguished from land cover data.

2.3   Case Studies of recent farmland abandonment

2.3.1   *Regional differences in abandonment and intensification in Finland*

Monitoring of the structure of agricultural landscapes in four regions in Finland over the 15-year period 1990-2005 showed that the area of intensively managed arable fields dropped by 4%, and by 16% in East Finland, the least productive region. Overall, the area of extensively managed meadows, abandoned fields and long-term fallows increased by 19%, especially in South-Western Finland where there was a 39% increase, but in Pohjanmaa, the most intensive dairy region, extensively managed land decreased by 12%. The increases in extensively managed land have been mainly in the area of abandoned fields and long-term fallows, while the area of meadow has dropped by 9% on average, but by 51% in East Finland. More than three-quarters of the lost meadows were turned into forest, with the forest area increasing by 3% on average and by 7% in East Finland. Bushes and trees have

increased everywhere, with some habitats overgrown, and there has been a negative impact on species associated with intensive arable fields and a positive impact on extensive habitats and forests (Kuussaari et al 2008).

2.3.2   Land use and land-cover change in the Carpathians after 1989

Local−scale studies are important for understanding fine-scale patterns and drivers of land use and land cover changes, but regional and trans-national studies may capture a broader range of underlying drivers, particularly differences in social and economic factors and policies. At the regional scale, analysis of multi-temporal satellite images of approximately 18 000 km^2 in the border region of Poland, Slovakia and Ukraine revealed widespread land-use change after 1989, with rates of change and spatial patterns differing markedly between regions and countries. Up to 15–20 % of the cropland used in socialist times was abandoned after the system change in all countries, probably as a response to the decreasing profitability of agriculture and changes in ownership. Topography, accessibility of farmland, land-use patterns, as well as land ownership regimes during socialism and land reforms after 1989, strongly determined the spatial pattern of abandonment (Kuemmerle *et al,* 2008 and Kuemmerle *et al,* 2009 quoted in EEA, 2010).

2.3.3   Recent land use changes in the new EU Member States

During the last decade twelve new Member States joined the EU, most of them former Soviet countries that were still undergoing major social and economic changes, which had already led to significant abandonment of farmland. At the same time major changes were taking place in the EU policies that were being phased in across Eastern Europe, notably the CAP. This appears to have resulted in high rates of land abandonment compared to elsewhere in the EU, over a particular period of time.

IEEP and Veen (2005) noted that that the scale of land abandonment varied according to a range of local conditions. In the Baltic countries and Poland land abandonment was concentrated in regions where the productive capacity of the soil was low as a result of wet, peaty soils or poor moraine soils. In Central Europe, it was found in hilly areas with poor sandy soils and in river valleys with wet soils. In contrast land abandonment in south-eastern Europe was more prominent in dry plains where irrigation systems had collapsed, and in mountainous areas where traditional pasturing has ceased.

In an attempt to quantify the extent of land abandonment, the 2004-06 Rural Development Programmes were analysed but precise data could only be found in the plans for Poland and the three Baltic countries, which shows that in 2002:
- in **Poland 17.6%** of the agricultural land was abandoned, and in some provinces the rate of abandonment increased strongly between 1998 and 2002, for example with increases of 100% or more in Mazowieckie, Lubelskie, Podkarpackie and Podlaskie;
- in **Estonia 10.1%** of the agricultural land was abandoned, with south-eastern Estonia, the west coast and the islands particularly affected;
- in **Latvia 21.1%** of the agricultural land was abandoned, and the Latgale region was particularly affected. The main problems driving abandonment appeared to be poor soil, unfavourable climatic conditions and the small scale of farms;

- in **Lithuania 10.3%** of the agricultural land was abandoned, with poor soils and unfavourable economic conditions mentioned as the main factors (IEEP and Veen, 2005).

The scarcity of published studies and the infrequency of time series data sets makes it very difficult to find out what has happened in these and other EU-12 countries since then. The CLC 2006 data have just become available, and the ten-yearly FSS census data are being collected this year, so it will be some time before work based on this new data is published.

However, unpublished data for Poland suggest that between 2002 and 2005, the situation changed and in three years the area of abandoned land (mainly arable) decreased by more than 30%. In Bulgaria there are no official data on abandoned agricultural land, but government statistics record 'non-utilised land', which is defined as arable land that has not been included the crop rotation for at least two years, but could be brought back into production without significant work (grasslands appear to be excluded). Between 2008 and 2009 the area of this 'non-utilised' arable land appears to have declined by 15.9%, but at the same time the total area of UAA also decreased (and also, it is assumed, the area for which CAP Single Area Payments was claimed). It is unclear how much of the 86,853 hectares of unused former arable land was brought back into cultivation in 2009, and how much was abandoned or converted to other uses.

Table 2.3 Changes in agricultural areas in Bulgaria between 2006 and 2009 (Bansik No. 151/2009 www.mzh.government.bg, quoted by Stefanova, V. *pers comm*)

	2009		2008		2007		2006	
Area	ha	**% of territory**	ha	**% of territory**	ha	**% of territory**	ha	**% of territory**
Non-utilised agricultural land	460,528	4.1	547,381	4.9	550,116	4.9	519,680	4.7
UAA	5,029,585	45.3	5,100,825	46	5,116,220	46.1	5,190,053	46.8

Anecdotal evidence suggests that in parts of EU-12 some formerly abandoned arable areas have been taken back into cultivation, but other land remains unused, while some grassland has been converted to arable. In other places whole villages have been abandoned. The causes are likely to be complex, highly variable from place to place and may include factors such as rural depopulation, disputed or uncertain tenure, loss of local markets, decline of semi-subsistence farming, availability and cost of labour, capital and inputs and impacts of agricultural and economic policies.

2.4 Discussion and conclusions

Land abandonment is a dynamic process driven by many factors, and the choice of different time spans and different regions for study can be expected to give very different results. The availability of time series data has shaped the design of the studies quoted here, which mostly span a period of significant change, particularly in many of the EU-12 Member States. The timing of data collection, and the time lag to publication of EU-wide data sets, mean

that published studies of land abandonment tend to be several years out of date, and it is surprisingly difficult to find information on recent land abandonment or re-use of formerly abandoned land. On the basis of available literature, which mostly covers the period from the mid 1980s to 2000, it is clearly very difficult to obtain an accurate picture of land abandonment, even at a small scale, using the best available data, as Pointereau et al (2008) illustrate.

On the basis of the above analysis we draw the following specific conclusions:

- Environmental data sets such as CORINE, using satellite imagery, have a limited ability to identify abandoned farmland reliably. It is difficult to distinguish abandoned land from other land cover such as semi-natural grazing land still in agricultural use, fallow land and naturally regenerating forest. This, together with problems of over and underestimation limit the usefulness of CORINE, but it remains the only pan-European set of land cover data, and is widely used in computer modelling.

- Agricultural data sets such as FSS and FADN collect structural and economic information at farm level, more frequently than CORINE, but exclude some farms and land at high risk of abandonment; the value of FADN would be improved if the detailed farm-level data were attributed to specific enterprises, rather than collated for the whole farm.

- The recently developed field survey programme LUCAS is a potentially promising new source of information, which might be useful in validating or supplementing land cover and agricultural data.

- To understand farmland abandonment it is essential to have farmland data at a sufficiently small scale; to have data on forest land available at the same scale; and to be able to understand flows of land between different uses, not just the apparent net loss or gain. This information is simply not available concurrently. There is a generic problem that abandonment is difficult to distinguish from the planned expansion of woodland, including via natural regeneration. Nearly all data sets suffer from this weakness.

- Some of the contributory causes of land abandonment are locally specific (eg poor or exhausted soils and steep slopes) and some may be temporary (afforestation policies, land restructuring); this suggests that there are considerable risks of extrapolating results from one time period to another, and from one region to another;

- There appears to be such a wide variation in land abandonment between and within regions of Europe that there are limits to the value of an EU-wide approach, using agricultural data, either for studying past abandonment or for predicting areas at risk of abandonment.

3   DRIVERS OF FARMLAND ABANDONMENT AND THEIR LIKELY TRENDS

The studies of past abandonment reviewed in Chapter 2 clearly indicate that abandonment of farmland, whether temporary or permanent, is influenced by a complex range of drivers, which vary over both time and space. As a result, land use change is characterised by a high diversity of change trajectories depending on the local conditions, regional context and external influences (Verburg *et al,* 2007). Farmland abandonment is influenced by drivers of both agricultural intensification and marginalisation, which interact with each other, sometimes in complex and dynamic ways and over varying timescales. The response of farmers is very context specific, and similar combinations of drivers can produce quite different responses, depending on the farming system, biophysical conditions (soil, slope,

altitude, climate), farm structure, the availability of additional factors of production (land, labour and capital), and social circumstances.

This chapter considers some risk factors for land abandonment and the key drivers that may influence future abandonment, including agricultural and biofuels markets, social factors, the CAP and other EU policies, and the impacts of climate change on agriculture.

3.1 Risk factors for land abandonment

Land abandonment is one possible outcome of a process of marginalisation driven by a combination of social, economic, political and environmental factors, by which certain areas of farmland cease to be viable under existing land use and socio-economic structures. Marginalisation is a dynamic concept, related directly to the conditions at the moment of analysis and depending on a multitude of factors, including the geographical situation and the age, financial resources and character of the farmer concerned (Pinto-Correia and Sørensen, 1995). Marginalisation takes a variety of forms and occurs at different scales, ranging from the individual patch of land to sizeable regions (Baldock *et al,* 1996). Depending on individual circumstances and opportunities available, economic marginalisation may lead to many very different responses from farmers. These are summarised in Table 3.1 below, and include changes in the type and intensity of production (to reduce costs or increase market income), different forms of abandonment, land transfers and restructuring or a change of land use out of agriculture altogether.

Table 3.1. Farmers' responses to drivers of marginalisation (after Brouwer *et al,* 1997)

The different responses of farmers to the economic viability of their current farming system becoming marginal depends on a complex mix of factors at the time, but will have a series of consequences for the land-use pattern, landscape and ecosystem services of a region. Possible responses at farm level include:

- attempts to improve farm income by intensifying production and increasing output per hectare, especially where investment aid is available (for example, the production-oriented grants in most EU Member States during the 1960s and 1970s were a significant driver of intensification, and current EAFRD Axis 1 investment and restructuring support could have the same effect in EU-12 Member States).

Where increasing the productivity of existing farming systems is not an option, other choices aimed at maintaining economic viability include:

- a change from one agricultural land use to another, eg from crops to permanent grassland, typically involving the simplification of a mixed farming system into livestock production only;
- changes within farming systems eg reduced inputs, labour and/or stocking densities, reduced maintenance of infrastructure (often known as 'extensification' in English);
- a 'contraction' of the farming system, usually involving an intensification of production on the better land and the running down or abandonment of poorer, less accessible parcels;
- restructuring of holdings as some farmers leave the land and others take it over in order to increase their farm size (often known as 'extensification' in French);
- complete or partial abandonment, or cessation of productive farming while complying with cross-compliance standards in order to obtain CAP income support payments;
- a change of land use out of agriculture, for example to forestry recreation or urban building.

Given the complexity of the driving factors, their dynamic nature and the differing responses of individual farmers, it is very difficult to generalise about specific causes of land abandonment, or predict exactly where and when it will occur. Observers have identified a range of contributory factors in localised studies, for example steep slopes, soil quality, distance from roads (Gellrich and Zimmermann, 2006), small field size and farm succession

problems (Mottet, 2005). A recent overview study of the extent, location and risks of farmland abandonment found a strong relationship between farmland abandonment and farming type, particularly for extensive, traditional grazing systems on rough grasslands, and also an association with low farm income, which may be in turn linked to other variables, such as small farm size, small parcel size, lack of investment and poor soils (Pointereau *et al*, 2008). This study synthesised the factors indicating risks of farmland abandonment from an overview of the literature, as summarised in Table 3.2.


Table 3.2 Factors indicating risk of land abandonment (after Pointereau *et al*, 2008)

Geographic
- Steep slopes
- Distance from the farm to the field
- Low accessibility
- Small field size

Agro-ecological
- Poor soils
- Alpine pastures
- Small parcels

Demographic
- Decrease in number of workers
- Decrease in number of farmers
- Population changes (immigration, emigration)

National and EU policies
- Sometimes problems in renewing agri-environment contracts after 5 years duration.
- New CAP sanitary requirements from in eastern European countries since 2004
- Decoupling of direct payments from production

Socio-economic
- High cultivation costs and low yield potential
- Decrease in livestock numbers
- Low land price
- Farmers close to retirement without successors
- Difficult farm inheritance because of discord between children and parents
- Very small farms
- Other institutional factors

Historical
- For Eastern European countries, transition to free market economies with a breakdown of the agricultural economy during the 1990-2004 period

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Brouwer et al (1997) identified two types of region that they considered to be susceptible to marginalisation, and hence at greater risk of abandonment. One type is characterised by extensive agriculture, where the stocking density of grazing livestock was very low (0.6 LU[8] per ha of forage crops), and the other by more intensively managed small-scale farms (average size 5 ha), many of them growing permanent crops. This analysis pre-dated the EU-12 accession, which brought into the EU significant areas of very small farms (many of them semi-subsistence).

Figure 3.3 illustrates how much variation there was across the EU in 2005 and 2007 in the proportion of total farmland that is forage land with low livestock densities, one indicator of extensive livestock farming. The EU-15 data covers the period 2005-07, when decoupling of livestock payments was implemented, suggesting that the apparent increase in the proportion of UAA which is extensively managed farmland may be the result of farmers reducing their stocking rates when their direct CAP payments were no longer linked to the number of animals they kept. In the Baltic countries, Portugal, Sweden and Austria more than 40% of the farmed land has livestock densities less than 1 LU per forage ha, in contrast to Ireland, the Netherlands and Belgium which, although important livestock farming areas, appear to have had no large scale extensively managed forage land in 2005 or 2007.

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[8] Livestock Unit: one Livestock Unit is usually defined as the grazing equivalent of one adult dairy cow

Figure 3.3. Percentage of Utilised Agricultural Area (UAA) with livestock density <1 LU/ha forage area in 2005 and 2007 (excluding Bulgaria) (source: own chart based on summary table 3.4.3.2 of areas of extensive agriculture in EC, 2008 and EC, 2009)
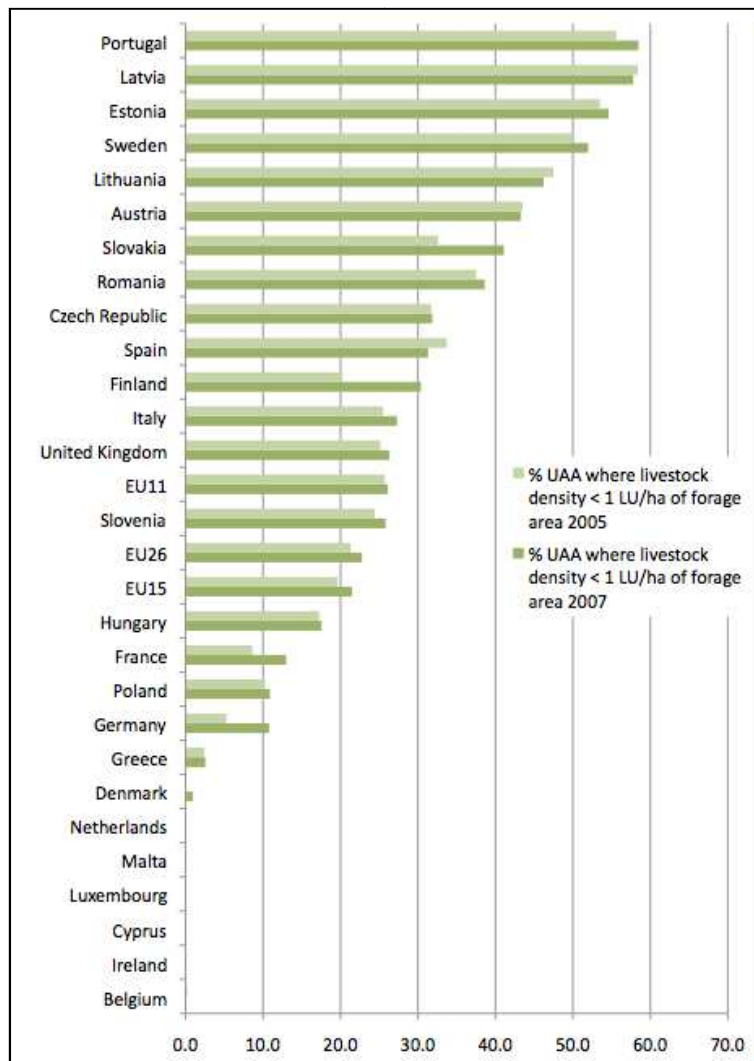
The structural scale of farms affects the ability to use certain machinery and technologies, the availability of labour, and the opportunities to maximise returns per hectare by changes to stocking and cropping. Smaller farms have several attributes which may, in principle, result in their adopting less intensive management techniques. These include constraints on economies of scale achievable, limited access to capital in many cases and the disproportionate representation of more traditional part-time and organic producers. (Cooper *et al,* 2009). Figures 3.4 and 3.5 illustrate the importance of semi-subsistence farms in EU-12 and the Mediterranean area, although these data should be interpreted with care. A high proportion of very small farms does not indicate the proportion of the UAA they occupy, and not all these farms are necessarily at risk of marginalisation leading to abandonment – in the UK, for example, the apparent number of small farms rose significantly when the decoupled Single Payment Scheme was introduced, as 'hobby' farmers registered for the new payments. Nevertheless, in some of the new Member States a significant area of land occupied by small farms is at risk of marginalisation and possibly abandonment.

Figure 3.4. Distribution of physical farm size in the EU, 2007 (source EC, 2009, derived from FSS data)
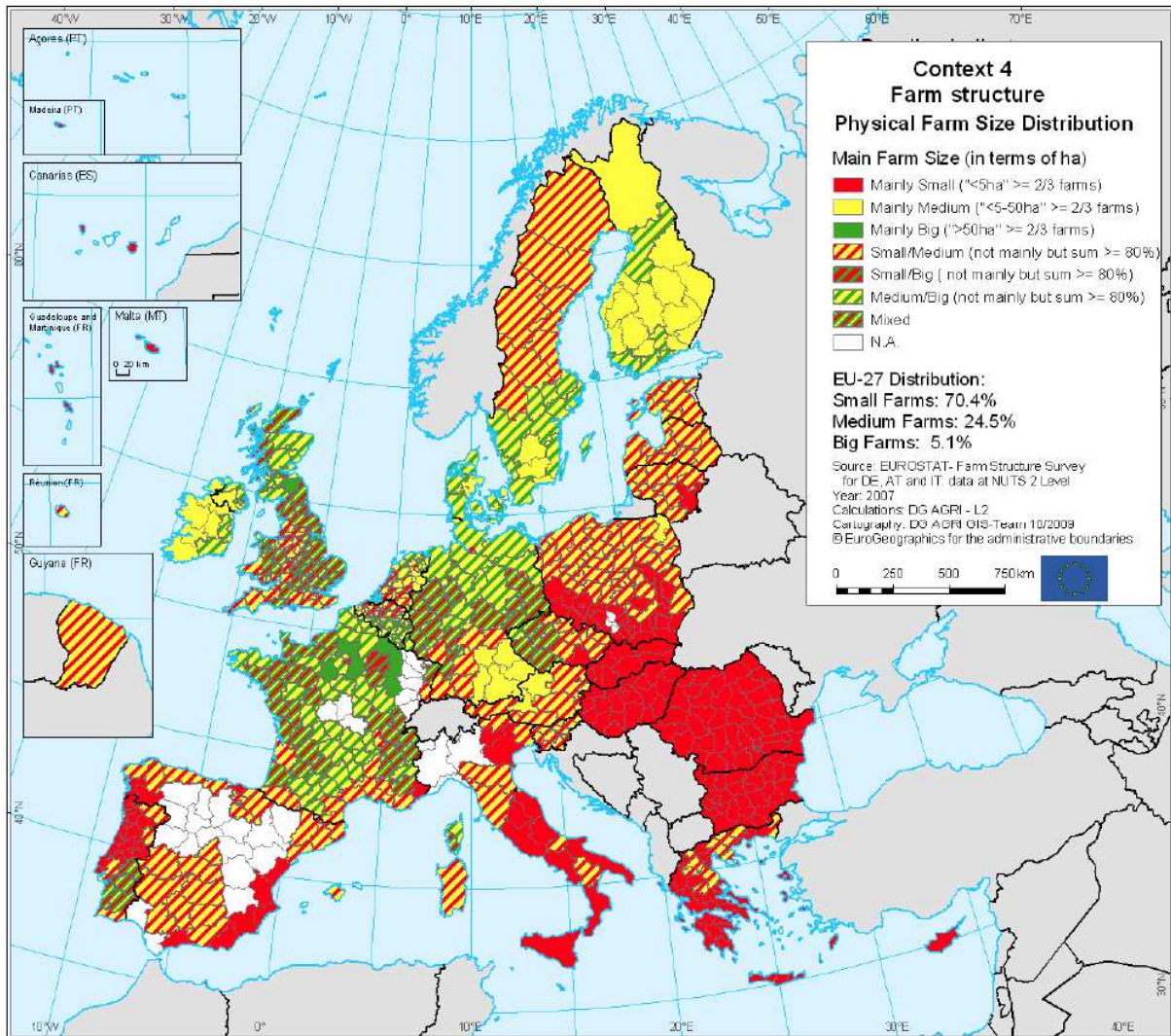
Figure 3.5. Proportion of semi-subsistence farms, 2007 (<1 ESU[9]) (source EC, 2009, derived from FSS data)
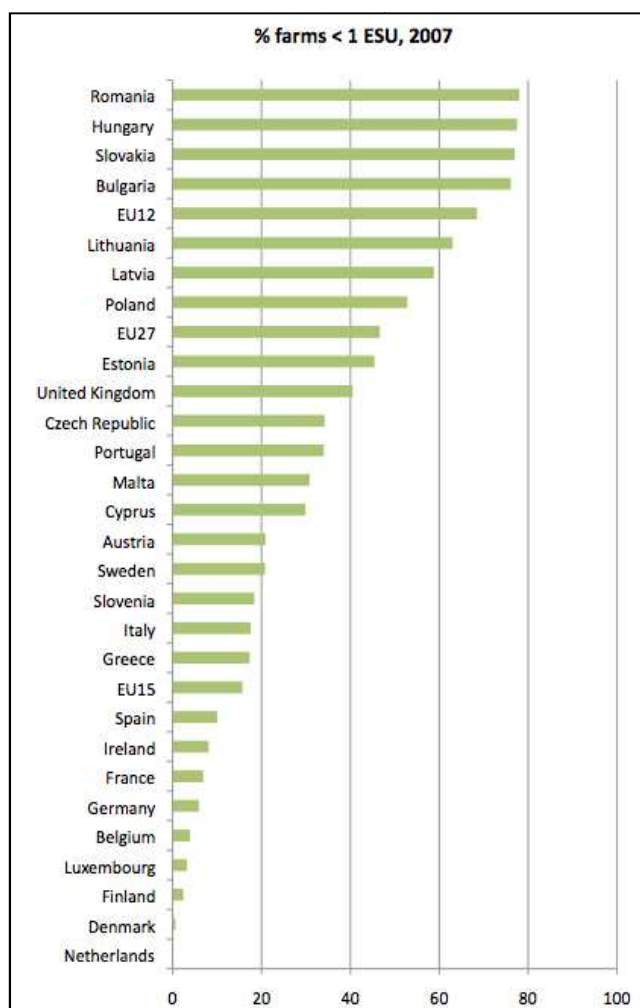
A report on rural areas in the new Member States completed just before accession found a detectable tendency for migration away from peripheral regions to the capital regions, especially by young people, with metropolitan suburbs particularly gaining in population (IAMO, 2004). Rural regions in the eastern Member States and at the southern and northern borders of the EU are distinctly more marked by population decrease than Western Europe. In 2007, the eight EU Member States reporting an overall population decline were Bulgaria, Germany, Estonia, Latvia, Lithuania, Hungary, Poland, and Romania (Nowicki *et al,* 2009). Young people may be unwilling to take on farms that are economically marginal, if they can find better employment opportunities and higher standards of living in urban areas. Figure 3.6 illustrates the ratio of older/younger farmers across the EU in 2007, the red and orange colours indicating where there are relatively high proportions of older farmers. A change in ownership of farms, particularly a generational change, may often be accompanied by changes to land management or farm structures, and lack of successors may lead to abandonment.

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[9] ESU, is a standard gross margin of EUR 1 200 that is used to express the economic size of an agricultural holding or farm

Figure 3.6. Ratio of farm holders <35 years/>55 years, 2007 (source EC, 2009, derived from FSS data)
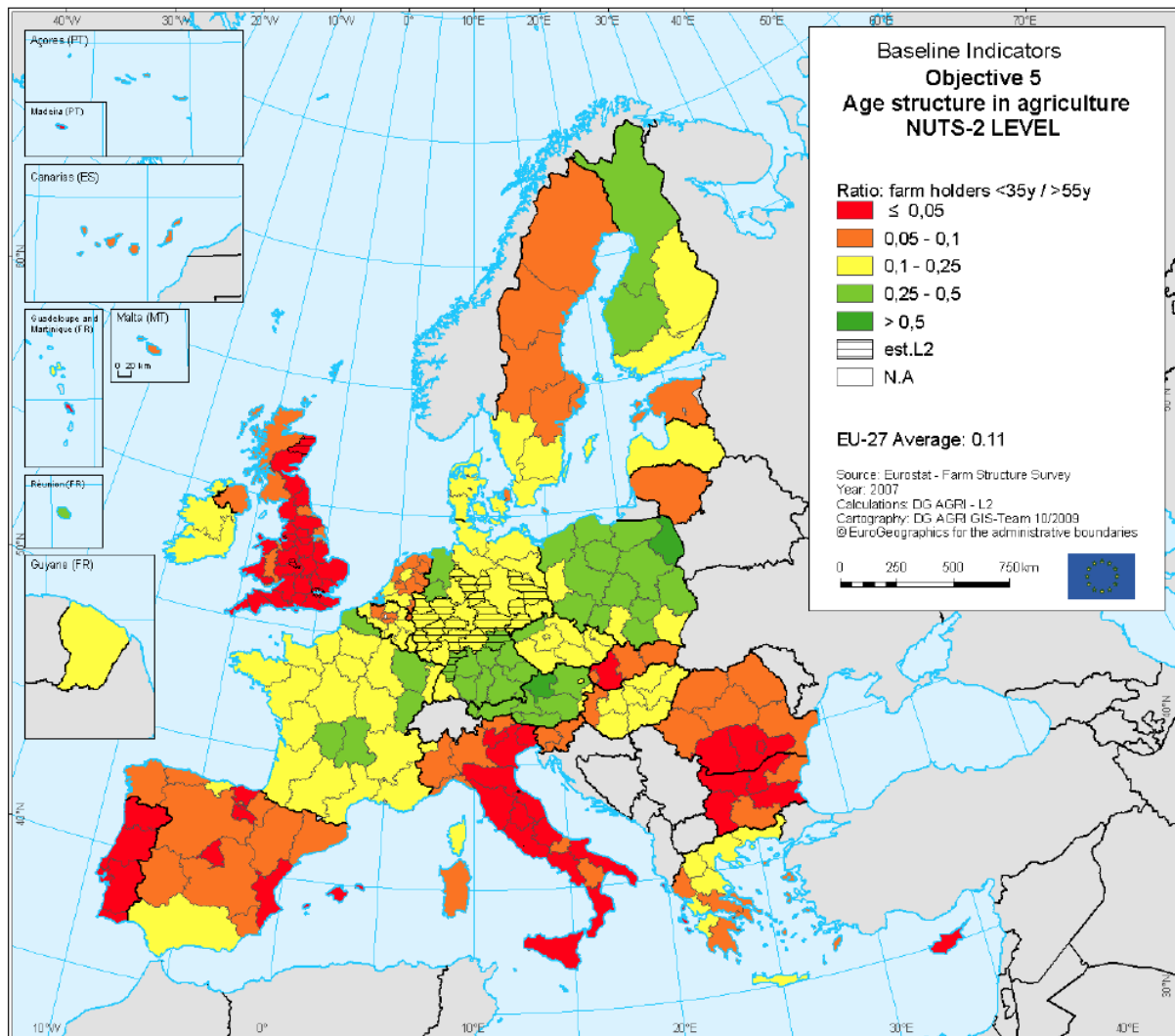
3.2   Agricultural commodity markets

The world population is projected to rise to 9.1 billion in 2050 from a current 6.7 billion, and the FAO estimates that a 70% increase in farm production will be required over the next 40 years, coming mostly from yield growth and improved cropping intensity rather than from farming more land[10]. Although the population in the EU and other developed regions of the world is not expected to increase as sharply, EU annual per capita consumption of meat is projected to increase from 85.1 kg/head in 2008 to 87.6 kg/head in 2015 (DG Agriculture, 2009).

International commodity prices in the next decade are anticipated to be higher, on average, than in the decade before the price spike of 2007-08, as shown in Figure 3.7 below. This forecast is based on the resumption of economic growth, above all, in developing countries, increased demand due to rising biofuel production, and anticipated higher costs of energy related inputs. Since the price spike of 2006-08, short-term price volatility has increased

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[10] FAO Director-General Jacques Diouf opening statement of the Forum on How to Feed the World in 2050, held 12-13 October 2009 in Rome

considerably, but the evidence is inconclusive as to whether and how price volatility has changed over the long term for the major food crops. Average wheat and coarse grain prices are projected to be nearly 15-40% higher in real terms in 2010-19, relative to 1997-2006, while for vegetable oils real prices are expected to be more than 40% higher. Average meat prices in real terms, other than for pigmeat, are expected to surpass the 1997-2006 average over the coming decade initially due to lower supplies, higher feed costs and rising demand. Average dairy prices in real terms are expected to be 16-45% higher in 2010-19 relative to 1997-2006, with butter prices showing most gains, supported by higher energy and vegetable oil prices (OECD-FAO, 2010).

Figure 3.7. Average commodity prices 2007-08 and predicted for 2010 – 19 (source OECD-FAO, 2010)
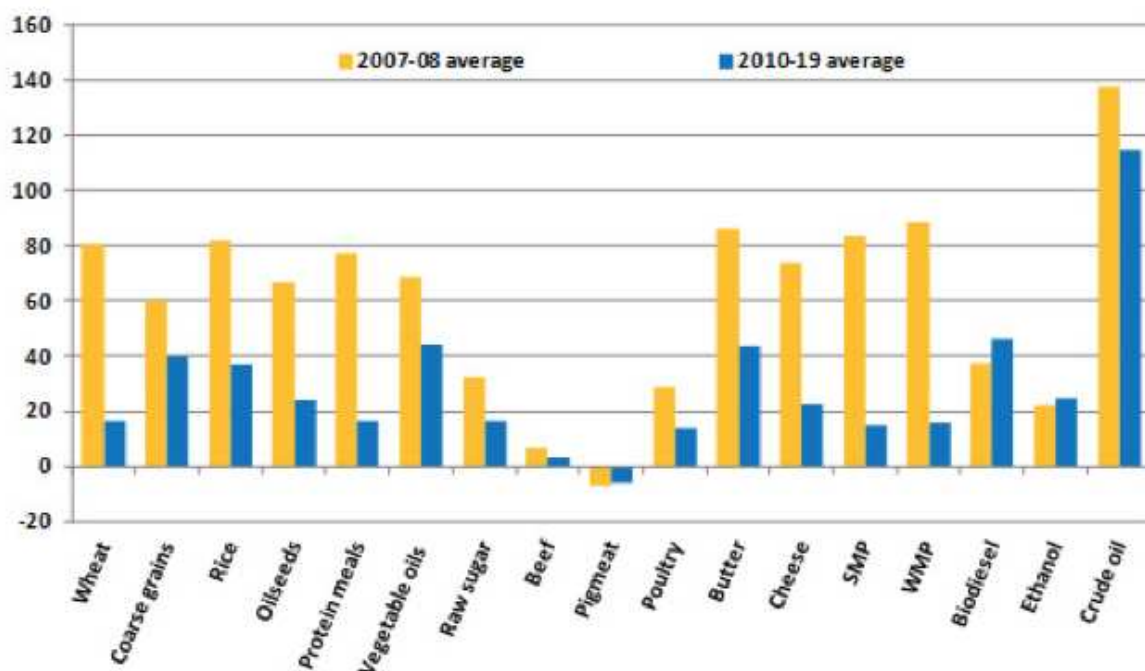
One of the main factors in rising crop prices is production costs, which are particularly sensitive to crude oil prices, also projected to rise significantly. Agricultural commodity production other than wheat and coarse grains is expected to shift increasingly towards the world's developing regions, especially for meat and dairy products. EU cereals production, after the peak of 2008/09 with more than 310 million tonnes, is projected to decline slightly over the next couple of years before growing over the medium term and reach just above 300 million tonnes, by 2015. Some of this increase has come from the more than 3 million hectares of former set-aside land, much of it already returned to production. Wheat will remain predominantly a food commodity, but the share of vegetable oil used for biodiesel is expected to increase worldwide from 9% in 2006-08 to 20% in 2018.

Although growth in agricultural productivity in the EU slowed over 2000 - 2006 relative to the 1990s, as in other developed economies, some further increases in crop yields per hectare and outputs per animal are expected in response to higher prices driving technological change. Over the next decade rises in agricultural productivity will be greatest in the EU-12 Member States, with rapid transfer of new and existing technologies (Cooper *et*

al, 2009). There are significant regional differences in these predicted changes. For example, farmers in the EU-12 Member States who were previously unable to afford fertilisers and pesticides may increase usage of such inputs as these become more affordable in the context of full participation in the CAP. Farmers' incomes in the EU-12 are now 47% higher than before accession as a result of the CAP, the single market and higher market prices[11]. In contrast, in EU-15 for the period 2008-18 there will be general reductions in all plant nutrient consumption, compared to a general increase in EU-12 (except Slovenia). This is partly due to the current low phosphorus and potassium application rates in the majority of the EU-12 countries, but also the result of a significant rise in nitrogen consumption in the EU-12, which will outstrip the projected decrease in EU-15 consumption, leading to an overall increase in N consumption for EU-27. The implication of these trends is likely to be the intensification of arable production in parts of EU-12 and consolidation of existing patterns of specialisation and concentration of production in EU-15.

Fluctuations in cereal prices affect livestock prices too, particularly for farming systems that depend on cereal-based feed for all or part of the year. As increased feed prices drive up consumer prices of meat, demand for beef and lamb is likely to decline in favour of cheaper poultry and pig meat. There is predicted to be a continuing decrease in beef production to 7.9 million tonnes in 2015, a decline of 4.3% from 2007 (DG Agriculture, 2009). Competition from external markets, such as Argentina and Brazil, further dampens the prospects for the EU's beef sector. The outlook for the sheep and goat farming sectors is equally unpromising, in line with past long-term trends and the impact of decoupling of ewe premiums in the major producing countries. Production is expected to be less than 1 million tonnes by 2015, a decline of 9.6% from 2007 (DG Agriculture, 2009). This is likely to further undermine the viability of marginal beef, sheep and goat systems, increasing the threat of land abandonment particularly in the new Member States, where there were significant declines in grazing livestock numbers (largely cattle) between 1990 and 2000, whilst the share of pig production increased. A predicted EU-27 increase in milk production of 2.3% above 2007 levels by 2015 masks a decline of 4.2% in EU-12, driven by a steady decrease in subsistence production (DG Agriculture, 2009).

This analysis suggests that current market conditions will serve to underline the vulnerability and inherent fragility of low-intensity grazing livestock systems in many parts of the EU and especially small, semi-subsistence farms in EU-12. This can be expected to generally have negative influence on the biodiversity quality of permanent pasture, and increase the risk of abandonment on land unsuited to other systems of production. In arable areas, by contrast, the outlook for economic returns is much more positive with a consequent reduction in the risk of abandonment.

3.3   Biofuel markets

The bioenergy sector, particularly biofuels, has created a new market outlet for cereals, sugar and oilseeds both in Europe and beyond. It is a rapidly developing market that emerged as a result of concerns over energy security and unsustainable levels of greenhouse gas emissions, and is now underpinned by related policy interventions. The US, Brazil, Thailand, India and China have all set mandatory targets for the use of biofuels in liquid

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[11] source: http://ec.europa.eu/budget/budget_detail/current_year_en.htm (October 2010)

transport fuels (Timilsina and Shrestha, 2010), and the EU is pursuing ambitious targets for 2020[12]. These targets are driving global demand for biofuel feedstocks, and by 2020 some EU Member States could be relying almost entirely on imports to meet their biofuel demand (Figure 3.8). Domestic consumption of EU-grown cereals is projected to keep growing over the medium term, mainly driven by the rapid growth in bioethanol use, which is expected to more than double (from a very low base) over the next six years (OECD-FAO, 2009 and DG Agriculture, 2009). Based on sustained political support for biofuels, the OECD projects increasing world biofuel prices, also be underpinned by rising crude oil and energy prices.

The EU is expected to be a major player in the biodiesel market, with total biodiesel use anticipated to reach almost 24.4 billion litres by 2019. The world biodiesel price is projected to increase up to 2015 and then to remain at a plateau of almost USD 144 per hl as second generation biofuel will increasingly become available in the EU towards 2019. As biomass based second generation ethanol and biodiesel are only expected to take-off during the next 10 years, reaching respectively 7% and 6% of global production by 2019, most of the biofuel production in the short-term will come from agricultural commodities (OECD-FAO 2010).

Figure 3.8. Reported reliance of selected Member States on the imports of biofuels to meet demand in 2020 (source: Bowyer, 2010)
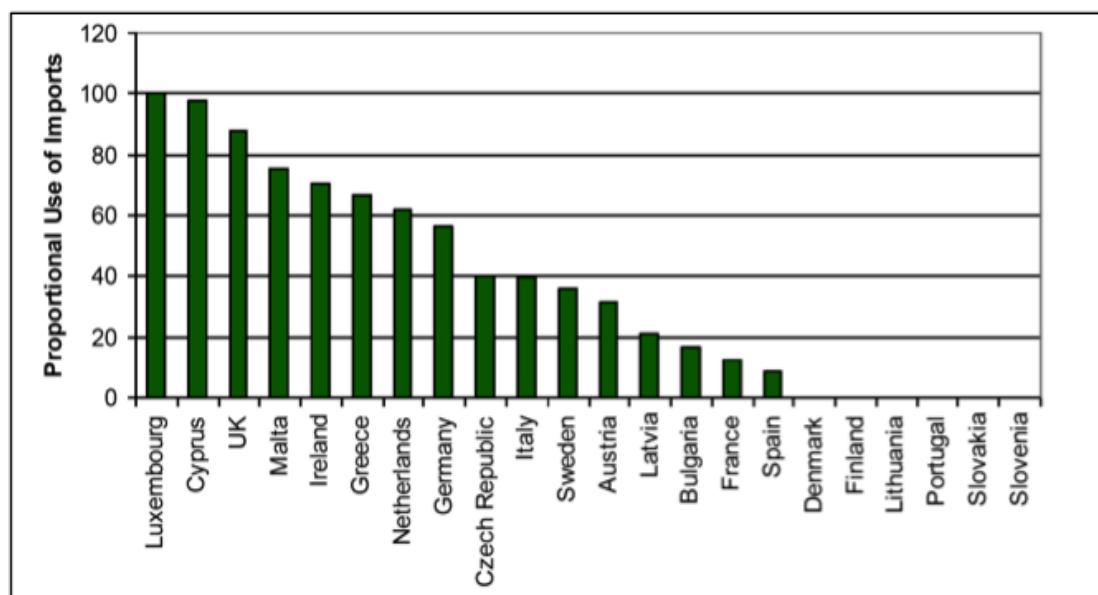
An increasing demand for biofuels globally, and specifically in the EU, means that more agricultural land around the world will need to be dedicated to producing crops for this purpose. Conservative trajectories produce figures that range from 35 to 166 million hectares (Bringezu *et al*, 2009), highlighting the disparity of opinions on this topic.

Although much of the research to date does not seem to agree on how much land may be needed to meet an increased demand in biofuels, it does find consensus as to where they will be grown. It is widely accepted that in meeting the EU targets for biofuels, much of the

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[12] On 17 December 2008 the European institutions adopted a Directive on renewable Energy. Amongst other things this sets a target that at least 20% of the EU's total energy consumption by 2020 will be renewable (with different targets for individual Member States), and renewable energy should account for at least 10% of the EU's total fuel consumption in all forms of transport by this date.

demand will be met by producers outside of the European Community (Edwards *et al,* 2010). With large percentages of the EU's biofuel feedstocks being provided by international growers in Brazil and other countries with favourable climate conditions, it is likely that much of the impact of Europe's additional consumption of biofuels is being displaced to developing countries (Bringezu *et al,* 2009). A theoretical study by Scarlat *et al* (2008) of the land use impact of meeting a significant proportion of the 2020 biofuel target mainly from EU production demonstrates that the land requirements for biofuels production in the nine scenarios investigated (ranging from 30 Mha to 17 Mha), would exceed the EEA's estimates of potentially available arable land for bioenergy crops. This study illustrates the significant role that imports (and possibly second generation biofuels) will play in meeting the 2020 targets.

There is some concern that grazing land may be converted to grow energy crops, or to grow conventional arable crops if energy crops displace these from currently arable land. The Renewable Energy Directive attempts to limit the negative consequences of expanded European demand for biofuels by proposing a series of sustainability criteria, including that biofuels 'shall not be made from raw material obtained from land with high biodiversity value', defined as forests, nature reserves and 'highly biodiverse' grasslands. If energy feedstocks fail to meet sustainability criteria they will not count towards RED target or be eligible for EU subsidies and therefore will not be financially viable. However the projected increase in oilseed crops for biofuel and consequent displacement of other arable crops could still lead to indirect pressure on grasslands in the more fertile areas, as has already happened in Germany with the displacement of silage maize (Oppermann, R. *pers.comm*). In Finland there is direct competition between biofuel crops and grass (Roeder *et al,* 2007).

3.4   The Common Agricultural Policy – Pillar 1

Although the original social and economic objectives of the CAP have remained unchanged since 1958[13] the policy measures have been regularly adapted for a variety of reasons (eg to counter over-production, to adapt to world trade rules and to accommodate new Treaty objectives such as economic and social cohesion and environmental protection). Farmers are still adjusting to the radical CAP reform of 2003, which was intended to create a more competitive, market responsive agricultural sector and align rural development expenditure with EU priorities and coincided with the enlargement of the EU from 15 to 27 Member States. There will be further reform of the CAP in 2013, when the current budgeting and rural development programme periods end, this time driven by pressures to reduce the CAP budget and to focus more closely on the public benefits of agriculture.

The basic structure of the CAP, likely to remain in place after 2013, is often characterised as comprising two 'Pillars', with around three quarters of the budget in Pillar 1 where it is

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[13] Article 33 (39) of the EC Treaty sets out the formal objectives of the CAP:
- to increase agricultural productivity by promoting technical progress and ensuring the optimum use of the factors of production, in particular labour;
- to ensure a fair standard of living for farmers;
- to stabilise markets;
- to assure the availability of supplies;

mainly used for direct payments to farmers. The remainder of the budget forms the European Agricultural Fund for Rural Development (EAFRD) to fund Pillar 2, used by Member States to support seven-year rural development programmes. The CAP budget for 2009 was €55.8 billion (41% of the EU budget). Prior to the 2003 CAP reform farmers in EU-15 countries received direct payments per hectare of crops and set-aside or per head of beef cattle, sheep and goats. This had a distorting effect on both individual farmers' stocking and cropping decisions and on overall production. The key features of the 2003-05 CAP reform were the decoupling of Pillar 1 direct support payments in EU-15 (previously linked to livestock numbers and area of crops); new cross-compliance requirements for farmers; and the introduction of compulsory modulation (annually moving a proportion of the Pillar 1 budget into Pillar 2, in the EU-15 Member States[14]). In 2008 the so-called 'Health Check' of the CAP broadened and deepened some of these reforms. Set-aside has already been phased out, followed by milk quotas (permits for farmers to sell milk) which will be phased out by 2015. The effect of these changes will be further rationalisation, specialisation and perhaps intensification in the arable and milk sectors.

3.4.1 Decoupled Pillar 1 payments

The environmental significance of decoupling is in the shift from supporting farm production (of crops and livestock) to supporting farmers' incomes. Farmers can choose not to grow crops or keep stock at all and still receive decoupled payments, provided they observe cross-compliance requirements. In the EU-12 new Member States direct support from Pillar 1 has been paid on a flat rate per hectare basis since accession, with the opportunity to differentiate payments between arable land and grassland. In most of the EU-15 Member States decoupled payment rates per hectare vary from farm to farm, because they are based on an individual farm's historic payments before decoupling, with the highest rates per hectare on the most intensively managed farms (because they had received higher payments per farm under the previous 'coupled' system). One of the issues currently being debated is the extent to which flat rate Pillar 1 payments should be adopted across the EU after 2013. This would create significant 'winners and losers' between types of farm and between Member States. Although technically Pillar 1 payments are an income support measure, not linked to the farm business, changes in the payment system could have a major impact on the assumptions used in modelling land abandonment.

The intensive arable sector in EU-15 was already strongly market–oriented before decoupling and although decoupled Pillar 1 income support may cushion the impact of price variability on the farm business, and possibly allow farmers to make more 'risky' cropping decisions, markets are likely to remain the main driver of cropping decisions. On more productive land, farmers' greater responsiveness to the market may lead to further intensification, and more rapid changes in cropping patterns and possibly the cropped area, with land being converted from grassland to arable, for example in response to fluctuating world cereal prices or the emerging biofuels market.

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[14] The rate of compulsory modulation started at 3% in 2005 and will rise to 10% by 2012 (with exemptions for small farms and higher rates for very large farms). The UK and Portugal are continuing to use additional voluntary modulation, with a total modulation rate of 19% in England for the period 2009-2012 (used to fund agri-environment and other measures).

The livestock sector is likely to see significant changes as a result of decoupling, especially in the marginal, extensively managed grazing systems on permanent grasslands and semi-natural habitats where farm incomes are heavily dependent on CAP payments, and decoupling breaks the link between number of livestock and farm household income. In many of these areas livestock numbers are declining as a result of decoupling, and both beef and sheep production may move to more productive land. In the dairy sector decoupling makes it easier for marginal dairy farmers to move into beef production, or out of livestock altogether without losing their direct payments. In some parts of the EU there is concern that numbers of grazing livestock, particularly cattle, will be too low to maintain important habitats because these extensive systems are uneconomic. Some HNV grassland habitats, eg in parts of southern and eastern Europe, are already suffering major problems of abandonment and a dramatic decline in livestock numbers following the socio-political changes of the past 20 years. However, decoupled payments are helping to maintain some important grassland habitats, some of which now are mown rather than grazed to meet cross-compliance requirements.

3.4.2 Cross-compliance

Farmers risk losing part of their CAP payments if they fail to observe cross-compliance requirements on the whole farm. These are in two parts, Statutory Management Requirements (SMR) linked to EU legislation, and standards for maintaining land in Good Agricultural and Environmental Condition (GAEC) which are defined by Member States within a common EU framework. The SMR compliance standards at farm level cover a range of obligations on farms in the environmental, animal health and related realms. One strand concerns the protection of Natura 2000 habitats and species on farmland, and helps to secure the future of permanent grassland and other farmland habitats which are designated Natura sites (or used by Natura species). But in practice it is very difficult to separate out any additional effect of SMR cross-compliance on farmers' behaviour, because this legislation applies at farm level irrespective of whether or not CAP payments are claimed. Whether overall compliance with regulations has increased is unclear, and inspection rates are low, at only 1% (although 75% of the compliance inspections must be based on risk assessment). On the basis of audit checks in seven Member States the European Court of Auditors (ECA, 2008) concluded that some countries had only partially implemented cross compliance, and that the legal framework was too complex, particularly for some SMR requirements. There is also some evidence that the most frequent penalties for non-compliance relate to standards such as cattle identification, which are more easily inspected than the site-specific requirements of the Habitats and Birds Directives.

The stated purpose of the GAEC part of cross-compliance is 'to ensure that all agricultural land, especially land which is no longer used for production purposes, is maintained in good agricultural and environmental condition'. GAEC is primarily a broad-brush mechanism to ensure observance of minimum standards, and it is part of the baseline or 'reference level' for Pillar 2 environmental land management payments, which means that farmers cannot receive agri-environment funding for anything required by GAEC standards. Member States must define verifiable farm-level requirements for GAEC based on the framework shown in Table 3.3 below, taking into account the specific characteristics of the areas concerned, including soil and climatic conditions, existing farming systems, land use, crop rotation, farming practices and farm structures. The GAEC framework was extended as part of the

2009 Health Check of the CAP, with the addition of new standards for: buffer strips along watercourses (to be implemented by 2012); for water abstraction; and for the establishment and/or retention of habitats, offering Member States an opportunity to recapture some of the environmental benefits of set-aside (both to be implemented in 2010). Other changes include a more detailed specification of landscape features, and a distinction made between compulsory and optional standards.

Table 3.3. Framework of issues and standards for GAEC cross-compliance (standards shown in italics were added in 2009) (source: Annex III of Regulation EC 73/2009)

Issue	Compulsory standards	Optional standards
Soil erosion: Protect soil through appropriate measures	- Minimum soil cover	- Retain terraces
	- Minimum land management reflecting site-specific conditions	
Soil organic matter: Maintain soil organic matter levels through appropriate practices	- Arable stubble management	- Standards for crop rotations
Soil structure: Maintain soil structure through appropriate measures		- Appropriate machinery use
Minimum level of maintenance: Ensure a minimum level of maintenance and avoid the deterioration of habitats	- Retention of landscape features, including, where appropriate, *hedges, ponds, ditches trees in line, in group or isolated and field margins*	- Minimum livestock stocking rates or/and appropriate regimes
		- *Establishment and/or retention of habitats*
	- Avoiding the encroachment of unwanted vegetation on agricultural land	- Prohibition of the grubbing up of olive trees
	- Protection of permanent pastures	- Maintenance of olive groves and vines in good vegetative condition
Protection and management of water: *Protect water against pollution and run-off, and manage the use of water*	- *Establishment of buffer strips along water courses*	
	- *Where use of water for irrigation is subject to authorisation, compliance with authorisation procedures*	

Several GAEC standards are directly relevant to reducing the risk of land abandonment, including:
- compulsory standards for the protection of permanent pasture and avoiding the encroachment of unwanted vegetation on agricultural land;
- optional standards for minimum stocking rates; and
- (from 2010) the establishment or retention of habitats.

GAEC standards vary significantly from country to country, reflecting regional priorities. In some countries farmers have to maintain pasture by grazing or mowing – for example, Spain and Greece have set national minimum stocking levels (with regional variations) and appropriate mowing regimes. In France, stocking density criteria are set locally, while in

Ireland stocking levels are set only in targeted areas including commonages. In Luxembourg, abandonment of agricultural land is prohibited.

In this sense GAEC standards represent a considerable disincentive for severe reductions in management and ultimate abandonment. The efficacy of GAEC rules as a brake on abandonment is not entirely clear however, partly because there is little information about levels of enforcement in practice. As Pillar 1 payments are reduced, either by modulation until 2013 and as a result of CAP reform after that, the leverage exerted by GAEC cross-compliance requirements above the regulatory baseline will gradually weaken on economically viable farms that do not receive Pillar 2 support. In future, it is possible that some of these farmers may choose to forego Pillar 1 income support, particularly in years when market prices are strong, and GAEC requirements will no longer apply. This effect could be expected to be strongest on the most competitive farms rather than those at greatest risk of abandonment but might also affect those with large areas subject to scrub invasion.

3.4.3 'Recoupling' Pillar 1 payments - Article 68

The 2003 CAP reform offered all the EU-15 Member States (and subsequently Slovenia and Malta) a different, more targeted way of 'recoupling' Pillar 1 payments, in which they could top-slice 10% of the Pillar 1 funds within a sector to provide additional support for 'specific types of farming which are important for the protection or enhancement of the environment or for improving the quality and marketing of agricultural products'. In the 2009 Health Check reform these recoupling options were broadened to include animal welfare, buffering the phasing-out of milk quotas, and risk management (such as insurance premiums and compensation for animal or plant diseases). There is also new scope for redistributing this recoupled part of the budget between farming sectors within Member States. If well designed decoupled payments, are a potentially useful way of providing extra support for economically vulnerable types of livestock farming, including mountain dairy farms, where the grazing systems maintain semi-natural habitats. This could help to prevent marginalisation particularly in the uplands, and support grazed habitats including permanent grassland. The future of such payments after 2013 is likely to depend on the model of Pillar 1 payments which emerges.

3.5   The Common Agricultural Policy – Pillar 2

The European Fund for Rural Development (EAFRD), which forms Pillar 2 and has approximately a quarter share of the total CAP budget until 2013, offers Member States a flexible suite of measures from which to build their seven-year Rural Development Programmes (RDPs). RDP expenditure is co-financed by the Member States, which are required to spend at least a given proportion of their EAFRD allocation on each of the objectives – 25% in the case of measures to improve the environment and countryside. These are expected to 'contribute to three EU-level priority areas: biodiversity and the preservation and development of high nature value farming and forestry systems and traditional agricultural landscapes; water; and climate change'[15]. There is only one compulsory measure, for agri-environment support, which Member States must offer across

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[15] Community Strategic Guideline for Rural Development (programming period 2007 to 2013) Council Decision of 20 February 2006 (2006/144/EC)

the whole of their territory. An extra €5 billion of rural development funding[16] made available from 2010 must be used to address the 'crucial new challenges for European agriculture' of climate change, renewable energies, water management, biodiversity and dairy restructuring. With all the revised RDPs approved early in 2010, Member States appear to be giving highest priority to biodiversity, which has been allocated 31% of the additional funding, followed by water management with 27%, dairy restructuring and climate change, each allocated around 14%. The following analysis focuses on the key EAFRD measures relevant to the risk of land abandonment, of which the most important are the agri-environment, Natura 2000 and LFA (natural handicap) measures, and afforestation of farmland.

3.5.1 Agri-environment

For the 2007-13 period there are 88 RDPs operational in the 27 Member States, all offering farmers the option of 5 or 7-year contracts for specific environmental management activities, in return for annual payments based on costs incurred and profits foregone. In total, about €68 billion of public money is allocated for 2007-2013 across 13 measures under Axis 2, accounting for approximately 46% of all public expenditure under the EAFRD. This is a substantial budget, and provides by far the largest source of funding for landscape and nature conservation related land management in the EU, representing 16% of the total CAP budget for 2007-2013. There are significant differences between regions in the relative priority given to agri-environment expenditure within RDPs, as shown in Figure 3.9.

Figure 3.9. Agri-environment expenditure as a percentage of allocated Pillar 2 total expenditure (EAFRD and co-financing), by RDP (IEEP, 2008)
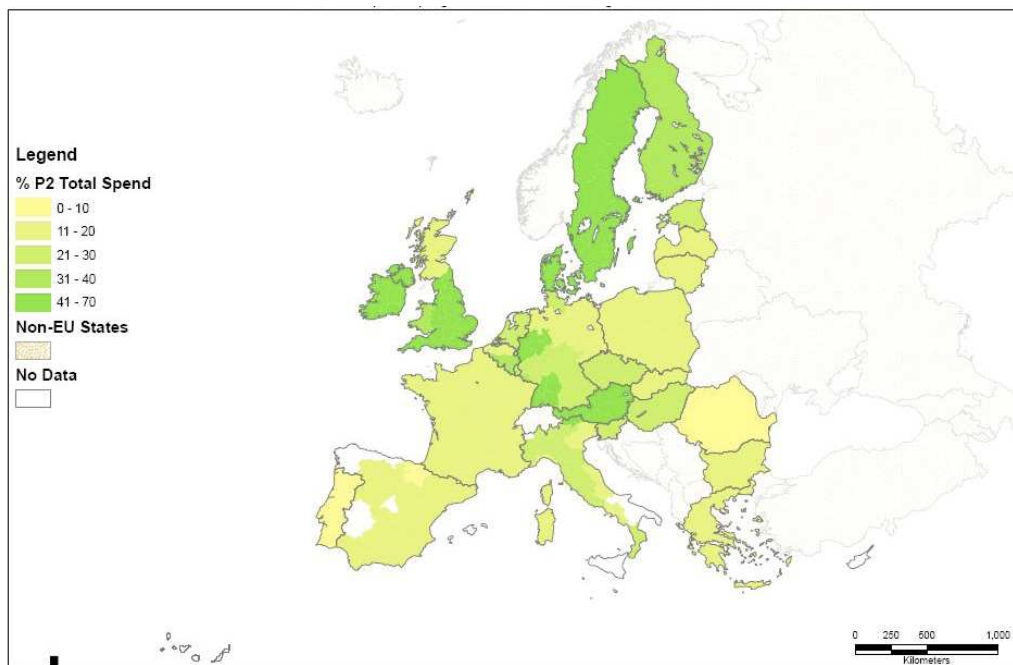
Agri-environment schemes tend to differ in three key ways, often reflecting societal preferences, institutional arrangements and financial and political pressures: the level of

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[16] Generated from the higher rate of compulsory modulation following the CAP Health Check and the EU Economic Recovery Package

expenditure dedicated to the measure; the environmental objectives of the schemes, and the ways in which they are targeted and delivered (for example geographically delimited or open to all farmers across the territory). Agri-environment payments can be used to support appropriate grazing measures designed for specific habitats, and thus both protect biodiversity and contribute to the economic viability of potentially marginal farms. However, their impacts depend not just on the locally available measures and budget, but also on the farmers' level of enrolment, their ability to meet GAEC cross-compliance standards and provide the required grazing animals. They are required to have management control of the grazing land for five years. This can be a problem where land is rented on short leases or graziers with their own flocks use other farmers' land or common land for seasonal grazing (which is important in preventing abandonment of HNV mountain grasslands throughout Europe, and other grasslands in Romania, Bulgaria, Turkey, Spain and France). The agri-environment payment measure is expected to continue in the post-2013 CAP but it is not clear whether it will remain compulsory, what level of co-financing will be required from Member States or, crucially, what the budget allocations will be.

3.5.2 *Natura 2000*

This measure provides annual compensation payments for the legal restrictions resulting from the Natura 2000 designation of farmland so contributes to the viability of a range of environmentally sensitive farms. It is used on a relatively limited scale however, for a variety of reasons. This measure has been used in 25 RDPs, most extensively in Germany (Saxony-Anhalt, Brandenburg, Schleswig-Holstein and North Rhine Westphalia), Ireland and Spain (Asturias) where it accounts for between 5-15% of Axis 2 expenditure. Given the failure to meet the EU 2010 biodiversity target, and the high proportion of terrestrial Natura 2000 sites on farmland, it is likely that this measure will survive the CAP reform process.

3.5.3 *Less Favoured (Natural Handicap) Areas*

More than half of the farmland in the EU has been classified by Member States as Less Favoured Areas (LFA) that suffer from handicaps which threaten the continuation of agricultural land use. Therefore they have a direct role in containing land abandonment. LFA compensation payments (now called natural handicap payments) have been available to farmers for more than 30 years, originally linked to numbers of livestock or area of crops, but now paid on a per hectare basis, and using a significant proportion of RDP funding in some Member States. Although often viewed by farmers as a long-standing form of CAP income support, natural handicap payments are an optional EAFRD measure, and are being phased out of some RDPs and replaced by more targeted agri-environment schemes (eg in parts of the UK). Nevertheless, LFA payments remain the second most frequently used measure in the 2007-13 RDPs, accounting for more than €21 billion public expenditure across 72 regions or Member States. An evaluation for the European Commission found that LFA payments had made a significant contribution to farm family income, particularly in mountain areas, and that the focus on livestock farms has helped to address the key environmental issue of continued grazing on farms where profitability tends to be low (Cooper *et al,* 2006). This may counteract pressures of marginalisation, and help to maintain the use of permanent grasslands and prevent abandonment, but other authors see the failure to target HNV farming systems as a weakness (Boccaccio, 2009).

Following criticism of differences in interpretation of the LFA designation criteria and failures to target support (ECA, 2003), the European Commission has proposed new, biophysical criteria for defining 'natural handicaps' with the intention of putting a revised classification system in place by 2014. There is currently some discussion of the possibility of moving LFA payments from Pillar 2 to Pillar 1, but it is not clear what the impact of this would be on the co-financing of LFA support, or the available budget.

3.5.4   Afforestation of farmland

Forest expansion may occur opportunistically as a result of the abandonment of marginal farmland, or deliberately by planting or national regeneration. Most planting will take place only with a subsidy in current conditions and in many cases this will be eligible for EAFRD support for "environmentally beneficial afforestation" of agricultural land. Some Member States have set ambitious targets for afforestation of farmland, offering farmers an element of income support for up to 15 years, in addition to planting and initial maintenance payments. To be eligible for EAFRD support, the afforestation schemes must have environmental objectives, which can include the extension of forest resources as a contribution to climate change mitigation (provided that this will not harm biodiversity or cause other environmental damage). In practice marginal grassland areas may be targeted for planting, especially where there are few prospects of improving agricultural incomes. Consequently there remain concerns about the protection of valuable (HNV) grasslands from permanent loss to tree planting. This is possible to avoid but depends on the forestry authorities identifying grasslands important for biodiversity and refusing applications for these sites. More specific protection is provided by the Habitats Directive for designated Natura 2000 grasslands in that afforestation must be consistent with the management objectives of the site.

According to current target figures for the 2007-13 RDPs, Member States expect that approximately 890,000 ha of new forests will be established during the programming period, and more than 650,000 ha of this will be on agricultural land. In addition, there is a target that new agroforestry systems will be established on 60,000 ha of agricultural land (EC, 2009a).

3.6   Impact of climate change on agricultural land use

The effects of rising atmospheric carbon dioxide concentration, higher temperatures, changes in annual and seasonal rainfall patterns and in the frequency of extreme events will be seen in agricultural productivity, giving some farming areas in Europe an advantage while disadvantaging others. By the 2030s some southern European regions could experience a 5-10 % decrease in yields compared to current levels, mainly because of shortening of the growing season (Figure 3.10).

Figure 3.10. Projected crop yield changes between the 2030s and the reference period 1961-1990 (source: (EC 2009b), based on the results of PESETA project)
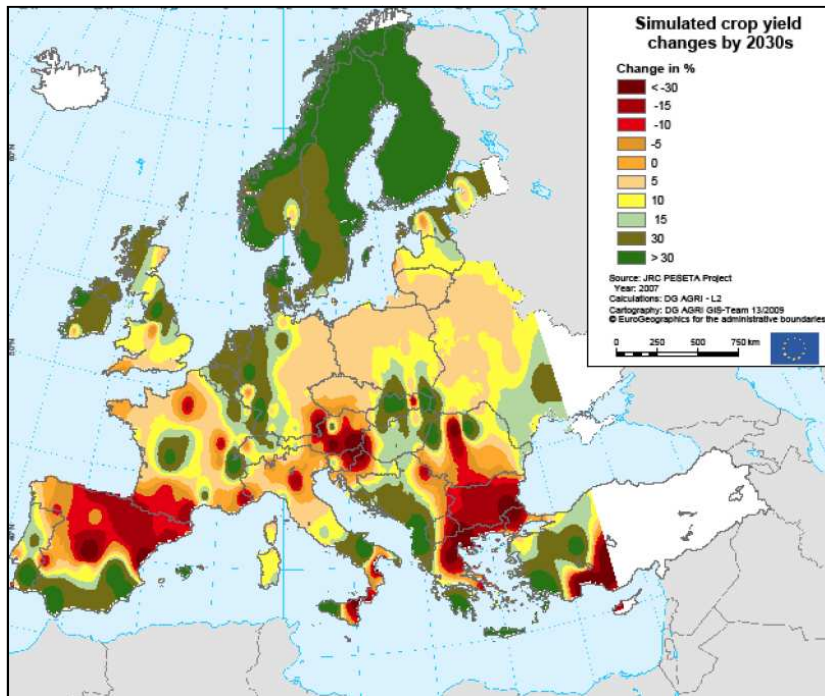
The extent of yield losses will depend on seasonal patterns of rainfall, which remain very uncertain, and ultimately on water use and water policy. Productivity improvements in Northern countries of about 5 to 10% are forecast because of a lengthened growing season, higher minimum winter temperatures, and extension of the frost-free period (EC 2009b). This implies that the risk of land abandonment may increase in the areas of suffering reduced crop yields, especially in areas that already are arid. On the other hand, the risk of abandonment of some grasslands in these areas may be reduced, as hotter summers increase the risk of forest fires and it becomes important to maintain grazed or mown grasslands around and between forest blocks.

The effect of climate change targets on the demand for biofuels is likely to help maintain the viability of arable farming, but a quite different impact of climate change, which is only just becoming a topic of discussion among policy makers, is the scope for meeting EU carbon targets through changes to land management. The impetus may come from the burden sharing measure within the EU climate and energy package of policies in which 10% of the reduction of emissions required to meet the 2020 carbon reduction targets has to come from non-ETS sources, not participating in the EU emissions trading scheme (ETS) including land management. There is potential for changes to arable cropping practices such as reduced tillage, the use of perennial crops and increasing crop cover (Smith, 2004). The extent to which this will protect land from abandonment is unclear, but Roeder et al (2007) report that electricity companies in Portugal for example, are financially supporting the conversion of arable land to grasslands as a mean of carbon sequestration. But in many situations carbon sequestration rates could probably be further increased by afforestation.

Carbon offsetting could also support the reduction or complete withdrawal of grazing from some upland peatlands (Worrall *et al,* 2009).

3.7   The indicator approach to identifying the risks of abandonment

3.7.1   IRENA

Some of the drivers of abandonment described above have been taken into account in the development of agri-environmental indicators under the IRENA initiative. This initiative, launched in 2002, aimed to develop and compile, for the EU-15, a set of 35 agri-environmental indicators[17] at appropriate geographical levels using, as far as possible, existing data sources. The IRENA operation was finalised in December 2005 and its outputs include 40 indicator fact sheets and their corresponding data sets (in the form of Excel files) and an Indicator Report, which reviews the interactions between farming and the environment on the basis of the indicator results. Two IRENA indicators (15 intensification/extensification and 17 marginalisation) were intended to capture key trends in farming activities at an aggregate level (measured at NUTS 0/1, except ES, FR and IT, which were NUTS 2). In the IRENA evaluation exercise the intensification/extensification indicator was considered 'useful' and the marginalisation indicator 'potentially useful', and these recommendations are being taken forward in the improved set of agri-environment indicators now being developed by DG Agriculture and JRC (see next section bleow). While they are clearly useful, the limitations of the IRENA indicators include the absence of EU-12 data, and the scale and age of the data for EU-15.

The challenges facing the improvement of agri-environment indicators include the limited availability of the relevant information at the required geographical level. Precise spatial referencing of relevant data sets in a geographical information system (GIS) is a key element for improving regional environmental analysis, and enables integration with other data sets. Another issue is the development and validation of models, which is an important approach for overcoming the lack of direct measurements, but requires good input data and gathering of field data to calibrate and validate the estimates. Other challenges include the better use of administrative data; integration of databases; and developing the farm typology approach used for some driving force indicators (eg cropping/livestock patterns) as a means of relating indicators to different types of farms (CEC, 2006).

3.7.2   A new agri-environment indicator of land abandonment

Following the assessment of the IRENA process, the Commission published proposals to maintain a core set of 28 agri-environmental indicators (CEC, 2006; see Annex 2) which include:

- the former IRENA 15 **indicator of intensification/extensification**, proposing that the farm typology approach could be further explored; a framework for comparing FADN input cost data between Member States should be developed; extending the animal and crop statistics to a regional level could be investigated; and FADN input data could be better harmonised; and

- the development of the IRENA 17 indicator of marginalisation as an **indicator of land abandonment**, noting that the indicator needs conceptual and technical development; that a modelling approach combining socio-economic data with an

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[17] identified in the Commission Communications COM(2000) and COM(2001) 144

assessment of the risk of farm abandonment resulting from geographic conditions could be developed; and that an assessment could be undertaken of the relevance and possibility of including data on land in receipt of direct payments, and so covered by obligatory standards of good agricultural and environmental condition (GAEC), but which is not actually being used for farming purposes.

3.8   Discussion

There have been few periods in the history of European agriculture when farming has been so diverse and also undergoing such a sustained process of adapting to significant policy changes at farm, European and global levels. The diversity is expressed in both biogeographical terms, with different climates, soils, crops, farming systems and environmental issues from northern Sweden to the Mediterranean, and in terms of agricultural and social structures from very small semi-subsistence farms in parts of Romania and Bulgaria to arable farms of several thousand hectares in the UK, Germany and the Czech Republic.

Risks of land abandonment appears to be associated with structural factors such as small farm size, poor soils, and accessibility of land, social factors such as out migration of young people, and the economic pressures of competition from global markets. The relative importance of drivers of land abandonment differs markedly between farming types and between EU-15 and EU-12, with market pressures significant for all farm types, given their fundamental role in determining farm productivity. Market trends are likely to minimise the risk of arable land abandonment but increase the risk of abandonment for low intensity livestock systems on poorer land, and for small units of permanent crops. As a result, CAP payments and polices have a correspondingly greater influence on the viability of such systems, particularly outdoor livestock.

The next CAP reform is underway, but the last one is still not fully implemented. Pillar 1 payments are being decoupled in EU-15, while not yet fully phased in for most of EU-12, and the Health Check revisions are now being implemented across EU-27. The period until 2013 will be one of consolidation and adjustment, as farmers adapt to the effects of decoupling, and rural development plans use the additional funding from compulsory modulation to address the 'new challenges' of climate change, renewable energy, biodiversity and water.

The detailed proposals for the 2014 CAP reform will be published in November 2010, and the forthcoming debate is likely to be fiercely fought, with legislative proposals anticipated in autumn 2011 for all elements of the CAP, linked to proposals for the 2014-2020 Financial Perspective. One of the key messages coming out of the recent Commission consultation and subsequent conference, was that the CAP should be refocused on the provision of public goods in line with society's demands and that it should address the diversity of environmental, social and economic situations in different regions of the EU-27. While the concept of public goods appears to be the dominant rationale currently being used for the future provision of public support under the CAP, there is a strong body of stakeholders who continue to argue that food production should remain a central plank of future agricultural support, using concerns surrounding future 'food security' as a justification for continuing to provide income support to farmers. Therefore, any redistribution of support between funds and between Member States will be highly politicised, and coupled with the prospect of

adjustments to the allocation criteria of CAP support under both pillars, a markedly different pattern of 'winners and losers' could emerge post-2013.

Given this background of change and diversity it is not surprising that the impact of the drivers and policies described above on the risks of land abandonment will be equally diverse, and difficult to predict. Responses to a particular combination of drivers are very context dependent and may lead to intensification in one place and to structural or land use change in another. These locational and structural differences in impacts make it difficult to draw EU wide conclusions, and have implications for both modelling land use change and for the design and implementation of biodiversity policies. Nevertheless it is possible to draw some tentative conclusions:

- Increasing exposure to global markets will sustain the trend towards specialisation and economies of scale in most sectors, with production moving towards the most competitive parts of Europe; the scope for further intensification in EU-15 is rather limited, but there is considerable scope in parts of EU-12, where rising levels of inputs such as arable crop nutrients and mechanisation could lead to abandonment of plots of marginal land at a farm scale.

- Marginal arable land may move in and out of production/fallow in response to price fluctuations and, in response to climate change, some arable production may move within Europe, as yields improve in northern latitudes and water resource limitations become more of a problem in the south. The permanent crops sector will also see a shift to larger units and a further decline in small, low-intensity units cropping older trees, as these systems are intensified or abandoned.

- The EU livestock sector will suffer from weak profitability in the beef, sheep and goat sectors, driven by global competition, and will see major restructuring of the dairy sector to fewer, larger units of production by the time quotas are removed in 2015. There is likely to be increasing polarisation of all the grazing livestock sectors, with the intensively managed farms using more permanent housing of livestock (including cattle) in larger units, while low-intensity grazing systems using beef, sheep and goats, together with mountain (and semi-subsistence) dairy systems become even less viable, with significant declines in the numbers of livestock, particularly in EU-12. In many cases the result will be a decline in grazing management across many semi-natural habitats, with partial or complete abandonment in some cases. Elsewhere, especially in some parts of EU-12, significant restructuring will take place with small low-intensity farms combined into larger units, landscape features removed and grassland management intensified. Some grazing land may be converted to arable, afforested or used for development. These trends will be tempered to a certain extent by the effect of CAP income support and targeted Pillar 2 payments, but it is likely that many environmentally important low-intensity grazing systems will not survive, and those that do will require significant long-term public funding.

- The cost of CAP environmental support for both voluntary (agri-environment) and compensatory (LFA, Natura 2000) measures will rise, as a result of the profitability of the arable sector on the one hand and the increased risk of structural change or abandonment of small, low-intensity livestock and permanent cropping farms on the other.

- The 2014 CAP reforms, whatever the outcome, are likely to have a bigger impact on the future land use decisions of farmers with extensive livestock enterprises on

marginal land than on farmers operating intensive livestock and arable systems on better quality land.

- The future of land still managed by semi-subsistence farming systems, for example in Romania and Bulgaria, will depend on the complex interaction of agricultural, environmental, economic and social polices for these areas; the speed and direction of changes in land use will also be influenced by possible reforms of land ownership structures.

- The direct impacts of climate change on risks of land abandonment will vary geographically, with a greater risk of marginalisation in the south, possibly exacerbated by water availability, but improved productivity in northern Europe.

4   LAND USE MODELS AND THEIR PROJECTIONS OF FUTURE FARMLAND ABANDONMENT

This chapter describes the computer models that have been used to explore land use changes in the EU. These are based to varying degrees on the key drivers of land use change described in the proceeding chapter and aim to test EU policy scenarios likely to have an influence on farmland abandonment. Different modelling approaches have been developed in recent years to link the spatial and economic aspects of land change, and the CLUE and CAPRI-Spat approaches described below are representative of these different types of models (Britz *et al,* 2010). Recent, relevant applications of these models are reviewed and their land use changes projections are used to attempt to estimate likely scales and locations of abandonment. The reliability and limitations these results are then discussed and future opportunities for further model development and projections are identified.

4.1   Modelling rationale

Economic simulation models provide a structured, numerical description of actions affecting land use, and the models which integrate commodity price feedback are typically based on a rather stringent simplification of the real-world system. This is partly due to limited data availability, but also results from the rule of parsimony that requires modellers to determine the minimum set of parameters that are needed to explain the trends in the data (to be as simple as possible, but not simplistic). The main advantage of models is their ability to assess complex feedback loops in the real-world-system in a consistent way, which is impossible for the human brain even with moderately-sized problems (Terres *et al,* 2010). The relationship between the model and the real world is shown in Figure 4.1, in the context of policy impact. Rural areas are complex systems with many sub-systems and components interacting via complex, non-linear feedback loops. The economic simulation model abstracts from that complexity by describing only a few subsystems and their relations in a structured way, as shown in the upper half of the diagram.

Figure 4.1. Schematic representation of real-world and model relationships (Terres *et al,* 2010)
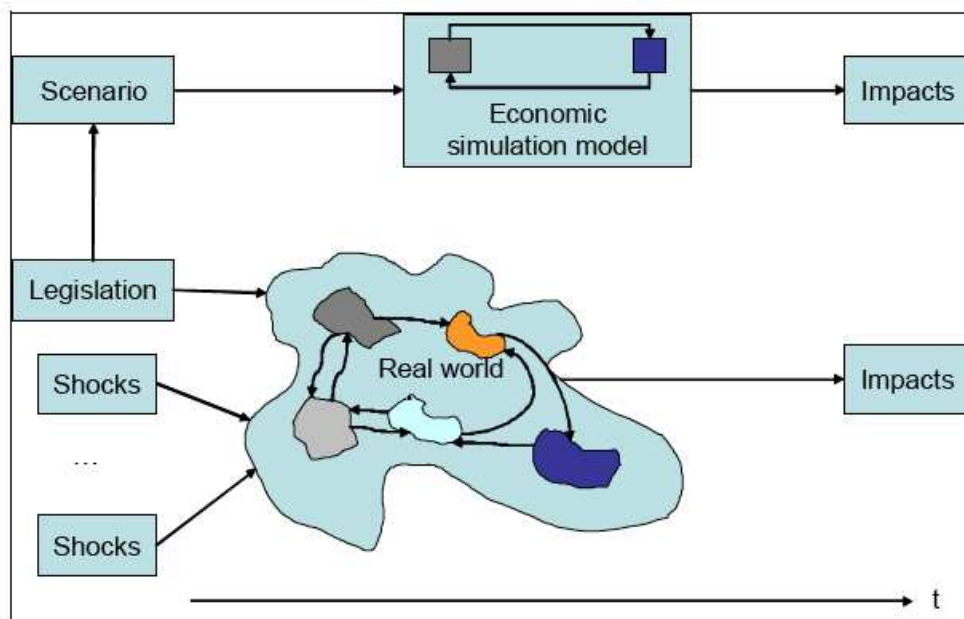
Both economic and environmental modelling require observations on the systems they simulate in order to be parameterized, calibrated and evaluated. Environmental modelling can draw, at least in parts, on controlled experiments, but economic modelling relies on observations of how agents such as farmers reacted to changes in markets and policies in the past. Those observations are typically aggregated in space and time due to data privacy issues or procurement costs. Consequently, even specialised economic models for agriculture work on temporal and spatial scales too aggregated for most environmental assessments. Location specific environmental impacts cannot be properly be addressed by the aggregated results of economic models (Britz *et al,* 2010). Descriptive analysis based on behavioural assumptions expressed as cause-effect relations can be applied in a far more flexible way compared to economic model application, but flexibility might come at the price of a less objective evaluation (Terres *et al,* 2010).

A number of land use models have examined land abandonment issues in European, either directly, or by looking at aspects of agricultural land use closely linked to abandonment, such as the effects of intensification and marginalisation. Table 4.1 summarises these models and their most significant recent uses with respect to land abandonment, the results of which are discussed in Section 4.4. Further details of each model and their application to abandonment studies are provided in section 4.2 below. However, it is important to note the models described above are research tools that are continually being developed, refined and adapted for a range of different studies.

Table 4.1. Recent modelling studies relevant to land abandonment

MODEL	Context used	Outputs relevant to land abandonment	Publications
CAPRI and CLUE-s	**Scenar 2020 study** for DG Agriculture (Volumes 1 and 2)	Estimates of abandoned land under different scenarios Maps and data tables of potential land abandonment	Nowicki et al (2006)
CAPRI (CLUE-s was not used for detailed land-use projections in the Scenar 2020-II update, due to time and budgetary restraints)	**Scenar 2020-II study** for DG Agriculture	Discussion of risks of abandonment	Nowicki et al (2009)
CLUE-s	**EURURALIS 2.0** a scenario study towards 2030; **FP6 SENSOR** integrated project	Estimates of scale of abandonment under four different scenarios Maps and data on abandonment (on the website)	Methodology described by Westhoek *et al,* (2006) results summarised in Rienks, (2008); detailed results in http://www.eururalis.eu/index.htm
	Environmental benefits of land services	Discussion of impacts of intensification and marginalisation on risks of abandonment Map land use/cover changes 2000-30	IEEP and Alterra (2010)
Dyna-CLUE	**EURURALIS** & **FP6 SENSOR** integrated project	Estimates of abandonment under different scenarios	Verburg and Overmars (2009)
	Land Use Modelling – Implementation (LUM-I), preserving and enhancing the environmental benefits of 'land-use services'	Maps	Pérez-Soba et al (2010) and Verburg et al (in press)
CAPRI and Dyna-CLUE	**Assessing the potential for undesirable land abandonment** (or land use change) from further CAP reform or trade liberalisation (for Defra, UK)	Work in progress	Not yet published
CAPRI	Other current applications of CAPRI include: *Effects of CAP reform since 2010 on the EU farm sector*(financed by OECD, Paris)	In progress, but outputs expected to be relevant to future work on land abandonment.	Work in progress, not yet published A list of current and recent applications of CAPRI can be found at http://www.capri-model.org/projects.htm

4.2   Models and scenario building

4.2.1   *CAPRI (Common Agricultural Policy Regional Impact assessment)*

CAPRI's principal aim is to analyse impacts on European agriculture and global agricultural markets, mostly over the medium term (8–10 years ahead), resulting from changes in EU or international agricultural policies and market conditions. For each of the NUTS 2 regions, CAPRI simulates changes in crop areas and yields for 35 crops, herd sizes for 13 animal production processes, as well as feed and fertiliser practices.

The CAPRI modelling system consists of specific databases, a methodology, the software and the researchers involved[18]. The databases use official data wherever possible, eg from EUROSTAT, FAOSTAT, OECD and FADN. The model templates are structurally identical, to ensure comparability of results across products, activities and regions, and to enable integration within a large modelling network such as SEAMLESS.

4.2.2   *CAPRI-Spat*

The CAPRI-Spat model adds a spatial component by downscaling regional results for all crops and all animals covered by CAPRI (as well as yields and fertilizer application rates) to a grid of 1 km × 1 km resolution for EU-27. Individual pixels are clustered into homogenous agronomic and environmental units, while detailed agricultural land use is represented by crop shares within each unit. There is no detailed crop share map available for the EU so, in contrast to land use/cover models such as CLUE (which compare future scenarios to a baseline land use map), CAPRI generates the most probable distribution of crop shares in space (Britz *et al,* 2010). The crops identified in CAPRI include fallow land, and in total occupy the whole of the available agricultural area. CAPRI-Spat data relevant to land abandonment are limited by the absence of key management information, such as fertilizing practice and pesticide input in FSS. Data sets on crop shares, yields, stocking density are available only for larger administrative units, and there are no harmonised data on linear landscape elements available at EU level.

4.2.3   *CAPRI-RD*

CAPRI-RD[19], a four year project (from March 2009) under the European Commission's FP7 research programme, aims to develop and apply an operational, pan-European tool (including all Candidate and Potential Candidate countries) to analyse the regional impacts of CAP Pillar I and II policy measures across a wide range of economic, social and environmental indicators. CAPRI-RD's core contains consistently linked economic models at the NUTS 2 level[20], and spatial downscaling algorithms which break down land use results to 1x1 km grid cells.

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[18] The modelling system may be defined as a 'club good': there are no fees attached to its use but the entry in the network is controlled by the current club members. The members contribute by acquiring new projects, by quality control of data, new methodological approaches, model results and technical solutions, and by organising events such as project meetings or training sessions.

[19] Common Agricultural Policy Regionalised Impact - the Rural Development Dimension (CAPRI-RD) http://www.ilr1.uni-bonn.de/agpo/rsrch/capri-rd/summary.htm

[20] These are: the CAPRI model for agriculture, and a newly developed layer of regional Computerized General Equilibrium models. Given the importance of the EU's agricultural trade, CAPRI includes a global agricultural market model. The project will improve price transmission modelling inside the EU market, review the implementation of de-coupled payments, and maintain the CAPRI farm type layer. Harmonised and regularly updated databases, including regional Social Accounting Matrices, act as the models' sources.

CAPRI-RD is of interest in the context of land abandonment because of the possibility of developing new indicators, beyond those already specified in the Rural Development Regulation's Common Monitoring and Evaluation Framework (CMEF)[21], and of modelling the impacts of policies likely to affect land at risk of abandonment. In CAPRI-RD, indicators are defined so that the same indicator can be used for baseline trend (probable future state of the system with no new policy) and for impacts (new policy applied). However, some of the CMEF indicators require data which cannot be simulated in economic models or easily forecast using existing databases, and the project will try to develop and test scientifically-sound alternatives. This work is likely to include testing the former IRENA indicator on *intensification vs. extensification*, and a landscape indicator using the components of *naturalness* and *structure*, developed in the context of Commission proposals for a consolidated set of integrated agri-environmental indicators (see Section 3.72). One potential problem for testing environmental indicators is the detailed scale required because interactions of soil, climate, farming practices, biodiversity, and water status vary considerably with local conditions. This implies that the information necessary for building the indicators (such as crop shares, livestock density, nutrient fertilisation) needs to be provided through statistical downscaling procedures within CAPRI-RD (Terres *et al,* 2010).

4.2.4   Dyna-CLUE (Dynamic Conversion of Land Use and its Effects)

This version of the CLUE model, used for European level simulations, combines the top-down allocation of land use change at national level (to 1km × 1 km grid cells) for all EU Member States with a bottom-up determination of conversions for specific land use transitions (Verburg and Overmars, 2009). The resulting maps depict up to 18 different land use types (derived from CORINE as shown in Table 4.2) shown yearly at 1 km^2 resolution, and can be used to analyse land cover changes, or as input to other models.

Dyna-CLUE can accommodate changes in total agricultural area and in built-up area, combining these top-down net changes with locally determined processes of vegetation change based on general successional patterns that are modified according to local conditions (Verburg and Overmars, 2009). CLC data are used to establish the existing vegetation types (ie to start the model runs). Thus, in a grid cell formerly occupied by agricultural land the process of vegetation succession is simulated as a function of the local growing conditions (soil and climate), human population density and grazing pressure (Fig. 4.2). When the demand for agricultural land at the national level as specified by the macro-economic models is decreasing, the CLUE allocation procedure will allocate less agricultural area. Land no longer used for agriculture is first converted to so-called 'recently abandoned farmland' and if the land is not taken into production again it will automatically be converted to semi-natural vegetation and/or forest. Given the higher reconversion cost it becomes less likely that these areas will return to agricultural use. The CLUE approach addresses the full range of land cover types and their spatial interactions, but information within the agricultural sector is limited to distinguishing grassland, arable land and permanent crops (Britz *et al,* 2010).

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[21] Annex VIII of Commission Regulation 1974/2006 laying down detailed rules for the application of Council Regulation 1698/2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD)

Table 4.2. Land use classes in CLUE as derived from the CLC2000 dataset (source Britz *et al,* 2010).

CLC2000 land use/cover class	Model representation in CLUE
Built-up area Arable land (non-irrigated) Irrigated arable land Pasture (permanent grasslands excluding temporary grasslands as part of a crop rotation) Arable land devoted to the cultivation of (annual) biofuel crops Permanent crops	Demand determined by multi-sector modeling (Eickhout et al., 2007; Meijl et al., 2006) 'top-down allocation'
Glaciers and snow Sparsely vegetated areas Beaches, dunes and sands Salines Water and coastal flats Heather and moorlands Inland wetlands	Assumed to be constant during simulation (unsuitable for agricultural/urban expansion and natural succession hampered by adverse environmental conditions)
Recently abandoned pasture land (includes very extensive pasture land not reported in agricultural statistics, grasses and shrubs below 30 cm) Recently abandoned arable land (i.e. "long fallow"; includes very extensive farmland not reported in agricultural statistics, herbaceous vegetation, grasses and shrubs below 30 cm) (Semi-)natural vegetation (including natural grasslands, scrublands, regenerating forest below 2m, and small forest patches within agricultural landscapes) Forest (production and natural forest > 2m)	Dynamics between land cover types determined by local processes 'bottom-up allocation'

Figure 4.2. Schematic representation of the land use/cover transitions following abandonment of agricultural land (Verburg and Overmars, 2009)
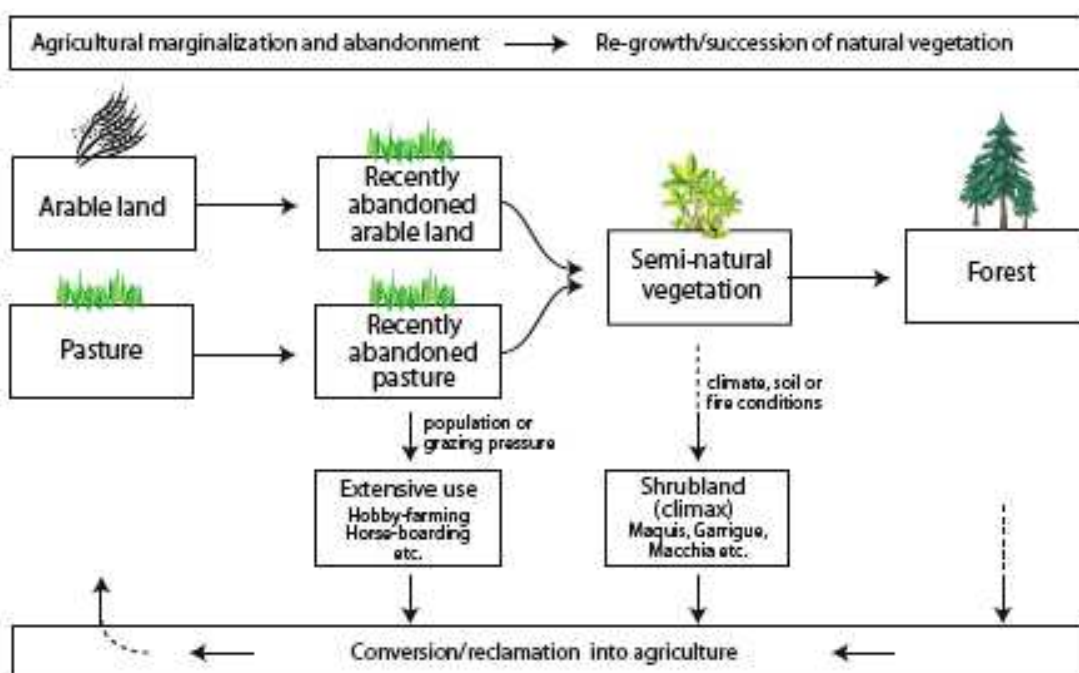
There are a number of obvious limitations in the use of CLUE and the CLC dataset to predict the extent and location of abandoned land. Importantly, satellite-based information does not allow sufficient differentiation of CLC grassland classes, and EEA (2005) has suggested exploring the possibility of complementing CORINE with ground-based grassland surveys that are available for at least some Member States (Bulgaria, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia) where there are large areas of HNV grassland at risk of abandonment[22]. There is also an urgent need to update the 10 year old CLC2000 dataset, especially for EU-12, but at EU-27 level this is hampered by the gaps in the newly released CLC2006 dataset, notably for the UK and Greece, which make it unlikely that CLUE will be updated until the full EU-27 CLC dataset is available (Pérez-Soba, *pers.comm*). Furthermore, the assumption in the DynaCLUE model that heather and moorlands are assumed to be constant (Table 4.1 above) may not be valid, if farming activities cease on moorlands that have been maintained as sub-climax vegetation by grazing with agricultural livestock (and in some cases management burning), especially if there are nearby forest seed sources (eg in Scotland).

DG Environment commissioned a study during 2009 of the potential for a European land-use modelling framework to support environmental policy, ie the Land Use Modelling – Implementation (LUM-I) study. The land use model Dyna-CLUE forms the core of the modelling framework, with global multisectoral models LEITAP and IMAGE used to define demand for different types of land use, based on predictions of world-wide economic drivers. The output of the global-level models is translated into a land demand in km^2 for the specific land-use types in the Dyna-Clue model. This framework has been used with two reference scenarios to explore eight different policy alternatives (results published in Pérez-Soba *et al*, 2010; Verburg et al in press). CLUE was used in another study for DG Environment of the environmental benefits of 'land services' which looked at the marginalisation of land use and permanent grassland, and the risks of abandonment (IEEP and Alterra, 2010).

Pérez-Soba et al (2010) pointed out that further development of their EU-CLUE scanner modelling framework is limited by the available data and the state of understanding the land system. Modelling changes in land use intensity is hampered by the availability of spatially explicit data on land use intensity, for example the difference between extensive and rotational grasslands. Increasing the spatial resolution (from 1 km^2 to 1 ha, for example) is possible, in principle, because CLC data support the higher resolution, but many of the data used in CLUE to identify the location factors determining the competitive advantage of the different land use types do not support such spatial detail. Further research is also needed if the model is to address feedbacks between the environmental impacts and the driving factors of land change and needs, and to quantify the ecosystem service trade-offs for the different scenarios (the current model uses some indicators that are proxies for ecosystem services provided by the land). Indicator models need to be chosen with care - many are based on detailed understanding of processes at the micro-level and therefore may be subject to scaling errors when applied at a 1 km^2 spatial resolution, and not all fit with the thematic content of the different land use classes in CLUE.

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[22] see Veen Ecology at http://www.veenecology.nl/index.php?id=5

4.3   Comparison of the modelling approaches and their limitations

Recognising the relative merits and disadvantages of different types of models, Britz et al (2010) compared CLUE and CAPRI-Spat, and the different ways in which they link geographic and economic domains. These two models focus on different processes - CLUE remains restricted to land cover while CAPRI addresses mainly land management, and the authors argue that these differences are valid not just for these two specific models - most land cover change models tend to use information derived from remote sensing images as a primary source of information, while most economic approaches and models addressing land management use survey and census information as the main data source because land management aspects are difficult to observe by remote sensing. These conceptual differences have led to different choices of data sources, model geometry, and the downscaling procedure. For example, there are differences in the modelling concept (dynamic generic land cover model in CLUE vs. static disaggregation model for agricultural land use in CAPRI-Spat), the underlying data sources (land cover map vs. land use statistics or projections) and the intended application (assessment of land cover change vs. detailed (sub-) regional impact assessment of agriculture). CLUE builds on CLC data which are based on interpretation of remote sensing data, whereas the CAPRI-Spat maps are linked to agricultural regional statistics such as the Farm Structure Survey (FSS). Most importantly, there are differences in the definition of 'agricultural land' including the interpretation of 'abandoned land' (in CLUE) versus 'fallow land' and 'set-aside' (in CAPRI-Spat). Common land grazing is another specific problem for land use change modelling in some European regions.

In defining the totality of 'agricultural land' the CLC farmland area estimations (all agricultural classes and natural grassland) give different results from the UAA/agricultural areas as available in the FSS due to differences in data-collection, methodology and definitions. The main differences between the FSS survey and a land use/cover survey such as CLC or LUCAS (or a national land use survey such as TERUTI in France), is that FSS is based on the farmer's declaration while the CLC is based on photo-interpretation of remote-sensing images, and LUCAS gathers information through field survey. Table 4.3 illustrates the main differences between FSS and CLC data. The definitions of utilised agricultural land and non-utilised agricultural land are not exactly the same, due to the fact that these two categories of survey are based on two different approaches: land use and land cover. This is one of the reasons why these surveys may have different UAA. CLC data should be used with care for area estimation. The direct use by simple polygon measurement can give strongly biased results, for several reasons, but mainly because the scale that is not suitable for area statistics and area-estimation of the UAA/agricultural areas (Pointereau, 2008).

Table 4.3. Comparison of UAA and land cover categories in FSS and CLC (after Pointereau, 2008)

	Farm Structure Survey	CORINE Land Cover
For all categories		Small areas are captured by the dominant categories (in the minimum 25 ha mapping unit) with a risk of underestimating agricultural land cover in urban or forest areas, and overestimating it in predominantly agricultural areas.
UAA	Declared by the farmer, includes fallows and scrublands that are grazed extensively.	Includes some land owned by non-farmers and managed as farmland. For example: properties of less than 1 ha (generally grasslands grazed by horses or sheep). Can exclude some rough grasslands and some 'old' fallow lands.
Fallow land	Included in the UAA. FSS distinguishes fallow land with no economic use and set-aside land used for the production of nonfood products	There is no specific category for fallow land. If the set-aside is cultivated with non-food products, it will be classified as arable land. Fallow land can be included either in agricultural areas or in semi-natural areas. If the area of fallow land is small, it will generally be included in agricultural area.
Grassland	Included in the UAA in several different categories: temporary grasslands, productive permanent grasslands and rough grasslands.	Classified either under pastures (agricultural areas) or as natural grassland (forest and semi-natural areas)
Common land	Excluded, FSS only records that the farmer uses common land.	Included (as unable to differentiate common land from private pastures or natural grasslands).
Non-utilised agricultural land	Only the area which has not been recorded as part of the UAA, but is within the holding,	The non-utilised agricultural land is classified in different categories such as 'agriculture and significant natural vegetation mosaics' or 'moors and heathland'.
Forest and other wooded areas	All wooded land on the holding.	Forests are classified in different types.
Artificial areas	Not included.	Specific categories.

In CAPRI, fallow land is one of the possible land use choices for farmers, and will shrink and extend depending on economic returns for productive alternatives. It is, however, not clear if the land is abandoned completely and cannot come back into production. Farmers might also have idled their land under voluntary set-aside programmes, and in the base year, agricultural land use was also idling under obligatory set-aside. All three types of non-productive land are downscaled by CAPRI-Spat, which also provides much detail on changes in the agricultural sector including cropping patterns, stocking densities and management practices. Given the large areas covered by agriculture in Europe and the wide variation in agricultural practices and intensity across Europe, Britz et al (2010) argue that this information is essential for environmental impact assessments, but a linkage to CLUE could enhance the reliability of CAPRI-Spat in forward looking analysis, especially for dynamic processes such as land abandonment and natural succession. In addition, many indicators can only be calculated from a full land cover data set as provided by a model such as CLUE. Britz et al (2010) concluded that the combined application of CLUE and CAPRI-Spat would provide added value, but that differences in the underlying data sets on land cover are large enough to preclude full harmonization.

In the UK, Defra has commissioned some work on land abandonment in the EU using both CAPRI and DynaCLUE, with land supply incorporated in CAPRI, as an attempt to overcome the lack of capacity within CAPRI for expansion/shrinkage of total farmland area and substitution of arable/grassland. This work is at draft report stage and not yet available (Renwick A, *pers.comm*).

4.4   Recent model based projections of farmland abandonment in the EU

Table 4.4 provides a summary of the projections of land abandonment in the EU each of the studies described below. Overall conclusions are provided in Section 4.5.

Table 4.4. Recent model based projections of land abandonment in the EU

Sources: **Scenar 2020** (Nowicki *et al,* 2006) and **Scenar 2020-II** (Nowicki *et al,* 2009); **EURURALIS 2.0** Rienks, 2008; Verburg & Overmars, 2009, detailed results http://www.eururalis.eu/index.htm); **Environmental benefits of land services** IEEP and Alterra, (2010); **Land Use Modelling – implementation (LUM-I)** study (Pérez-Soba *et al,* 2010; Verburg *et al,* in press).

Study and publication (Models) / Scenario	Scale of abandonment over EU territory	Areas with highest risk of abandonment
Scenar 2020 (LEITAP, ESIM, CAPRI and CLUE-s) and Scenar 2020-II (LEITAP, ESIM, CAPRI)		
Baseline (business as usual)	1.4% of total land area by 2020*	Finland, Sweden & parts of NW Iberia, SE France, Austria and Slovakia
Regionalisation	0.7% of total land area by 2020*	Finland, Sweden & parts of NW Iberia, Austria and Slovakia
Liberalisation	3.7% of total land area by 2020*	Finland, Sweden, Scotland, NW Iberia, Austria, Slovakia, Denmark, southern France, the Alps, Germany and parts of Italy
EURURALIS 2.0 (CLUE-s)		
Global Economy	4.4% of total land area by 2030	Sweden, Finland, Alps, Germany, Italy & N-W Iberia.
Continental Market	2.2% of total land area by 2030	Sweden, Finland, E-Alps, Italy, Portugal & Romania
Global Cooperation	6.7% of total land area by 2030	Sweden, Finland, Alps, Germany, Italy, N-W Iberia, Romania & Greece
Regional Communities	5.9% of total land area by 2030	Sweden, Finland, Alps, Germany, Italian Apennines, N-W Iberia, Romania & Greece
Environmental benefits of land services (CLUE-s)		
Global Cooperation	No European-wide quantification. 19.8% of arable land in HNV farmland by 2030 28.1% of HNV grassland by 2030	Spain and Portugal, parts of Finland and Sweden, highland areas of France, Italy, Germany, Romania, Bulgaria and the UK, and parts of Greece
Land Use Modelling – Implementation (Dyna-CLUE)		
Global Cooperation and reference scenario, and other derivative scenarios (see Section 4.4.4), except below	Extensive: not quantified	Spain, Portugal, Apennines, Alps, Brittany, , S France, Germany and Greece
Biofuel scenario with EU production, biodiversity scenario + EU biofuel production	Moderate: not quantified	NW Portugal, Apennines, Alps, Brittany, upland areas of Germany and Greece
Biofuel scenario with EU production + full forest protection	Minimal: not quantified	NW Portugal, Apennines and upland areas of Germany

Note. *this is based only on the proportion of land categorised as recently abandoned in 2020, ie land which is not expected to have developed semi-natural vegetation or forest cover (see Table 4.2).

4.4.1 *Scenar 2020 (Scenario study on agriculture and the rural world)*

The Scenar 2020 study, which was carried out for DG Agriculture, had the overall aim of identifying future trends and driving forces that will be the influencing framework for European agricultural and the rural economy up to 2020 (Nowicki *et al,* 2006). In outline its approach consisted of the following elements:

- the establishment of an extensive database covering the period 1990-2005 to identify drivers and corresponding global, national and regional level trends.
- the elaboration of indicators to interpret the data in order to formulate assumptions for the development of a baseline scenario and two policy framework scenarios up to 2020.
- the quantification of changes in agricultural and rural economy and land-use, where possible through modelling.
- the extrapolation and downscaling of trends for some parameters where modelling is not possible
- the interpretation of the information gained above through a strengths, weaknesses, opportunities and threats (SWOT) analysis within the context of the scenario framework.

The study adopted a scenario framework based on two levels of drivers. Firstly, exogenous drivers, which are drivers that are not directly influenced by policies, or at least not in the Scenar time horizon (ie up to 2020). As indicated in Annex 3.3 these include population growth, macro-economic growth, consumer preferences, agri-technology, environmental conditions and world markets. The second level of drivers relate to policies that are expected to have a discernable effect within the Scenar time horizon, including EU agricultural policies, enlargement decisions and implementation, WTO and other international agreements and environmental policies.

On the basis of its analysis of drivers the study developed the following three scenarios for further investigation (see Annex 3.3 for details).

- **Baseline**: assumes the continuation of recent trends in exogenous drivers, and the development of agricultural and rural policy according to current policy objectives, including the successful outcome of the Doha Round negotiations.
- **Regionalisation**: assumes that, in the absence of a successful conclusion of the Doha Round, then not only will further bilateral and multi-lateral negotiations continue but also at the same time more encouragement will be given to promoting the production of commodities in the internal market.
- **Liberalisation**: current trends towards more open markets at the international level will be strengthened. In this scenario, all forms of market and trade policies and income support – that are related to agricultural commodity production – will be abolished in the EU and the rest of the world.

As indicated in Figure 4.3, the spatial land use modelling carried out in the study uses CLUE-S to build on the outputs of the three economic models (LEITAP, ESIM, CAPRI) to produce 1 by 1 km resolution maps of land use (according to the classes described in Table 4.2 above). This required the incorporation of additional policy assumptions, which are summarised in Table 4.5 below.

Figure 4.3. Model linkages within the Scenar study (Source: Nowicki *et al, 2006*)
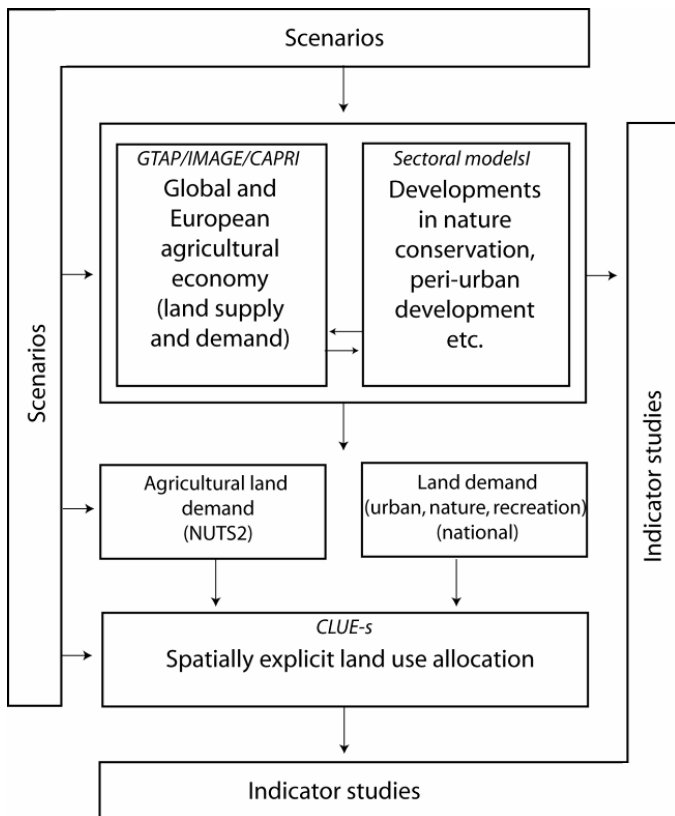
The results of the study suggest that the area of land subject to land use change will be significant, although it will vary according to scenario, with 4.3% of EU-25 land area[23] changing under the Regionalisation scenario, 5.1% under the Baseline scenario and 9.2% under the Liberalisation scenario. The amount of change also varies amongst the EU Member States with the landuse changes being most frequent in north-west Iberia, Italy, Brittany, the Alps, Germany, Bulgaria and Romania.

The most obvious pattern in the projected land use changes is a widespread decline in arable agriculture, especially in north-west Iberia, Ireland and western UK, Scandinavia, central Europe and Italy; which coincides with areas that least suitable for arable production. Significant increases in arable farming are, however, projected under all the scenarios to some degree in Romania, Bulgaria and the Baltic States. Arable expansion is expected to be greatest in these areas under the liberalisation scenario, with increases of over 10% over much of the region compared to 2000.

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[23] Nowicki et al (2006) actually state in Table 4.10 that the percentages changes relate to Europe, but the total area given matches the EU-25.

Table 4.5. Summary of spatial policy scenario settings

Policy	Baseline	Regionalisation	Liberalisation
Set-aside	No change in set-aside policy / level at the time of the modeling (ie 10%[24])	1% increase in arable set-aside as set in 2000 from 2014 to 2018	Abolished from 2014 to 2018 in equal steps
LFA	Moderate LFA support: In LFA areas the suitability of arable and grassland is increased in order to represent the compensation of farmers to adverse conditions.	High LFA support: In LFA areas the suitability of arable land and grassland is strongly increased in order to represent the compensation of farmers to adverse conditions	No LFA support: No LFA compensation implemented.
Urban planning policies	New built-up area is considered to arise close to existing built-up area, but spill-over sprawl in rural areas is possible as well. This measure favours both provincial towns and bigger cities.	New built-up area is considered to arise close to existing built-up area. This measure favours both provincial towns and bigger cities.	New built-up area is considered to arise close to existing built-up area, grasslands and nature. This measure favours growth in existing urban areas and sprawl in rural/ natural area, which reflects a more liberal housing policy.
Natura 2000	All conversions from nature (forest and (semi-) natural vegetation) to other land uses are only allowed outside the Natura 2000 areas.	All conversions from nature (forest and (semi-) natural vegetation) to other land uses are only allowed outside the Natura 2000 areas. Agriculture is supported in Natura 2000 areas: In Natura 2000 areas the suitability of arable and grassland is increased. This reflects the implementation of second pillar/second axis policies in this scenario that aim to compensate farmers for unfavourable conditions in these areas.	No strict application of the Natura 2000 policy.

The projects patterns of grassland change are more complex, though widespread declines are apparent in Scandinavia, and the Baltic States and eastern Europe, with the exception of Bulgaria and Romania, where grassland expansion is expected. Again the greatest projected changes occur under the Liberalisation scenario.

Forest changes are relatively modest in the model projections due to the time required for forest development. Nevertheless, in all scenarios southern France, Italy and north-west Iberia show an increase in forested area. This is considered by the authors to be due to succession from areas that are currently under semi-natural vegetation (mostly scrubland on formerly abandoned farmlands). In contrast, forest area is projected to decline by over 25% compared to 2000 over much of Bulgaria and Romania in all the scenarios. But these rates of forest loss seem questionable given that much of the Romanian and Bulgarian forests are within Natura 2000 sites and therefore strictly protected under the Habitats Directive.

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[24] Set-aside was at a fixed rate of 10% from 2000 until it went to 0% in 2007, and was abolished in 2008.

It is difficult to calculate the exact amount of projected abandonment that occurs over the region between 2000 and 2020 from the results presented in the study report. Projected percentage land cover changes are provided in the report's annex, including those for recently abandoned arable land and recently abandoned grasslands (Table 4.6). These indicate that as of 2020 as much as 3.7% of land cover could potentially be categorised as recently abandoned (and over 5% in several EU Member States) according to the Liberalisation scenario. However, recently abandoned land only amounts to 1.4% under the Baseline scenario and 0.7% under the Regionalisation scenario.

Figure 4.4 overlays the projections for agricultural abandonment[25] under each scenario to provide an indication of the regions of Europe that are expected to be most at risk from abandonment. This clearly indicates that a large proportion of farmland in Finland and Sweden is likely to be at risk of abandonment under all scenarios, as are parts of north-west Iberia, Austria and Slovakia. Where abandonment is greater than 20% under only one scenario then this always refers to the Liberalisation scenario. Abandonment under this scenario is clearly widespread, with marked levels of abandonment projected to occur in Scotland, Denmark, southern France, the Alps, Germany and parts of Italy, in addition to the higher risk areas listed above.

However, the Liberalisation scenario might be regarded as unrealistic as it assumes an extreme level of global competition, no LFA support and very weak application of environmental policies. In fact, the authors of the Scenar report suggest that the lower rates of abandonment are due to LFA support. But as there is no specific analysis of the impact of LFA support, it does not seem possible to deduce this as the scenarios include a range of differing assumptions.

The Scenar study's results on abandonment also need to be treated with caution because some areas that are stated as being abandoned may in fact be areas that are subject to very low levels of management (and may therefore be only temporarily abandoned) or be areas that are planted with trees (eg under afforestation programmes) and under active management. Furthermore, some of the scenario assumptions are no longer valid. In particular, set-aside is included in all of the Scenar scenarios, but it was set at 0% in 2007 and abolished in the 2008 Health Check. Also the assumption that moorland and heathland area remains constant (see table 4.2) is unlikely to be valid in some areas.

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[25] It is assumed that this refers to the projected percentage of land that is categorised as recently abandoned in 2020, although this is not made clear in the report.

Table 4.6 Percentage total land cover (ie territory) projected to be categorised as recently abandoned in 2020

	Recently abandoned arable land			Recently abandoned grass land			Total of recently abandoned land		
	Baseline	**Regionalisation**	**Liberalisation**	**Baseline**	**Regionalisation**	**Liberalisation**	**Baseline**	**Regionalisation**	**Liberalisation**
Austria	0.2%	0.0%	2.1%	0.0%	0.0%	1.6%	0.2%	0.0%	3.7%
Belgium/Luxembourg	1.3%	0.4%	2.2%	0.0%	0.0%	1.9%	1.3%	0.4%	4.1%
Bulgaria	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Cyprus	2.1%	0.7%	1.3%	0.5%	0.3%	0.4%	2.6%	1.0%	1.7%
Czech Republic	0.6%	0.2%	1.6%	1.3%	0.9%	1.7%	1.9%	1.1%	3.3%
Denmark	3.5%	1.7%	6.4%	0.2%	0.1%	1.2%	3.7%	1.8%	7.6%
Estonia	0.0%	0.0%	0.9%	0.4%	0.2%	1.6%	0.4%	0.2%	2.5%
Finland	0.8%	0.4%	1.4%	0.1%	0.1%	0.2%	0.9%	0.5%	1.6%
France	1.6%	0.6%	4.3%	0.1%	0.0%	1.0%	1.7%	0.6%	5.3%
Germany	2.2%	0.8%	4.9%	0.1%	0.1%	0.9%	2.3%	0.9%	5.8%
Greece	0.8%	0.5%	2.0%	0.6%	0.5%	0.4%	1.4%	1.0%	2.4%
Hungary	1.2%	0.3%	2.8%	1.2%	1.2%	1.5%	2.4%	1.5%	4.3%
Ireland	1.3%	1.0%	0.0%	3.0%	3.0%	0.0%	4.3%	4.0%	0.0%
Italy	1.9%	1.1%	3.7%	0.0%	0.1%	1.4%	1.9%	1.2%	5.1%
Latvia	0.0%	0.0%	0.3%	0.5%	0.2%	1.0%	0.5%	0.2%	1.3%
Lithuania	0.0%	0.0%	0.3%	0.2%	0.1%	0.4%	0.2%	0.1%	0.7%
Malta	3.5%	1.3%	1.6%	0.9%	0.6%	1.3%	4.4%	1.9%	2.9%
Netherlands	1.5%	0.6%	3.4%	0.0%	0.0%	0.4%	1.5%	0.6%	3.8%
Poland	0.4%	0.1%	1.7%	1.7%	0.9%	2.0%	2.1%	1.0%	3.7%
Portugal	0.8%	0.4%	2.0%	0.1%	0.2%	0.5%	0.9%	0.6%	2.5%

	Recently abandoned arable land			Recently abandoned grass land			Total of recently abandoned land		
	Baseline	Regionalisation	Liberalisation	Baseline	Regionalisation	Liberalisation	Baseline	Regionalisation	Liberalisation
Romania	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Slovakia	1.0%	0.2%	2.0%	2.3%	2.2%	2.8%	3.3%	2.4%	4.8%
Slovenia	0.5%	0.1%	0.7%	1.3%	1.3%	1.5%	1.8%	1.4%	2.2%
Spain	1.0%	0.6%	3.6%	0.7%	0.5%	1.8%	1.7%	1.1%	5.4%
Sweden	0.7%	0.2%	1.0%	0.0%	0.1%	0.2%	0.7%	0.3%	1.2%
United Kingdom	0.4%	0.0%	3.1%	0.0%	0.0%	2.5%	0.4%	0.0%	5.6%
Overall %	**1.0%**	**0.4%**	**2.6%**	**0.4%**	**0.3%**	**1.1%**	**1.4%**	**0.7%**	**3.7%**
Area km^2	**42,151**	**16,860**	**109,593**	**16,860**	**12,645**	**46,366**	**59,011**	**29,506**	**155,959**

Note. Recently abandoned pasture land includes very extensive pasture land not reported in agricultural statistics, grasses and shrubs below 30 cm. Recently abandoned arable land (i.e. "long fallow") includes very extensive farmland not reported in agricultural statistics, herbaceous vegetation, grasses and shrubs below 30 cm).

Figure 4.4. Regions most affected by agricultural abandonment in 2020 according to projections from the Scenar study (Source: Nowicki *et al,* 2006).

Legend:
Agricultural abandonment > 20 %
of total agricultural area under:

- 0 scenario
- 1 scenario
- 2 scenarios
- 3 scenarios
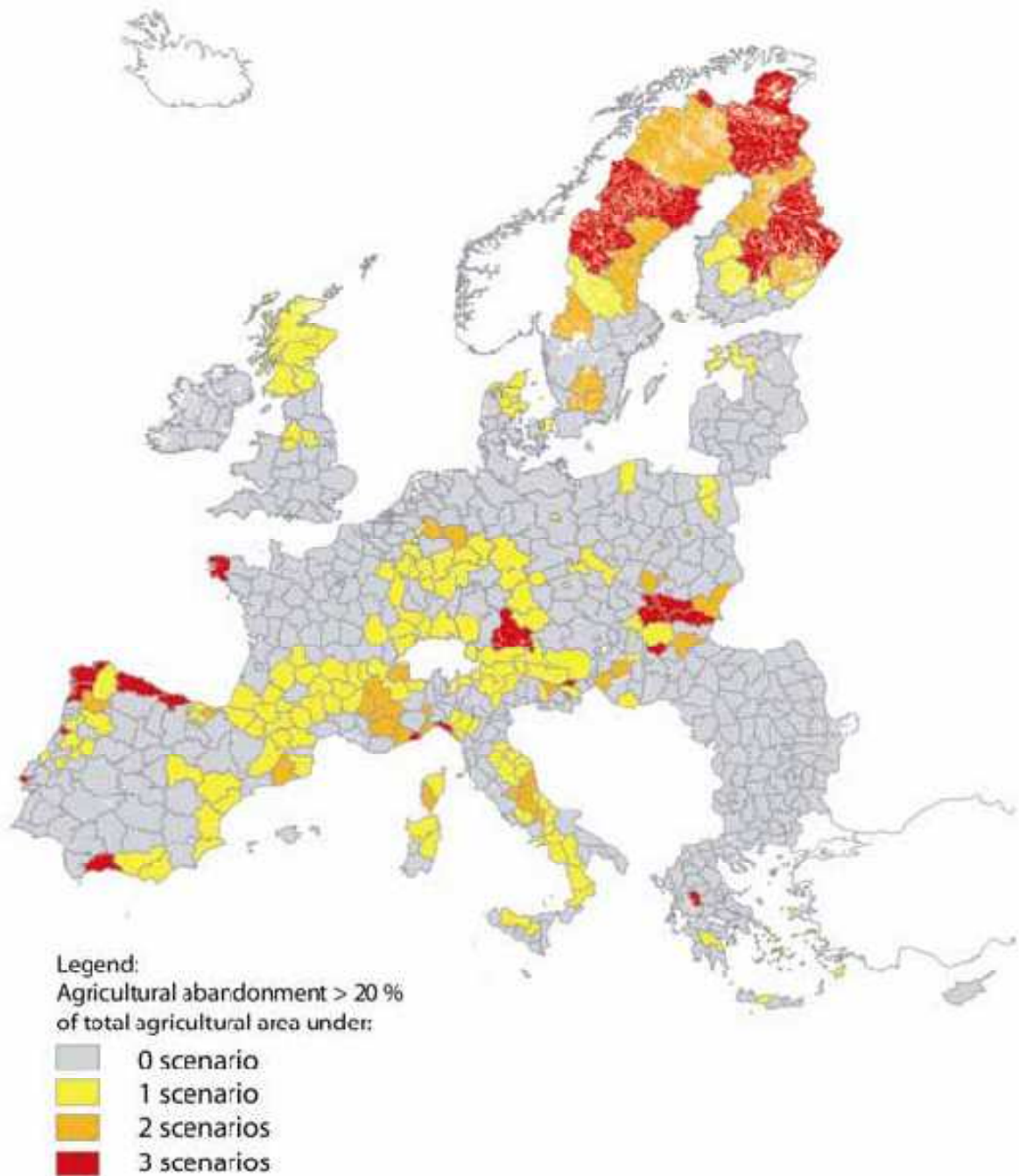
It is important to note that the data on recently abandoned land provide only part of the picture. Over the 2000 to 2010 period some abandoned areas would be expected to develop into semi-natural vegetation, and some of this, as well as existing areas of semi-natural habitats (eg shrublands) may then develop into forest cover. Therefore a more comprehensive analysis would track land that moves through these categories. Such data are not provided in the Scenar report.

Further analysis of the land use change projections could be carried out by adding changes in semi-natural habitats and forest area to the recently abandoned category. But it is considered that this would be inappropriate as abandonment that leads to development of semi-natural vegetation and forest habitats in one area may be offset by losses in other areas (eg as a result of agricultural expansion or urbanisation). Furthermore, forest areas may also include areas that have been purposefully afforested rather than merely abandoned. Although it can be considered that afforestation is often a response to marginalisation (ie it pre-empts abandonment) such afforestation often creates even-aged plantations with minimal structural and species diversity; which are often monocultures of alien species. The additional analysis would also be unable to include grasslands that have developed from abandoned arable land.

4.4.2 EURURALIS

The results of the EURURALIS study suggest that relatively significant areas of abandonment may occur in Europe by 2030, according to the four adopted scenarios. These scenarios follow the concept storylines of the IPCC Special Report on Emission Scenarios (SRES; IPCC, 2001a,b) which are structured along two axis distinguishing globalisation from regionalisation; and development pursuing narrowly defined economic objectives from more broadly defined economic, social and environmental objectives (see Figure 4.5). These outline scenarios have been elaborated for investigations of land use issues and agricultural policies typical for Europe (Westhoek *et al,* 2006), which has resulted in a series of four scenarios distinguished by different degrees of global (market) integration and different levels of (policy) regulation (see Annex 3). Scenarios with a relatively low level of regulation include the A1 Global Economy and A2 Continental Market scenarios. The other two scenarios: B1 Global Co-operation and B2 Regional Communities assume a relatively high level of regulation, including specific spatial and agricultural policies.

Figure 4.5. The primary axes of the scenarios used in the EURALIS study

The elaboration of the scenarios also included the quantification of variables exogenous to the simulation models representing the developments assumed in the scenarios. These exogenous variables include demography, institutions, trade barriers and technology parameters. A selection of the assumptions made in the four scenarios that are explicitly accounted for in the simulations is provided in Annex 3.2.

The results of the EURURALIS study suggest that relatively significant areas of abandonment may occur in Europe by 2030, under all but the A2 Continental Markets scenario (Table 4.7). Abandonment is particularly significant under the A1 Global Economy, amounting to as much as 16% of total agricultural area up to 2030. These results seem to indicate a continuation of recent trends noted in Chapter 2. However, as with the Scenar study, some areas that are stated as being abandoned may in fact be areas that are subject to very low levels of management (and may therefore be only temporarily abandoned) or be areas that are planted with trees (eg under afforestation programmes) and under active management.

Table 4.7. EURURALIS abandonment projections for the EU between 2000 and 2030, according to each study scenario (source: www.eururalis.eu/index.htm)

	Scenario			
	A1 Global economy	**A2 Continental Markets**	**B1 Global Cooperation**	**B2 Regional Communities**
Abandoned area as % of agricultural land	10.1	4.7	16.0	13.8
Abandoned area as % of all land	4.4	2.2	6.7	5.9
Area (km^2)	185,464	92,732	282,412	248,691

The results also need to be treated with caution because some of the policy assumptions are no longer valid, such as the retention of set-aside (A2, B1 and B2 scenarios), as also assumed in the Scenar 2020 and LUM-I studies. Other assumptions may be unrealistic, such the downscaling of Rural Development funds (see Annex 3.2 for details). Furthermore, given the scenario assumptions for the know drivers of abandonment and the policy measures to maintain farming (eg LFA payments), it is surprising that abandonment is greatest under the Global Cooperation scenario and significantly less under the Continental Markets scenario. For all these reasons, it does not seem possible to draw reliable conclusions from the EURURALIS study on the extent of actual abandonment as defined in this study.

The model results may, however, provide more readily interpretable and reliable results on the locations that are at most risk of abandonment, and how these may differ amongst the four scenarios. Figure 4.6 provides maps of the locations with the highest risk of abandonment according to each scenario. These clearly show that there are some areas that are consistently at risk of abandonment, most obviously Sweden and parts of Finland, but also the Alps, parts of central Europe and the Italian Apennines. North-west Iberia is also subject to high rates of abandonment in three of the four scenarios. But these maps must be interpreted with care. For example, although a high proportion of total agricultural land is abandoned in Sweden and Finland, the absolute area involved is small compared in these heavily wooded regions, to regions that are dominated by agricultural land uses (cf Figure 4.6 below).

Figure 4.6. Land use abandonment in 2030 as percentage of agricultural land in 2000 for the reference scenarios (source http://www.eururalis.eu/eururalis2.htm**).**
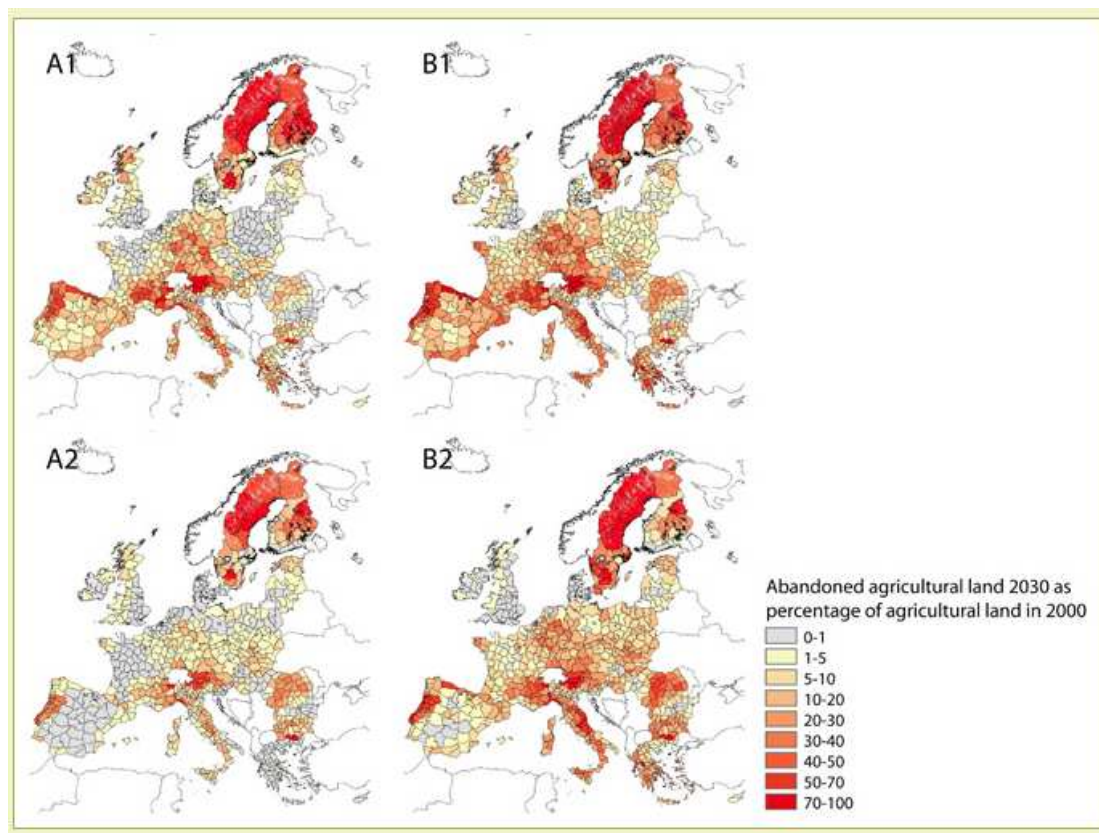
These patterns are further illustrated in Figure 4.7, which shows in more detail the overlap in projections for abandonment. Blue areas are projected to be abandoned in one or two of the scenarios while red areas show abandonment in three or all four scenarios. This suggests that some regions are thought most likely to face large scale abandonment (red in the map), regardless of the scenario or policy response options. These are nearly all mountainous or hilly areas, and include the Pyrenees, Massif Central, Apennines, Alps, Harz Mountains and Thuringian Forest of central Germany, Elbe Sandstone mountains, Ore Mountains (Erzgebirge) and Bavarian Forest / Bohemian Forest of the German / Czech border and to a lesser extent the Carpathians. Similarly we can be reasonably confident that some areas will not face significant agricultural abandonment under any likely future scenario (ie dark grey areas in Figure 4.7).

There are, however, some apparent differences in the patterns of projected abandonment amongst the scenarios. Figure 4.6 suggests that in the A1 Global Economy scenario agriculture is preferentially concentrated in highly productive areas while the B2 Regional Communities scenario tends to favour regional production and protection of cultural-historic landscapes.

Figure 4.7. Aras of overlap in abandonment projections from the EURURALIS study (source: http://www.eururalis.eu/eururalis2.htm)
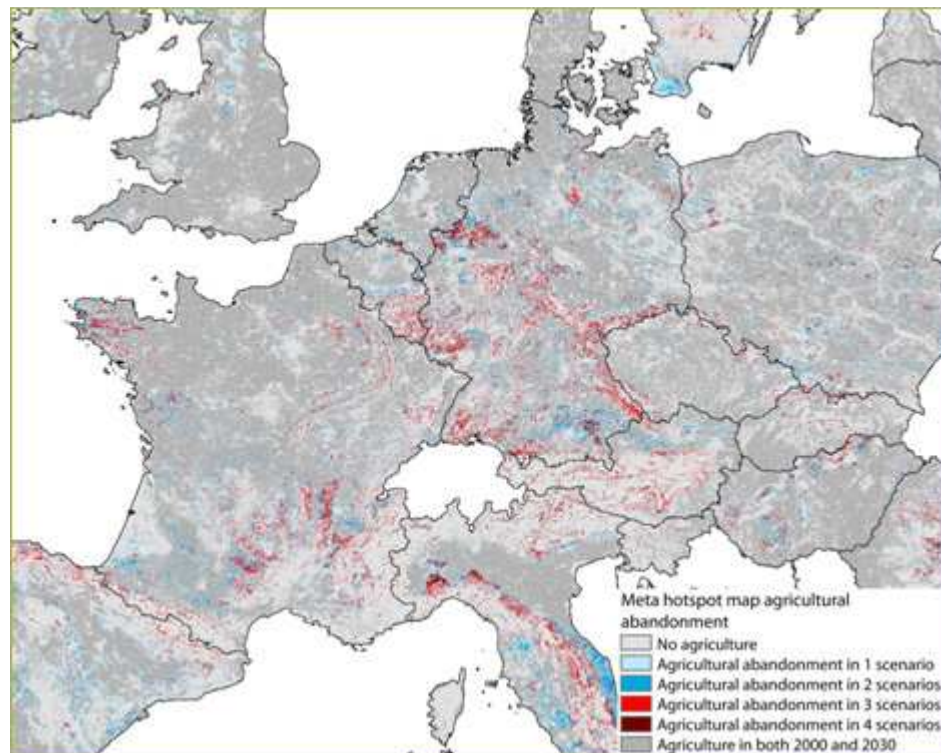
4.4.3   Land Services study

This study by IEEP and Alterra (2010), which was carried out for DG Environment, focussed on one reference scenario that was based on the B1 Global Cooperation scenario developed for the EURURALIS project (see above and Annex 3.2). Figure 4.8 presents a synthesis of the modelling results for this reference scenario. This provides a generalised view of the main projected changes in land use/cover over the 2000-2030 period, with the colours indicating the dominant land use change in the region. This map clearly suggests that, under this scenario, there will be widespread abandonment. However, **it is important to note that such maps can give the impression that the depicted dominant land use changes are more extensive than they actually are**. In reality finer-scale patterns of change, which cannot be shown in such small-scale maps, will be more diverse.

Nevertheless, the projected magnitude of abandonment is clearly substantial, particularly in Spain and Portugal, parts of Finland and Sweden, highland areas of France, Italy, Germany, Romania, Bulgaria and the UK, and parts of Greece. These patterns of abandonment are similar to those described in other modelling studies (see Table 4.4) and are mostly in accordance with the expectations based on known drivers of abandonment. However, the projections of significant abandonment in parts of lowland Germany and France, the UK and Ireland do not seem to be associated with known drivers of abandonment and do not match those of other models, including those based on the Global Cooperation scenario (eg see Figure 4.9).

The IEEP and Alterra study did not quantify overall abandonment in the EU, but did include a detailed analysis of abandonment in HNV farmland areas, as these are considered to be particularly susceptible to marginalisation and abandonment (as discussed in Chapter 3). The analysis was carried out by overlying the land use changes projections with the potential distribution map of HNV farmland produced by the JRC - Institute for Environment and Sustainability and the EEA (Paracchini *et al,* 2008). As indicated in Table 4.8, the analysis confirms that HNV farmland areas have a particularly high risk of abandonment. On the basis of B1 Global Cooperation scenario projections, 10.9% of non irrigated arable land may turn into recently abandoned arable and a further 9.0% may develop semi-natural vegetation between 2000 and 2030. The projected abandonment trend for pasture is even greater with 20.4% developing into recently abandoned pasture, and 7.7% into semi-natural vegetation areas. The loss of HNV pasture areas in the Mediterranean countries (Greece, Spain, Portugal and Italy) is particularly significant. Of existing semi-natural vegetation areas, 17.3% is expected to develop into forest. Additionally 8.5% of the permanent crops category may become recently abandoned arable land. In contrast, the projections suggest that there will be very little intensification of agricultural systems in HNV farmland areas.

Figure 4.8. Generalised dominant land use / cover change for 2000-2030 according to the Land Services study's projections (B1 Global Cooperation scenario). (Source: IEEP and Alterra, 2010)

Table 4.8. Land use flow inside HNV areas between 2000 and 2030 according to the Land Services study's projections (B1 Global Cooperation scenario). Source: IEEP and Alterra (2010) projections based on the B1 reference scenario

Note. Land use classes corresponding to potential HNV farmland are shaded in green

Clue class 2030 / 2000	0. Build-up area	1. Arable land (non irrigated)	2. Pasture	3. (Semi-) natural vegetation	4. Inland wetlands	5.Glaciers and snow	6.Irrigated arable land	7. Recently abandoned arable land	8. Permanent crops	9. Arable land for annual biofuel crops	10. Forest	11. Sparsely vegetated areas	12.Beach, dunes and sands	13. Salines	14. Water and coastal flats	15.Heather and moorlands	16. Recently abandoned pasture	17. Perennial biofuel crop
0. Build-up area	100.00%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1. Arable land (non irrigated)	0.26%	68.85%	4.34%	9.05%	0.00%	0.00%	0.00%	10.77%	0.38%	5.42%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%
2. Pasture	0.46%	0.11%	70.48%	7.73%	0.00%	0.00%	0.00%	0.00%	0.53%	0.02%	0.22%	0.00%	0.00%	0.00%	0.00%	0.00%	20.44%	0.00%
3. (Semi-) natural vegetation	0.02%	1.76%	0.53%	79.98%	0.00%	0.00%	0.00%	0.07%	0.00%	0.20%	17.35%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%	0.00%
4. Inland wetlands	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5. Glaciers and snow	-	-	-	-	-	100.00%	-	-	-	-	-	-	-	-	-	-	-	-
6. Irrigated arable land	-	-	-	-	-	-	100.00%	-	-	-	-	-	-	-	-	-	-	-
7. Recently abandoned arable	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Permanent crops	0.11%	0.77%	3.15%	4.14%	0.00%	0.00%	0.00%	8.50%	83.07%	0.08%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.15%	0.00%
9. Arable land for annual biofuel crops	0.00%	10.64%	5.45%	1.61%	0.00%	0.00%	0.00%	6.44%	0.00%	75.87%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10. Forest	0.02%	1.44%	0.52%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.17%	97.80%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%
11. Sparsely vegetated areas	-	-	-	-	-	-	-	-	-	-	-	100.00%	-	-	-	-	-	-
12. Beaches, dunes and sands	-	-	-	-	-	-	-	-	-	-	-	-	100.00%	-	-	-	-	-
13. Salines	-	-	-	-	-	-	-	-	-	-	-	-	-	100.00%	-	-	-	-
14. Water and coastal flats	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.00%	-	-	-
15. Heather and moorlands	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.00%	-	-
16. Recently abandoned pasture	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17. Perennial biofuel crop cultivation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

4.4.4 Land Use Modelling – Implementation study

The Land Use Modelling – Implementation (LUM-I) study (Pérez-Soba *et al,* 2010; Verburg *et al,* in press) was based on two reference scenarios that were used in combination with a number of policy variations to provide eight illustrative policy-scenarios. The first reference scenario was the B1 Global Cooperation scenario (as described above under the EURURALIS and Land Services studies and in Annex 3). This was combined with the following set of policy variations concerning the implementation of the Renewable Energy Directive (Directive 2009/28/EC):

1. Policy promoting biofuel use in five non-European countries (USA, Canada, Japan, Brazil and South Africa) with unrestricted conversion of forests into agricultural land (i.e. no protection of forests).
2. Same as 1) with the same policy also implemented in EU. This scenario is also used as a 2nd reference.
3. Same as 2) with full protection of all existing forests.

Each biofuel scenario assumes a blending target of 5.75% biofuels in total final transport fuels by 2010, and 10% by 2020.

In addition a biodiversity policy alternative (to the first and second reference scenarios) was introduced to explore the potential impacts of a number of ambitious nature conservation measures. The measures of most relevance to abandonment included compensation for extensive farming (especially permanent pastures) in HNV areas with support levels similar to LFA support, increased CAP Pillar 2 funding in Natura 2000 sites to provide stronger incentives for maintaining extensive practices, and LFA payments targeted to HNV areas with increased CAP Pillar 2 funding. In addition, despite the fact that set-aside was abolished in 2008, the biodiversity policy alternative included an increase in set-aside from 10% (as included in the reference scenario) from 2015 onwards by 1% per annum to a maximum level of 15%.

Two further variations on the biodiversity policy alternative were also investigated, firstly the scenario without the post-2015 increase in set-aside, and secondly, the scenario with a high demand for land through combination with the 3rd biofuel policy scenario (see above).

Finally a Soil and Climate Change policy alternative (to both reference scenarios) incorporated adaptation and mitigation measures related to water management and soil protection, including the following policy themes: flood damage reduction, restoring water balance, protection of permanent pastures, protection of peat land, soil protection and erosion prevention.

The LUM-I study does not provide tabulated quantitative results, but instead depicts principal land use changes in maps in a similar way to the IEEP and Alterra (2010) Land Services study (see Figure 4.8) above. In fact the Land Services and LUM-I

studies used the same models and the B1 Global Cooperation scenario as a baseline scenario (termed Reference Scenario in the Land Services study), and were both carried out by Alterra. It would therefore be expected that the two studies' maps of projected land use change would show similar patterns of abandonment. There are indeed similarities, with abandonment in both studies being particularly prevalent in the Apennines, parts of the Alps, north-west Iberia, Brittany, and the upland areas of Germany. However, the projected extent of abandonment under the Global Cooperation scenario appears to be substantially less in LUM-I study (Figure 4.9) than the Land Services study (see Figure 4.8 above). Furthermore, the projected expansion of agriculture is much more widespread in eastern Europe in the more recent LUM-I study, leading to a clear east-west dichotomy in land use change. The reasons for these discrepancies are not clear from the study reports, though it could be partly due to the inclusion of 10% set-aside in the LUM-I scenarios .

Figure 4.9. Generalised dominant land use / cover change for 2000-2030 according to the LUM-I study B1 Global Cooperation baseline scenario. (Source: Verburg *et al*, in press. Reproduced with kind permission of Peter Verburg)
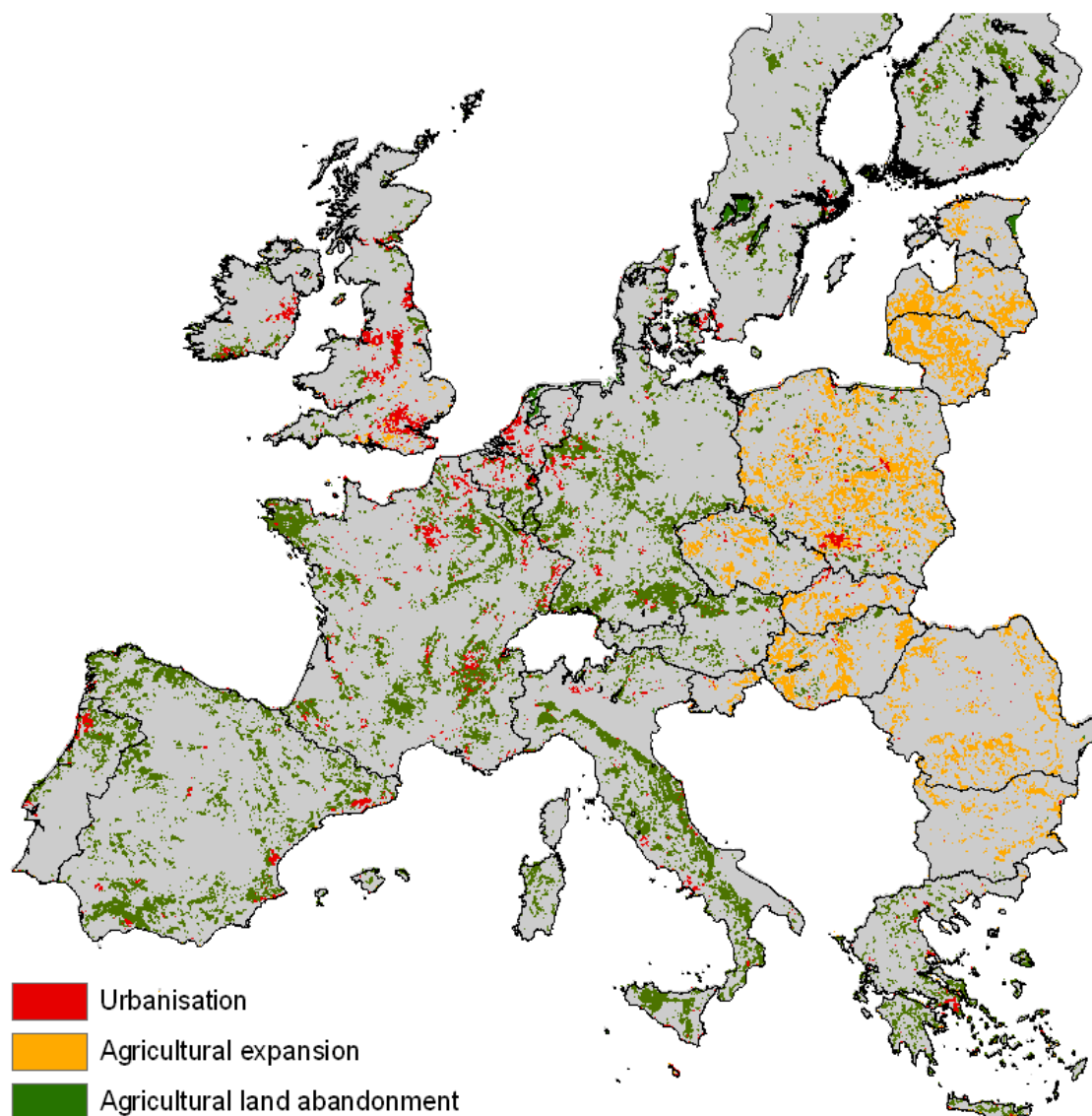
Of perhaps most importance though are the results concerning the impacts of biofuels policy on abandonment. Comparison of the projected land use scenarios for each biofuel policy variation clearly suggests that substantial production of biofuels in the EU (ie under the scenario with biofuel policy variation 2 above), would significantly reduce land abandonment. Furthermore, the same policy of biofuel production in the EU as well as the five non-EU countries with full protection of forests (ie biofuel policy variation 3 above) would virtually eliminate land abandonment over most of Europe. Under this scenario the only concentrations of abandonment would remain in the Apennines and Sicily. This would presumably be largely through the knock-effect of increased competition for land. Indeed, it is worth noting that agricultural expansion is particularly widespread in eastern Europe under the biofuel scenarios, and this leads to the loss of semi-natural vegetation and forests in the region.

However, the report does not quantify the biofuel feedstock production in the EU or the area of land that would be needed under the various biofuel policy scenarios. It is therefore difficult to ascertain how realistic the study's biofuel scenarios are, given that it is expected that a significant proportion of production will occur outside Europe (see Section 3.3). Furthermore, the Renewable Energy Directive includes sustainability criteria that should prevent the production of biofuels in protected areas and on forested land, wetlands and species-rich grasslands. But the modelled projections do not seem to take these criteria into account because the LUM-I study report notes that the scenario with biofuel production in the EU leads to widespread conversion of forests to arable land. Forest and grassland conversion could potentially occur as a result of indirect land use change (ie biofuel crops displacing intensive food and fodder crops, which are not covered by sustainability criteria, onto extensive grasslands and forest). However, it seems implausible that such large-scale arable expansion could be due to indirect land use changes. Thus the scenarios with high biofuel production in Europe are probably unrealistic.

The biodiversity policy scenario investigated in the LUM-I study appears to reduce abandonment to a small extent. One possible reason for this could be the increase in the set-aside level after 2015 (see above). But the projections from the model run without set-aside appear (from a visual inspection of the land use change maps) to be no different in terms of extent or distribution of abandonment. But the study does not provide any quantitative data on abandonment under these biodiversity policy variations, and therefore it is not possible to assess the differences accurately.

According to the land use change maps and a summary histogram of land use changes across all the scenarios (Figure 24 in Pérez-Soba 2010) the soil and climate policy scenario appears to reduce the extent of abandonment slightly. But again no quantitative results are provided, so this cannot be assessed accurately.

4.5 Conclusions

Land use models are useful tools for examining the combined impacts of drivers of land use change according to plausible future socio-economic scenarios. Projections from model-based studies generally suggest that significant areas of land will be abandoned over the next few decades, especially if agricultural markets are further exposed to global competition. Mountainous and remote areas with marginal agricultural production are also consistently identified as areas that are most likely to be abandoned. However, careful analysis of the models, and their underlying data and assumptions indicate that projected levels and locations of abandonment should be treated with caution because:

- Future land use and policy impacts projections are constrained by the availability, scale, geographical coverage and type of input data used in the models.
- There tends to be a significant time lag in the data sets (especially environmental data) and policy assumptions used in models – some of which may have a major influence on land abandonment, such as set-aside and LFA support.
- The models may be overly deterministic, as they do not take into account social and cultural factors that may encourage the continuation of uneconomic farming activities, such as use of the land for recreation, and the desire to continue cultural or family traditions and stay in the community.
- Some areas that are stated as being abandoned may in fact be areas that are subject to very low levels of management (and may therefore be only semi-abandoned) or be areas that are planted with trees (eg under afforestation programmes) and under active management.
- The model-based studies have mostly used the same models or derivations of earlier versions, and similar socio-economic scenarios, and therefore it is expected that they would show similar results. However, some studies using similar modes and scenarios have produced differing results.

Furthermore, it is clear that the rates of abandonment vary according to the overall scenarios and detailed policy assumptions used, and it is questionable whether some of those that project the largest rates of abandonment are plausible, at least in the foreseeable future.

It is also necessary to carefully interpret some of the maps of abandonment that have been produced from the studies, as they can be misleading. In order to visually depict within a report where abandonment is most likely some studies show generalised maps of dominant land use (eg Figure 4.8 above). But due to the small scale of the maps the detailed patterns of projected land use change are not visible, and instead dominant land uses tend to coalesce, thus giving the appearance of widespread land abandonment that is beyond the magnitude indicated from the quantitative models results.

5   CONCLUSIONS

This study's main focus is long-term abandonment of agricultural activity that allows natural succession, leading to the formation of semi-natural grasslands, shrublands and forest, as this is likely to have the most significant nature conservation impacts. But this 'actual abandonment' can be difficult to define, study and predict. This is primarily because land abandonment is driven by a variety of interacting factors, which result in complex and dynamic changes in agricultural management and land use; such that abandonment can be gradual, and sometimes temporary.

Furthermore, the scarcity of time series data has constrained many of the studies of abandonment. Most of the available data cover the period from the 1980's to 2000, which was a period of significant change, particularly in many of the EU-12 Member States. It is surprisingly difficult to find information on recent land abandonment or re-use of formerly abandoned land.

The satellite information based CORINE maps currently provide the only European data set that can be used to track and assess pan-European changes in land use. However, reviews of CLC data have revealed that it is difficult to distinguish abandoned land from other land cover such as semi-natural grazing land still in agricultural use, fallow land and naturally regenerating forest (EEA, 2006). As a result some documented hotspots of abandonment have not been detected in studies using CLC data (Verburg and Overmars, 2009). This, together with other problems limits the usefulness of CORINE in assessing land abandonment, though it is widely used in computer modelling.

A number of detailed case studies of abandonment in specific regions have been carried out. These have revealed that it is very difficult to obtain an accurate picture of land abandonment, even at a small scale, using the best available data (eg as Pointereau *et al*, 2008 illustrate). To reliably asses land abandonment it is essential to have detailed small-scale farmland and forest land data; and to be able to understand flows of land between different uses, not just the net loss or gain. Nevertheless, the case studies reviewed in Sections 2.2 and 2.3 do confirm that significant abandonment has occurred in the past, resulting in, for example, annual UAA loses from the late 1980's to the end of the 1990's of 0.17% in France, 0.66% in Poland, and 0.8% in Spain (Pointereau et al, 2008). Other studies suggested that 15-20% of cropland in Slovakia, Poland and Ukraine were abandoned as a result of the political changes at the end of the 1980's (Pointereau et al, 2008). Similarly extensive abandonment also occurred in the Baltic States (IEEP and Alterra, 2010). However, some anecdotal observations suggest that a large proportion of land abandoned in this era have been returned to agricultural production in the EU-12 in recent years.

The case studies also clearly show that many of the contributory causes of land abandonment are locally specific (eg fragile soils) and some may be temporary (eg due to afforestation policies and land restructuring). Therefore, because the cases studies are not representative samples, it is inappropriate to extrapolate results from them, eg from one time period to another, and from one region to another; or

to attempt an EU-wide estimation of past abandonment. Moreover, past trends are not necessarily a guide to more recent developments, not least because of significant changes in policy.

As discussed in Chapter 3, past land abandonment and consideration of current institutional as well as physical factors, points to a number of drivers that could be expected to lead to marginalisation and increase the risk of abandonment. These are primarily factors that reduce the profitability of farming enterprises. These include physical factors that reduce yields and/or increase the costs of farming, namely poor and erosion-prone soils, extreme and unpredictable climates, steep ground, remote locations and difficult access. These physical factors interact with dynamic economic drivers, such as commodity prices, subsidies, and other sources of farm income. Secondary drivers may then include the loss of farm workers and the wider impacts of rural depopulation (such as reduced community services). Such rural depopulation may in part be a result of the poor livelihoods and undesirable working conditions that are typical of many extensive farming systems. In addition there are institutional factors such as highly fragmented ownership patterns, complex tenure arrangements, land tax regimes, changes in property rights (as in many new Member States) and the activities of major landowners.

It is very difficult to predict with any certainty future trends in these drivers of abandonment, and hence predict its future extent. However, this report has provided evidence that some of the key drivers are likely to remain and even increase. Marginal extensive grassland systems are undoubtedly at most risk because the EU grazing livestock sector is expected to suffer from weak profitability, as a result of global competition over the next decade or more. As a result, low-intensity production of beef, sheep and goats, together with mountain (and semi-subsistence) dairy systems will become even less viable, with significant declines in the numbers of livestock, particularly in EU-12. In some cases such grasslands will be converted to arable systems, but often they will be unsuitable and grazing management across many semi-natural habitats will decline, leading to partial or complete abandonment in many cases. However, some of this abandoned grazing land may be intentionally afforested or used for development.

In contrast to the impacts on the livestock sector, market trends may reduce the risk of arable abandonment. Market prices of cereals and other arable crops are expected to remain relatively high, at least until the end of the decade (see Section 3.2). This will help to support marginal arable farming systems in Europe, and may drive some expansion of farming and conversion of grasslands to arable, especially in the EU-12. But some marginal arable land is likely to move in and out of production/fallow in response to future price fluctuations, as it has done in the past.

It is also possible that food prices and the need for arable land may increase further as a result of increasing global demand for biofuels (see Section 3.3). Biofuel demand has been stimulated in the EU as a result of transport fuel targets under the Renewable Energy Directive. However, it is expected that a sizeable share of biofuel production for the EU market will be met from outside Europe, and therefore result

in relatively weak indirect effects on land use in the region. Furthermore, the Directive's sustainability should ensure that forests, protected areas and biodiverse grasslands are not used for biofuel production; although indirect pressures on such areas could still occur from large scale production in the EU.

Most of the other key drivers of abandonment are also expected to remain or increase. For example, extensive soil erosion is continuing in much of Europe, especially in the Mediterranean region and mountainous areas (Kirby et al, 2004). Unless abated by effective soil protection measures, this will ultimately end farming in many of the affected areas. Furthermore, such impacts are likely to be exacerbated by climate change, especially in areas that are vulnerable to extreme weather events (EEA, 2004). The long-term impacts of climate change are difficult to predict on a regional basis, and impacts on agriculture will vary within Europe (see Section 3.6). Some areas, such as northern Europe are expected to benefit from climate change as a result of increases in the growing season (see Figure 3.10), which may support farming and encourage arable conversion in some areas. However, in contrast, large areas of south-west, southern-central and south-east Europe are expected to experience significant declines in yield, as result of droughts and high temperatures.

As discussed in Section 3.4, the drivers of abandonment in the EU may be offset to some extent by CAP policy measures that aim to support farming and rural communities in marginal farming areas (such as LFA payments) and cross-compliance measures that aim to maintain agricultural land through grazing requirements and other forms of vegetation control. Agri-environment measures also make a significant contribution to maintaining many HNV farmland systems, especially within Natura 2000 sites. Tourism and recreation is often associated with extensive farming systems, potentially offering additional sources of farm family income to make otherwise uneconomic farming systems viable. Furthermore, as the profitability of extensive farming systems falls then CAP payments and other polices that provide alternative incomes will have a correspondingly greater influence on the viability of such systems.

It is uncertain how these measures that support extensive farming will be affected by the forthcoming reform of the CAP. It may be that the future CAP will be more focused on the provision of public goods and support the delivery of a range of environmental, social and economic needs. This may result in increased support for HNV farming, especially where it is of particularly high nature conservation importance (eg within Natura 2000 sites) and supports the provision of ecosystems services associated with carbon sequestration and storage and water resources. But such changes are by no means certain and it is unlikely that the scale of redistribution of funds will be sufficient to overcome the primary drivers of abandonment as described above.

Given the complex interactions amongst drivers of land abandonment it is difficult to predict the magnitude and locations of future abandonment without the use of sophisticated economic/land use models. Furthermore, to be realistic, spatial models

are necessary, as responses to a particular combination of drivers are very context dependent and may lead to intensification in one place and to structural or land use change in another. As described in Chapter 4, a number of models have been developed that forecast projections of land use change across Europe according to a range of socio-economic scenarios and associated sets of fairly consistent policy assumptions. These scenarios tend to vary according to two key axes: the degree of globalisation and the degree of regulation assumed.

The projections from all of the recent modelling studies (as summarised in Table 4.4) suggest that there are likely to be significant levels of abandonment in Europe over the next 20-30 years. However, the projected levels of abandonment vary significantly, both within and amongst the scenarios, ranging from 0.7% of land area by 2020 (Scenar 2020 Regionalisation Scenario; Nowicki et al, 2006) to 6.7% by 2030 (EURURALIS Global Cooperation Scenario). There is a tendency for the highest projected levels of abandonment to result from scenarios with high levels of global competition in agriculture (which sustain the trend towards specialisation and economies of scale in most agricultural sectors), combined with low levels of CAP support for extensive farming (eg with low levels of agri-environment support and the absence of LFA payments). However, significant abandonment is also projected under scenarios with reduced global competitiveness, high levels of support for agriculture and the environment, and strong regulations. This suggests that abandonment trends may be tempered to a certain extent by the effect of CAP income support and targeted Pillar 2 payments, but it is likely that many low-intensity grazing systems will not survive, and those that do will require significant long-term public funding. Furthermore, projections from the biodiversity scenario in the LUM-I study suggest that even ambitious widespread measures to protect semi-natural habitats in Natura 2000 sites and support HNV farming will have little impact on abandonment.

The scenarios that lead to the lowest levels of abandonment in Europe are those included in the LUM-I study that assume high levels of biofuel production in the EU. However, although obligations under the EU Renewable Energy Directive have stimulated demand for biofuels, it is expected that a significant proportion of production will occur outside Europe. Furthermore, the Directive's sustainability criteria do not appear to have been fully taken into account. Thus the scenarios with high biofuel production in Europe appear to be unrealistic.

The models tend to be consistent in indicating that the areas most at risk from abandonment will be in Finland and Sweden, the Pyrenees, north-western Iberia, Massif Central (France), Apennines (Italy), Alps, Harz Mountains and Thuringian Forest of central Germany, Elbe Sandstone mountains, Ore Mountains (Erzgebirge) and Bavarian Forest / Bohemian Forest of the German / Czech border and to a lesser extent the Carpathians. Most of these areas are mountainous, hilly or in northern latitudes and are likely to include large areas of HNV farmland. The Land Services study's probably pessimistic projections suggest that 19.8% of arable farmland and 28.1% of grassland within HNV farmland areas could be abandoned by 2030 (IEEP and Alterra, 2010). However, within these high risk areas there are likely to be

complex smaller scale patterns of abandonment. In practice, the future of HNV land still managed by semi-subsistence farming systems, will depend on many local factors and their various interactions with a range of agricultural, environmental, economic and social polices.

In conclusion, there is reasonable evidence from expected trends in key drivers of abandonment and from the spatial land use models that aim to utilise these, that there will be significant abandonment in Europe over the next few decades (and even more widespread semi-abandonment). This will primarily affect semi-natural habitats managed by extensive farming systems, especially in northern latitudes and mountainous regions. It is also clear that there will probably be a much larger area that will be partially abandoned, with the minimum management being undertaken to enable CAP payments to be claimed. Such inadequate management is also of concern as it may undermine the nature conservation and productive value of existing habitats, whilst also preventing restoration and re-wilding benefits.

It is very difficult to estimate reliably the extent of future abandonment (especially semi- abandonment), and predict its locations. Although the land use models have projected similar levels of abandonment, these need to be treated with considerable caution, because their assumptions about future socio-economic conditions, policy measures (scenarios) and farmer behaviour are subject to considerable uncertainty. The models are also all similarly deterministic and assume that landowners will swiftly react to primarily economic factors. However, in reality many farmers carry on unprofitable farming for a variety of reasons (eg for social reasons, to claim CAP payments or because they have alternative incomes that are linked to management of the their land). There is also considerable uncertainty over the outcome of the future CAP reform, and how it might influence land abandonment. But it is possible that future targeting of support under the CAP will focus more on the provision of public goods, and this may further help to support the continuation of marginal farming systems, especially in HNV farmland areas.

The projections of very high levels of abandonment should be treated especially cautiously as they the scenarios concerned assume levels of market liberalisation and weak environmental regulation that are probably unrealistic, at least over the next 10-20 years.

On the other hand, some aspects of the models may underestimate abandonment. In particular, some of the models include the continuation of set-aside payments and some scenarios increase these. The continuation of mandatory arable set-aside might have been expected to help maintain demand for agricultural land to some extent, but it has now been abolished. A further constraint on the models is that they do not include social factors such as rural depopulation, which in fact may be a major driver of abandonment in some particularly remote and harsh areas. Nor do the models explicitly take into account climate change projections and their impacts, which will become increasingly significant. These may increase yields in some areas, such as northern latitudes, but they are likely have more detrimental impacts in

many parts of southern Europe, which may lead to extensive abandonment in the long-term.

Although the certainty levels and biases in the modelled projections of land abandonment cannot be quantified, its seems that they may to some extent balance out. Taking these factors into account it is therefore suggested that a mid-range estimate of farmland abandonment of 3-4% of total land area by 2030 is most plausible, which would amount to 126,000 – 168,000 km^2. However, the magnitude of abandonment will undoubtedly vary considerably from place to place according to local circumstances.

The impacts of abandonment will also vary according to their context. Nevertheless, it is clear that large areas of semi-natural habitats of high conservation concern are likely to be at risk, especially in HNV farmland areas. On the other hand, some abandonment may provide opportunities for beneficial habitat restoration. However, a substantial proportion of abandoned land may be intentionally converted to forestry plantations or used for other purposes, which would significantly reduce its existing biodiversity value and the potential for habitat restoration and re-wilding.

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ANNEX 1. DATA SETS RELEVANT TO THE STUDY OF LAND ABANDONMENT

CORINE (Coordination of Information on the Environment)

The EU established CORINE 25 years ago to create pan-European databases on land cover, biotopes (habitats), soil maps and acid rain. CORINE Land Cover (CLC) maps are based on interpretation of satellite image and provide comparable digital maps of land cover for each country, across most of Europe. The choice of a 1:100.000 scale, a minimum mapping unit of 25 hectares and a minimum width of 100 metres for linear elements were a trade-off between production costs and level of detail of land cover information (Heymann et al., 1994) and have remained the same for the three CORINE inventories: CLC1990, CLC2000 and the current CLC2006. CLC is the only data source which provides the flows between the different land uses, estimating the withdrawal of land from farming and the conversion of farmland to artificial surfaces (Pointereau et al, 2008). The standard CLC nomenclature includes 44 land cover classes, grouped in a three-level hierarchy (5 major categories at the first level, 15 land cover categories at the second level and 44 categories at the third level - see Table A.1). These 44 categories have not changed since the first CLC inventory (1986–1998), although the definitions of most of the elements have been improved, and can be found with photographic illustrations at http://etc-lusi.eionet.europa.eu/CLC2000/classes.

The latest CORINE land cover map is now being produced using satellite data from 2006 (+/− 1 year), so called IMAGE2006. As in previous years, image production was centrally organised, while the land cover mapping has been done in the Member States to benefit from local knowledge. The aim of CLC20006 is to have European coverage of real land cover changes that: are larger than 5 ha, regardless of location, are wider than 100 m, occurred between 2000 and 2006, and are detectable on satellite images (EEA, 2007). By early 2010 the CLC2006 coverage was complete for 25 of the 27 EU Member States (interpretation had not started in Greece and was underway in the UK). The incomplete CLC2006 data is at http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-clc2006-100-m-version-12-2009 (accessed 2 October 2010).

CORINE has had general problems of image interpretation (Gallego, 2002 and Schmit et al., 2006, quoted in Britz, 2010), making the distinction between temporary, permanent and natural or abandoned grasslands difficult, bearing in mind that these land cover types might also include rotational or stationary set-aside. In 2006 the EEA validated CLC2000 data covering 18 countries of Europe (3.4 million km^2) through an independent CLC reinterpretation of Image2000 data from more than 8 200 LUCAS PSUs, based on ground photographs and LUCAS LU and LC codes. The total reliability of CLC2000 was found to be 87 percent, but subjectivity of photo interpretation could be noticeable in 18 percent of the samples. The most subjective CLC classes included several types of land cover associated with land abandonment, for example: agriculture with significant amount of natural vegetation (2.4.3); transitional woodland, shrub (3.2.4) and complex cultivation patterns (2.4.2) and mixed forest (3.1.3). The majority (78 percent) of classification errors occurred at

levels 3 and 2, but Level 1 misclassifications mostly occurred between 'agriculture' and 'forest and semi-natural' classes (EEA 2006b), which cover transitional vegetation associated with land abandonment. Additionally, given the image resolution and the methodology for the interpretation process, land use features below a certain threshold are not classified, and either attributed to neighbouring larger land cover features or shown as mixed classes (Nol et al., 2008, quoted in Britz, 2010).

Table A.1 CORINE Land Cover classes (http://etc-lusi.eionet.europa.eu/CLC2000/classes/index_html)

1. Artificial surfaces	2. Agricultural areas
1.1 Urban fabric	2.1 Arable land
1.1.1 Continuous urban fabric	2.1.1 Non-irrigated arable land
1.1.2 Discontinuous urban fabric	2.1.2 Permanently irrigated land
1.2 Industrial, commercial and transport units	2.1.3 Rice fields
1.2.1 Industrial or commercial units	2.2 Permanent crops
1.2.2 Road and rail networks and associated land	2.2.1 Vineyards
1.2.3 Port areas	2.2.2 Fruit trees and berry plantations
1.2.4 Airports	2.2.3 Olive groves
1.3 Mine, dump and construction sites	2.3 Pastures
1.3.1 Mineral extraction sites	2.3.1 Pastures
1.3.2 Dump sites	2.4 Heterogeneous agricultural areas
1.3.3 Construction sites	2.4.1 Annual crops associated with permanent crops
1.4 Artificial, non-agricultural vegetated areas	2.4.2 Complex cultivation patterns
1.4.1 Green urban areas	2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation
1.4.2 Sport and leisure facilities	2.4.4 Agro-forestry areas
3. Forest and semi-natural areas	**4. Wetlands**
3.1 Forests	4.1 Inland wetlands
3.1.1 Broad-leaved forest	4.1.1 Inland marshes
3.1.2 Coniferous forest	4.1.2 Peat bogs
3.1.3 Mixed forest	4.2 Maritime wetlands
3.2 Scrub and/or herbaceous vegetation associations	4.2.1 Salt marshes
3.2.1 Natural grasslands	4.2.2 Salines
3.2.2 Moors and heathland	4.2.3 Intertidal flats
3.2.3 Sclerophyllous vegetation	**5. Water bodies**
3.2.4 Transitional woodland-shrub	5.1 Inland waters
3.3 Open spaces with little or no vegetation	5.1.1 Water courses
3.3.1 Beaches, dunes, sands	5.1.2 Water bodies
3.3.2 Bare rocks	5.2 Marine waters
3.3.3 Sparsely vegetated areas	5.2.1 Coastal lagoons
3.3.4 Burnt areas	5.2.2 Estuaries
3.3.5 Glaciers and perpetual snow	5.2.3 Sea and ocean

Examples of the use of CORINE data relevant to land abandonment:
- IRENA indicators (to 2005, for EU-15)
- in CLUE models and other economic/environmental models
- for the new agri-environment indicator of land abandonment (see below).

LUCAS (Land Use/Cover Area frame statistical Survey)

LUCAS is a Eurostat field survey programme initially developed to deliver annual European crop estimates for the European Commission[26]. Over time the survey has developed as a means of gathering statistics on land use and land cover in the EU, together with ground evidence for calibration of satellite images and a register of points for specific surveys. The LUCAS data collection is based on ground observations by surveyors at sample points, using the same methodology and definitions across Europe (photographs are also taken). The pilot phase from 2000–07 initially involved 13 to 15 EU Member States, and based on this experience a new LUCAS survey began in 2008/09, intended to provide results reliable at EU level down to NUTS 2 and NUTS 3 levels. 230 000 survey points will be visited by the surveyors, in 25 EU Member States (Cyprus and Malta are not included), and many survey points from the previous LUCAS 2006 pilot survey will be resurveyed, with the intention of tracking changes in land cover and land use over time. For the first time, approximately 20 000 random soil samples being collected by the LUCAS surveyors for later analysis. The data will be used to assess soil organic carbon and to update the European soil map. In future other specific modules like this will be added to the survey – for example biodiversity (Eurostat, 2010). The LUCAS web pages are under revision and will be relaunched soon http://www.lucas-europa.info/NewsBASE/content_eftas_lucas01/frame_deutsch.php.

FSS (Farm Structural Survey)

The basic FSS, also known as the survey on the structure of agricultural holdings, is a census of farm holdings conducted by all EU Member States every 10 years, with intermediate sample surveys three times between the 10-year surveys[27]. The main purpose of FSS is to follow structural trends in EU agriculture, and Member States collect information from individual farm holdings about land use, livestock numbers, rural development, management and farm labour input (including the age, gender and relationship to the holder of the agricultural holding). The survey data is aggregated at different geographic levels (Member States, regions, and for basic surveys also district level), and can also be arranged by size class, area status, legal status of the holding, objective zone and farm type.

The (FSS) is constantly being reviewed with a view to adapting the survey to new user needs, but If time-series data are to be useful for environmental analysis, they have to be comparable between years. For instance, a change in threshold values for FSS data collection since 1990 diminished the comparability of 1990 and 2000 data. Where such threshold changes are necessary it would make data time-series analysis much easier if data prior to the threshold change could be adapted to the new definition. The FSS censuses only include holdings above a certain threshold and do not include all land relevant to land abandonment - for example, common grazing land that is not allotted to individual holdings is excluded (EEA, 2005). The FSS defines non-utilised (or unutilized) agricultural land as "agricultural land which is no

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[26] Decision 1445/2000/EC of 22 May 2000 on the application of aerial-survey and remote-sensing techniques to the agricultural statistics.

[27] The legal basis for the FSS is Regulation 1166/2008 of 19 November 2008 on farm structure surveys and the survey on agricultural production methods, which repealed Council Regulation 571/88

longer farmed, for economic, social or other reasons, and which is not used in the crop rotation system which means that no agricultural use is intended. This land could be brought back into cultivation using the resources normally available on an agricultural holding". This could be regarded as one definition of abandoned farmland, but in the data this land is grouped with 'other' land on the holding which is outside the UAA, such as farm buildings, tracks, ponds and quarries (Pointereau, 2008). Fallow land is included in the UAA for FSS datasets, where it is defined as 'bare land bearing no crops at all, land with spontaneous natural growth (the normal weeds that grow on any land), which may be used as feed or ploughed in, or land sown exclusively for the production of green manure (green fallow)'.

Aggregated FSS data is published by Eurostat (the latest data is from the FSS in 2007) at http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database

FADN (Farm Accountancy Data Network)

The main objective of FADN is the evaluation of the income of agricultural holdings and the analysis of economic impacts of the CAP, and it is the only harmonised micro-economic EU database combining data on farm structure, input use and economic variables. The individual Member States collect accountancy data every year through a sample survey of their agricultural holdings, and the FADN database only covers 'commercial' farms beyond a certain economic threshold, which varies from one country to another according to their agricultural structures.

FADN is only statistically representative at NUTS 0, 1 and 2 levels, tends to under-represent the smallest farms, and provides data only on the total value of expenditure on certain inputs (such as fertilisers, pesticides, feedstuff, energy, water, etc.) purchased by the holding (considered as a whole) and does not record the volumes of inputs used in specific production activities. The EEA (2006) suggested that the survey could be broadened to record the input volumes alongside the expenditure on inputs, and DG Agriculture indicated that it could be possible to include some information on volumes of energy and fertilisers used, but not on volumes of irrigation water. In some Member States, some input data is already available in the national FADN data sets. Despite these limitations, the combination of variables in one data set is helpful in linking different issues, and FADN has been used in the past for exploring general trends in intensification/extensification (IRENA 15) and in identifying high nature value (farmland) areas (IRENA 26). More recently FADN data has been used in applications of the CAPRI models and will be used in the development of new agri-environment indicators.

ANNEX 2. EUROPEAN COMMISSION'S PROPOSAL FOR A CONSOLIDATED AGRI-ENVIRONMENTAL INDICATOR SET

DPSIR Domain	DPSIR Sub-domain	No	Indicator	Level of development	Conceptual improvement	Model improvement	Availability of regional data	Data quality [2] S	Data quality [2] O
Responses	Public policy	1	Agri-environmental commitments	B					X
Responses	Public policy	2	Agricultural areas under Natura 2000	A					X
Responses	Technology and skills	3	Farmers' training levels and use of environmental farm advisory services	A/B	X				X
Responses	Market signals and attitudes	4	Area under organic farming	A					
Driving forces	Input use	5	Mineral fertiliser consumption	B			X	X	
Driving forces	Input use	6	Consumption of pesticides	C			X	X	
Driving forces	Input use	7	Irrigation	A					
Driving forces	Input use	8	Energy use	B	X		X	X	
Driving forces	Land use	9	Land use change	B			X		
Driving forces	Land use	10	Cropping/Livestock patterns	B	X			X	
Driving forces	Farm management	11	Farm management practices	B/C	X		X	X	
Driving forces	Trends	12	Intensification/extensification	A				X	
Driving forces	Trends	13	Specialisation	A					
Driving forces	Trends	14	Risk of land abandonment	C	X	X			
Pressures and benefits	Pollution	15	Gross nitrogen balance	B			X		X
Pressures and benefits	Pollution	16	Risk of pollution by phosphorus	New	X	X	X	X	X
Pressures and benefits	Pollution	17	Pesticide risk	New	X	X	X	X	
Pressures and benefits	Pollution	18	Ammonia emissions	B		X	X	X	X
Pressures and benefits	Pollution	19	Greenhouse gas emissions	A					X
Pressures and benefits	Resource depletion	20	Water abstraction	C			X		X
Pressures and benefits	Resource depletion	21	Soil erosion	B	X	X			
Pressures and benefits	Resource depletion	22	Genetic diversity	C	X		X		X
Pressures and benefits	Benefits	23	High nature value farmland	C	X				
Pressures and benefits	Benefits	24	Production of renewable energy	B	X		X	X	X
State/Impact	Biodiversity and habitats	25	Population trends of farmland birds	B			X		X
State/Impact	Natural resources	26	Soil quality	C	X		X		X
State/Impact	Natural resources	27.1	Water quality – Nitrate pollution	B			X		X
State/Impact	Natural resources	27.2	Water quality – Pesticide pollution	B			X		X
State/Impact	Landscape	28	Landscape – state and diversity	C	X	X	X	X	X

[1] More details on indicator description and measurements, and the improvements needed, are provided in Annex 2 of the Commission staff working document.

[2] Data sources that need improvement: S = statistical data sources (e.g. Farm Structure Survey), Farm Accountancy Data Network; O = other sources (e.g. administrative data; annual progress reports on the implementation of Rural Development Programmes).

(Source: CEC, 2006)

ANNEX 3: SCENARIOS USED IN LAND USE MODELS

Annex 3.1 The general storylines of the four EURURALIS scenarios

Source: Rienks (2008).

A1 Global Economy
The global economy depicts a world with *less government and intervention and fewer borders* in comparison with today. Trade barriers are removed and there is an open flow of capital, people and goods, leading to rapid economic growth, of which many, but not all individuals and countries benefit. There is strong technological development. The role of the government is very limited. Nature and environmental problems are not seen as a priority of legislation.

A2 Continental Markets
The Continental Markets scenario depicts a world of *divided regional blocks.* The EU and NAFTA together form one block. each block is striving for self sufficiency in order to be less reliant on other blocks (eg Latin America, the former Soviet Union or the Arab world). Agricultural trade barriers and support mechanisms continue to exist. A minimum of government intervention is preferred resulting ion loosely interpreted directives and regulations.

B1 Global Cooperation
The Global Cooperation scenario depicts *a world of successful international cooperation*, aimed at reducing poverty and reducing environmental problems. Trade barriers will be removed. Many aspects will be regulated by governments, eg carbon dioxide emissions, food safety and biodiversity. The maintenance of cultural and natural heritage is mainly publicly funded.

B2 Regional Communities
The Regional Communities scenario depicts *a world of regions*. People would have a strong focus on their local and regional community and prefer locally produced food. Agricultural policy will be aimed at self sufficiency. Ecological stewardship will be very important. This world will be strongly regulated by government interventions, resulting in restrictive rules in spatial policy and incentives to maintain small scale agriculture. Of the four scenarios, economic growth is the lowest in this scenario.

Annex 3.2. Selection of assumptions underlying policy measures in the four EURURALIS scenarios (Source: www.eururalis.eu)

Aspect	Model where aspect is implemented	A1 Global Economy	A2 Continental Markets	B1 Global Co-operation	B2 Regional communities
Trade of agricultural products	GTAP	Export subsidies and import tariffs phased out	Export subsidies kept in place but volumes reduces. Import tariffs kept in place	Export subsidies and import tariffs phased out. Slight increase in non-tariff barriers	Export subsidies phased out. Import tariffs maintained. Sharp increase in non-tariff barriers
Farm payments	GTAP	Phased out; abolished by 2030	Basically unaltered	Fully decoupled and gradually reduced (by 50% in 2030)	Increase in agri-environmental payments; other payments reduced
Intervention prices	GTAP	Phased out; abolished by 2030	Maintained, but maximum guaranteed areas/quantities are reduced	Phased out; abolished by 2030	10% increase, but maximum guaranteed areas/quantities reduced
Proportion of biofuels of transport fuel	GTAP, IMAGE, CLUE-s	Market driven, no obligation,	Market driven, no obligation,	5.7% obligation	5.7% obligation
Set-aside	GTAP, IMAGE, CLUE-s	Abolished	Gradually abolished, and never introduced in EU-12	Gradually abolished, and never introduced in EU-12	Continued and introduced to EU-12
Less favoured areas	CLUE-s	Abolished in 2010, partial compensation until 2020	Maintained at current level and applied to EU-12	Maintained at current level and applied to EU-12	Maintained at current level and applied to EU-12
Shifts in permanent pasture	CLUE-s	Fully allowed	Fully allowed	Incentives to prevent conversion to arable	Incentives to prevent conversion to arable
Nature conservation – measures in Natura sites	CLUE-s	All conversions allowed other than to agriculture	All conversions allowed other than to agriculture	Incentives to avoid abandonment	Incentives to avoid abandonment

Annex 3.3. Summary of scenario assumptions in the Scenar 2020 study (Source: Nowicki et al, 2006)

(a) Level 1: Assumptions on the exogenous drivers

Assumptions	Demographics	Macro-economic growth	Consumer preferences	Agri-technology	"World Markets"*
Baseline	Major population trends as observed in the past	Moderate growth as seen in the trends; Increasing trend for labour market liberalisation	More demand for value added and increasing absolute spending per capita; Consumption of organic and regional food as observed in the past	Continuous trends in cost saving technical progress; Biotechnology; GMO	Trends in agric-markets as observed in OECD/FAPRI studies adjusted for differences in macroeconomic and population growth as well as for changes in consumer preferences and agri-technology
Regionalisation	Trends according to baseline	Trends according to baseline	Trends according to baseline	Trends according to baseline	Trends according to baseline, endogenously adjusted for changes in policy related second level drivers (see following table).
Liberalisation	Trends according to baseline	Trends according to baseline	Trends according to baseline	Trends according to baseline	As Regionlisation

* partly endogenous in the study and determined by changes in global macro-economic and population growth, consumer preferences and agri-technology.

(b) Level 2: Assumptions on the policy-related drivers

Assumptions	Market policies	Direct payments	Rural development policy	Biofuels	Enlargement	WTO and other international agreements	Environmental policies impact on agriculture
Baseline	Balanced markets, i.e. keeping public stocks at 1 to 2% of domestic consumption	Financial discipline and 25% modulation	Taking into account the new financial perspective	Continuation of EU Biofuels Strategy	EU-27 plus the accession of Turkey and the Western Balkans	EU offer	Continuation of existing environmental legislation
Regionalisation	Existing CAP	Financial discipline and 5% modulation	Significant increase in funding of rural development through all EAFRD axes	Higher policy support to produce biofuels	Baseline	No WTO agreement /bilateral approach	Reinforcement of environmental legislation
Liberalisation	No internal support policies	Removing direct agricultural payments	Rural development is funded according to EAFRD provisions: decrease in funding of all EAFRD axes	No per hectare subsidies for biofuels	Baseline	Removing import tariffs	Partial withdrawal of environmental legislation