# FINAL REPORT

## ANALYSIS OF ACTUAL LAND AVAILABILITY IN THE EU; TRENDS IN UNUSED, ABANDONED AND DEGRADED (NON-)AGRICULTURAL LAND AND USE FOR ENERGY AND OTHER NON-FOOD CROPS

**REFERENCE: ENER/C2/2018-440**

Final Report:

**ANALYSIS OF ACTUAL LAND AVAILABILITY IN THE EU; TRENDS IN UNUSED, ABANDONED AND DEGRADED (NON-)AGRICULTURAL LAND AND USE FOR ENERGY AND OTHER NON-FOOD CROPS**

**ANALYSE DE LA DISPONIBILITÉ RÉELLE DES TERRES DANS L'UE ; TENDANCES DES TERRES ABANDONNÉES OU DÉGRADÉES ET OPTIONS POUR L'UTILISATION DES CULTURES À FINS ÉNERGÉTIQUES ET AUTRES FINS NON-ALIMENTAIRES**

Reference: ENER/C2/2018-440



16 October 2020

Wageningen Environmental Research
Droevendaalsesteeg 3
P.O. Box 47
6700 AA Wageningen
The Netherlands
Phone: +31 317 48 07 00
Fax: +31 317 41 90 00

IEEP (BE), ECOFYS (NL), CIEMAT (ES) and EIHP (HR)

## CONTENTS

# LIST OF REGIONAL CASE STUDY REPORTS

| Case | Authors |
|---|---|
| **Blagoevgrad region (Bulgaria)** | Vyara Stefanova, Yanka Kazakova and Boris Lagdinov |
| **Latgale (Latvia)** | Romualdas Zemeckis |
| **Basse-Normandie (France)** | Élodie Liénard, Alice Devot and Thierry Clement |
| **Sicily (Italy)** | Daniela Russi |
| **Brasov (Romania)** | Mark Redman |
| **Észak-Magyarország region (Hungary)** | Katalin Balázs |
| **Guarda region (Portugal)** | Eloi Carvahlo Ribeiro |
| **Kontinentalna Hrvatska region (Croatia)** | Željka Fištrek & Biljana Kulišić |
| **Soria (Spain)** | Pilar Ciria, Marina Sanz and Paloma Perez |

The reports of these case studies have been delivered to DG-ENER as final products of this study. They are however not published. All relevant material collected in these case studies is presented in this report. These case studies were a very important source of information.

## LIST OF TABLES

# LIST OF FIGURES

**The report should be cited as follows:**
Elbersen, B.; Hart, K.; Koper, M.; Eupen, van M.; Keenleyside, C.; Verzandvoort, S.; Kort, K.; Cormont, A.; Giadrossi, A.; Baldock, D. (2020). Analysis of actual land availability in the EU; Trends in unused, abandoned and degraded (non) agricultural land and use for energy and other non-food crops. Wageningen 16 October 2020. Reference: ENER/C2/2018-440

## Acknowledgements

The authors thank Kyriakos Maniatis and Eric Fee for the excellent collaboration and support during the implementation of the project and the writing of the report.

We thank all the experts that wrote the nine regional case study reports:

- Vyara Stefanova, Yanka Kazakova and Boris Lagdinov: case study Blagoevgrad region (Bulgaria)
- Romualdas Zemeckis: case study Latgale (Latvia)
- Élodie Liénard, Alice Devot and Thierry Clement: case study Basse-Normandie (France)
- Daniela Russi: case study Sicily (Italy)
- Mark Redman: case study Brasov (Romania)
- Katalin Balázs: case study Észak-Magyarország region (Hungary)
- Eloi Carvahlo Ribeiro: case study Guarda region (Portugal)
- Željka Fištrek & Biljana Kulišić: case study Kontinentalna Hrvatska region (Croatia)
- Pilar Ciria, Marina Sanz and Paloma Perez: case study Soria (Spain)

Special thanks go to Adam Houlbrook for the editing the draft version of this report, and to Anne Maréchal for the translation of the executive summary to French.

# LIST OF ABBREVIATIONS

| Abbreviation | Explanation |
|---|---|
| **AA** | agricultural area |
| **AECM** | Agri-environment-climate Measures |
| **AGFORWARD** | AGroFORestry that Will Advance Rural Development |
| **ANC** | Areas facing Natural Constraints |
| **APV** | agrophotovoltaics |
| **BPS** | Basic Payment Scheme |
| **CAP** | Common Agricultural Policy |
| **CEE** | Central and Eastern European |
| **CEEC** | Central and Eastern European countries |
| **CF** | Cohesion Fund |
| **CHP** | combined heat and power |
| **CLC** | CORINE Land Cover |
| **DA** | determined area |
| **DG-AGRI** | Directorate-General for Agriculture and Rural Development |
| **DG-ENER** | Directorate-General for Energy |
| **EAFRD** | European Agricultural Fund for Rural Development |
| **EAGGF** | European Agricultural Guidance and Guarantee Fund (EAGGF) |
| **EASA** | European Aviation Safety Agency |
| **ECA** | European Court of Auditors |
| **EC** | European Commission |
| **EEA** | European Environment Agency |
| **EFA** | Ecological Focus Areas |
| **EIA** | Environmental Impact Assessment |
| **EIP** | European Innovation Partnerships |
| **ENRD** | European Network for Rural Development |
| **ERDF** | European Regional Development Fund |
| **ESF** | European Social Fund |
| **ESR** | Effort Sharing Regulation |
| **ETC-SIA** | European Topic Centre for Spatial information and Analysis |
| **EU** | European Union |
| **EU-28** | memberships of the European Union in the period 1 July 2013 - 31 January 2020 |
| **FA** | total farm area |
| **FAA** | USA Federal Aviation Administration |
| **FADN** | Farm Accountancy Data Network |
| **FAO** | Food and Agriculture Organization |
| **FAOSTAT** | statistics of the Food and Agriculture Organization |
| **FOD** | Foreign Object Debris |
| **FSS** | Farm Structural Survey |
| **GD** | Green Deal |
| **GHG** | greenhouse gas |
| **GIS** | Geographic Information Systems |
| **H2020** | Horizon 2020 |
| **HNV** | High Nature Value |

| | |
|---|---|
| **IACS** | Integrated Administration and Control System |
| **ICT** | Information and communications technology |
| **ILUC** | Indirect Land Use Change |
| **JLS** | local self-government units (Croatian abbreviation) |
| **KET** | Key Enabling Technology |
| **LAG** | local action groups |
| **LAI** | leaf area index |
| **LAU** | Local Administrative Units |
| **lcf** | land cover flows |
| **LCOE** | levelized cost of energy |
| **LEAC** | Land Cover Accounts |
| **LPIS** | Land Parcel Identification System |
| **LSU** | livestock unit |
| **LUCAS** | Land Use and Coverage Area frame Survey |
| **LULUCF** | land use, land-use change and forestry |
| **MAGIC** | Marginal Lands for Growing Industrial Crops |
| **MS** | Member State of the European Union |
| **N2000** | Natura 2000 |
| **NCFF** | Natural Capital Financing Facility |
| **NDVI** | normalized difference vegetation index |
| **NECP** | National Energy and Climate Plan |
| **NMR** | National ... registration |
| **NUAA** | unutilised agricultural area as defined by Eurostat |
| **NUTS** | nomenclature of territorial units for statistics |
| **OECD** | Organisation for Economic Co-operation and Development |
| **OVAM** | Public Waste Agency of Flanders |
| **PEA** | potentially eligible area |
| **PG** | permanent grassland |
| **PV** | photovoltaic |
| **RDP** | Rural Development policy |
| **RED II** | Revised Renewable Energy Directive 2018/2001/EU |
| **SAA** | special holding areas |
| **SDG** | Sustainable Development Goal |
| **SAPS** | Single Area Payment Scheme |
| **SGM** | standard gross margin |
| **SOC** | Soil Organic Carbon |
| **SRC** | woody perennial crops in short rotation systems |
| **UAA** | utilised agricultural area |
| **UK** | United Kingdom |
| **UNECE** | United Nations Economic Commission for Europe |
| **USSR** | Union of Soviet Socialist Republics |
| **VCS** | Voluntary Coupled Support |
| **WA** | wooded area |
| **WFD** | Water Framework Directive |

# EXECUTIVE SUMMARY ENGLISH

Over recent decades two diverging trends in the use of agricultural land are apparent - intensification and specialisation on land with greater production potential and abandonment and degradation of more economically marginal land. At the same time, the ambition to move towards a more circular and bio-based economy is leading to increased demand for biomass to replace fossil resources with renewable resources, such as for the conversion to bio-based products and energy. Biomass resources can come from trees, agricultural crops and their residues. To avoid putting additional pressure on land and competing with food production, it is preferable to grow agricultural biomass crops on land that is no longer used, has become abandoned and/or degraded, as long as this can be done sustainably. This study examines the potential availability of land (excluding forest areas) to be used for the sustainable production of cropped biomass for energy or other non-food purposes through:

1. Providing data on the trends in the **utilised agricultural area (UAA)** since 1975, current UAA and reasons why agricultural land has become unused, abandoned and degraded.
2. Proposing policy measures that can reverse this trend towards unused, abandoned and degraded agricultural land and that can encourage their use for biomass production for energy and other non-food uses.
3. Identifying types of non-agricultural land that could be used for biomass production for energy and other non-food uses, alongside policy measures to stimulate this.

**Actual UAA and changes in UAA in all EU Member States since 1975**

Member States report data to Eurostat on **total farm area (FA), agricultural area (AA),** and UAA through the **Farm Structural Survey (FSS)**. UAA is the smallest of these areas, defined as 'the total area taken up by arable land, permanent grassland, permanent crops and kitchen gardens used by the holding, regardless of the type of tenure or of whether it is used as a part of common land'. AA consists of the UAA plus **non-utilised agricultural area (NUAA)** and **special holding areas (SAA)**. The largest area is the FA which consists of AA plus **wooded areas (WA),** which also includes areas of **short rotation coppice (SRC)** and other land, which is farmland occupied by buildings, farmyards, tracks, ponds.

The long-term analysis of UAA trends between 1975 and 2016 showed a total decline for all EU-28 Member States of almost 360,000 km$^2$, equivalent to 18% of the UAA in 1975, with a levelling off since 2005. Declines were seen in all Member States, but the largest occurred in Bulgaria, Czechia, Estonia, Greece, Spain, Croatia, Italy, Cyprus, Latvia, Hungary, Poland, Slovenia and Slovakia.

More recent data show that between 2005 and 2016 actual UAA for the EU-28 remained relatively stable, with an average of 1,737,200 km$^2$, peaking in 2010 at 1,758,150 km$^2$. The FA and AA showed a slight decline in this period (-2% and -1%, respectively). The difference between the UAA and AA suggests that around 5% of farmland is unused. The FA is around 15% larger than the AA.

Despite this stable picture for the EU-28, there were significant changes in UAA in certain Member States or regions over this period. The largest declines in UAA occurred in Cyprus and Austria. The largest increases were in Bulgaria, Estonia, Ireland, Greece, Croatia and Latvia. Looking in more detail at the actual land uses, arable and permanent cropland declined at EU-28 level in both absolute and relative terms, while the area of permanent grassland increased, at least until 2010.
The 2010 peak in permanent grassland in the EU-28 and in many EU Member States does not necessarily reflect a real increase in permanent grassland, but results from a 2010 adjustment in recording method for common land in the FSS. Comparing data since 2010 is likely to be more reliable therefore.

**Main drivers affecting the abandonment of agricultural land in the EU-28**
Literature shows that it is a combination of drivers that cause transitions in agricultural land use and these have different effects depending on the historical, geopolitical and socio-economic context. The most widespread drivers of agricultural land abandonment are unfavourable agro-ecological conditions and socio-economic drivers operating both at farm and regional level. Mountain areas are particularly sensitive to agricultural land abandonment. Declines in rural populations also lead to agricultural land abandonment in many parts of the EU, driven by better employment opportunities in more urban settings as well as declining rural infrastructure. Nonetheless, socio-cultural motivations can lead to the maintenance of agricultural activities in regions where it is not economically viable. In other cases land continues to be registered as agricultural but is not actively managed, something that can be characterised as 'hidden abandonment'. Policy is a less prominent driver of land abandonment, although issues with eligibility for **Common Agriculture Policy (CAP)** payments can have an effect.

Nine regional case studies confirmed many of the findings from the literature, such as the fact that the main drivers for agricultural land becoming unused or abandoned are socio-economic in nature. The most important drivers identified at the farm level were the profitability of holdings, the productivity of the land for crops and livestock, production costs, fragmentation of farmland and issues with land tenure and ownership. The decline in the profitability of agriculture, seen in all case study regions, has enhanced the trend of young people leaving rural areas, leaving behind an ageing farming population.

In contrast to the literature, natural constraints were not identified as the most important drivers of agricultural land abandonment in the case study regions, although mentioned in all. In some regions, they reinforced the socio-economic drivers, or were expected to become more relevant in the future as a result of the changing climate. In some regions land degradation was reported to be induced by management practices and in only a few regions was agricultural land abandonment itself reported to lead to land degradation, in the form of wildfires and soil erosion. Although policy was not considered a main driver of abandonment of agricultural land in the case study regions, the combination of CAP and national policies was not enough to keep all agricultural land in active use. Surveys in several regions also mentioned poor or incomplete land administration or cadastral systems as a reason for agricultural use converting to other uses.

**Data gaps and data needs for measuring UAA and detecting land abandonment**
Despite the changes in definitions and rules for recording of data on UAA over time, and the variations Member States are permitted for recording certain agricultural land categories, the FSS database remains the best relatively uniform source for determining the UAA for Member States and regions as well as trends over time. The two main issues to be aware of in relation to changes in UAA between years are: first, the 2010 change relating to the registration of common land; and second, inconsistencies in reporting by national statistical offices, leading to issues in distinguishing between agricultural and forest areas and identifying agroforestry.

There are no statistical and spatial data that record unused, abandoned or degraded lands. There is some information in LUCAS (Land cover/use statistics, Eurostat), which identifies ‘fallow and abandoned land’ as a separate land cover class, but the precise location of these areas is not mapped. Unused and abandoned land that remains out of production for multiple years loses its agricultural land status and is therefore no longer recorded in agricultural statistics. Furthermore, land abandonment involves a gradual process, which makes it difficult to determine if and when land has become completely abandoned.

Despite this, there are ways to improve the detection and recording of abandoned and unused land (e.g. through high spatial and temporal resolution information from satellites to measure in-field vegetation development and management activity or lack of it, for example using the **Normalised Difference Vegetation Index (NDVI)**). In the last few years, much progress has been made with identifying crop types and land management through remote sensing and aerial photographic interpretation which would enable the identification of in-parcel management or the lack thereof.

**Barriers and opportunities for growing biomass crops for energy and other non-food uses on unused, abandoned and degraded agricultural lands**
Literature showed that the introduction of biomass crops on unused, abandoned and degraded land can provide a range of socio-economic opportunities, including additional income and the creation of new employment. It may also help diversify farmers’ income and create local access to new and clean energy resources. The case studies confirmed the need for alternative land use activities within and outside agriculture. However, experts differed on whether it was realistic to bring unused, abandoned and degraded agricultural land back into use for this purpose. A key reason for the diverging views is the uncertainty regarding the financial return of non-food crops, particularly because the market demand is generally not (yet) well developed. This specifically concerns lignocellulosic biomass crops, most suited for cultivation on abandoned and degraded lands. Furthermore, there are technical challenges to restore the suitability of the land for agricultural use.

In terms of environmental risks and opportunities, the analysis shows that there are more co-benefits with perennial crops and agroforestry systems. On bare unused, abandoned or degraded lands, the establishment of any crop that creates soil cover will help stabilise the soil. However, perennial crops are more effective than annual crops in reducing soil erosion, building up soil carbon and reducing nutrient leaching. The same applies for agroforestry systems, particularly those that combine trees with permanent crops and permanent grassland. Many agroforestry systems are better at erosion control and overall maintenance of soil fertility than conventional forestry, cropping or pasture systems.

The soil carbon effect of perennial biomass crops and agroforestry systems very much depends on the previous land use. The clearing and tillage of grasslands, long abandoned lands with dense shrub and/or forest vegetation cover or wetlands for the purpose of cultivating perennial biomass crops results in serious declines in carbon (both above and below soil), with variable restoration periods. The potential effects on biodiversity depend on the landscape and habitat context. For example, a shift from vegetated abandoned land to rotational arable land will diminish shelter and breeding opportunities for mammals and birds as well as floristic diversity.

***The role of policy in maintaining land under agricultural production, bringing it back into active use and stimulating biomass cropping for energy and other non-food purposes***

Policy can play an important role in reversing the abandonment and degradation of agricultural land and restoring active production. The CAP, in conjunction with some national policies (taxes, financial instruments, spatial planning policies and processes for land registration and to address land structure and tenure issues), was found to have the greatest influence.

Land degradation or land abandonment is not generally the primary target of these policy instruments. Instead, they address these issues indirectly through supporting the viability of the agricultural sector as a whole and maintaining the diversity of farming types and structures. In some cases, they seek to maintain specific forms of production and address issues of generational renewal and land tenure. Policy instruments such as CAP rarely target hotspots of abandonment or the cultivation of feedstocks for energy and other non-food purposes. Yet, where they coincide, they may help counter the socio-economic drivers affecting abandonment. National policies have evolved to address the specific issues faced nationally, regionally and locally. A particular set of policies were identified in the central and eastern European case studies, designed to address the special circumstances around land structure and tenure issues arising from the process of land restitution, including addressing issues of land registration. Except for some of the CAP's environmental measures (the agri-environment-climate measure, for example), the sustainable management of agricultural land is not a key consideration of the majority of policy tools identified.

In practice, the current policy mix is often insufficient to counter the broader socio-economic drivers of land abandonment, such as those leading to rural depopulation. These wider rural issues deserve more attention alongside support at the farm level and attempts to address farm structure and tenure issues if the most socio-economically vulnerable farming systems are to be maintained. The extent to which this is possible will vary regionally and depend on the relative economic buoyancy of the economy more generally. Nonetheless, some policy measures (CAP direct payments and ANC measures) help maintain large areas of land in agricultural use that would otherwise move out of production, but they do not secure the sustainable management of these areas. It is also clear that processes are limited for determining the climate and environmental implications of bringing land back into production. Finally, policy plays only a limited role in decisions about whether to plant biomass crops for energy or other non-food purposes on land brought back into production. These rest with the land manager and are influenced by a range of factors, primarily market related. The key role of policy should be to ensure that the way crops are grown is sustainable, protecting natural resources and biodiversity, and delivering a mix of ecosystem services.

**Non-agricultural lands suitable for dedicated biomass cropping**

Looking at the potential of non-agricultural land suitable for biomass cropping, a number of categories were evaluated to identify the barriers and opportunities of using them for this purpose. For the three most interesting categories (based on size, feasibility for conversion, financial viability, competing uses), more detailed investigation was carried out: airport land, agrophotovoltaics (APV) which involves biomass cropping combined with PV systems; and closed landfills.

For biomass cropping on airport land, the main barriers identified were that farming activities can pose an additional risk to aviation activities and cropping activities may attract certain biodiversity (e.g. birds and mammals) that may increase collision risks with airplanes. However, airport farming could generate additional financial income, thereby increasing the economic viability of the land since it is comparatively large in extent and easily accessible. Crops on airports could remediate noise and chemical pollution and could dampen the negative effects of extreme weather events (high temperatures). Effective wildlife management at airports is a minimum requirement.

For APV, the main barrier identified was the level of investment costs, which are significantly higher than those for utility scale PV systems. Electricity from APV is currently not price competitive, although there could be a potential benefit to bridge this from the additional income generated from biomass crops. Uncertainty about the ownership of land can also hinder implementation. The potential area that could be used for APV in the EU is significant at around 500,000 ha. APV could be used to restore degraded soils on arid or semi-arid land and the PV-arrays can protect crops from weather and climate impacts (e.g. direct sunlight, drought, heat, hail and rain), thus reducing the farmer’s risks of crop failure. Vegetation cooling the PV arrays from behind can also improve PV efficiency.

For biomass cropping on closed landfills the main barriers identified were that soil pollutants and poor soil quality could lead to low yields or biomass quality issues and that operational costs are expected to be relatively high due to the smaller and sub-optimal geometry of the patches and the necessary soil fertility treatment. However, biomass crop production on closed landfills was identified as a useful temporary use until permanent solutions are found for remediation, even providing options for soil remediation or reduction of environmental risks associated with leakage.

**Conclusions and Recommendations**

Although, little evidence exists in EU literature, statistics and in this study's case studies for setting up new cropping activities in unused, abandoned or degraded lands, there is some potential to bring land back into agricultural production. This could be (former) agricultural land that is abandoned and/or degraded and where the establishment of crops would deliver multiple ecosystem services. This could also be certain non-agricultural land types presented in this study. There could be societal resistance to the use of some non-agricultural lands related to potential loss of vegetation and issues of ecological integration or landscape impacts. In other areas, greening (urban) non-agricultural lands through bioenergy crops can contribute to ongoing initiatives to green European cities. Bioenergy crop production is a valuable and suitable activity for short and long term land use and can therefore be an option for cases where land is only temporarily available.

Three requirements need to be met for non-food biomass production to effectively reduce land abandonment and degradation or return abandoned and degraded land to production in a sustainable way. Firstly, a market demand for biomass needs to be in place to provide consistent market signals that instill confidence to produce crops for energy and other non-food uses. Secondly, data and understanding needs to be created of which areas are abandoned and degraded and which are at risk of becoming unused, abandoned and/or degraded and where and how it is most appropriate to create multiple ecosystem services through agricultural use or through other purposes (e.g. afforestation, rewilding, eco-tourism, hunting). Thirdly, policies need to be put in place to stimulate the production of biomass for food and non-food purposes where it leads to the sustainable management of land and, where it is needed, to enable environmentally and climate beneficial land use change that takes advantage of new markets such as agroforestry and perennial crops in marginal areas. The following specific recommendations result from this study.

*Recommendations for data improvements:*

- Differences in definitions to distinguish between agricultural and forest areas and identifying agroforestry lead to inconsistencies in FSS data reported by Member States. Establishing greater uniformity in the rules for Member States on tree cover levels and clarifying the definition of agroforestry areas for reporting to Eurostat would help resolve these issues.
- It would be useful to register the absence of management for several years in a row for land in the agricultural domain, as well as areas that are unused for a long time and lose their official agricultural land use status. A good indirect indicator of marginality and land degradation in arable lands is yield. Detailed annual recording of yields per hectare at regional level (preferably at LAU level) are very informative and can help identify regions where agricultural marginalisation may lead to (further) abandonment. Degraded land both on agricultural and other land uses should be recorded in statistical or spatial data sources.

*Policy recommendations*

- To improve the way the CAP responds to issues of land abandonment, Member States should identify the drivers of land abandonment in the SWOT and needs analyses of their CAP Strategic Plans and carry out analysis to identify which areas at risk it is most appropriate to maintain in agricultural use. Member States should use this to choose, design, tailor and target the appropriate mix of CAP interventions to support the sustainable management of land in combination with addressing the wider societal issues of poverty and social exclusion in rural areas. Better integration of the CAP with funding from the Structural Funds as well as national measures could help reduce the level of resources required to address the issues.

- There is considerable interest in agroforestry systems as a source of biomass for non-food purposes, particularly since it has the potential to deliver multiple ecosystem services. However, a relatively small amount of CAP support is provided currently by Member States. In the future, payments and advisory support for sustainable new agroforestry and the restoration/maintenance of existing agroforestry systems should be competitive with afforestation support at Member State level.
- Incomplete systems of land registration were identified as an issue in some Member States. Addressing this should be a priority so that it is clear who owns each parcel of land and that where issues of degradation, under-management and abandonment occur, owners can be contacted to address the issues.

There should be better coherence between the different layers of renewable energy and climate policy and the CAP and Structural Funds. Additionally, bioenergy crop production on non-agricultural land often requires cooperation between several industries or sectors that do not commonly interact. Policies enhancing sector collaboration would be expected to help the use of these types of land for bioenergy purposes. This could include financial benefits for consortia of companies from different sectors that cooperate to use land for multiple functions, or the development of legislative guidance for arranging (model) contracts for multiple uses of the same area. European certification for bioenergy crop production from (previously) non-agricultural lands could help in differentiating the biomass produced in these areas which could be a benefit in the market for green fuels.

# RÉSUMÉ FRANCAIS

Au cours des dernières décennies, deux tendances divergentes dans l'utilisation des terres agricoles ont émergé : l'intensification et la spécialisation des terres à potentiel élevé de production et l'abandon et la dégradation de terres économiquement plus marginales. Dans le même temps, l'ambition d'évoluer vers une économie plus circulaire et biologique conduit à une demande accrue de biomasse pour remplacer les ressources fossiles par des ressources renouvelables, comme la production de produits et d'énergie biosourcés. La biomasse peut provenir des arbres, des cultures agricoles et de leurs résidus. Pour éviter d'exercer une pression supplémentaire sur les terres et de concurrencer la production alimentaire, il est préférable de cultiver des cultures de biomasse agricole sur des terres qui ne sont plus utilisées, qui ont été abandonnées et / ou dégradées, pour autant que cela puisse être fait de manière durable. Cette étude examine la disponibilité potentielle de terres (à l'exclusion des zones forestières) en vue de leur utilisation pour la production durable de biomasse cultivée à des fins énergétiques ou à d'autres fins non alimentaires, en:

1. Fournissant des données sur les tendances de la **superficie agricole utilisée** (SAU) depuis 1975, la SAU actuelle et les raisons pour lesquelles les terres agricoles sont devenues inutilisées, abandonnées et dégradées.
2. Proposant des mesures politiques qui peuvent inverser cette tendance vers les terres agricoles inutilisées, abandonnées et dégradées et qui peuvent encourager leur utilisation pour la production de biomasse à des fins énergétiques et autres utilisations non alimentaires.
3. Identifiant les types de terres non agricoles qui pourraient être utilisées pour la production de biomasse à des fins énergétiques et autres utilisations non alimentaires, ainsi que des mesures politiques pour en encourager l'utilisation.

**SAU réelle et évolution de la SAU dans tous les États membres de l'UE depuis 1975**

Les États membres communiquent à Eurostat des données sur la **superficie de l'exploitation agricole** ('total farm area', **FA**), la **superficie agricole** ('agricultural area', **AA**) et la SAU par le biais de l'enquête sur la structure des exploitations (Farm Structural Survey, **FSS**). La SAU est la plus petite de ces superficies, définie comme « la superficie totale couverte par les terres arables, les prairies permanentes, les cultures permanentes et les jardins potagers utilisés par l'exploitation agricole, indépendamment du type de possession ou du fait que les terres soient utilisées comme une partie de terre commune ». L'AA comprend la SAU plus la **superficie agricole non utilisée** (non-utilised agricultural area, **NUAA**) et la **superficie de production agricole spéciale** (special holding areas, **SAA**). La plus grande zone est la FA qui se compose de AA plus des **superficies boisées** (wooded areas, **WA**), qui comprend également les **superficies de taillis à rotation rapide** (short rotation coppice, **SRC**) et d'autres terres, qui sont les terres agricoles occupées par les bâtiments, cours de ferme, chemins, étangs.

L'analyse à long terme des tendances de la SAU entre 1975 et 2016 a montré une baisse totale pour tous les États membres de l'UE-28 de près de 360 000 km$^2$, soit 18% de la SAU en 1975, avec une stabilisation depuis 2005. Des baisses ont été observées dans tous États membres, mais les plus importantes ont eu lieu en Bulgarie, en Tchéquie, en Estonie, en Grèce, en Espagne, en Croatie, en Italie, à Chypre, en Lettonie, en Hongrie, en Pologne, en Slovénie et en Slovaquie.

Des données plus récentes montrent qu'entre 2005 et 2016, la SAU réelle pour l'UE-28 est restée relativement stable, avec une moyenne de 1 737 200 km$^2$, avec un pic en 2010 à 1 758 150 km$^2$. La FA et l'AA ont connu une légère baisse sur cette période (-2% et -1%, respectivement). La différence entre la SAU et l'AA suggère qu'environ 5% des terres agricoles sont inutilisées. La FA est environ 15% plus grande que l'AA.

Malgré ce tableau stable pour l'UE-28, des changements significatifs de la SAU ont été observés dans certains États membres ou régions au cours de cette période. Les baisses les plus importantes de la SAU ont eu lieu à Chypre et en Autriche. Les augmentations les plus importantes ont été enregistrées en Bulgarie, en Estonie, en Irlande, en Grèce, en Croatie et en Lettonie. En examinant plus en détail les utilisations réelles des terres, les terres arables et les terres cultivées permanentes ont diminué au niveau de l'UE-28 en termes absolus et relatifs, tandis que la superficie des prairies permanentes a augmenté, au moins jusqu'en 2010.

Le pic de 2010 des prairies permanentes dans l'UE-28 et dans de nombreux États membres ne reflète pas nécessairement une augmentation réelle des surfaces, mais résulte d'un ajustement en 2010 de la méthode d'enregistrement des terres communes dans le FSS. La comparaison des données à partir de 2010 devrait donc être plus fiable.

**Principaux facteurs affectant l'abandon des terres agricoles dans l'UE-28**

La littérature montre que les changements dans l'utilisation des terres agricoles résultent d'une combinaison de facteurs dont les effets diffèrent selon le contexte historique, géopolitique et socio-économique. Les facteurs les plus répandus sont des conditions agro-écologiques défavorables et des facteurs socio-économiques opérant à la fois au niveau des exploitations et au niveau régional. Les zones de montagne sont particulièrement sensibles à l'abandon des terres agricoles. Le déclin des populations rurales conduit également à l'abandon des terres agricoles dans de nombreuses régions de l'UE, en raison de meilleures opportunités d'emploi dans des zones plus urbaines ainsi que du déclin des infrastructures rurales. Néanmoins, des motivations socioculturelles peuvent conduire au maintien des activités agricoles dans des régions où elles ne sont pas économiquement viables. Dans d'autres cas, les terres continuent d'être enregistrées comme étant agricoles mais ne sont pas gérées activement, ce qui peut être qualifié d '« abandon caché ». Les politiques publiques sont un facteur moins important d'abandon des terres, bien que des problèmes d'éligibilité aux paiements de la **politique agricole commune (PAC)** puissent avoir un effet.

Les neuf études de cas régionales conduites dans le cadre de cette étude ont confirmé bon nombre des conclusions de la littérature, comme le fait que les principaux facteurs de non-utilisation ou d'abandon des terres agricoles sont de nature socio-économique. Les facteurs les plus importants identifiés au niveau des exploitations étaient la rentabilité des exploitations, la productivité des terres pour les cultures et le bétail, les coûts de production, la fragmentation des terres agricoles et les problèmes de régime foncier et de propriété. La baisse de la rentabilité de l'agriculture, observée dans toutes les régions étudiées, a renforcé la tendance des jeunes à quitter les zones rurales, laissant derrière eux une population agricole vieillissante.

Contrairement à la littérature, les contraintes naturelles n'ont pas été identifiées comme les principaux facteurs d'abandon des terres agricoles dans les régions étudiées, bien qu'elles soient mentionnées dans toutes. Dans certaines régions, elles ont renforcé les facteurs socio-économiques ou devraient devenir plus importantes à l'avenir en raison du changement climatique. Dans certaines régions, la dégradation des terres a pu être induite par des pratiques de gestion et dans quelques régions seulement, c'est l'abandon des terres agricoles lui-même qui a pu entraîner la dégradation des terres, sous forme d'incendies de forêt et d'érosion des sols. Bien que la politique n'ait pas été considérée comme le principal facteur de l'abandon des terres agricoles dans les régions étudiées, la combinaison de la PAC et des politiques nationales n'a pas été pas suffisante pour maintenir toutes les terres agricoles en activité. Des enquêtes menées dans plusieurs régions ont également mentionné une administration foncière ou des systèmes cadastraux médiocres ou incomplets comme raisons de la conversion des utilisations agricoles à d'autres utilisations.

**Lacunes et besoins en données pour mesurer la SAU et détecter l'abandon des terres**
Malgré les changements dans les définitions et les règles d'enregistrement des données sur la SAU au fil du temps, et les variations autorisées pour les États membres pour certaines catégories de terres agricoles, la base de données du FSS reste la source la plus uniforme disponible pour déterminer la SAU nationales, régionales ainsi que pour les tendances. Les deux principaux problèmes à prendre en compte en ce qui concerne les changements de SAU entre les années sont : le changement de 2010 relatif à l'enregistrement des terres communes, et des incohérences dans les rapports des offices nationaux de statistique, qui entraînent des problèmes de distinction entre les zones agricoles et forestières et l'identification de l'agroforesterie.

Il n'y a pas de données statistiques et spatiales qui enregistrent les terres inutilisées, abandonnées ou dégradées. Il y a des informations dans LUCAS (statistiques sur l'occupation et l'utilisation des sols d'Eurostat), qui identifie «les terres en jachère et abandonnées» comme une classe de couverture terrestre distincte, mais l'emplacement précis de ces zones n'est pas cartographié. Les terres inutilisées et abandonnées qui restent hors de production pendant plusieurs années perdent leur statut de terres agricoles et ne sont donc plus enregistrées dans les statistiques agricoles. De plus, l'abandon des terres implique un processus graduel, ce qui rend difficile de déterminer si et quand les terres sont complètement abandonnées.

Malgré cela, il existe des moyens d'améliorer la détection et l'enregistrement des terres abandonnées et inutilisées (par exemple grâce aux informations à haute résolution spatiale et temporelle provenant des satellites pour mesurer le développement de la végétation sur le terrain et les activités (ou absence d'activité) de gestion des terres, par exemple en utilisant l'**Indice de Végétation à Différence Normalisée (NDVI).** Au cours des dernières années, de nombreux progrès ont été accomplis dans l'identification des types de cultures et la gestion des terres grâce à la télédétection et à l'interprétation de photographies aériennes qui permettraient d'identifier la gestion, ou l'absence de gestion, au niveau de la parcelle.

**Obstacles et opportunités pour la culture de biomasse à des fins énergétiques et autres utilisations non-alimentaires sur des terres agricoles inutilisées, abandonnées et dégradées**
La littérature a montré que l'introduction de cultures pour la biomasse sur des terres inutilisées, abandonnées et dégradées peut offrir un éventail d'opportunités socio-économiques, y compris des revenus supplémentaires et la création de nouveaux emplois. Cultiver de la biomasse peut également aider à diversifier les revenus des agriculteurs et à créer un accès local à des ressources énergétiques nouvelles et propres. Les études de cas ont confirmé la nécessité d'utilisations alternatives des terres au sein mais aussi en dehors de leur usage agricole. Cependant, les experts divergent sur s'il est réaliste de remettre en service des terres agricoles inutilisées, abandonnées et dégradées à cette fin. L'une des principales raisons de ces divergences est l'incertitude concernant le rendement financier des cultures non-alimentaires, notamment parce que la demande du marché n'est généralement pas (encore) bien développée. Cela concerne spécifiquement les cultures de biomasse lignocellulosique, les plus adaptées à la culture sur des terres abandonnées et dégradées. En outre, il existe des défis techniques pour la restauration des terres pour permettre un usage agricole.

En termes de risques et d'opportunités environnementaux, l'analyse montre qu'il y a plus de co-bénéfices avec les cultures pérennes et les systèmes agroforestiers. Sur des terres nues inutilisées, abandonnées ou dégradées, la mise en place de toute culture créant une couverture du sol aide à stabiliser le sol. Cependant, les cultures pérennes sont plus efficaces que les cultures annuelles pour réduire l'érosion des sols, accumuler du carbone dans le sol et réduire le lessivage des nutriments. Il en va de même pour les systèmes agroforestiers, en particulier ceux qui combinent des arbres avec des cultures permanentes et des prairies permanentes. De nombreux systèmes agroforestiers sont meilleurs pour le contrôle de l'érosion et le maintien global de la fertilité du sol que les systèmes conventionnels de foresterie, de culture ou de pâturage.

L'effet carbone du sol des cultures de biomasse pérennes et des systèmes agroforestiers dépend beaucoup de l'utilisation antérieure des terres. Le défrichage et le travail du sol des prairies, des terres abandonnées depuis longtemps avec un couvert végétal dense d'arbustes et/ou forestiers ou des zones humides dans le but de cultiver des cultures de biomasse pérennes entraînent de graves baisses de carbone (au-dessus et au-dessous du sol), avec des périodes de restauration variables. Les effets potentiels sur la biodiversité dépendent du paysage et du contexte de l'habitat. Par exemple, le passage des terres végétalisées abandonnées aux terres arables en rotation diminuera les possibilités d'abris et de reproduction pour les mammifères et les oiseaux ainsi que la diversité floristique.

**Le rôle des politiques publiques dans le maintien des terres sous production agricole, leur remise en service actif et la stimulation de la culture de la biomasse à des fins énergétiques et non-alimentaires**
Les politiques publiques peuvent jouer un rôle important pour inverser l'abandon et la dégradation des terres agricoles et rétablir une production active. La PAC, en conjonction avec certaines politiques nationales (taxes, instruments financiers, politiques d'aménagement du territoire et processus d'enregistrement foncier et de résolution de problèmes de régime foncier), s'est avérée avoir la plus grande influence.

La dégradation ou l'abandon des terres n'est généralement pas la cible principale de ces instruments politiques qui abordent ces problèmes indirectement en soutenant la viabilité du secteur agricole dans son ensemble et en maintenant la diversité des types et des structures agricoles. Dans certains cas, ils cherchent à maintenir des formes spécifiques de production et à résoudre les problèmes de renouvellement des générations et de régime foncier. Les instruments politiques tels que la PAC ciblent rarement les hotspots de l'abandon des terres ou la culture de matières premières à des fins énergétiques et à d'autres fins non-alimentaires. Pourtant, là où ils coïncident, ils peuvent aider à contrer les facteurs socio-économiques affectant l'abandon. Les politiques nationales ont évolué pour répondre aux problèmes spécifiques rencontrés aux niveaux national, régional et local. Des politiques publiques spécifiques ont été identifiées dans les études de cas d'Europe centrale et orientale, conçues pour aborder les circonstances particulières entourant les problèmes de structure et de régime fonciers découlant du processus de restitution des terres, notamment les questions d'enregistrement foncier. À l'exception de certaines des mesures environnementales de la PAC (la mesure agroenvironnementale et climatique, par exemple), la gestion durable des terres agricoles n'est pas un élément-clé dans la majorité des outils politiques identifiés.

En pratique, la combinaison actuelle des politiques publiques en place est souvent insuffisante pour contrer les facteurs socio-économiques de l'abandon des terres, tels que ceux qui conduisent au dépeuplement rural. Ces problèmes ruraux de grande échelle méritent plus d'attention, parallèlement à un soutien au niveau des exploitations et à la résolution des problèmes de structure et de régime foncier des exploitations, si l'on veut maintenir les systèmes agricoles les plus vulnérables sur le plan socio-économique. La mesure dans laquelle cela est possible variera d'une région à l'autre et dépendra de la vigueur économique relative de l'économie en général. Néanmoins, certaines mesures politiques (paiements directs de la PAC et mesures pour les zones soumises à des contraintes naturelles) contribuent à maintenir de vastes superficies de terres à usage agricole qui, autrement, ne seraient plus productives, mais elles ne garantissent pas la gestion durable de ces zones. Il est également clair que les processus sont limités pour déterminer les implications climatiques et environnementales de la remise en production des terres. Enfin, la politique ne joue qu'un rôle limité dans la décision de planter des cultures de biomasse à des fins énergétiques ou à d'autres fins non-alimentaires sur les terres remises en production. Celles-ci relèvent du gestionnaire foncier et sont influencées par une série de facteurs, principalement liés au marché. Le rôle clé de la politique devrait être de garantir que la manière dont les cultures sont cultivées soit durable, la protection des ressources naturelles et de la biodiversité, et de fournir un ensemble de services écosystémiques.

**Terres non-agricoles adaptées à la culture de la biomasse**

En examinant le potentiel des terres non-agricoles adaptées à la culture de la biomasse, un certain nombre de catégories ont été évaluées pour identifier les obstacles et les opportunités de les utiliser à cette fin. Pour les trois catégories les plus intéressantes (en fonction de la taille, de la faisabilité de la conversion, de la viabilité financière, des utilisations concurrentes), une enquête plus détaillée a été menée : terrains aéroportuaires, terrains agrophotovoltaïques (APV) où la culture de biomasse est combinée à des systèmes PV, et décharges fermées.

Pour la culture de biomasse sur les terrains des aéroports, les principaux obstacles identifiés sont que les activités agricoles peuvent présenter un risque supplémentaire pour les activités aériennes et également attirer une certaine biodiversité (par exemple, oiseaux et mammifères) qui peuvent augmenter les risques de collision avec les avions. Cependant, l'agriculture aéroportuaire pourrait générer des revenus financiers supplémentaires, augmentant ainsi la viabilité économique du terrain car il est relativement vaste et facilement accessible. Les cultures sur les aéroports pourraient atténuer la pollution sonore et chimique et les effets négatifs des événements météorologiques extrêmes (températures élevées). Une gestion efficace de la faune dans les aéroports est une exigence minimale.

Pour l'APV, le principal obstacle identifié est le niveau des coûts d'investissement, qui sont significativement plus élevés que ceux des systèmes PV à grande échelle. L'électricité produite par APV n'est actuellement pas compétitive en termes de prix, même s'il pourrait y avoir un avantage potentiel grâce aux revenus supplémentaires générés par les cultures de biomasse. L'incertitude quant à la propriété des terres peut également entraver la mise en œuvre. La superficie potentielle qui pourrait être utilisée pour l'APV dans l'UE est importante, avec environ 500 000 ha. L'APV pourrait être utilisée pour restaurer les sols dégradés sur des terres arides ou semi-arides et les panneaux photovoltaïques peuvent protéger les cultures contre les effets du temps et du climat (par exemple, la lumière directe du soleil, la sécheresse, la chaleur, la grêle et la pluie), réduisant ainsi les risques d'échec des récoltes pour les agriculteurs. La végétation refroidissant l'arrière des panneaux PV peut également en améliorer l'efficacité.
Pour la culture de la biomasse sur des décharges fermées, les principaux obstacles identifiés sont que les polluants du sol et la mauvaise qualité du sol peuvent entraîner de faibles rendements ou des problèmes de qualité de la biomasse et que les coûts d'exploitation sont relativement élevés en raison de la taille plus petite et sous-optimale des parcelles et le traitement de fertilité des sols nécessaire. Cependant, la production de cultures issues de la biomasse dans des décharges fermées a été identifiée comme une utilisation temporaire utile jusqu'à ce que des solutions permanentes soient trouvées pour l'assainissement, offrant même des options pour l'assainissement des sols ou la réduction des risques environnementaux associés aux fuites.

**Conclusions et recommandations**
Malgré le peu d'informations disponibles dans la littérature, les statistiques et les études de cas de l'UE concernant la mise en place de nouvelles activités de culture sur des terres inutilisées, abandonnées ou dégradées, un certain potentiel existe pour la réintroduction de ce type de terres dans la production agricole. Il peut s'agir de (anciennes) terres agricoles abandonnées et/ou dégradées et où l'établissement de cultures fournirait de multiples services écosystémiques. Il pourrait également s'agir de certains types de terres non-agricoles, comme celles présentées dans cette étude. Une résistance de la société à l'utilisation de certaines terres non-agricoles n'est pas à exclure en raison de la perte potentielle de végétation et des problèmes d'intégration écologique ou d'impacts sur le paysage. Dans d'autres domaines, l'écologisation des terres non-agricoles (urbaines) par le biais de cultures bioénergétiques pourrait contribuer aux initiatives en cours en Europe pour verdir les villes. La production de cultures bioénergétiques est une activité précieuse et appropriée pour une utilisation des terres à court et à long terme et peut donc être une option dans les cas où la terre n'est disponible que temporairement.

Trois conditions doivent être remplies pour la production de biomasse non-alimentaire afin de réduire efficacement l'abandon et la dégradation des terres ou de restituer les terres abandonnées et dégradées à la production de manière durable. Premièrement, il doit y avoir une demande du marché en biomasse pour fournir des signaux de marché stables qui donnent confiance en la production de cultures à des fins énergétiques ou non-alimentaires. Deuxièmement, il y a un besoin en données pour comprendre quelles zones sont abandonnées et dégradées ou risquent de le devenir et pour décider où et comment il est le plus approprié d'encourager l'utilisation de ces terres pour la fourniture de multiples services écosystémiques (par exemple par le boisement, reboisement, écotourisme, chasse). Troisièmement, des politiques publiques doivent être mises en place pour stimuler la production de biomasse à des fins alimentaires et non-alimentaires là où elle conduit à une gestion durable des terres et, le cas échéant, pour permettre un changement d'utilisation des terres bénéfique pour l'environnement et le climat qui tirerait parti de nouveaux marchés tels que l'agroforesterie et les cultures pérennes dans les zones marginales. Les recommandations spécifiques suivantes résultent de cette étude.

*Recommandations pour l'amélioration des données :*

- Les différences dans les définitions des zones agricoles et forestières et pour identifier l'agroforesterie entraînent des incohérences dans les données du FSS communiquées par les États membres. Une plus grande uniformité dans les règles applicables aux États membres sur les niveaux de couvert arboré et une clarification de la définition des zones en agroforesterie à communiquer à Eurostat contribueraient à résoudre ces problèmes.
- Il serait utile de pouvoir enregistrer l'absence de gestion de terres agricoles pendant plusieurs années consécutives, ainsi que les terres inutilisées depuis longtemps et perdant leur statut officiel de terres agricoles utilisées. Un bon indicateur indirect de la marginalité et de la dégradation des terres sur les terres arables est le rendement. L'enregistrement annuel détaillé des rendements par hectare au niveau régional (de préférence au niveau des unités administratives locales) est très informatif et permettrait d'identifier les régions où la marginalisation agricole peut conduire à l'abandon. Les terres dégradées à la fois pour l'utilisation agriculture et pour d'autres utilisations doivent être enregistrées dans des sources de données statistiques ou spatiales.

*Recommandations pour les politiques publiques :*

- Pour améliorer la manière dont la PAC répond aux problèmes de l'abandon de terres, les États membres doivent identifier ses moteurs dans l'analyse SWOT et l'analyse des besoins de leurs plans stratégiques de la PAC et effectuer une analyse pour identifier les zones à risque qui serait les plus intéressantes de maintenir dans un usage agricole. Les États membres devraient utiliser cette analyse pour choisir, concevoir, adapter et cibler une combinaison pertinente d'interventions de la PAC afin de soutenir la gestion durable des terres en combinaison avec la résolution des problèmes sociétaux plus larges de la pauvreté et de l'exclusion sociale dans les zones rurales. Une meilleure intégration de la PAC avec le financement des Fonds Structurels ainsi que les mesures nationales permettrait de réduire le niveau de ressources nécessaires pour résoudre ces problèmes.
- Les systèmes agroforestiers suscitent un intérêt considérable en tant que source de biomasse à des fins non-alimentaires, ainsi que pour leur potentiel à fournir des services écosystémiques multiples. Cependant, les États membres soutiennent ces

pratiques par un montant relativement faible de soutien de la PAC. À l'avenir, les paiements et le conseil pour créer des zones en agroforesterie durable et pour la restauration/le maintien des systèmes agroforestiers existants devraient être encouragés davantage au niveau des États membres au travers de l'aide au reboisement.

- Des systèmes d'enregistrement foncier incomplets ont été identifiés comme un problème dans certains États membres. S'attaquer à ce problème devrait être une priorité afin qu'il soit clair à qui appartient chaque parcelle de terre et que lorsque des problèmes de dégradation, de sous-gestion et d'abandon surviennent, les propriétaires puissent être contactés pour résoudre les problèmes.
- Une meilleure cohérence est nécessaire entre les politiques sur les énergies renouvelables et le climat, la PAC et les Fonds Structurels. De plus, la production de cultures bioénergétiques sur des terres non-agricoles nécessite souvent une coopération entre plusieurs industries ou secteurs qui ne sont généralement pas amener à être en contact. Les politiques publiques renforçant la collaboration sectorielle devraient contribuer à l'utilisation de ces types de terres à des fins de bioénergie. Cela pourrait inclure des avantages financiers pour les consortiums d'entreprises de différents secteurs qui coopèrent pour utiliser les terres pour de multiples fonctions, ou l'élaboration de directives législatives pour la conclusion de contrats (modèles) permettant des utilisations multiples de la même zone. La certification européenne pour la production de cultures bioénergétiques à partir de terres (auparavant) non-agricoles pourrait aider à différencier la biomasse produite dans ces zones, ce qui pourrait être un avantage sur le marché des carburants verts.

# 1 INTRODUCTION, SCOPE AND PURPOSE OF THE STUDY

**Chapter aim and contents:**
This chapter presents the scope, wider context and objectives of the study, and the overall structure of the report. It also sets out the overall methodological approach, including the selection of case studies.

## 1.1 Study scope and objectives

While agriculture has historically shaped the biodiversity heritage of rural areas in the EU over the last 60 years, this synergistic relationship has declined. Polarisation has occurred, particularly in the last decades, between intensification and specialisation of agricultural production on land with more production potential on the one hand, and marginalisation and abandonment of agricultural land on the other (Polakova et al., 2011; Sutcliffe et al., 2015). At the same time, influenced by growing ambitions for a more circular and bio-based economy, there is increasing demand to replace non-renewable resources, such as fossil resources, with biomass to be converted to bio-based materials, chemicals and energy. This additional demand for biomass for non-food purposes must be sustainably produced and can come both from the use of residual biomass waste (from municipalities, agriculture and forestry), as well as dedicated crops and direct harvests from forests. To avoid putting additional pressure on land and competing with food production, it is preferable to grow these biomass crops on land that is no longer used, has become abandoned and/or degraded, as long as this can be done sustainably.

It is in this context that the study presented in this report was commissioned by the EC-DG-ENER. The study objectives are to:

1. provide, based on most recent statistical and scientific data, the current area of utilised agricultural area (UAA) in all EU-28 countries and an evaluation of how UAA has evolved since 1975.
2. provide the most recent statistical data, scientific and EU case study evidence on declines in agricultural land in the EU countries and the reasons why agricultural land becomes unused, abandoned and degraded.
3. support the Commission in proposing policies that can reverse this trend of agricultural land becoming unused, abandoned and degraded.
4. support the Commission in proposing policies aimed at reclaiming unused, abandoned and degraded agricultural land and putting it under active biomass production for energy and other non-food uses.
5. review recent data and scientific evidence to identify different types of non-agricultural land in the EU that could potentially be used for active biomass production for energy and other non-food uses.
6. support the Commission in proposing policies aiming at reclaiming non-agricultural land for active biomass production for energy and other non-food uses.

**Box 1.1 Types of land reviewed for the production of cropped biomass for energy and other uses in the EU-28**

The study focuses on **agricultural and non-agricultural land** that is/has become unused and that could potentially be used for active biomass production for energy and other non-food uses.

For **agricultural land**, the focus is on land that is no longer used for food, fibre, and feed production or severely degraded lands. This is land that has been partly in agricultural use in recent years (the last 20 years) as well as land that is likely to go out of production in the near future. These areas are currently defined or will be defined in the near future according to the RED II[1] definitions for low indirect land use change (ILUC) land:

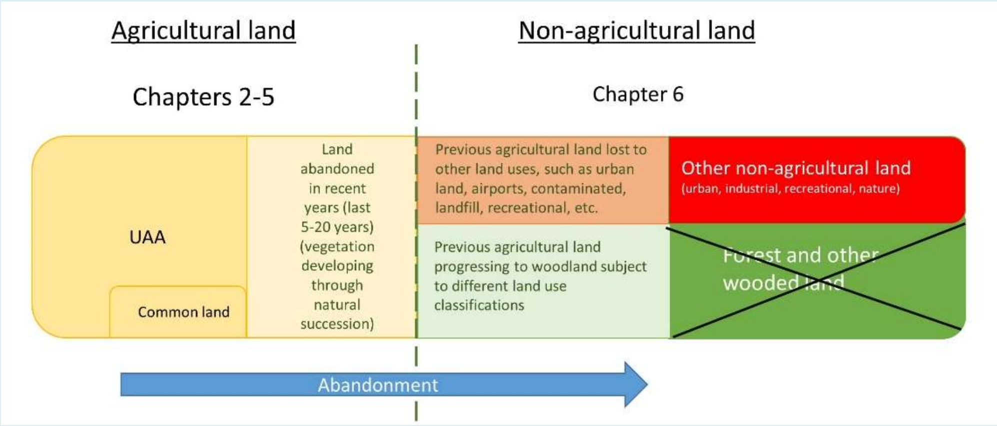
- '**unused land**' means areas which, for at least five consecutive years, were not used for the cultivation of food and feed crops, other energy crops, or any substantial amount of fodder for grazing animals;
- '**abandoned land**' refers to unused land which was used in the past for the cultivation of food and feed crops, but where this cultivation ended due to biophysical or socio-economic constraints;
- **'severely degraded land'** is land that, for a significant period of time, has either been significantly salinated or had significantly low organic matter content and has been severely eroded.

The study also focuses on **land resources that either were agricultural over 20 years ago or have never been agricultural** and that could potentially be used for biomass cropping. Such land may include any type that is temporarily or permanently out of productive use, or that is in use but where such use can be combined with biomass cropping. However, this study does **not** cover forest land.

Figure 1.1 gives an overview of which type of land is the focus of each chapter. Chapters 2, 3, 4 and 5 focus on (former) agricultural land that is currently unused, has been recently abandoned, or is degraded. Chapter 6 discusses the options for biomass cropping on non-agricultural land, with the exception of forest land.

[1] Commission Delegated Regulation (EU) 2019/807 of 13 March 2019 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council as regards the determination of high indirect land-use change-risk feedstock, for which a significant expansion of the production area into land with high carbon stock is observed and the certification of low indirect land-use change-risk biofuels, bioliquids and biomass fuels.

Figure 1.1 Overview of types of land included in the report.




As well as agricultural land resources that have become unused and/or abandoned for food and feed production or degraded, the study also focuses on **non-agricultural land** that has potential for producing cropped feedstock for energy and other uses (see **Box 1.1**). For both types of land, it examines whether biomass could potentially be grown and if this production has adverse environmental and climate impacts.

The study's scope is the EU-28[2], with the most recent UAA area figures evaluated for the EU-28 at Member State-level and at the sub-regional level where data allow (LAU 2/3)[3]. Historic trends and recent UAA figures are evaluated and underlying processes causing land abandonment identified. These drivers are partially mapped in order to link to emerging land use transitions.

A case study approach is used for both further understanding agricultural land abandonment and for in-depth data collection on three non-agricultural land categories, and the possibilities to use these for biomass cropping for energy and other non-food uses. The agricultural land case studies, nine in total, enable the relationship between drivers (and combinations of drivers) and land use transitions that lead to the abandonment of agricultural land to be studied. Three case studies were selected for in-depth analysis of the non-agricultural land categories (Chapter 6).

---

[2] As when the study was commissioned the UK was still in the EU.

[3] Eurostat maintains a system of Local Administrative Units (LAUs) compatible with NUTS. These LAUs are the building blocks of the NUTS and comprise the municipalities and communes of the EU.Until 2016, two levels of Local Administrative Units (LAU) existed:

- The upper LAU level (LAU level 1, formerly NUTS level 4) were defined for most, but not all of the countries.
- The lower LAU level (LAU level 2, formerly NUTS level 5) consisted of municipalities or equivalent units in the 28 EU Member States.

Since 2017, only one level of LAU has been kept this is a subdivision of the NUTS 3 regions.
Source: https://ec.europa.eu/eurostat/web/nuts/local-administrative-units

The study also looks at the options for cropped biomass for energy and other non-food uses. Box 1.2 gives an overview of the biomass crops that are reviewed for their potential to be grown on unused, abandoned and degraded agricultural and non-agricultural land. Chapter 4 provides a literature review on the barriers and opportunities for biomass crops that are suitable for biomass production for energy and other non-food uses.

The report also examines the roles different policies can play in influencing and supporting the maintenance of land under agricultural production, bringing it back into active use and stimulating biomass cropping for non-food purposes on agricultural and non-agricultural land. It examines the role of both EU and national/regional policies, including the ways that different Member States have implemented EU policies. The assessment of national and regional policies is based on the case study findings, with evaluation results presented in Chapter 5 for policies covering agricultural land and in Chapter 6 for policies affecting non-agricultural land.

**Box 1.2 Types of crops considered with potential to be grown on unused, abandoned, degraded agricultural and unused non-agricultural lands in EU-28**

Three types of crops can be considered as relatively novel crops that are producing either lignocellulosic material and/or oil, sugar and starch that is a suitable feedstock for the production of advanced biofuels, or other bio-based materials or chemicals. The selection listed below is based on the initial selection of crops in the MAGIC project (Alexopoulou et al., 2019; Cossel et al., 2019) and a report on agroforestry systems in Europe (Elbersen and van Eupen, 2019).

| Category | Definition | Examples |
|---|---|---|
| **Annual oil, starch or sugar crops used for 1G biofuels and bioproducts** | Crops that can be harvested once a year and need to be planted every year. Usually they are to be grown in rotation with other annual crops. The main type of resource harvested is oil, sugar and starch (and straw). | Sugarbeet, oil seed rape, sunflower, cereals (for example, wheat, barley, maize) |
| **Perennial herbaceous crops** | Crops that can be harvested on average once a year over several years (between 10 to 25 years) without the need for ploughing up and new planting. The main type of resource harvested is herbaceous lignocellulosic biomass. | Miscanthus (*Miscanthus*), switchgrass (*Panicum virgatum*), reed canary grass (Phalaris arundinacea), giant reed (*Arundo donax)*, tall wheatgrass (*Thinopyrum ponticum or cristatum or sibiricum*), wild sugarcane (*Saccharum spontaneum L.*), common reed (Phragmites australis, suitable for palludiculture) |
| **Woody perennial crops in short rotation systems (SRC)** | SRC refers to trees that are harvested by cutting the growing stem to its base, allowing the growth of new stems. These can be harvested once every 3 to 6 years and plantations of SRC usually last for between 10 to 25 years, during which no ploughing and replanting is needed. The main type of resource harvested is woody biomass. | Poplar (*Populus*), willow (*Salix alba*), Siberian elm (*Ulmus*), eucalyptus, black locust (*Robinia pseudoacacia*), black alder (Alnus glutinosa, suitable for palludiculture) |
| **Perennial multipurpose crops** | Crops that can be harvested on average once a year over several years (between 10 to 15 years) without the need for ploughing up and new planting. The main type of biomass | Cardoon (*Cynara cardunculus)*, lupin (*Lupinus*), lisse (Iridaceae, suitable for palludiculture) |

| | | |
|---|---|---|
| | harvested is a combination of herbaceous lignocellulosic biomass and oil or starch. | |
| **Annual non-food oil crops** | Crops that can be harvested once a year and need to be planted every year. Usually they are grown in rotation with other annual crops. The main type of resource harvested is oil (and straw). | Camelina (*Camelina sativa*), castor bean (*Ricinus communis*), crambe (*Crambe*), Ethiopian mustard (*Brassica carinata*), Pennycress (*Thlaspi*), safflower (*Carthamus tinctorius*) |
| **Annual non-food multipurpose crops** | Crops that can be harvested once a year and need to be planted every year. Usually they are grown in rotation with other annual crops. The main type of resource harvested is lignocellulosic biomass and oil or starch. | Hemp (*Cannabis sativa*), biomass sorghum (*Sorghum Moench 1794*), kenaf (Hibiscus cannabinus). |
| **Agroforestry systems** | Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, and so on) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components (Lundgren and Raintree, 1983).[4] | Examples of agroforestry practices in Europe (Mosquera-Losada et al., 2009):<br>1) Silvoarable agroforestry: widely spaced trees inter-cropped with annual or perennial crops. It comprises alley cropping, scattered trees and line belts.<br>2) Riparian buffer strips: strips of perennial vegetation (tree/shrub/grass) natural or planted between croplands/pastures and along water sources.<br>3) Multipurpose trees: fruit and other trees randomly or systematically planted in cropland or pasture for the purpose of providing fruit, fuelwood, fodder and timber, among other services.<br>4) Silvopasture: combining trees with forage and animal production. It comprises forest or woodland grazing and open forest trees which can deliver wood residues for energy and other uses. |

## 1.2 Study background

The EU Energy Union Framework Strategy calls on Member States to develop a long-term, secure, sustainable and competitive energy system, with a continued increase in the share of renewable energy sources in the EU. The renewable energy Directive (2009/28/EC) set binding national targets on each Member State designed to deliver 20% of energy from renewable sources by 2020. The 2018 update of the Bioeconomy Strategy and RED II (EC Directorate-General for Research and Innovation, 2018) aims to accelerate the development of the European bioeconomy, and in particular to maximise its contribution towards the Paris

[4] The definition of agroforestry is also specified in Article 23 of EU Regulation 1305/2013 and sub-measure fiche 'establishment of agroforestry systems measure 8' as 'land use systems in which trees are grown in combination with agriculture on the same land'. It is further explained in the Agroforestry Measure Fiche: 'Agroforestry means land-use systems and practices where woody perennials are deliberately integrated with crops and/or animals on the same parcel and land management unit without the intention to establish a remaining forest stand. The trees may be arranged as single stems, in rows or in groups, while grazing may also take place inside parcels (silvoarable agroforestry, silvopastoralism, grazed or intercropped orchards) or on the limits between parcels (hedges, tree lines).'

Agreement[5], the 2030 Agenda[6] and the Sustainable Development Goals (SDGs)[7]. The update also aligns more closely to new EU policy priorities. Sustainability and circularity are now integrated with the bioeconomy objectives. Central to the Bioeconomy Strategy and Action Plan (EC, 2018) is the need to reconcile the competition between different sectors (food, feed and industrial uses) for biomass.

The **Green Deal** is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. It is expected that all EU actions and policies will have to contribute to the Green Deal objectives. Soon after the Green Deal, the **Circular Economy Action Plan** (COM(2020) 98 Final) was published in March 2020. This develops the Green Deal ambitions and specifies how the transition to further circularity in the EU economy should be brought about as an instrument to reach further climate-neutrality. It states that the climate-neutrality target by 2050 is not feasible without transitioning to a fully circular economy because half of total greenhouse gas emissions come from resource extraction and processing.

It is therefore clear that sustainability and circularity are now very closely integrated with the bioeconomy objectives of the EC. This implies that demand for biomass for energy and non-food uses can be expected to continue to grow, but that the requirements for it to be sustainably sourced cannot be ignored. The ambitions for a circular bioeconomy need to be carefully reconciled with other policy ambitions in relation to reaching more sustainability in agriculture, land use, biodiversity conservation, and climate mitigation, but also ensuring that there is enough food, jobs, and income. All these ambitions are also linked to the SDGs, to which the EC and all EU Member States have committed.

The focus on unused lands in this study is based on the expectation that demand for biomass for energy and non-food uses will increase in the future due to the influence of the policy driven transition to a circular bioeconomy. While it is claimed that there is sufficient biomass available in Europe to reach the 2030 goal of a bio-based economy (Panoutsou et al., 2016), mobilising biomass and setting up stable supply chains is one of the main barriers that hamper developments in the bio-based sector (Pelkmans et al., 2016; OECD, 2018). It is expected that waste and residual biomass sources will not suffice to supply the expected growing demand for biomass for non-food uses. For primary residual biomass, sourcing is often affected by farmers' and foresters' lack of willingness to supply biomass (Gyalai-Korpos et al., 2018; Dettenhofer, 2020), for instance due to focusing only on the main product and concerns and lack of knowledge about sustainably removable residual biomass and effects on soil health. Another issue is the variability of biomass quality. Most residual biomass is of low quality, but there is more demand for higher-quality residual biomass across a number of markets, which results in higher competition (Pelkmans et al., 2016). Bio-industries will also be cautious where there is uncertain biomass availability without fixed prices. Given these challenges, dedicated

[5] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[6] https://sustainabledevelopment.un.org/post2015/transformingourworld
[7] https://www.un.org/sustainabledevelopment/sustainable-development-goals

cropping to source bio-industries is gaining increased attention and the introduction of dedicated lignocellulosic crops is considered a feasible option. Using unused lands for their production is considered the viable alternative to minimise land-use competition for food production and its adverse (direct or indirect) effects on food security, land-based greenhouse gas (GHG) emissions and biodiversity loss. As part of this 'stock' of available land, abandoned unused and degraded agricultural lands have already been envisaged as land resources for the delivery of low ILUC biomass for biofuel production in RED II.

Non-food cropping will still have sustainability risks, such as the loss of ecosystem services (Bindraban et al., 2009; Berzky et al., 2011; Immerzeel, 2014; Plieninger and Gaertner, 2011), even if competition with food production is avoided. There are also many studies that claim that win-win situations can be created with the production of non-food crops on unused, abandoned and/or degraded lands (Dauber et al., 2012; Cossel, M. von et al., 2019; Smeets et al., 2009; Dale, 2010; Fernando, 2005; Zegada-Lizarazu et al. 2010; Zimmermann et al., 2012; Haughton et al., 2016). Cultivation of feedstock for energy and other non-food uses on unused, abandoned and degraded lands, or on land that would otherwise be abandoned, can be attractive especially if primary producers can gain additional income opportunities from it.

The options for creating such co-benefits from the production of industrial crops depend very much on what type of land conversions are involved, the time between lack of use and conversion to new crops, the type of crops used (perennials or annuals), the management practices, and the presence of other uses and ecosystem services (Pedroli et al., 2011; EEA, 2013; ETC-SIA, 2013; Immerzeel et al., 2014). In principle, the effects of biomass cropping for energy and other non-food purposes are the same as for other land-use activities such as for food and feed production. The specific challenge for biomass crops for non-food purposes is that this creates an additional demand for land and other inputs, for example, water and nutrients, over and above the already rising demand for food and feed due to a growing world population (Gough et al., 2018; Daioglou et al., 2020) and an increasing climate change effect (Cossel et al., 2019). The incremental increase in land use for agricultural production, whether a result of demand for biofuels, food, feed or other non-food applications, can directly or indirectly lead to an increase of $CO_2$ emissions and the loss of natural habitats, with adverse effects on biodiversity and ecosystem services.

It is important to highlight that it is not necessarily appropriate to bring back into production all land that is degraded or has been abandoned. Much land that is abandoned consists of small individual parcels scattered across an area which would not necessarily be economically viable to bring back into production. In other situations, land may be of high biodiversity value, in the process to reverting to forest over time, with associated climate and other environmental benefits, or fulfilling other important socio-economic and environmental functions and delivering ecosystem services, such as flood control and management. A precursor to any decision to bring land back into agricultural production therefore should be an assessment of the benefits and costs of doing so, taking into account the ecosystems services that are currently and could potentially be delivered in the future. This is necessary to ensure that vital ecosystem services are not lost in the process.

There may also be other barriers to the use of previously abandoned land for these purposes, including issues relating to markets, infrastructure, supply chains. Research within MAGIC (Elbersen et al., 2018), shows that abandoned land can often be marginal land with limited yield potentials. It could therefore be challenging to find large quantities of abandoned land within the EU that could be used for profitable cultivation of feedstocks for energy and other uses.

Given these different perspectives and the urgent need for biomass to supply the growing bioeconomy, this study aims to provide a more detailed understanding of the actual available land in the EU that has been and could be envisaged for biomass production. As part of this 'stock' of available land, it explores the potential to use abandoned agricultural lands for the production of biomass crops for energy and other non-food uses, thereby also stimulating the stewardship of such land by farmers, cooperatives and other players in the agricultural value chain, and revitalising rural areas. The study also provides an overview of policies and policy options to both reverse the trend in land abandonment and reclaim unused lands for biomass cropping.

## 1.3 Selection of case studies

Much of this study is derived from case studies, with two types of case studies selected:
Nine regional case studies to provide deeper understanding of land dynamics and relevant policies in relation to unused, abandoned and degraded agricultural lands.
Three thematic case studies of non-agricultural land types with potential to be used for biomass cropping for energy and other non-food uses. These were taken from a larger sample of 28 non-agricultural land types that were reviewed.

The selection of the nine case studies focusing on agricultural land that becomes unused, abandoned or degraded was based on a spatial analysis approach to identify hotspot regions of agricultural land abandonment, representing the diversity in biogeographical environments and socio-political contexts in the EU. To do this, three aspects were mapped at the regional level in the following order:

1. changes in UAA since 1975 and types of land use flows detected between 2000 and 2018 (see Chapter 2 and Annex III);
2. the main drivers of abandonment identified in the literature review (in Chapter 3); and
3. diversity in climate and historical political context.

This information was used to elaborate a typology of European regions, with a diverse combination of factors that lead to farmland abandonment. Regions with high land abandonment were further classified according to environmental and demographic characteristics. The nine cases studies were selected based on this typology and classification. To cover the wide agro-environmental diversity in the EU, case studies were selected in all its environmental zones, except the Boreal and Alpine zones. In these two zones, the climate (short growing season, low temperatures) severely constrains agricultural crop production and makes the development of biomass cropping unrealistic.

Annex VI gives further details of the approach taken, results of the regional typology mapping, and final case study selection.

The selection of the three thematic case studies for non-agricultural land options with a potential for dedicated biomass cropping was based on several steps. First, a longlist of potential non-agricultural land use categories was drawn up by experts involved in the project. This was then filtered to create a shortlist of categories based on size of availability, feasibility, and potential of co-benefits identified in the literature. For each shortlisted category, opportunities and barriers were identified through a literature search focusing on policy, funding options, co-benefits, pilot projects or existing initiatives, and positive public perception. Finally, three shortlisted categories were selected for in-depth analysis of their technical and economic feasibility for bioenergy production, and to identify existing policies that stimulate and/or hinder this.

## 1.4 Overview of this report

This report is the final deliverable of the 'Analysis of actual land availability in the EU; trends in changes (abandoned land, low fertility land, saline land etc.) and options for (energy) crop utilisation' study.

Chapter 2 focuses on the definition and quantification of UAA and changes in UAA in all EU countries since 1975. It also outlines the hotspot regions in the EU-28 where agricultural areas have declined.

Chapter 3 discusses the main drivers for agricultural land becoming unused, abandoned or degraded within the context of historical political changes in EU countries. It sets out the different types of abandonment processes that exist in the EU, based on the literature review and findings from the nine regional case studies.

Chapter 4 discusses the opportunities and barriers for using unused, abandoned and degraded agricultural land for various biomass crops. It provides a mapped overview of where barriers and opportunities occur in the hotspot regions.

Chapter 5 discusses the role of policies in relation to: maintaining land under agricultural production; bringing unused, abandoned and degraded land back into active use; and stimulating biomass cropping on unused, abandoned and degraded lands. It concludes with policy recommendations.

Chapter 6 focuses on the types of land outside agriculture use (excluding forest land) that can potentially be used for dedicated biomass cropping. A wider review of different types of land and their suitability for dedicated cropping is first presented. Based on this, three types of lands are selected for an in-depth case study-analysis of suitability, options and impediments. The case studies relate to agro-photovoltaic areas, airports, and contaminated land sites/closed landfill sites. Chapter 6 concludes with recommendations on how policy can stimulate and guide the development of cropping activities for biomass on these three non-agricultural land types.

Chapter 7 presents the main conclusions and recommendations. These address data gaps and data needs for measuring actual UAA, changes in UAA and mapping hotspots of land abandonment; main drivers for land abandonment; key characteristics of unused, abandoned and degraded agricultural lands; sustainable options for dedicated biomass cropping; and key EU and national and regional policies influencing the abandonment and bringing back into use of lands for biomass crops. For non-agricultural land, the conclusions focus on the key characteristics of non-agricultural lands suitable for dedicated biomass cropping. The main recommendations focus on improving policies targeting stabilisation and bringing (back) into production agricultural lands that are becoming unused, abandoned and degraded, and non-agricultural lands where biomass cropping can be introduced.

# 2 DEFINING AND QUANTIFYING THE ACTUAL UAA AND CHANGES IN UAA SINCE 1975 IN EU COUNTRIES AND REGIONS

**Chapter aim and contents:**
This chapter provides a description of the definition of UAA and two broader categories of agricultural land, namely agricultural area (AA) and farm area (FA). It then provides a quantified overview of these three types of land categories based on most recent statistical data sources in all EU-28 Member States, drawing conclusions on the current extent of UAA in the EU-28.

The final section presents a quantified assessment of changes in UAA and AA since 1975. Changes are set out in three time periods: 1975-1990, 1991-2005 and 2006-2016/18, and presented first at the national level and then at the regional level. Regional changes are further analysed to provide a more detailed characterisation of changes in UAA, from which hotspot regions of regional land use change have been mapped.

## 2.1 Introduction and approach

Based on most recent statistical and scientific data, the current area of UAA in all EU-28 countries and an evaluation of how this area has evolved since 1975 is presented here.

The approach followed here is involves extensive review of definitions of different agricultural land use categories and an extensive collection of statistical data from EU and national data sources.

## 2.2 Definitions of utilised agricultural area (UAA)

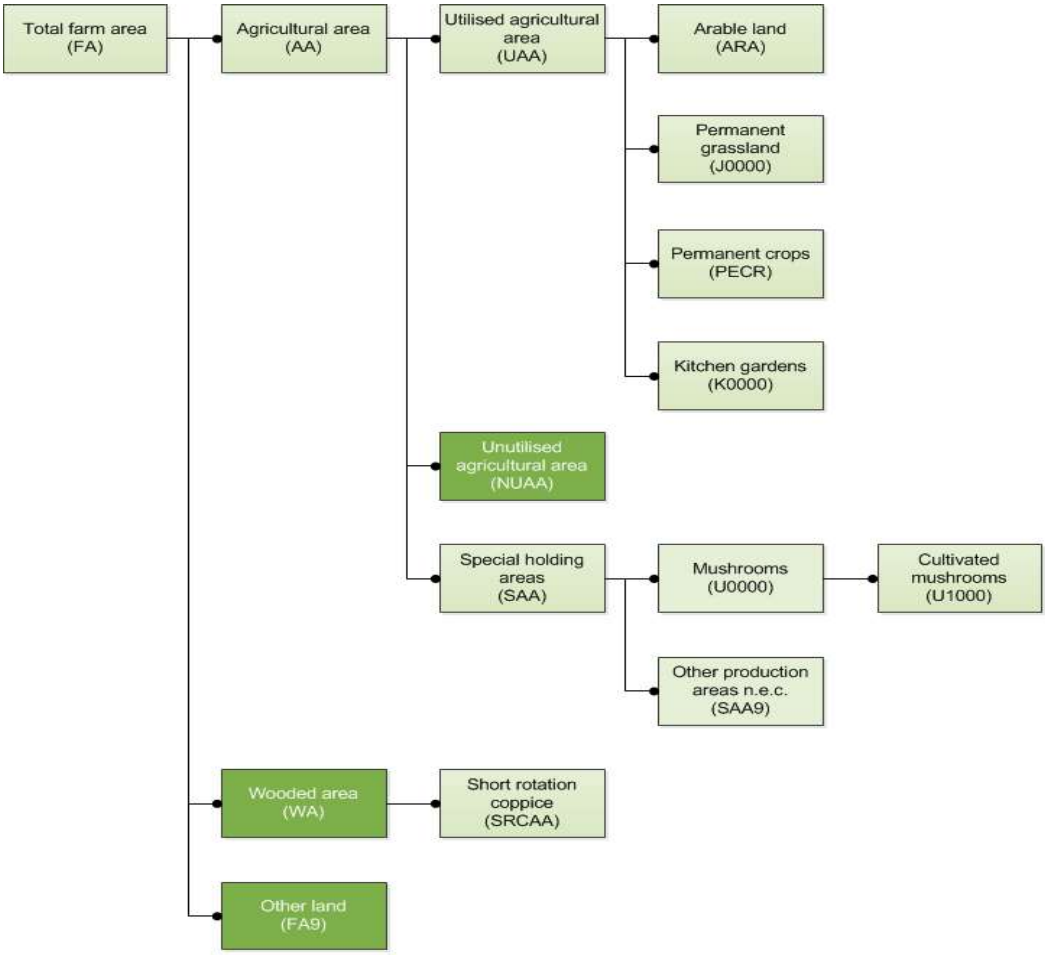
To identify abandoned farmland through changes in UAA over time, it is necessary first to determine how UAA and other agricultural land use classes are officially defined in statistics. It is also necessary to understand how these definitions translate in EU-wide and national datasets and how these datasets also relate to data determining the agricultural areas eligible for support under the Common Agricultural Policy (CAP). We will also show that what is registered by Eurostat as UAA does not necessarily match with what is registered in national agricultural and land use statistics. We also consider a broader interpretation of what can be regarded as farmland, and how this differs from what is officially registered as UAA following the statistical definitions.

Eurostat is the European statistical office that provides strict guidelines to all Member States on how they have to report their data to the farm structural survey (FSS). It ensures that there is regular data reporting according to a consistent methodology between all Member States. Eurostat makes a distinction between **FA, AA** and **UAA** (see Figure 2.1 and Table 2.1). **UAA** is the smallest area, and is defined as 'the total area taken up by arable land, permanent grassland, permanent crops and kitchen gardens used by the holding, regardless of the type of tenure or of whether it is used as a part of common land'. **AA** consists of the **UAA** plus

**unutilised agricultural area (NUAA)** and **special holding areas (SAA)**. The largest area is the **FA** which consists of **AA** plus **wooded area (WA)** and **other land (FA9)**, which is farmland occupied by buildings, farmyards, tracks, ponds, and so on.

Therefore, as soon as farmland becomes unutilised it is excluded from the UAA, but may remain part of the AA or FA. This confirms that changes in UAA as defined by Eurostat is in principle an indicator for measuring land that goes out of agricultural use, although it does not tell us what the land becomes after it leaves the UAA. There are also limitations to data sources that report on UAA, certainly when used for registering historical changes, which will be discussed below.

Figure 2.1 Eurostat overview of what is included in UAA, AA and FA.




Notes: Other land (SAA9) = Other areas on farms (so outside UAA, cultivated mushrooms, NUAA, wooded areas (WA) and SRCAA. Unutilised agricultural area (NUAA) = common land which is not used. Other land (FA9) = other land, occupied by buildings, farmyards, tracks, ponds, and so on.

The main difference between the AA and UAA registration in FSS is that AA also includes unused agricultural land and special holding areas, although the latter do not cover a large area. However, this does not imply that the categories of land included in UAA are always used. For example, the categories fallow and unused lands are included in FSS as part of UAA or AA. These are registered in FSS in sub-categories such as 'fallow land subject to payment of subsidies with no economic use' or 'permanent grassland and meadow - not used for production, eligible for subsidies'. This indicates that within the UAA registered in FSS there may be land included which is actually unused or even abandoned. For several categories of land, we do not know how it is managed. From the statistical classification into the 'fallow' or 'not used for production' categories it is not possible to conclude whether these categories of land are indeed abandoned for a longer time, or whether they refer to lands which is part of the crop rotation with a limited time out of production.

Unused agricultural area (NUAA) is an interesting category that is registered as is part of the agricultural area and not of the UAA. It is defined as 'common land which is not used'. From Section 2.1.2 (Table 2.3) it becomes clear that this category can cover large areas in certain countries and is responsible for the large differences that can exist between AA and UAA.

### 2.2.1 UAA and eligible farmland for CAP Pillar I payments

The first point to note is that Eurostat follows its own official definitions of UAA and its sub-classes, while the CAP eligible area is defined according to CAP Regulation (EU) No 1307/2013[8] (see Table 2.1). 'Agricultural area' in CAP seems to be practically the same as UAA in FSS, with the exclusion of kitchen gardens, as defined by Eurostat, and consists of three categories. There is however clearly a difference in how Eurostat and the CAP define sub-classes of UAA.

Table 2.1 Definitions of arable land, permanent grassland, permanent crops and kitchen gardens in FSS and according to CAP regulations

| | Eurostat – FSS metadata | Definition of subcategories of Agricultural Area (based on Commission Regulation (EU) No 1307/2013 and Regulation (EU) No 796/2004) |
|---|---|---|
| | **UAA** is the total area taken up by arable land, permanent grassland, permanent crops and kitchen gardens used by the holding, regardless of the type of tenure or of whether it is used as a part of common land. | **Agricultural area** is any area taken up by arable land, permanent grassland and permanent pasture, or permanent crops. |
| **Arable land** | Land worked (ploughed or tilled) regularly, generally under a system of crop rotation. | Land cultivated for crop production or areas available for crop production but lying fallow, including areas set aside in accordance with certain rural development measures. Greenhouses are considered eligible provided the land maintains the characteristics of an agricultural area. However, in specific situations, for example, cultivation of plants in pots with no |

[8] Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009.

| | Eurostat – FSS metadata | Definition of subcategories of Agricultural Area (based on Commission Regulation (EU) No 1307/2013 and Regulation (EU) No 796/2004) |
|---|---|---|
| | | interaction of the plant's roots with the soil, or greenhouses where the soil is concrete (e.g. hydroponic cultivation), the areas are considered not eligible because the soil is not contributing to the development of the crop. |
| **Permanent grassland** | Land used permanently (for several consecutive years, normally five years or more) to grow herbaceous fodder, forage or energy purpose crops, through cultivation (sown) or naturally (self-seeded), and which is not included in the crop rotation on the holding. The grassland can be used for grazing, mown for silage and hay or used for renewable energy production.<br>Grassland must have fodder interest, that is, they include vegetal species of fodder interest. Includes all harvested areas of permanent grass, regardless of the use such as:<br>Areas of permanent grassland used for renewable energy production.<br>Pastures and meadows that can normally be used for intensive grazing.<br>Rough grazings, which are permanent grazings with low yield, and normally in poor soils, in mountainous areas, normally not improved by use of fertilisers, soil mobilisation, sowing or drainage, and which are only suitable for extensive grazing.<br>Permanent grassland no longer used for production purposes and eligible for the payment of subsidies.<br>Land taken out of production for more than five years which is maintained in good agricultural and environmental conditions.<br>It excludes: Areas without fodder interest (i.e. without species that can be used for fodder) | Land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that has not been included in the crop rotation of the holding for five years or more. Other species such as shrubs and/or trees which can be grazed are considered part of the area provided that the grasses and other herbaceous forage remain predominant.<br><br>In addition, to recognise the ecological and agricultural value of some areas with extensive traditional pastoral/agricultural systems, Member States may decide to include in the category of permanent grassland any land which can be grazed and which forms part of established local practices even though grasses and other herbaceous forage are traditionally not predominant in grazing areas. Member States that decide to implement this extension of the definition of permanent grassland, which may be justified by any or a combination of the following practices:<br>(a) practices for areas for livestock grazing which are traditional in character and are commonly applied on the areas concerned;<br>(b) practices which are important for the conservation of habitats listed in Annex I of the Habitats Directive (Directive 92/43/EEC), biotopes and habitats covered by Regulation 639/2014. |
| **Permanent crops** | Land with ligneous crops, meaning trees or shrubs, not grown in rotation, but occupying the soil and yielding harvests for several (usually more than | Non-rotational crops other than permanent grassland and permanent pasture that occupy the land for five years or more and yield repeated harvests, including nurseries and short rotation coppice. |

| | Eurostat – FSS metadata | Definition of subcategories of Agricultural Area (based on Commission Regulation (EU) No 1307/2013 and Regulation (EU) No 796/2004) |
|---|---|---|
| | five) consecutive years. Permanent crops mainly consist of fruit and berry trees, bushes, vines and olive trees. | |
| **Kitchen gardens** | Areas of an agricultural holding devoted to the cultivation of agricultural products not intended for selling but for consumption by the farm holder and his household. | - |

Therefore, the UAA (excluding kitchen gardens) registered in Eurostat statistics is defined differently, and the area registered also differs, from the agricultural area eligible for CAP payments. Registration of the CAP eligible area is through a separate process, the Integrated Administration and Control System (IACS) and its geographic information system (GIS) layer, the Land Parcel Identification System (LPIS). This has to be set up by all Member States to manage the implementation of the CAP and is operationalised by the paying agencies of each Member State. IACS ensures that CAP payments are made correctly. LPIS identifies and quantifies agriculture land for the purpose of allocating CAP payments. Data are gathered each year through individual application forms filled out by every farmer claiming CAP payments. In IACS-LPIS the agricultural area definition applied is the same as that used in Eurostat and Farm Accountancy Data Network (FADN) sources (see Annex I). However, the representation of farms is again different. Figure 2.2, based on a fiche from the EC-DG-Agri[9] (2018), illustrates this. It shows that the eligible area at any time is smaller than the total UAA registered in Eurostat FSS statistics.

Figure 2.2 shows the differences between the determined area (eligible area on which CAP claims have been made), the PEA (potentially eligible area) and the UAA. The differences can be explained by two factors:

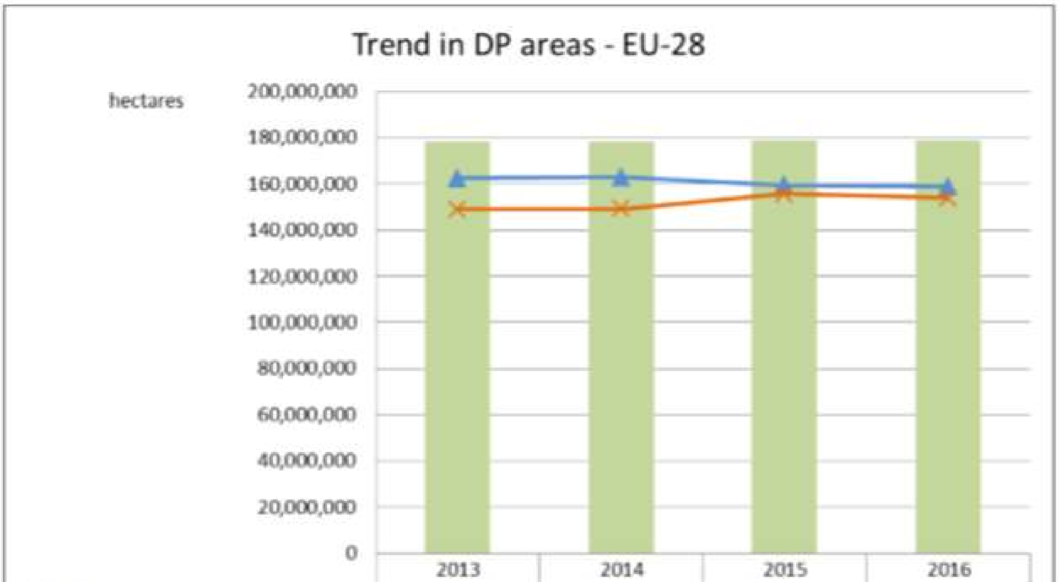
- There are farmers below the minimum requirements for being granted direct payments, or not fulfilling the eligibility conditions for being allocated payment entitlements in Basic Payment Scheme Member States (some fruit and vegetable or wine producers in certain Member States),
- There are farmers that do not apply for direct payments for several reasons (who are included in the determined area, but not in the PEA).

The Member States with the largest differences between UAA and determined area in 2016 were Croatia, Romania, Malta, Greece, Bulgaria, Portugal and Italy. The agricultural sectors in these countries are characterised by a large number of very small (and often marginal) farms. The UAA is usually higher than PEA and determined area. However, it is sometimes lower because of differences in the definition of eligible area for direct payments and UAA. One

[9] https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/direct-payments_en.pdf

reason is because common land is not always included in the UAA, particularly in UAA data from before 2010.

Figure 2.2 Relation between UAA and eligible area for CAP- Pillar I payments




| | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|
| Utilised Agricultural Area (UAA) | 178,301,160 | 178,115,230 | 178,543,810 | 178,566,050 |
| Potentially Eligible Area (PEA) | 162,424,144 | 162,904,433 | 159,479,951 | 158,677,227 |
| Determined area | 148,944,600 | 149,019,684 | 155,688,699 | 153,936,545 |

UAA: Utilised Agricultural Area.

PEA: Potentially Eligible Area. It corresponds to the total area declared by beneficiaries and potentially eligible for payment.

Determined area corresponds to the total area declared by beneficiaries and for which all eligibility conditions are met. It takes into consideration the result of administrative and on-the-spot checks and for the Basic Payment Scheme the number of payment entitlements.

Source: UAA – ESTAT and DG AGRI. PEA and Determined area – CATS.

*Definition of permanent grassland*

Another factor that may have increased the differences between UAA (in FSS) and PEA and determined area registration in IACS-LPIS is the definition of 'permanent grassland', which changed in 2013 when Regulation (EU) No 1307/2013 on CAP direct payments came into force. Under the previous regulation, the definition of permanent pasture was: 'land used to grow grasses or other herbaceous forage naturally (self-seeded) or through cultivation (sown) and that is not included in the crop rotation of the holding for five years or longer' (Commission Regulation EU No 796/2004). This definition was much debated during the CAP reform process in 2013. The broader definition gives Member States the option to extend the definition of permanent grassland eligible for CAP support to areas that are used for grazing as part of established local practices (Table 2.1). According to the EC (2016), nine countries chose to extend the definition (Table 2.2).

Table 2.2 clearly shows that the countries that have chosen to extend their permanent grassland since 2013 coincide with those where a lot of grazing takes place on lands where herbaceous vegetation is mixed with woodier and shrub vegetation. These land use classes include agroforestry areas, for example the *dehesa* and *montado* in Spain and Portugal, the *garrigue* and *maquis* in France, and other southern and Central and Eastern Europe (CEE) countries. However, FSS data for permanent grassland do not show an increasing trend from 2013 to 2016 in most countries that adopted 'established local practices' (see Annex II, Table 8.2). This leaves it unclear whether the permanent grassland registration change also led to a change in the registration of permanent grassland in FSS statistics. There are, however, other factors that influence registration changes in FSS.

Table 2.2 Choice for including permanent grasslands in the UAA based on 'established local practices' since the 2013 CAP reform

| **Member States having extended the definition of PG in case of established local practices** a) (traditional practices) and/or b) (conservation of habitats) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| DE | EL | ES | FR | IT | CY | PT | SE | UK |
| a+b | a | a+b | a | a | a | a | a+b | a |

Source: EC (2016). Fiche Eligibility for Direct Payments of the Common Agricultural Policy[10].

*Tree cover allowed in agricultural land eligible for CAP payments*

EC Delegated Act 640/2014 specifies that arable land is only eligible for CAP payments up to a maximum allowed tree cover of 100 trees per hectare. This limit also applies for permanent grassland unless the land is declared 'established local practices', as explained above. For permanent crops there is no minimum or maximum tree density specified in the Delegated Act. In addition to the 100 trees/ha, the Delegated Act also prescribes a maximum of 10% coverage for grouped trees per parcel. These are the rules regarding the definition of farmland eligible for CAP payments. They are again different from the rules regarding maximum tree cover to distinguish farmland from forest land in statistics.

CAP data registered in the LPIS is therefore not consistent with the area recorded as UAA, particularly in more marginal farm regions. Data on eligible FA will not necessarily reveal actual changes in management, including land that has become abandoned. In addition, changes in CAP definitions can be an important driver of land abandonment, through the potential effect on the viability of farm holdings if CAP direct payments are withdrawn (see Chapter 3 on drivers of farmland abandonment).

### 2.2.2 UAA definition and registration in FSS differs per country and over time

The UAA definition and registration in FSS may differ between countries and over time because of three main factors:

[10] https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/key_policies/documents/direct-payments-eligibility-conditions_en.pdf

- The difference in the way that common land is included as part of the UAA.
- Differences in how forest and agricultural lands are defined in terms of tree cover density.
- Recent increases in farmland registrations in several CEE countries. Recent EU accession countries required time to properly register farmland according to official definitions, and it takes time to bring farmland back into agricultural use, particularly as the land of former collective farms needs to be redistributed to previous and new owners.

*Common land*

In 2010 some adjustments were made to the way common land should be recorded in FSS (see Table 8.1 and Table 8.2 in Annex I) as additional countries started registering it as part of the UAA, for example, Hungary, Croatia, Slovenia, Bulgaria, France, Greece, Croatia and the UK. Table 2.3 shows that this can result in quite significant areas being added to the UAA, mainly permanent grassland areas, such as in Bulgaria, Greece, Croatia, Austria, Romania, Ireland and the UK.

Table 2.3 Common land (km$^2$) recorded in FSS before 2010 and after 2010 according to new common land registration rules introduced in 2010 (see also Annex I, Table 8.2)

| Country | 2000 | 2003 | 2005 | 2007 | 2010 | 2013 | % UAA 2010 | % UAA 2013 |
|---|---|---|---|---|---|---|---|---|
| Bulgaria | | - | - | - | 858 | 856 | 19 | 18 |
| Germany | : | : | : | : | : | : | : | : |
| Ireland | - | - | - | 421e | 422 | 423 | 8 | 9 |
| Greece | - | - | - | - | 1 699 | 1 475 | 33 | 30 |
| Spain | 2 554 | 2 367 | 2 353 | 2 246 | 1 727 | 1 605 | 7 | 7 |
| France | - | - | - | - | 749 | 675 | 3 | 2 |
| Croatia | | | | - | 160 | 439 | 12 | 28 |
| Italy | 653e | 656e | 635e | 637e | 610 | 285 | 5 | 2 |
| Cyprus | | 1e | 0.4e | 0.3e | 0.8 | 0.3 | 1 | 0.5 |
| Hungary | - | - | - | - | 73 | 67 | 2 | 1 |
| Austria | 414e | : | 371e | 240 | 253 | 202 | 9 | 7 |
| Portugal | 70e | 124e | 148e | 162e | 128 | 102 | 3 | 3 |
| Romania (1) | | 2 485e | 1 940e | 1 735e | 1 498 | 1 515 | 11 | 12 |
| Slovenia | 22 786 e | 22 786 e | 22 786 e | 9 062 e | 8 221 | 8 733 | 2 | 2 |
| United Kingdom | 1 199e | 1 207e | 1 207e | 1 209e | 1 195 | 1 195 | 7 | 7 |
| **Note: Table presents the part of the common land data which can be identified in the dataset or is reported in the National Methodology Reports (NMRs)**. | | | | | | | | |
| Special values: - | Common land data were not collected in the FSS. | | | | | | | |
| **:** | Common land data were collected in the FSS but exact figure is unknown. | | | | | | | |
| **e** | National estimate of common land | | | | | | | |
| **(1) Only the permanent grassland is considered common land.** | | | | | | | | |

The inclusion of common land and change in the definition of permanent grasslands has meant that the area that falls within the UAA (as registered in FSS) has suddenly increased in many EU countries, but has also led to more inconsistencies between countries in relation to what can be defined over time as AA and UAA.

Comparison of the 2000 national estimates and the 2016 registrations in FSS of common land area in Table 2.3 shows that large declines took place, particularly in Spain, Italy, Austria and Slovenia. This indicates a shift of part of the common land from agricultural to forest due to vegetation development in situations where management is absent (for example, grazing).

One important conclusion is that apparent changes in permanent pasture area need to be treated with great caution, and changes in UAA data overall either side of 2010 are not very accurate for this reason alone. However, data since 2010 might be more reliable.

*Maximum tree cover in agricultural land*

The difference between land that can be defined in statistics as agricultural and forest land is determined by the tree cover allowed in each land use class. The general rule for forest land definition used by FAO-UNECE (and followed by Forest Europe, Eurostat and the EEA) is: 'land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds in situ'. However, there is also an in-between category which is 'other wooded land', defined as 'land not defined as "forest", spanning more than 0.5 ha, with trees higher than 5 m and canopy cover of between 5% and 10%, or trees able to reach these thresholds, or with a combined cover of shrubs, bushes and trees above 10%'. This category of land can (partly) overlap with agricultural land, often agroforestry (Mosquera-Losada et al., 2016), up until the minimum tree density for forestry is reached. This density can vary per country (Table 2.3). As there is no land use class for agroforestry registered in the FSS database, areas with a tree cover below the minimum for forests are sometimes registered as agricultural and sometimes not, and this is inconsistent across Member States.

Table 2.4 Minimum values for area size, tree crown cover and tree height per Member State for the definition of forest

| Country | Area (ha) | Tree crown cover (%) | Tree height (m) | Country | Area (ha) | Tree crown cover (%) | Tree height (m) |
|---|---|---|---|---|---|---|---|
| Belgium | 0.5 | 20 | 5 | Luxembourg | 0.5 | 10 | 5 |
| Bulgaria | 0.1 | 10 | 5 | Hungary | 0.5 | 30 | 5 |
| Czech rep | 0.05 | 30 | 2 | Malta | | | |
| Denmark | 0.5 | 10 | 5 | Netherlands | 0.5 | 20 | 5 |
| Germany | 0.1 | 10 | 5 | Austria | 0.05 | 30 | 2 |
| Estonia | 0.5 | 30 | 2 | Poland | 0.1 | 10 | 2 |
| Ireland | 0.1 | 20 | 5 | Portugal | 1 | 10 | 5 |
| Greece | 0.3 | 25 | 2 | Romania | 0.25 | 10 | 5 |
| Spain | 1.0 | 20 | 3 | Slovenia | 0.25 | 30 | 2 |
| France | 0.5 | 10 | 5 | Slovakia | 0.3 | 20 | 5 |
| Italy | 0.5 | 10 | 5 | Finland | 0.5 | 10 | 5 |
| Cyprus | | | | Sweden | 0.5 | 10 | 5 |
| Latvia | 0.1 | 20 | 5 | UK | 0.1 | 20 | 2 |
| Lithuania | 0.1 | 30 | 5 | | | | |

Source: Annex 5 of Decision 529/2013/EU, in AGFORWARD deliverable 8.23 (Mosquera-Losada et al., 2016).

National definitions of forest land range in area size between a minimum of 0.05-1 ha in combination with a minimum tree crown cover range of between 10% to 30%, and a minimum tree height range between 2 m and 5 m (Table 2.4). There is therefore large variation in how countries divide land between agricultural, other wooded and forest classes, which also leads to differences in registrations of UAA and AA in statistical data sources, including FSS.

#### 2.2.3 Definitions of UAA in other EU and international data sources

As well as the FSS and IACS-LPIS, there are other international data sources that register AA and/or UAA. One other EU data source is the FADN. The UAA for which data is collected in FADN is based on the same definition as applied in FSS. One issue with this data source relates to the representation of farms (see below).

Other statistical data sources which collect farm data are from the **FAO and OECD**. These sources provide data aggregated at country level. FAOSTAT and OECD use the same definition of agricultural land, namely: ‘Land used for cultivation of crops and animal husbandry. The total of areas under ''Cropland” and “Permanent meadows and pastures”’. Like the UAA definition in CAP, it therefore covers cropland and permanent grassland. The FAO definition for permanent grassland is also broad enough to cover those grasslands that are declared ‘established local practices’: ‘Land used permanently (five years or more) to grow herbaceous forage crops through cultivation or naturally (wild prairie or grazing land). Permanent meadows and pastures on which trees and shrubs are grown should be recorded under this heading only if the growing of forage crops is the most important use of the area. Measures may be taken to keep or increase productivity of the land (i.e., use of fertilisers, mowing or systematic grazing by domestic animals.) This class includes: grazing in wooded areas (agroforestry areas, for example), grazing in shrubby zones (heath, maquis, garigue), grassland in the plain or low mountain areas used for grazing: land crossed during transhumance where the animals spend a part of the year (approximately 100 days) without returning to the holding in the evening: mountain and subalpine meadows and similar; and steppes and dry meadows used for pasture’.

FAO and OECD therefore define agricultural land categories in relatively similar ways as for the UAA in FSS and FADN. However, it is less clear where unused agricultural land is recorded and whether it is included under the agricultural land definition. Since data to FAO and OECD are the responsibility of individual Member States it is likely that they are based on similar national data sources as used for reporting data to Eurostat for the FSS.

## 2.3 Overview of EU-wide data sources used in this study to determine actual UAA

### *2.3.1* Statistical data

The three EU-wide statistical sources collecting information on UAA and AA are the FSS, FADN, and IACS-LPIS. All contain data collected through surveys, and complete population data collection approaches through surveys with farmers. All in principle collect information using practically the same land use classification (Figure 2.1), but following different definitions for the three sub-categories of UAA (Table 2.1). They cover the AA and UAA, but not all cover the total FA (see Annex I for technical details on these data sources).

Eurostat FSS is carried out by all Member States. It is conducted consistently throughout the EU with a common methodology on a regular basis and therefore provides relatively comparable and representative statistics across countries, at regional levels. Complete consistency between countries and over time is not to be expected for the reasons outlined previously. The minimum farm size threshold to register farm data in FSS also creates some small differences per country (see Annex I), but overall much lower than the minimal size threshold for farm data registered in the FADN.

The UAA for which data are collected in FADN is based on the same definition as applied in FSS but there is a much lower representation of small farms in the FADN sample, because farms have to be above an *economic size* threshold (see Annex I, Table 8.2). In FSS, the survey only excludes the smallest agricultural holdings which together contribute 2% or less to the total UAA (excluding common land), and 2% or less to the total number of farm livestock units. For FADN, the minimum threshold for farm inclusion ranges widely between EU countries, with a minimum of €4000 in economic size in 10 countries to €25,000 in five counties (Annex I, Table 8.2). This means that FADN, much more than FSS, excludes parts of the UAA where small farms predominate. From the perspective of land abandonment this is even more of a limitation as the drivers of farmland abandonment are most prominent in remote and economically marginal rural areas, and in these areas there are a relatively greater number of farms of limited economic size and part-time farmers, particularly in the CEE and Mediterranean countries. This leads to a significant under-representation of farms and related UAA in areas with high risk of land abandonment. FADN is therefore not considered a suitable source for undertaking analysis of developments in UAA in the different Member States.

IACS (see Annex I) registers agricultural land use at the level of agricultural parcels. CAP payments can only be linked to agricultural land which is 'eligible' and for which payments are also claimed by the farmer (the determined area, see Figure 2.2). This means that the UAA recorded under IACS-LPIS is mostly smaller than that under the FSS. IACS-LPIS is therefore not considered the most suitable source for analysing developments in UAA in the different Member States.

Statistical data sources from the FAO and OECD also collect land use information, and provide data aggregated at the country level. The definitions of agricultural land by FAOSTAT and OECD follow a relatively similar definition for UAA as the European statistical sources of FSS and FADN. As mentioned, it is likely that data to FAO and OECD are based on similar national data sources used for reporting data to Eurostat for the FSS.

There are therefore several reasons why statistical data that Member States provide on agricultural land must be carefully interpreted in relation to UAA and abandoned agricultural land. In spite of the changes in definition of the various components of UAA over time and the variations permitted to Member States for recording certain agricultural land categories, the

FSS database is the best relatively uniform source of information to determine the FA, AA and the UAA for EU countries and regions. We therefore use Eurostat FSS as the main data source. However, for data on AA and UAA before 1990 we also use FAOSTAT data since Eurostat data do not always cover all EU countries, particularly for periods before they joined the EU.

### *2.3.2 Spatial data*

Another important set of data providing information on the location and extent of agricultural land are spatial data sources which have been collected using aerial photographs and remote sensors, sometimes combined with field-based surveys. Annex I, Table 8.4 gives an overview of the most relevant spatial sources which provide data on agricultural land in the EU, both currently and historically.

**Box 2.1 Change in agricultural area based on statistics and on spatial data sources**

The difference in AA changes derived from statistics and from spatial data sources is illustrated by the following. According to satellite information, on which Corine Land Cover (CLC) data are based, the area covered by agricultural land decreased by 1.2% across the EU between 2000 and 2018. The most significant losses were observed in Poland and the UK, as well as in parts of Spain and Germany. However, in Romania and Bulgaria, as well as in certain regions of Spain, Italy, Austria, France, Ireland and Sweden, agricultural land cover increased. However, this overall 1.2% decline of agricultural land is not consistent with what was detected through FSS data, which showed a much larger decline in UAA over the EU and in most Member States. This difference is related to the fact that CLC is based on satellite imagery that is interpreted to land cover classes (see last column of Table 4 in Annex I). However, CLC is a very useful source to detect changes in land use to obtain information on where loss of agricultural lands takes place and to what it is converted (Annex III).

Differences between what is registered as AA or UAA occur between statistical and spatial data due to the different approaches to detecting it. To detect declines in UAA and to identify where agricultural land becomes abandoned both types of data sources are needed (see Box 2.1). Statistical data sources can only provide an indication of how agricultural land is changing at the administrative scale (national or regional level) at which they are collected or available. Spatial data provide information on land use changes at a higher spatial resolution and can also help detect what land use agricultural land changes to. Based on these land use flows (see Section 2.4 and Annex III), it can then be established whether agricultural land becomes urbanised, afforested, industrialised, used for recreation or transport, or a more undefined class – areas that are more likely to represent abandoned land.

To establish the current extent of UAA and how it changes over time, it is recommended to compare data from different data sources and to interpret the data taking into account the known limitations of the sources. By combining different sources and interpreting them for each Member State, it is possible to come to the best estimate of actual UAA and historic changes that the data allow.

## 2.4 Results: actual UAA

### *2.4.1 Approach to detecting actual UAA*

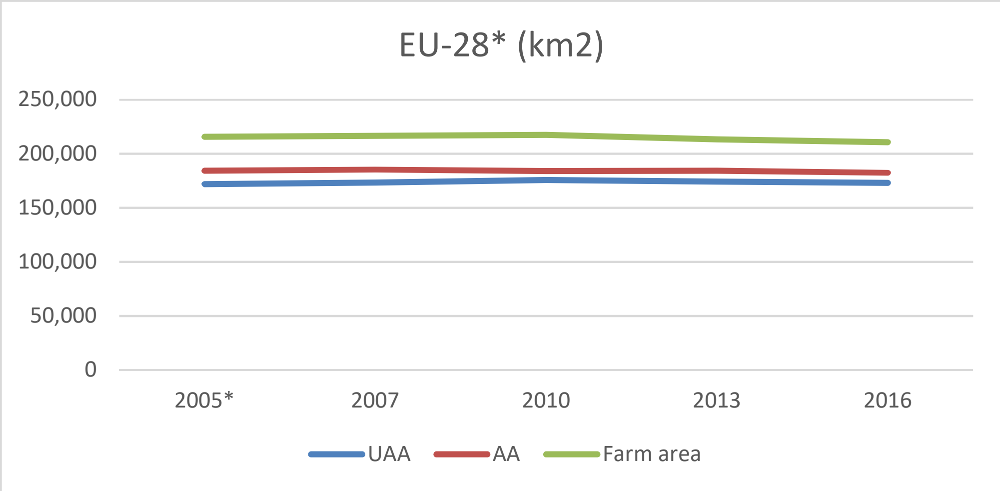
The FSS database records FA, AA, UAA and the total, and the AA and UAA registered in FSS are also the most uniform in the EU and consistent with the definitions in the CAP regulations. However, looking at historical data from FSS for the long-term analysis, the definitions of UAA and AA have changed several times, for reasons already discussed. In addition, over time there have been some CAP instruments and other trends such as the set-aside policy or afforestation of agricultural lands, which also influenced the uniform interpretation of changes in the UAA. However, these definition changes mostly relate to what is included in FA, AA and UAA, unless it involves afforestation without CAP Pillar II payments. Usually if certain categories are excluded from one of the three, for example, UAA, they reappear in another, for example, in AA or FA. When assessing the trend in agricultural land use, it is therefore recommended to look at the UAA, the AA and the FA. If the same land decline trend is seen in all three categories, this as strong evidence that the land is abandoned or converted to other land categories outside the agricultural domain.

The use of spatial data to detect the UAA is not recommended because, while all the spatial databases reviewed do detect agricultural land categories, they do not follow the CAP definitions for AA and UAA to classify what is registered. Spatial data sources are however very suitable for detecting land use changes over time, and will therefore be used to explain to what land uses agricultural lands shifted to and whether these indicate land abandonment.

### *2.4.2 Actual UAA*

To determine what can be identified as actual UAA we first selected and analysed data from the Eurostat FSS database for the last 10 years (2005-2016) for each EU Member State and then the total for all Member States.

Figure 2.3 UAA, AA and FA 2005-2016 for EU-28




Source: Eurostat, FSS data.
Note: *2005 excludes Croatia.

Figure 2.3 and Table 2.5 show the total EU-28 data. Between 2005 and 2016 the actual UAA remained relatively stable with an average level of 173,720 km$^2$, with its highest peak in 2010 at 175,815 km$^2$. FA and AA showed a slight decline in this same period.

Table 2.5 AA, UAA and FA and subcategories (km$^2$) 2005-2016 for EU-28

| | 2005* | 2007 | 2010 | 2013 | 2016 | % change since 2005 |
|---|---|---|---|---|---|---|
| FA | 215,746 | 216,472 | 217,391 | 213,446 | 210,741 | -2 |
| AA | 184,479 | 185,403 | 183,960 | 184,290 | 182,422 | -1 |
| UAA | 171,996 | 173,376 | 175,815 | 174,358 | 173,052 | 1 |
| *Arable land* | *104,717* | *105,072* | *103,923* | *104,203* | *103,142* | *-2* |
| *Permanent grassland* | *55,984* | *56,897* | *60,840* | *59,566* | *59,194* | *6* |
| *Permanent crops* | *10,872* | *11,015* | *10,703* | *10,303* | *10,505* | *-3* |
| *Kitchen gardens* | *426* | *393* | *350* | *286* | *247* | *-42* |

Source: Eurostat, FSS data.

In the EU-28 overall, over this 10-year period arable land and permanent cropland declined, while the permanent grassland area increased, at least until 2010 which was why the UAA peaked in 2010. Kitchen gardens declined the most, but their area is small and therefore has little influence on the total UAA.

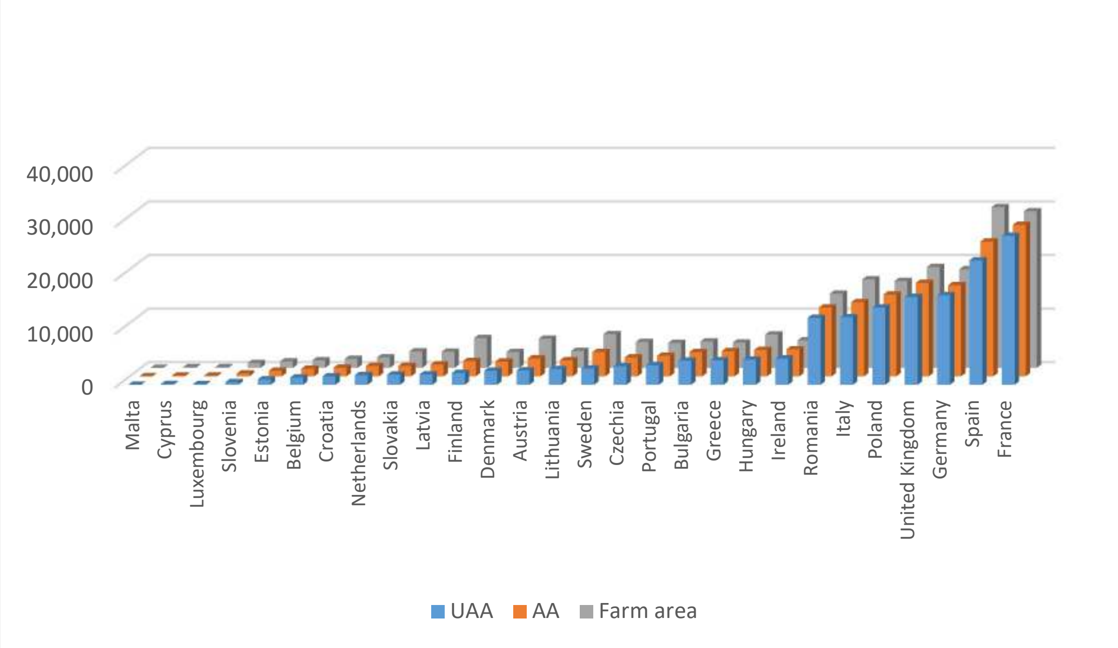
The UAA covers between 80% and 82% of the FA, and between 85% and 87% of the AA over this 10-year period. The difference between the UAA and the AA implies that around 5% of farmland is in the unused agricultural land category which is registered as part of AA and not

UAA. The difference of around 15% between the AA and the FA is mostly made up of wooded areas (with SRC), and other land, which is occupied by buildings, farmyards, tracks, ponds.

The EU-28 totals tell us little about whether the actual UAA was relatively stable on the ground in the last 10 years as changes level out across 28 countries. To understand recent developments in UAA we need to look at the national and regional levels of UAA (Figure 2.4 and Figure 2.5 and Annex II).

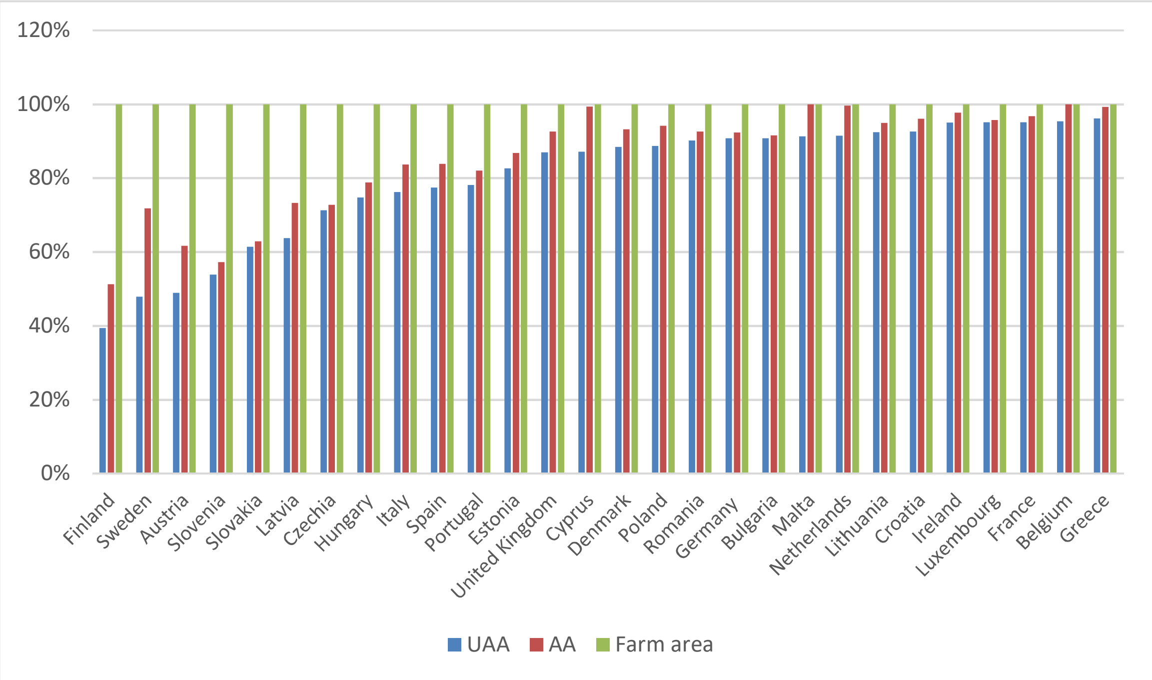
France has the largest UAA, but the largest FA is registered in Spain. Figure 2.4 and Figure 2.5 show large differences within countries between FA, AA and UAA. The largest differences occur in countries such as Finland, Sweden, Austria, Slovenia, Slovakia where farming activities are often combined with forestry.

Figure 2.4 UAA, AA and FA 2005-2016 for EU-28 Member States (km²)




Source: FSS data.

Figure 2.5 Relative difference between UAA, AA and FA 2016 (FA=100%)

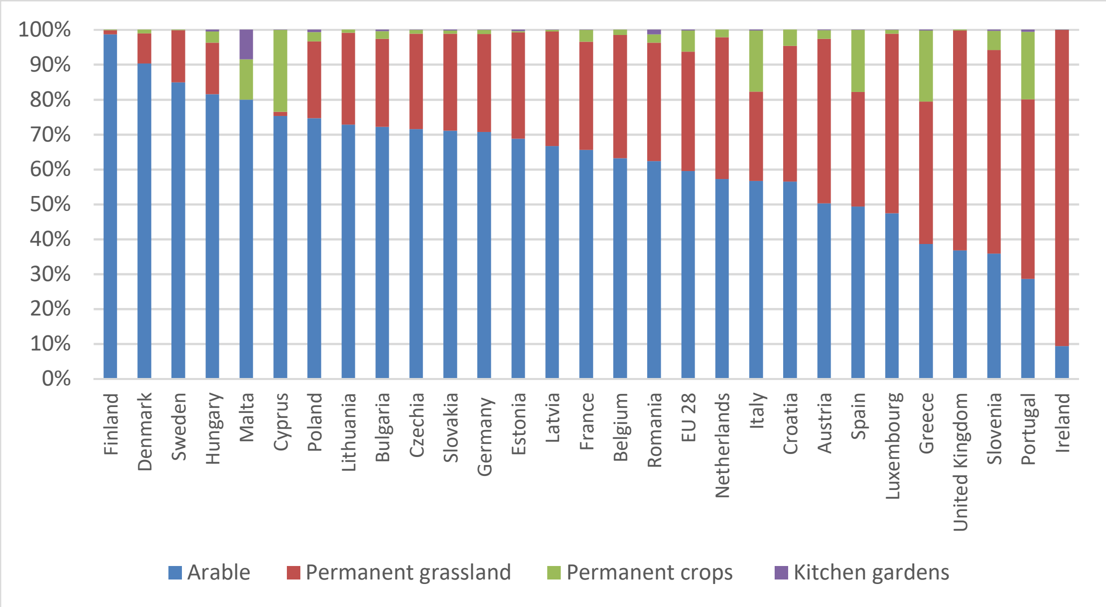



Source: Eurostat, FSS data.

The stability of the UAA in the last 10 years is very different between EU countries (see Annex II, Table 9.1). The countries with the most stable UAA are France, Portugal, Luxembourg, Slovenia and Slovakia. The largest declines are seen in Cyprus, Austria, Netherlands and Romania. The largest increases are found in Bulgaria, Estonia, Ireland, Croatia and Greece. The increases in Bulgaria, Croatia and Estonia are most extreme and likely related to their recent accession to the EU, which required time to properly register farmland as UAA according to Eurostat definitions and also to redistribute the lands of former collective farms to previous and new owners.

Generally, the trends in increases and declines seen for UAA also apply to AA and FA (see Figure 2.4 and Annex II, Table 9.1). However, in countries where there is a clear decline in UAA the decline in FA is usually relatively larger. In the countries with an increase in UAA the increase in FA is usually relatively lower, such as in Croatia and Bulgaria, indicating towards a shift from FA towards UAA which is likely to be partly explained by the taking up of arable activities on lands which were before part of collective farms.

Figure 2.6 Relative distribution of the UAA over arable, permanent grassland, permanent crops and kitchen garden per EU Member State in 2016




Source: FSS data.

The composition of the UAA in the different countries is also very diverse (Figure 2.6). Arable land dominates in most EU countries, particularly in many northern and Central European countries (for example, Finland, Sweden, Denmark, Lithuania, Estonia, Germany). The countries where permanent grassland dominates are limited to Ireland, the UK, Slovenia, Portugal and Luxembourg. In southern European countries, the share of permanent crops is much more significant.

Data in Table 9.4 in Annex II provide a better understanding of where the largest recent changes in UAA took place. The largest declines in UAA (more than 10%) occurred in Cyprus (-26%) and Austria (-18%). Romania, Spain, Netherlands, Sweden, Belgium, Czechia, Denmark, Germany, Italy, Poland, Portugal and Finland showed more modest declines in UAA. The largest increases in UAA (more than 10%) are seen in Bulgaria (64%), Estonia (20%), Ireland

(16%), Greece (14%), Croatia (60%) and Latvia (13%). Smaller increases are seen in France, Lithuania, Luxembourg, Slovenia, Slovakia, the UK, Hungary, and Malta.

Countries with declining arable and permanent cropland areas are more common than countries with declines in permanent grassland areas. The highest relative increases in permanent grassland area are seen in Bulgaria, Croatia, Greece and Cyprus. In the latter two countries this was combined with a strong decline in arable and permanent cropland, while in the first two it is in line with the overall increase in UAA, AA and FA. This increase in likely to be related to the registration of common land in FSS since 2010 in Bulgaria, Greece, Croatia, Austria, Romania and the UK (see Table 9.3 in Annex II). This common land is almost always permanent grassland and therefore this new registration will also have increased the permanent grassland area since 2010 and thus the total UAA in these countries, particularly where the common land area makes up a significant share of the UAA.

### *2.4.3 Evidence of changes in UAA in national data compared to FSS*

In the former changes in UAA have been presented based on Eurostat-FSS data. In Annex IV data are also presented from national statistical sources. The reason is to evaluate to what extent these national sources use similar definitions for UAA and other sub-categories of agricultural land and how their reported totals relate to the FSS totals.

A comparison at national level (Table 11.1 in Annex IV) reveals that the differences in UAA area published by Eurostat and national data sources are very small. However, there are exceptions for certain countries and for specific years. The biggest differences between Eurostat and national levels are seen in Bulgaria, France and UK. It is likely that these differences are particularly related to how sub-categories of UAA, such as arable, permanent grassland and permanent crop land are defined.

Differences in totals of arable land are generally smaller than for the permanent crops and permanent grassland categories. This is for instance well illustrated by the comparison of FSS data with national data from the Spanish Ministry of Agriculture (MAPA) and the Spanish LPIS data (SIGPAC) (see Annex IV 'Spain'). The large differences in area coverage for all sub-categories as arable land, permanent crops and permanent grassland between FSS and national sources is related to two factors. The first relates to differences in tree cover determining the difference between agricultural and forest area. For example, to the definition change of permanent grassland in the CAP allowing for inclusion of areas with shrubs and trees in permanent grassland surface eligible for CAP payments lead to an important increase in grasslands with tree and shrub cover registered in SIGPAC (Spanish LPIS) as permanent grassland. In FSS and partly in MAPA they fall out of the agricultural land boundary and are categorized forest land. The second reason is related to the unclear definition of agroforestry land. In Spain large areas are covered with these dual systems in which trees are combined with arable, permanent crops and/or grasslands for grazing. FSS does not register this class separately, nor has a definition for it. Countries have all different approaches to including this type of land use systems in different sub-categories of UAA.

In the comparison between FSS data and national data in Hungary and Croatia we observe that differences in what is registered as UAA as for sub-categories are large, but seem to diminish in time. This is related to the gradual adaptation of their national statistical registration to the Eurostat definitions. However, another factor is registration of UAA in national statistics and in the national LPIS systems. In LPIS this is lower because of differences in definitions and parcels not being registered in LPIS due to ownership issues.

From the comparison we conclude that using the data from FSS for actual UAA analysis is better and more consistent between EU countries than when basing it on national statistical sources. At the same time, we suspect that also in the reporting by national statistical offices to Eurostat FSS inconsistencies occur particularly in relation to minimum and maximum tree cover rules and in relation to categories of agroforestry areas.

Further, uniformity in tree cover levels between EU Member States determining the difference between forests and agricultural areas is recommended. With this improvement, it would also be strongly recommended to define more clearly agroforestry areas and develop clear agreement on how to register them in FSS. This could either be as a separate category of agricultural land or as part of the different sub-categories, but clear rules need to be established for which type of agroforestry area is registered under which subcategory of UAA (arable, permanent crops or permanent grasslands).

#### *2.4.4 Results from agricultural land use flows based on Corine Land Cover*

Annex III provides a regional analysis on land cover flows, derived from analysis of CLC data of 2000 to 2018. It aims to provide a better understanding at regional level of agricultural land use decline and the type of land use/cover flows this involves.

The results show that the signs of abandonment between 2000 and 2018 in agricultural land are evident throughout the EU. Only ‘shift to agricultural land abandonment’ (Figure 10.1, Annex III) is considered ‘real’ agricultural land abandonment here. This conversion took place on about 6% of the EU-28 agricultural land surface in 2000. Half of these conversions went together with forest formation and indicate to longer term abandonment. It was also noted that the large majority of these conversions to abandonment (80%) are outside Natura 2000 areas. The largest total conversions of agricultural land to abandonment between 2000 and 2018 were seen in Spain, Finland, Estonia, Latvia, Portugal, Austria, Ireland, UK and Romania.

Conversion of agricultural land to urban land covered around 2% of the EU-28 agricultural land surface in 2000 and make up a small part of the agricultural land use conversions. In spite of this, they can be relatively large in certain areas, particularly around big cities and in coastal regions.

Largest conversions of the average 4.5% of EU-28 agricultural land surface in 2000 took place within agricultural land and involved shifts from arable to fallow, permanent grassland and set-aside. This can be interpreted as extensification and may sometimes point towards a process of hidden abandonment. Largest conversions within agricultural lands towards more extensive land uses, such as set-aside, pasture and fallow, were seen in Germany, Estonia, Ireland, Lithuania, Luxembourg, Latvia, Portugal, Romania and UK.

## 2.5 Results: changes in UAA since 1975

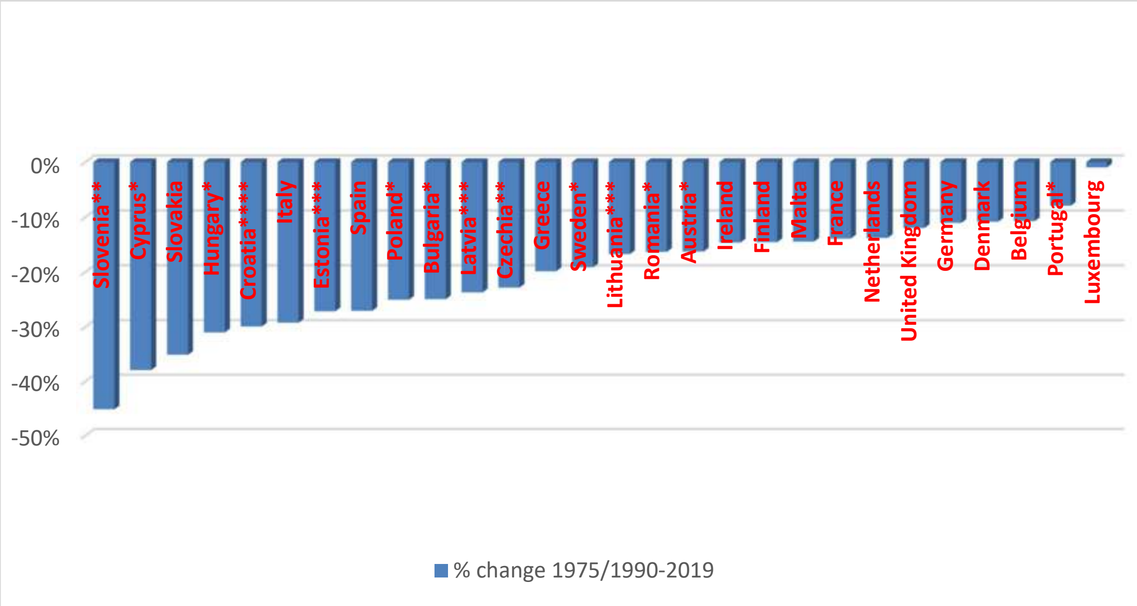
### *2.5.1 National overview*

Data to quantify actual UAA, AA and FA are available from FSS and also from most national statistical sources. Data on UAA and AA that go back until 1975 are more difficult to find, particularly for countries that have joined the EU since 2004 or later[11]. For these countries national-level data on agricultural land as defined in FAOSTAT are mostly available. However, countries like the Baltics and those of former Yugoslavia (Croatia and Slovenia) and former Czechoslovakia only started reporting to FAOSTAT as independent countries from 1990 and much later to the EU. In Annex VI ( Section ‘Hotspot regions of declining UAA’ ) the detailed steps taken to obtain values for the UAA in 1975 for these countries are described. Important to notice that the long term UAA change (since 1975) could not be completely quantified for the three Baltic States because they were non-existent in 1975. For these countries, the data on change in UAA only apply to 1990-1975 period. In the total EU UAA area, their land share is relatively small (3% of total UAA in 2016).

The results of the analysis of changes in UAA at country level, for the three periods between 1975 and 2016, are presented in Figure 2.7 and Annex II (Table 9.5) per country. In all countries, the UAA decreased between 1975 and 2016. The largest declines are seen in Cyprus, Slovenia and Slovakia. In most CEE countries, the decline was particularly large during 1990-2005, directly after the transition from planned to market economies (Annex II, Table 9.3). In this period large state farms ceased to exist, agricultural production decreased tremendously, land was partly claimed back by pre-communist-period owners, and several areas of land were left unused because legal rights remained unclear and/or production for the market became difficult. After entry into the EU, agricultural production started to grow and more land was taken into use, as shown by the increase in UAA in most of these countries between 2005 and 2016. Despite this, the overall decline in UAA between 1975 and 2016 is significant and generally much larger for these former communist countries than for the rest of the EU (Figure 2.7).

[11] Bulgaria (2007), Croatia (2013), Cyprus (2004), Czechia (2004), Estonia (2004), Finland (1995), Hungary (2004), Latvia (2004), Lithuania (2004), Malta (2004), Poland (2004), Romania (2007), Slovakia (2004) and Slovenia (2004).

Figure 2.7 Change in UAA 1975-2019




Source: Eurostat FSS data 1975-2016. Where data missing, FAOSTAT data were used.

Notes: * Data from FAOSTAT for 1975 and from Eurostat for other years. ** Data from FAOSTAT from former Czechoslovakia for 1975. Distribution over Czechia and Slovakia according to agricultural land use share in 1990. *** Data for FAOSTAT from former Yuguslavia for 1975. Distribution over Croatia and Slovenia according to agricultural land use share in 1990 of the six countries into which it was split. **** No data available for 1975 in FAOSTAT. Change in last column calculated for the period 1990-2016 instead of 1975-2016, as for all other countries.

Within the group of non-former communist countries, some show a decline over all three periods, such as Belgium, Denmark, Finland, Sweden, Germany, Spain, Netherlands. In some of these the declines are modest, for example, Belgium, Denmark, Germany, and in others it is larger, for example, Spain. There are also countries that show a decline until 2006, but a clear increase in UAA in the last 10 years. This is especially seen in Greece, Ireland, the UK, France and Malta. In these countries, except for Malta, this was due to a clear increase in grazing land often caused by the inclusion of common land in the FSS statistics after 2010. Luxembourg has the smallest decline overall. Portugal and Austria are also exceptions in terms of the pattern of change. In 1975-1990 they showed UAA increases while most other EU countries saw declines, followed by larger declines after 1990 and particularly since 2000 for Austria.

The total decline in UAA between 1975 and 2016 for all current EU countries, except for the three Baltic states[12], amounts to almost 36,000 km$^2$. This is equivalent to 18% of the UAA area in 1975.

[12] Estonia, Lithuania and Latvia are not included because no data on UAA were available in 1975, therefore a comparison in area between 1975 and 2016 is not possible. In Table 4.1 and Figure 4.3 the relative area change is included for 1990-2016 for these countries.

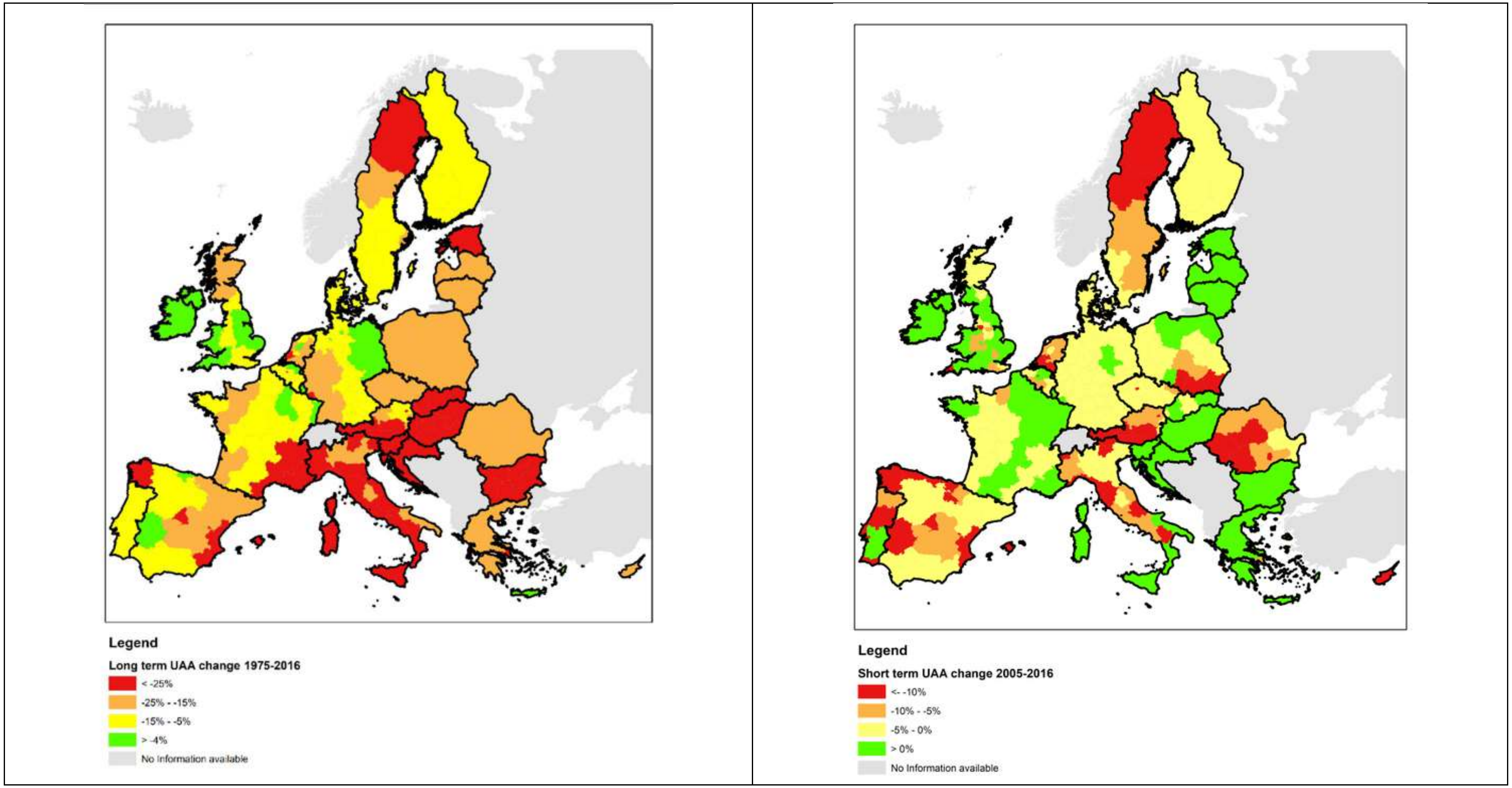
### *2.5.2 Regional overview: hotspot regions of declines in UAA*

It is also useful to understand where the largest changes in agricultural area took place at the regional level. The change in UAA was analysed over the long term (1975-2016) and short term (2005-2016) at the NUTS2 and NUTS3 regions level (Table 2.8). The regions with large declines in UAA (>25%) in the period 1975-2016 are in Spain, France, Italy, Austria, Slovenia, Croatia, Hungary, Slovakia, Bulgaria, Estonia and Sweden. The regions with large declines in 2005-2016 (>10% with reference to UAA in 2005) are located in Sweden, Portugal, Spain, Italy, Austria, Romania, Cyprus, Poland and the Netherlands.

Focusing on signs of abandonment linked to conversions to nature protection areas (within current Natura 2000 boundaries) gives a more diverse picture. Again, in the southern EU area strong signs are seen in all Spanish and Portuguese regions, in Italy most strongly in Sicily, Apulia, Basilicata, Liguria and Aosta, in Slovenia and the Mediterranean region of Croatia, and several northern Greek regions. In central and eastern EU the regions with strongest signs within Natura 2000 are found in Austria in Tirol and Lower Austria, in most of western Romania, the south-western half of Bulgaria, the Zachodniopomorskie and Podkarpackie regions in Poland, and the eastern regions of Slovakia.

The results also show that only a small part of the agricultural land declines lead to land becoming unused or abandoned, while most conversions involve urbanisation and also afforestation in some regions.

Figure 2.8 Long-term change in UAA (1975-2016) with reference to the UAA in 1975 (left) and recent change in UAA (2005-2016) with reference to the UAA in 2005 (right).




Source: Eurostat-FSS.

## 2.6 Data on unused, abandoned and degraded lands in data sources

*Statistical data*

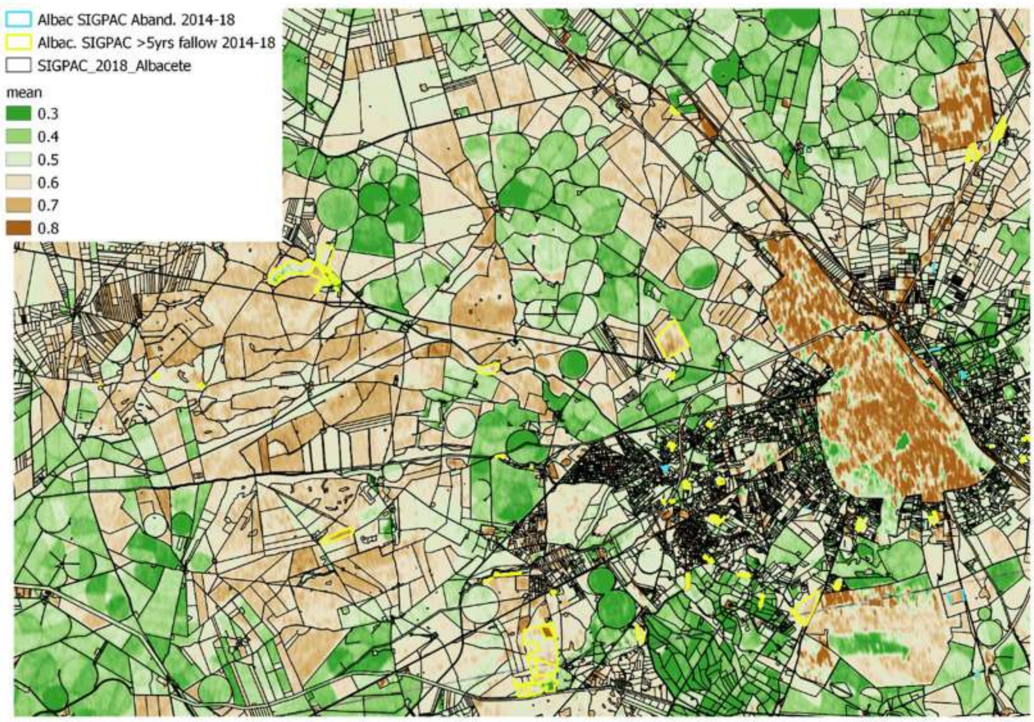
This section outlines data sources that exist that register EU unused lands. The main reason for not registering land that goes out of production and becomes abandoned or degraded is because it then also loses agricultural land status and is therefore no longer registered. Declines in FA, AA and UAA are therefore good proxy indicators for land going out of agricultural production. However, whether this land becomes unused, abandoned, degraded or has other urban or forestry uses, cannot be determined based on such an analysis. For this, spatial land use and land cover flow analysis needs to be undertaken, based on CLC data.

In FSS, for some categories of unused lands data have been collected over time. The first category, NUAA is part of the AA and not of the UAA. It is defined as 'common land which is not used'. This category can cover large areas in certain countries and is responsible for the large differences in areas that can exist between AA and UAA (Annex I, Table 8.4), which are most significant in the UK, Italy, Spain, Poland, Greece. Between 2005-2016 these NUAA have declined strongly in almost all EU countries. Some of this decline may be related to the change in the registration of these lands since 2010 as part of the UAA (see Section 2.2) or because new owners/users have brought these lands into production. Part of these lands may also have disappeared from the FSS registration completely because of a change in land use, such as to forest due to abandonment. The fate of these lands is not clear from the statistics, but the sudden drop indicates that these are not a reliable source of data on unused or abandoned lands.

As part of the UAA, land use categories are registered that are not always used, such as the categories 'fallow land subject to payment of subsidies with no economic use' or 'permanent grassland and meadow - not used for production, eligible for subsidies'. This implies that the UAA registered in FSS may include land which is actually unused or even abandoned. For several categories of land we do not know how it is managed. Based on the statistical classification into 'fallow' or 'not used for production' it is not possible to conclude whether these categories of land are indeed abandoned for a longer time, or if they refer to lands which are part of the crop rotation with a limited time out of production.

IACS-LPIS also compiles some indirect information on the management status of the land. The paying agencies have to review this since CAP payments can only be made to agricultural lands maintained in good environmental and agricultural condition. If lands go out of management for five consecutive years, they are no longer eligible for CAP payments, unless specific measures or arrangement apply. Paying agencies monitor this through comparing the registrations of land uses in LPIS across different years, but also through the use of Normalised Difference Vegetation Index (NDVI) indices derived from remote sensing data indicating the biomass development in a field. This information is normally only used by the paying agencies and not always made public. Figure 2.9 gives an example of such information.

Figure 2.9 Parcels in Albacete, Spain from SIGPAC (Spanish LPIS), showing parcels in yellow with no management for five consecutive years




The nine regional case studies also investigated whether unused, abandoned or degraded lands were registered in any official national or regional statistical data source. In Annex V (Table 12.2) an overview is presented. Fallow land is registered in most national statistical sources and refers to the fallow land that is part of the rotation. Registration of this category is logical as it also needs to be reported as a separate category to Eurostat for FSS. In a couple of case regions the share of land that could be categorized as 'unused' could be estimated by subtracting the area that was registered as ' agricultural land' and ' used agricultural land' in national statistical data sources. In Latvia and the Bulgarian Blagoevgrad region data this could be done. This explicit registration of used land is in line with what Eurostat also asks Member States to report to make a distinction between AA and UAA, but Eurostat-FSS defines this difference as 'unused common land' only, while in the 2 example case studies it refers to all agricultural land irrelevant of whether it is common land.

In the Romanian Brasov region it was reported in the case study that 'Degraded and unproductive lands' were registered by the Romanian National Institute of Statistics. The land registered only referred to land outside the UAA and was defined as 'land that permanently lost the ability of agricultural production through erosion, pollution or some other destructive action of anthropogenic origin'. It is likely that part of this land overlaps with the REDII definition of degraded land. The registration of this type of land was not seen in the other case studies. It is however an interesting category of land to be registered from the perspective of land degradation and low-ILUC.

Overall, we conclude however that unused, abandoned and degraded lands, certainly as defined in the REDII are not registered in any EU wide or national data sources.

*Spatial data sources*

The only data source that maps abandonment status of lands directly (by surveyors on the ground) is the land use and cover area frame survey (LUCAS). In the LUCAS system a category of land registered as a separate land cover class is 'fallow and abandoned land'. 'Fallow' land includes all crop land not included in the crop rotation for at least one year. 'Abandoned lands' are defined as 'all agricultural land that is set aside for a long term'. LUCAS also registers agricultural land and as the survey is repeated every three to five years, trends in agricultural land use can be detected. Annex V, Figure 12.1 and Figure 12.2 present the total agricultural area and land registered as fallow and abandoned lands from LUCAS for different survey years in absolute and relative terms. The largest shares are in Cyprus, Croatia, Greece, Malta, the UK, Italy, Ireland, Spain, Sweden. Annex V, Table 12.1 presents the top 10 regions with the largest area of unused and abandoned lands. These are mainly regions from Spain, Finland, Sweden, the UK (Scotland), Italy, Greece, France, Croatia and Latvia.

The limitation of the LUCAS data is that it is point information collected in a sample, which is then scaled-up to a total area share per region (NUTS 1,2 3 level). It therefore gives a good indication of how much land abandonment there is roughly per region, country, and land cover class, but does not map the precise location of abandoned land or the spatial extent.

## 2.7 Conclusions

Eurostat provides strict guidelines to all Member States on how they report their data to FSS and ensures that there is regular data reporting according to a consistent methodology between all EU Member States at national and regional levels and over time. However, statistical data provided by Member States on agricultural land must still be carefully interpreted in relation to UAA and abandoned agricultural land. In spite of the changes in definition of the components of UAA over time and Member States' permitted variations in recording certain agricultural land categories, the FSS database is the best relatively uniform source of data to determine the FA, AA, and the UAA for EU countries and regions. Reporting on the actual UAA therefore takes Eurostat FSS as its primary data source. For some countries, before their accession to the EU we also use FAOSTAT data since Eurostat data do not always cover all EU countries, particularly before they joined the EU.

The FSS includes data on FA, AA and UAA. FA is the largest area, including AA plus wooded area (defined as SRC) and other land (farmland occupied by buildings, farmyards, tracks and ponds). AA covers UAA plus NUAA, defined as 'common land which is not used'. The UAA consists of arable land, permanent crops, permanent grassland, and kitchen gardens. As soon as farmland becomes unutilised it is excluded from the UAA, but may remain part of the AA and/or FA.

*Short-term changes in UAA 2005-2016*

- At EU-28 level, the total UAA increased by 1%, AA decreased by -1% and FA by -2%. Within the UAA, arable land decreased by -2%, permanent grassland increased by 6%, and permanent crops decreased by -3%.

- Large declines in UAA (<= -10%) occurred in Cyprus (-26%) and Austria (-18%).
- Medium declines in UAA (< -10% to-5%) occurred in Romania, Spain, the Netherlands and Sweden.
- Small declines in UAA (-5% to 0%) occurred in Belgium, Czechia, Denmark, Germany, Italy, Poland, Portugal and Finland.
- Small increases in UAA (0-5%) occurred in France, Lithuania, Luxembourg, Slovenia, Slovakia and the UK.
- Medium increases in UAA (>5%-10%) occurred in Hungary and Malta.
- Large increases in UAA (>10%) occurred in Bulgaria (64%), Estonia (20%), Ireland (16%), Greece (14%), Croatia (60%) and Latvia (13%).
- At the regional level the largest declines (<-10%) were seen in northern Sweden, central Portugal, north-west and central Spain, most of Italy except for the deep south, Sicily and Sardinia, eastern and southern Austria, south-west Romania, Cyprus, south-east Poland and the southern Netherlands.
- Reasons for increases in UAA in most CEE countries relate to the period after entry into the EU, when agricultural production started to grow and more land was taken into use.

*Long-term changes in UAA 1975-2016*

- The total decline in UAA between 1975 and 2016 for all current EU countries amounts to almost 36,000 km$^2$. This relates to 18% of the UAA in 1975. Declines were seen in all countries in this period.
- Large declines in UAA (<= -20%) occurred in Bulgaria (-25%), Czechia (-23%), Estonia (-27%), Greece (-20%), Spain (-27%), Croatia (-30%), Italy (-29%), Cyprus (-38%), Latvia (-24%), Hungary (-31%), Poland (-25%), Slovenia (-45%) and Slovakia (-35%).
- Medium declines in UAA (< -20% to-10%) occurred in Belgium, Denmark, Germany, Ireland, France, Lithuania, Malta, Netherlands, Austria, Romania, Finland, Sweden and the UK.
- Small declines in UAA (-10% to 0%) occurred in Luxembourg and Portugal.
- At regional level, the largest declines (<-25%) were seen in northern Sweden, Estonia, Galicia, Madrid, Valencia, Alicante, Castellon, Provence-Alpes, Languedoc-Roussillon, most Italian regions, southern Austrian regions, and all regions in Slovakia, Hungary, Bulgaria, Slovenia and Croatia.
- In most of the CEE countries the decline was particularly large between 1990-2005, directly after the conversion from communist to market economies. In this period large state farms ceased to exist, agricultural production decreased tremendously, land was partly claimed back by pre-communist owners, and several areas of land were left unused because legal rights remained unclear and/or production for the market became difficult.

Data on unused, abandoned or degraded lands are practically not available in EU-wide data sources, nor in national or regional data. The main reason for not registering land that goes out of production and becomes abandoned or degraded is because it then also loses agricultural land status and is therefore no longer registered in agricultural statistics. This is confirmed by the fact that the only unused land categories for which data are collected refer to lands that are temporarily out of use, such as fallow land or unused lands. However, if they are unused for a couple of years the lands lose agricultural status and are no longer registered. Wider land use statistics may still cover these lands, and register them according to the land use or land cover they become. This can be forest, urban, nature conservation area, industrialised, used for recreation or transport, or a more undefined class possibly more likely to be abandoned. However, there have been problems using remote sensing data to identify the level of intensity (or even presence) of active management of permanent pastureland (grassland, heaths, agroforestry, and so on). For these lands, it then becomes very challenging to understand whether they relate to former abandoned or degraded agricultural lands.

Land use and land cover data is therefore needed, on which spatial flow analysis needs to be undertaken. Box 2.1 gave an example of this using CLC data for 2000 and 2018. The land cover flow analysis showed what agricultural lands converted to. For the EU-28, a shift to abandonment with and without forest formation was seen on about 6% of the agricultural area (relative to 2000), around 2% involved urbanisation and 4.5% internal agricultural shifts from arable to set-aside, fallow and permanent grassland. It was also clear from the land cover flow analysis that in all EU countries the majority of this type of abandonment takes place outside Natura 2000 (80% on average EU28).

The CLC flow analysis only identifies those flows that are dominant in terms of land cover, so those that cover a large area. Small area changes are missed, which can accumulate to significant amounts. This is related to the coarse spatial resolution of the satellite data used for CLC, that have a minimum mapping unit of 25 ha. This means that detailed spatial information is lost and small abandoned fields become part of the mosaic classes in CLC. Identifying these from the CLC then becomes impossible unless additional data are collected.

Another reason why data detecting abandoned lands are missing is because it involves a gradual process of transition from agricultural land to shrubs and eventually forest. It is therefore very difficult to determine exactly when land has become completely abandoned or when it is still managed. Detecting abandonment based on land cover data alone is difficult. A combination of statistical and different spatial data sources from different time periods is usually needed, providing information on land use, land management and land cover.

# 3 FACTORS THAT LEAD TO AN INCREASE OF AGRICULTURAL LANDS BECOMING UNUSED, ABANDONED AND DEGRADED

**Chapter aim and contents:**
This chapter provides an overview of factors leading to agricultural land in the EU becoming unused, abandoned and degraded, based on a literature review and evidence from nine case studies.

## 3.1 Introduction and approach

Establishing successful planning and management policies for sectors that depend on agricultural land requires an understanding of the mechanisms leading to agricultural land becoming unused, abandoned and degraded. In this chapter, we therefore identify such land and outline the historical context of land use changes in different parts of the EU. We adopted an existing classification for unused, abandoned and degraded land, and distinguished main categories of underlying drivers. We then made an inventory of drivers for agricultural land abandonment using literature on agricultural land abandonment in the EU and evidence from nine case studies. We conclude with a summary of the spatial distribution of drivers in the EU and the hotspot regions where these concur (see Annex VI).

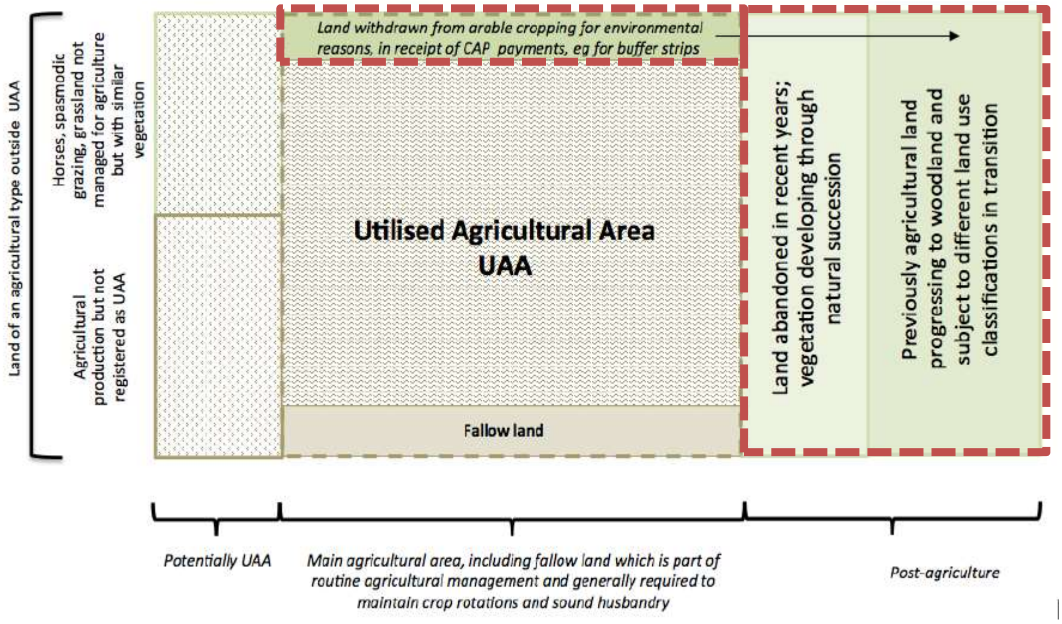
Information on the occurrence of unused, abandoned and degraded land in the case study regions and drivers was derived from interviews with 65 stakeholders. See Annex VIII for details on the types of respondents, response rates and interview questions.

### *3.1.1 Identifying types of unused, abandoned and degraded lands*

The extensive literature on farmland abandonment in Europe shows the difficulty in identifying land on which agricultural activities have ended for economic, political or environmental reasons (for example, Wiegman et al., 2008; IEEP, 2010; Allan et al., 2014; Elbersen et al., 2014; Keenleyside and Tucker, 2010; Elbersen et al., 2015; Terres et al., 2013; Lasanta et al., 2017).

Figure 3.1 shows that land can be in different stages of abandonment. The stages reflect a complex process of reduced farming activity over a continuum, ranging from land that is temporarily unused (overlapping here with fallow) to semi-abandoned land (managed only to comply with CAP cross-compliance requirements but not currently used for production). At the end of the range is land that is entirely abandoned and where management is withdrawn completely. Usually this last category of land loses its status as agricultural land and is also no longer eligible for direct payments under the CAP.

Figure 3.1 Agricultural land use transitions




Source: Allen et al. (2014).
Notes: Types in dashed red boxes are the focus of the regional case studies.

If land stays unused for at least five consecutive years, it is classified as unused and abandoned in RED II. However, the land use classification of RED II does not acknowledge the complex process of reduced farming activity described above. Keenleyside and Tucker (2010) overcome this drawback by distinguishing between temporarily unused lands, transitional and actual abandonment (see **Box 3.1**).

**Box 3.1 Classification of abandoned land and process of abandonment, adapted from Keenleyside and Tucker (2010)**

**Temporarily unused land:** land that is likely to be temporarily unused and includes fallow and former compulsory set-aside (under CAP until 2008), but also semi-abandonment or hidden abandonment.

**Fallow** is generally part of the crop rotation, and involves a temporary suspension of cultivation ranging from one or several vegetation periods (for example, short (1-2 years) and long-term fallow (>=3 years)).

*N.B. Keeping lands in fallow generally helps to recover soil fertility, although brown fallow (without vegetation cover) may also increase the risk of soil erosion, while green fallow (fallow with vegetation cover) has a lower risk for soil loss. Furthermore, fallow lands also have a positive contribution to biodiversity, particularly in arable monocultural landscapes.*

*Example of short-term fallow land: land in use for cereals every two to three years in the Soria region, Spain. Photo: Michiel van Eupen.*

*Example of long-term fallow land: land not in use for agriculture for three to five years in the Soria region, Spain. Photo: Michiel van Eupen.*

**Semi or hidden abandonment** refers to land with a very low level of management. The land is not (yet) formally abandoned and is subject to some form of management, which might be simply to keep it available for future use, for example, for agriculture, recreation or tourism. Such land may also be subject to the minimum management necessary to meet cross-compliance requirements by those claiming direct payments under the CAP. Very extensive or intermittent farming operations may also fall into this category. Such extensive farming is generally associated with very low direct economic returns, but may be continued for personal or social reasons, to support other farm income streams, for example, from hunting and tourism, or for nature and landscape conservation. It may also be kept in extensive use to maintain a long-term family investment.

*Example of semi-abandoned land: land not in use for agriculture for three years in the Soria region, Spain due to a family dispute. Photo: Michiel van Eupen.*

**Transitional abandonment** has been observed particularly in Central and Eastern Europe as a result of restructuring and land reforms, and in other Member States as a result of compulsory or voluntary set-aside, until this was abolished in 2008, or as a result of land use change. This includes land that is held for optional conversion to urban or infrastructural use. Transitional abandonment can be seen also in areas that are economically marginal in production terms. These areas can move in and out of agricultural use depending on market prices for certain commodities.

*Example of land under transitional abandonment: abandoned land previously in use as meadow, pasture and orchard in the Kontinentalna Hrvatska region, Croatia. Photo: Željka Fištrek.*

**Actual abandonment:** where the farmland is not used at all. The vegetation may change through natural succession into tall herb, bush and forest ecosystems after a period, depending on climatic and soil conditions. On rich and wet soils, the outcome is likely to be forest ecosystems but, in contrast, on poor dry soils in south-eastern Europe, it can be 'steppe-like' grassland vegetation that is able to survive for many years without any active management such as mowing or grazing.

*Example of abandoned land: land not in use for agriculture for more than ten years in the Soria region, Spain. Photo: Michiel van Eupen.*

### *3.1.2 Historical context and abandonment*

Agricultural land use and tenure systems developed differently across Europe over many centuries, and therefore the starting point for abandonment was diverse. The abandonment of agricultural land in Europe can be traced to the early nineteenth century. It increased after the Second World War due to the collapse of societies in mountainous regions (Lasanta et al., 2017; Corbelle-Rico, et al., 2015). Differences in abandonment patterns between the western and eastern parts of Europe may reflect fundamentally different underlying causes and timescales that triggered agricultural land abandonment. In Western Europe, abandonment appeared to be mainly driven by gradual industrialisation, market orientation, and urbanisation (MacDonald et al., 2000; Verburg et al., 2010). In contrast, abandonment in Eastern Europe was triggered by the collapse of socialism and subsequent institutional reforms (Baumann et al., 2011).

#### *Change of political systems in Central and Eastern Europe (after 1990)*

Many studies mention that the breakdown of the Soviet Union in 1991 triggered widespread abandonment of agricultural land in countries in Central and Eastern Europe (for example, Loffe et al. 2004; Henebry, 2009; Kuemmerle et al., 2008; Estel et al., 2015; Kuemmerle et al., 2016; Plutzar et al., 2016; Terres et al., 2015; van Vliet et al. 2015). In south-eastern Europe millions of hectares of farmland were abandoned (for example, 15–20% of cropland in Slovakia and Poland, (Keenleyside and Tucker, 2010 and Van Dijk et al., 2004; Zakkak et al., 2015, cited in: Leal Filho et al. 2017). Alcantara et al. (2013) quantified the extent of abandoned farmland (cropland and pastures) in Central and Eastern Europe using satellite images. They found that abandoned farmland was widespread, totalling 52.5 million ha. The variation in rates of agricultural land abandonment across the area was driven to a large extent by differences in institutional and socio-economic factors among countries, rather than by biophysical settings. The driving factors included differences in governmental support for agriculture after 1989-1991, the level of reorganisation of agricultural sectors (Kuemmerle et al., 2016), and accession to the EU. Land reforms took place in various ways: by restitution of agricultural land, distribution of land shares, or continuation of state ownership.

The mechanism behind agricultural land abandonment in Central and Eastern Europe consisted of a restructuring of agricultural and forestry sectors in the transition to free market economies (Pointereau et al., 2008). This process was characterised by privatisation, price liberalisation of inputs and agricultural products (Brooks and Gardner, 2004; Lerman et al. 2004, cited in: Alcantara et al., 2013), integration into global markets, and the disappearance of guaranteed markets in the Eastern Bloc.

The dismantling of large collective or state farms in the process of land privatisation resulted in land abandonment because property rights were not well established, or because co-ownership or lack of information on the landowner impeded the allocation of land. For example, in Bulgaria, the forced co-ownership of land parcels created inadequate property rights, inefficient land allocation and farmland abandonment (Vranken et al., 2004, 2011, cited in: Terres, Nisini Scacchiafichi and Anguiano, 2013). Returning land to previous owners was also complicated by a lack of interest from some owners who had migrated to cities or other countries (Bell etal., 2009), and by a lack of start-up capital for agricultural enterprises (Bell et al., 2009, 2010, cited in: Lasanta et al., 2017).

The variety of socio-economic changes mentioned above resulted in the abandonment of properties (Bell et al., 2009) or in high fragmentation and small size of agricultural plots and holdings, impeding the development of profitable and commercial farming (Terres et al., 2013). Other barriers for agricultural land use included lack of equipment, limited access to capital, scarcity of advice and technical support, difficulties with markets, and low levels of government support (Keenleyside et al., 2005, cited in: Terres et al., 2013).

*Accession to the EU*

After 2000, several countries joined the EU: the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia in 2004; Bulgaria and Romania in 2007; and Croatia in 2013. This enabled farmers to access agricultural support payments and new markets (Alcantara et al., 2013). Agricultural commodity prices increased, and restitution of agricultural land and forests to former owners progressed. As a result, abandoned agricultural land was partly recultivated, and agricultural yields and forest yields increased in some countries (Rozelle and Swinnen, 2004; Griffiths et al., 2013, cited in: Plutzar et al., 2016).

## 3.2 Main drivers of land becoming unused, abandoned and degraded in the EU

We grouped drivers according to the main categories distinguished in the reviews by Pointereau et al. (2008), Keenleyside and Tucker (2010), Terres et al. (2013, 2015), Filho et al. (2017) and Lasanta et al. (2017) and Castillo et al. (2018), and applied in the spatially explicit mapping approach of marginal lands for industrial cropping in Europe (Elbersen et al., 2017). These categories include: natural constraints limiting the suitability for agricultural uses (Table 3.1 and Annex VI under point 4.), socio-economic drivers at the farm level (Table 3.2), and broader socio-economic drivers (Table 3.3). We added a fourth category for drivers from policy (Table 3.4).

Table 3.1 Category 1 - Natural constraints and land degradation limiting the suitability for agricultural uses

| Driver | Mechanism and aspects | References |
|---|---|---|
| **Adverse climate** | Low temperature or short growing season limiting crop growth.<br>Dry conditions and water stress affecting crop physiological processes. | Terres et al., 2015; Elbersen et al., 2019; Elbersen et al., 2018; Schneider, Blanchard, Levers, and Kuemmerle, 2015; Lasanta et al., 2017; Castillo et al., 2018; Terres et al., 2013 |
| **Soil and terrain properties** | Limitations in rooting of crops, in soil drainage and excessive wetness constraining crop production and farming operations.<br>Low soil fertility, acidity, alkalinity, salinity, sodicity.<br>High altitude limiting crop growth.<br>Steep slopes complicating use of agricultural machines.<br>Steep slopes being rocky and having low fertility.<br>Water accumulation on fields in valley bottoms, inundation risk. | Leal Filho et al., 2017; Elbersen et al., 2019; Elbersen et al., 2018; Lasanta et al., 2017; Castillo et al., 2018; Terres et al., 2013; Terres et al., 2015; Plutzar et al., 2016; Ciria, Sanz, Carrasco, and Ciria, 2019; Tóth et al., 2008; Castillo, Aliaga, Lavalle, and Llario, 2020; Schneider et al., 2015 |
| **Land degradation** | Soil erosion, decline in soil organic matter, soil salinisation, forest fires as forms of land degradation constraining agricultural production[13]. | Leal Filho et al., 2017; Lasanta et al., 2017; Estel et al., 2015; Jones, 2015; Stolte et al., 2016; Tóth et al., 2008 |
| **Landscape configuration and land use** | Reduction of heterogeneity promoting the encroachment of vegetation and increased fire frequency.<br>Proximity to forest edge likely promoting secondary succession on abandoned farmland. | Leal Filho et al., 2017; Schneider et al., 2015; Vinogradovs, Nikodemus, Elferts, and Brūmelis, 2018 |

Table 3.2 Category 2 - Socio-economic drivers at farm level

| Driver | Mechanism and aspects | References |
|---|---|---|
| **Agricultural viability** | Land becoming unprofitable to farm, generating insufficient farm income.<br>Lack of financial capital or credit to maintain assets and machinery.<br>Low investments indicating farming activity in decline. | Leal Filho et al., 2017; Allen et al., 2014; Elbersen et al., 2019; Elbersen et al., 2018; Alcantara et al., 2013; Terres et al., 2013; Terres et al., 2015; van der Sluis, Pedroli, Kristensen, Lavinia Cosor, and Pavlis, 2016; |

[13] Agricultural land abandonment is also reported to lead to land degradation, for example, in the Mediterranean, where abandonment of traditional terrace systems lead to soil erosion and shallow landslides (Arnaez et al., 2011; Cammeraat et al., 2007; Nadal-Romero et al., 2012), and abandonment of grazing adjacent to forests or in grassy firebreaks leading to increased risk of forest fires (for example, Lourenço, 2018). Other main forms of land degradation caused by agricultural land abandonment include degradation of peat soils, desertification, and landslides (Stolte et al., 2016).

| Driver | Mechanism and aspects | References |
|---|---|---|
| | Non-economic motivations and options for future use maintaining agricultural land under some form of management (semi- or hidden abandonment). | Bell et al., 2009; Lasanta et al., 2017; Castillo et al., 2018; Keenleyside and Tucker, 2010; Hart et al., 2013 |
| **Farm structure** | Small parcels and land fragmentation causing difficulties in mechanisation and poor accessibility of fields.<br>Remoteness of fields inducing higher costs of transportation to markets, processing and labour costs.<br>Fragmented ownership structure leading to higher management cost and hampering succession.<br>Small farm size leading to limited access to credit and other institutional services; limited options to benefit from economy of scale and use of machinery.<br>Enrolment in support schemes favouring commitment to continue farming.<br>Uncertainty in land tenure or property rights, disputed ownership and transitional arrangements (owner deceased, acquisition for purposes of land development) causing land to be kept out of production. | Terres et al., 2013; Leal Filho et al., 2017; Lasanta et al., 2017; Vinogradovs et al., 2018; Terres et al., 2015; Elbersen et al., 2019; Elbersen et al., 2018; Castillo et al., 2020; Allen et al., 2014; Baumann et al., 2011; Krčílková and Janovská, 2016; Castillo et al., 2018; Bell et al., 2009; Viedma, Moity, and Moreno, 2015; Hart et al., 2013 |
| **Farm holder characteristics** | Old age of farmers and proportion of farmers near retiring age.<br>Lack of continuity in the agricultural enterprise due to the absence of direct descendants in families or other successors, family dispute the inheritance or other problems in handling inheritance.<br>Landowners living in towns at distance with no interest to farm/maintain the land.<br>Level of education or training of farm holders and use of advisory services indicate the professionalism of the farm and willingness to invest. | Lasanta et al., 2017; Castillo et al., 2018; Terres et al., 2013; Terres et al., 2015; Kosmas et al., 2015; Vinogradovs et al., 2018; Viedma et al., 2015; Cvitanović, Blackburn, and Rudbeck Jepsen, 2016; Krčílková and Janovská, 2016; Bell et al., 2009 |
| **Farm practices and intensity of agricultural use** | Abandonment of traditional farming practices.<br>Intensive management leading to the over-exploitation of natural resources.<br>Low intensity management systems becoming economically marginal. | Estel et al., 2015; Hart et al., 2013; Jones, 2015 |

Table 3.3 Category 3 - Broader socio-economic drivers

| Driver | Mechanism and aspects | References |
|---|---|---|
| **Economic opportunities in other regions and sectors** | Concentration of actively cultivated land in productive areas, and a decrease in others due to intensification of agriculture or structural changes.<br>Increasing imports of agricultural products from other regions.<br>Employment opportunities in other sectors (industry and services) shifting active population and labour forces away from farms.<br>Decreased attractiveness of agriculture when income is below regional income. | Leal Filho et al., 2017; Estel et al., 2015; Hart et al., 2013; Lasanta et al., 2017; Terres et al., 2013, 2015; Cvitanović et al., 2016; Baumann et al., 2011 |
| **Demographic trends and settlement pattern** | High emigration rate from rural areas to cities and industrial sites, especially of younger population; decline in rural population.<br>Loss of services and infrastructure in villages.<br>Family background, childhood history and attachment to rural landscape determining whether people continue to live in rural areas. | Castillo et al., 2018; Estel et al., 2015; Lasanta et al., 2017; Leal Filho et al., 2017; Terres et al., 2015; van Vliet et al., 2015; Ceausu et al., 2015; Bell et al., 2009 |
| **Level of technology, industrialisation and training in a region** | Lack of new technology, equipment and technical support.<br>Modernisation of agricultural practices (mechanisation and chemical fertilisation) in marginal areas leading to overstocking.<br>Competition of smallholders in dry and mountainous areas with large-scale mechanised farms elsewhere in Europe.<br>Intensification of agricultural use of the most productive land and abandonment of remote, marginal land.<br>Level of training[14] and advice in a region required for adaptation of agricultural enterprises to changing socio-economic circumstances. | Lasanta et al., 2017; Terres et al., 2013; Jones, 2015; Corbelle-Rico et al., 2015; Alcantara et al., 2013 |
| **Accessibility, rural infrastructure and proximity to urban areas** | Possibility to access the land with machinery and human workforce to perform agricultural operations, to supply inputs and transport harvest, and to implement infrastructure for irrigation or drainage.<br>Distance of farm holdings to social infrastructure (for example, schools, hospitals), opportunities, activities or assets in other areas. | Leal Filho et al., 2017; Terres et al., 2013, 2015; Bell et al., 2009; Vinogradovs et al., 2018 |

[14] 'Training' falls under the key criterion 'farmer qualification' in the indicator on the risk of farmland abandonment developed by JRC (Terres et al., 2013). This refers to technical and economic training, including expertise in new information technologies, as well as adequate awareness of product quality, results of research and sustainable management of natural resources, including cross-compliance requirements and the application of production practices compatible with the maintenance and enhancement of the landscape and the protection of the environment.

| Driver | Mechanism and aspects | References |
|---|---|---|
| | Availability and condition of rural infrastructure (schools, hospitals, roads, houses, public buildings, financial and market structures).<br>Proximity of urban areas making land attractive for real estate developers. | |
| **Land markets** | Weak land market with low demand for land translating into low prices (selling or renting).<br>Imperfections in credit markets and property rights, high transaction costs. | Leal Filho et al., 2017; Terres et al., 2013, 2015 |
| **Agricultural market constraints** | Unfavourable agricultural markets in the region or beyond, for example, when small-scale farming has difficulties competing economically with a more structured, intensive agricultural market.<br>Market globalisation and global competition among agricultural commodities, low commodity prices stimulating import of goods from abroad.<br>Trend towards specialisation and achieving greater economies of scale in most agricultural sectors in the EU, reducing the viability of marginal livestock systems. | Castillo et al., 2018; Lasanta et al., 2017; Leal Filho et al., 2017; Terres et al., 2013; Kuemmerle et al., 2016; EEA, 2019; Keenleyside and Tucker, 2010 |

### *3.2.1 Drivers from policy*

The CAP is the main policy tool affecting the use and management of agricultural land and agroforestry. Literature shows that several CAP measures have clear potential benefits in combating drivers of land abandonment and restoring abandoned or unused land to production (see Chapter 5). However, there are some situations where the CAP may also contribute to land being abandoned, because of the implementation choices made by individual Member States in defining, targeting and funding specific CAP measures. There is little evidence at the EU level of biodiversity and water policies acting as drivers of land abandonment or degradation and, like the CAP, they too can be implemented at national or regional level to combat land abandonment.

Table 3.4 Category 4 - Drivers for agricultural land abandonment from policy at the EU level.

| Policy instrument | Mechanism and examples |
|---|---|
| **CAP direct payments (Pillar 1)** | Hart and Bas-Defossez (2018) found that excluding certain farmland habitats from being defined as agricultural means that this land is not eligible for CAP direct payments, which often leads to it being abandoned, or to agricultural intensification to ensure that it is eligible.<br><br>For example, in 2015, just four Member States opted to define as eligible, grazing land on which herbaceous forage is not predominant (Greece, France, Spain and the UK (except Wales) (Alliance Environnement, 2019). In Andalucía (Spain), the eligibility criteria for direct payments and the definition of permanent grassland has led to a decrease in the area of wooded grasslands (dehesa) declared as eligible for Pillar 1 support and may lead to abandonment (Alliance Environnement, 2018).<br><br>In the 2007-2013 CAP programming period significant areas of high nature value (HNV) farmland in active agricultural use were not eligible for CAP support. These included thousands of hectares of Annex 1 habitats of European importance (under the Habitats and Species Directive), consisting of semi-natural grasslands, wooded pastures, heathland, dunes, fens, phrygana scrub and pseudo-steppe (Keenleyside et al, 2014).<br><br>In the current period (2014-2020) in Croatia, out of 607,000 ha of utilised permanent grassland, only one third is inscribed in LPIS and receiving CAP support. Most of the grassland outside the CAP is either abandoned or farmed at a (semi)-subsistence level by elderly farmers, and thus at high risk of abandonment, and most of this is HNV karst grassland rich in rare species (Alliance Environnement, 2019). |
| **Forest measures (Pillar 2)** | European Agricultural Fund for Rural Development (EAFRD) support for afforestation of agricultural land can change the use of land still in production, effectively removing it from the UAA once the trees are established. |

### *3.2.3 Combinations of drivers*

The literature review for agricultural land in the EU becoming unused, abandoned or degraded points out that these transitions are caused by combinations of drivers from the categories reported above. Agricultural land abandonment can be triggered by primary drivers related to either low productivity, remoteness or mountainous regions, or to unfavourable soil or climate conditions for agriculture (Castillo et al., 2018). In combination with natural constraints, factors such as the absence of markets, difficult accessibility, poor infrastructure, low population density and declining population were identified as drivers for farmland abandonment (Elbersen et al., 2018; Kosmas et al., 2015; Terres et al., 2013). A case study in southern Romania illustrates how drivers from all four categories interacted to cause land abandonment and reforestation (Stringer and Harris, 2014). Land that was returned and redistributed after the ending of the socialist governance became abandoned and unused in response to land degradation, a lack of irrigation, agricultural labour shortages, and the economic unviability of farming small plots.

Drivers can also occur in sequence, as demonstrated in a modelling study of changes in fire hazard through time as a result of agricultural land abandonment in a large rural area in west-central Spain for the period 1950-2000. From 1950 to 1978, land abandonment was driven by local environmental and socio-economic constraints (small farms, in distant locations, in municipalities with low population and a low percentage of employees in the primary sector). In the subsequent period, land abandonment was driven by factors in the wider context (large farms, in more productive soils, closer to towns, municipalities with high rates of unemployment, and higher employment in the services sector). Throughout the entire period, a low level of mechanisation in municipalities and a high proportion of landowners over 55 years old influenced the probability of agricultural land abandonment in this region (Viedma et al., 2015).

Table 3.5 summarises how the drivers in the categories presented above can be linked to the different types of land in the stages of passing out of use, and the resulting types of unused and abandoned land according to the definition adopted in this study (**Box 3.1**). Degraded land occurs in all land types, and is therefore not indicated as a separate land type.

Table 3.5. Summary of categories of unused and abandoned land used in this review in relation to drivers

| Land type | Sub-type | Natural constraints limiting the suitability for agricultural uses | Socio-economic drivers at farm level | Broader socio-economic drivers | Drivers from policies |
|---|---|---|---|---|---|
| **Temporarily unused land** | a. Fallow (short-term: 1-2 years) | X | X | | XX |
| | b. Fallow (long-term: >=3 years) | X | XX | X | XX |
| | c. Semi- or hidden abandonment | X | XX | XX | X |
| **Abandoned land** | a. Transitional abandonment | X | XX | XX | X |
| | b. Actual abandonment | X | XX | XX | X |

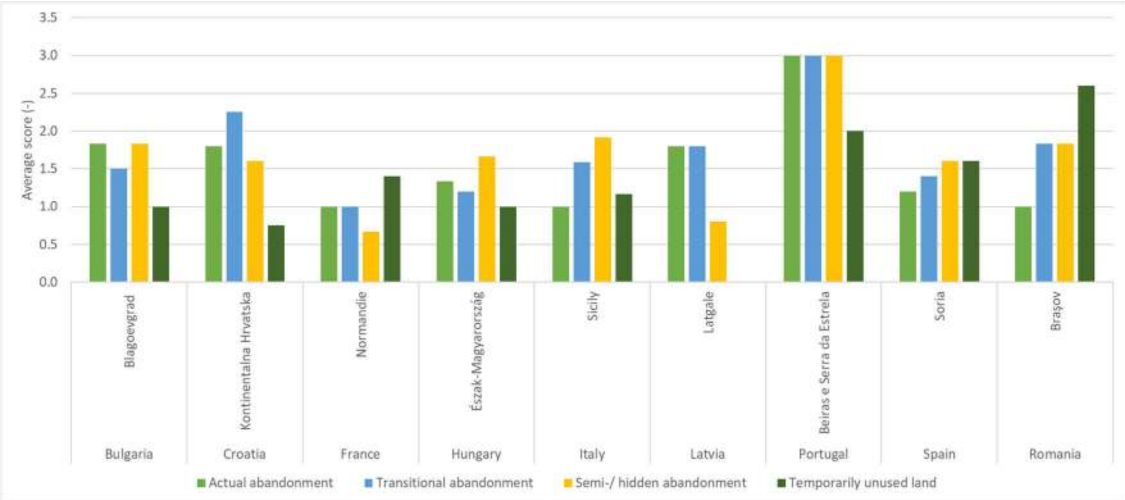
Source of land type classification: Keenleyside and Tucker, 2010.
Notes: X: small influence of driver, XX: large influence of driver.

## 3.3 Evidence from the case studies for drivers of land becoming unused, abandoned and degraded in the case study regions

### *3.3.1 Scale, type and location of land abandoned*

*Scale*

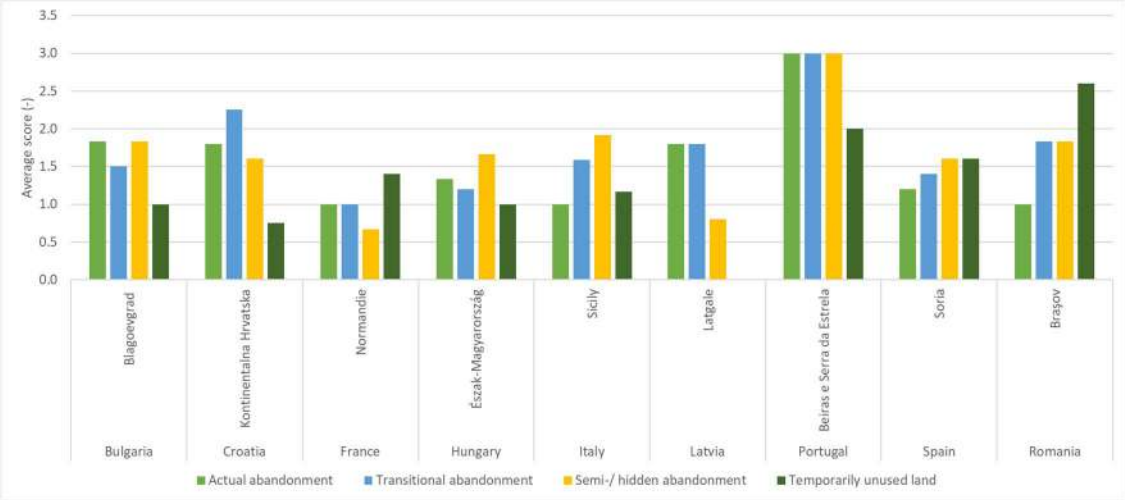
Case study interview respondents estimated that land abandonment (actual and transitional or hidden forms) and unused land occur on less than 5% of agricultural land[15] in most case study regions, with the exception of Portugal (Figure 3.2




). Land under transitional abandonment was attributed relatively high scores for the region in Croatia. This could be explained by market price fluctuations of certain commodities and optional conversion to urban or infrastructural use. Price fluctuations in commodities, having appeared especially since Croatia entered the EU market, can influence farmer's decisions to reduce production of these commodities and to leave land of lower quality abandoned until the situation changes (Fištrek and Kulišić[16], pers. comm.). The lowest scores for forms of abandoned land were given for the region in France. This confirms the demand for land from the agricultural and commercial sectors (see Figure 3.2).

[15] According to Eurostat's definition, agricultural area includes UAA, NUAA, and SAA (see Section 2.2).
[16] These were the experts for the case study region in Croatia.

Figure 3.2 Estimated scale of occurrence of abandoned and unused land in case study regions according to definitions of Keenleyside and Tucker (2010).




Notes: Average scores from respondents: 0: not present; 1: <1% of the agricultural area; 2: 2-5%; 3: >5%.

The estimates of the occurrence of abandoned or unused land by respondents should be interpreted with caution, because respondents found it difficult to distinguish between the land types, and some restricted their answer to areas smaller than the case study region.

### *Types of land abandoned and destination*

Respondents reported mainly arable land, permanent grassland and marginal land to have been subject to abandonment in the past 20 years (reported in 29, 42, and 38 responses respectively, out of 145 in total). Arable land was mentioned in all case study regions except for the region in France, where permanent grassland was the most frequently reported type of abandoned land. Grassland and permanent grassland were also mentioned as abandoned for the regions in Bulgaria, Latvia, Italy and Romania. Marginal land was reported as subject to abandonment by respondents from all regions. Characteristics of this type of land that were mentioned include steep slopes, shallow, stony or wet soils, land with low profitability, producing low quality forage, and land where cultivation with machines is difficult.

Respondents considered the same types of land use likely to become abandoned in the near future: arable land, (permanent) grassland and marginal land (19, 24 and 25 responses respectively, out of 103 in total). For arable land this applies mainly to the regions in Bulgaria, Croatia, Italy, Portugal and Spain. Grassland and marginal land were considered likely to become abandoned in all case study regions except for the regions in Portugal and Romania.

Shrubs and shrubs in combination with forest were most frequently mentioned as the land cover resulting from abandonment (80 responses out of 130), especially for the regions in Croatia (18 responses) and Portugal (15 responses). Forest and grassland, and combinations of grassland with shrubs, were mentioned respectively 16 and 12 times as land use types of destination. Only the case studies for the regions in Bulgaria and France indicated whether the change of land use to forest was deliberate or not: in Bulgaria part of the municipal and state common grasslands and lands with marginal biophysical conditions were abandoned and became shrubs and forests (so natural regeneration); in France permanent grasslands that became unused or abandoned in the past underwent a natural conversion to shrub land and forest. However, changes in land use from marginal land to naturally regenerated or planted forest or shrubs in the region in France were indicated to happen because landowners do not need to pay property tax for this land, and because it allows them to privately hunt on this land. In the case study region in Romania, unused or abandoned marginal lands tend to become overgrown with bushy woody vegetation and often continue to be used for grazing (notably sheep), but the quality of forage is poor and productivity is low.

The most frequently mentioned types of conversions in the past 20 years were from marginal land to shrubs or shrubs and forest (22 responses out of 130), and from permanent grassland and arable land to these land use types (23 and 18 responses, respectively).

*Specific locations*

Specific locations mentioned of land that has become unused or abandoned were in hilly or mountainous areas (Bulgaria, Croatia, France, Italy, Spain, Romania), remote or physically isolated territories (Bulgaria, Italy, Portugal), areas near forest (Croatia, France, Romania), flood-prone areas (Croatia, Hungary, Latvia) and protected areas (Bulgaria, Italy, Latvia, Romania). For example, about 50% of the territory of Braşov county in Romania is designated as Natura 2000 area. For the region in Croatia, areas suspected to carry mines from the war of 1991-1995 were mentioned as specific locations of abandoned land.

Locations near urban areas were mentioned for the regions in France and Italy due to expected benefits from conversion to built-up land, and in the region in Latvia around former buildings and sites with rubbish dumps or industrial waste (for example, from quarrying or mining). For the region in Croatia, it was mentioned that people living in rural areas in the vicinity of larger cities search for employment in cities and abandon family owned agricultural fields. This is predominantly visible in area around the capital, Zagreb.

*Changes in vegetation, biodiversity and degradation after abandonment*

For most case study regions, agricultural land abandonment was reported to lead to the subsequent natural regrowth of grasses, shrubs and trees, transforming into forest. This was reported to lead to an increased risk of forest fire for all countries, except for the regions in France and Hungary. Increased fire risk is explained by the appearance of weeds, tall grasses and bushes in combination with the incidence of dry summers (case study region in Bulgaria), the lack of maintenance of firebreaks and of shrubland and forest (case study regions in Portugal and Spain), the occurrence of sloping land (case study regions in France, Italy, and Spain), or by illegal practices of vegetation removal by fire or burning of residues (case study region in Croatia). In the case study region in Italy, fires are a significant phenomenon. Respondents mentioned two causes: fire-raising by shepherds who want to use land for their goats, or fire-raising for speculation, because deforested land has a higher price for construction purposes. In the region in Romania, a risk of wildfire exists on pastures that are not used or abandoned, and where it remains a common (though not legal) practice at the local level to burn dry grassland vegetation in the spring.

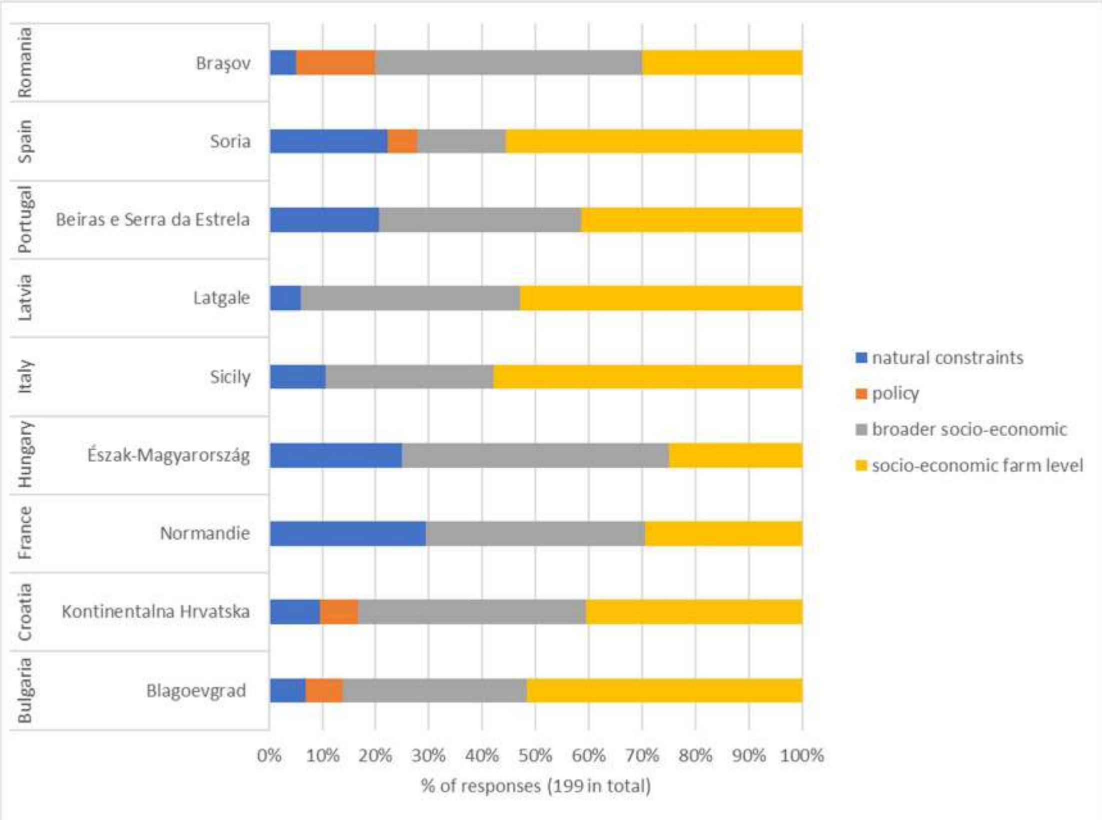
Abandonment of agricultural land was reported to cause soil erosion for the case study regions in Spain in abandoned terraces, by uncontrolled clearing of forest in the region in Croatia, in properties located on slopes and affected by floods in the region in Bulgaria, and by the disappearance of drainage systems in the region in Italy. Yet, some respondents reported a reduced soil erosion risk after abandonment because the vegetation of shrubs and forests that develops on abandoned land has higher potential for erosion reduction (case study regions in Croatia, France, Spain and Romania).

Invasive alien plant species and increased damage to crops from wildlife following abandonment were mentioned for the case study regions in Bulgaria, Croatia and Hungary.

### *3.3.2 Main drivers for agricultural land abandonment*

Socio-economic drivers were the main drivers for agricultural land becoming unused or abandoned according to respondents in most case study regions (Figure 3.3), accounting for 163 out of 199 responses, versus 27 responses for natural constraints and nine for drivers from policy.

Figure 3.3 Drivers for agricultural land abandonment reported in case studies: main categories




### *Socio-economic drivers at farm level*

Socio-economic drivers at farm level were most frequently mentioned for the case study regions in Bulgaria, Croatia, Italy and Portugal (Figure 3.3). Among these, small parcels and the fragmentation of holdings, factors determining the farm income, and issues with land tenure were most frequently mentioned (13, 14, 15 and 16 responses, respectively, out of 87 in total). Small parcels and fragmentation of farmland were reported for the regions in Bulgaria, Croatia, Italy, Portugal and Romania. In the regions in Croatia and Bulgaria, these resulted from the division of land between many heirs, leading to small parcels and co-ownership of single parcels. Landowners manage the land with different degrees of intensity and quality, and some are not aware of ownership of parcels. The small and scattered position of parcels cause low profitability and difficulties cultivating or selling these parcels. For the region in Romania, conflicts arising from unresolved errors in the cadastral system were mentioned, for example due to incorrectly placed boundaries.

Factors determining the farm income that were mentioned to drive abandonment include low income or low profitability of the holding (case study regions in Bulgaria, Italy, France, Spain), low productivity of the land for crops and livestock (case study regions in Spain, Romania), and increase in cost of production, resources or taxes (case study regions in Latvia, France, Romania).

Difficulties arising from land tenure that were mentioned include, for example, where people who had left the rural area keep the agricultural land that they inherited, but neither cultivate nor lease it (case study regions in Croatia and Latvia). Also mentioned were one-year leasing contracts which made it difficult to clear the land and demonstrate good agricultural and environmental condition, the difficulty of proving ownership of land in regions with a large number of owners (case study region in Bulgaria), the lack of legal tools to protect ownership and prevent expropriation of land (case study region in Italy), and problems arising from state ownership. Croatia went through a process of land reforms where much of the state-owned land was given under concession to farmers and companies, but much land still remains to be distributed (Fištrek and Kulišić, pers. comm.). Underutilisation of state-owned land was reported for the case study region in Italy.

*Broader socio-economic drivers*

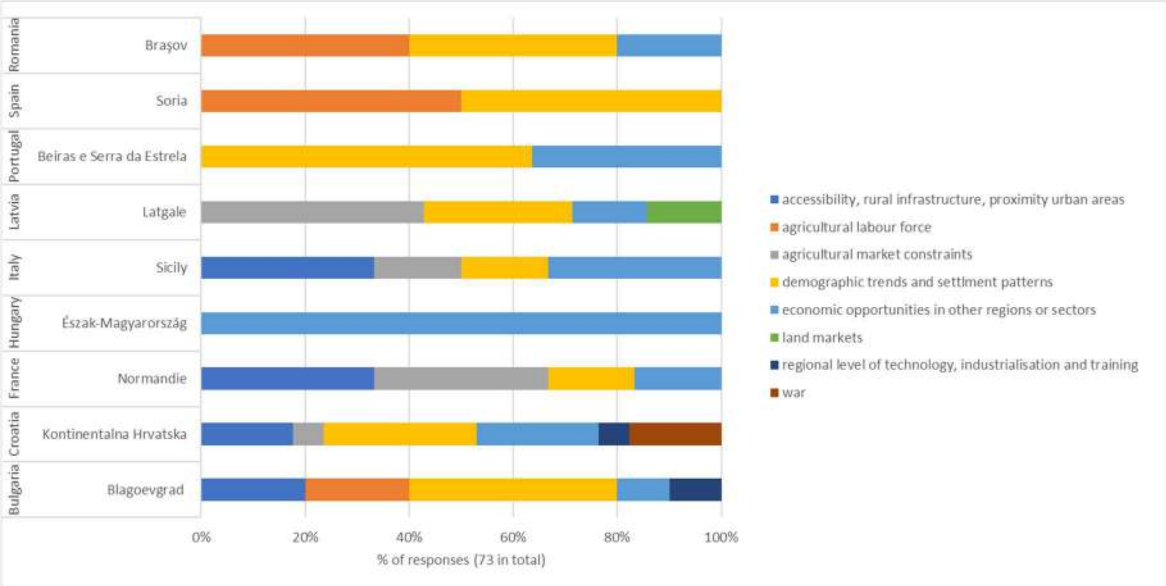
Figure 3.4 illustrates the distribution of broader socio-economic drivers of agricultural land abandonment in the case study regions. Respondents most often mentioned demographic trends and settlement patterns (25 out of 73 responses), economic opportunities in other regions or sectors (19 responses) and accessibility of agricultural land, presence of rural infrastructure and proximity to urban areas (nine responses).

The depopulation of rural areas was mentioned as a driver for abandonment for all regions except Hungary and is associated with an ageing population. Younger people migrate to urban centres or abroad in search for employment and better living conditions. This results in a lack of a younger population to farm the land and an ageing population of landowners, who are not able to cultivate the land or lack the skills or knowledge to adapt to new technology and markets (regions in Croatia, Latvia and Romania). These trends were reported to lead to shortage of both skilled and unskilled agricultural labour, an uneven distribution of income, employment and investments in the region, and rural areas being characterised by higher levels of poverty.

In all case study regions except for the region in Spain, respondents reported that agriculture becomes less profitable compared to other economic sectors, and that particularly young people search for employment in the industrial or tertiary sectors. Other socio-economic aspects mentioned in relation to agricultural abandonment include low salaries in the agricultural sector compared to the national average (case study regions in Croatia, Bulgaria) and an interest in land for investment and obtaining bank loans (case study regions in Latvia). Interest in agricultural land was also mentioned for recreational use in the case study regions in France and Romania, and for construction purposes in response to the expansion of metropolitan and sub-urban areas in the regions in Hungary and Romania. Land conversion for afforestation was mentioned for the region in Hungary.

A lack of transport infrastructure and public services in rural areas (for example, health and education) was mentioned as a driver for land abandonment in the case study regions in Croatia, Bulgaria and Italy. Examples include difficult access to agricultural land and markets, and poor internet connectivity. Conversely, the proximity of urban areas and infrastructure was mentioned to lead to the abandonment of agricultural land in the case study regions in Croatia, France and Romania. In the region in France, this relates to the demand for land in peri-urban areas, where plots have become unused or abandoned in the past by owners to enable a change of land use for construction, which resulted in an increase in the value of the land (case study report for the Normandie region, France).

Figure 3.4 Broader socio-economic drivers for agricultural land abandonment reported in case studies




### *Natural constraints and land degradation limiting the suitability for agricultural uses*

Adverse climate, soil properties and unsuitable terrain for agricultural use of land were most frequently mentioned as reasons for land becoming unused or abandoned in this category (21 responses out of 27 in total).

### *Land degradation as driver of abandonment*

Around half of the respondents (25 out of 44) indicated that there is degraded land in their region, and that land degradation leads to abandonment of agricultural land. The types of land degradation mentioned include contamination (from nearby abandoned buildings, mining, industrial or military activities) (case study regions in Latvia and Romania), soil erosion (case study regions in Italy, France, and Spain) and landslides (case study region in Romania), loss of soil structure and organic matter decline (case study region in Italy), and nutrient depletion and salinisation due to rising sea levels (case study region in France). Respondents from the regions in Croatia and Italy expected land degradation to increase in the future due to intensive or industrial forms of agriculture with inappropriate farming practices (use of pesticides, intensive mechanisation, destruction of soil fertility and biodiversity, monocultures).

However, according to 15 respondents from six case study regions, land degradation is not a driver for abandonment of agricultural land. The area of degraded land is insignificant (case study regions in Bulgaria, Latvia, Spain, and Romania) or degraded land is still used and land degradation is manageable.

*Drivers from policy*

Only five respondents, from case study regions in Bulgaria, Croatia, Spain and Romania, mentioned drivers from policy for agricultural land abandonment. There is evidence from the case study region in Croatia of cases where agricultural support payments are claimed, but where there is no actual production from that land. Also for this region, the area under permanent pastures has increased following adoption of the CAP, but the size of the livestock sector has significantly decreased. This could be interpreted as the first step towards abandonment, although respondents indicated that the increase in grassland areas is partly due to the change in the method by which the coverage of the UAA was registered. Other reasons given included the 'national inability' to tailor efficient measures from the CAP for the sector, and the fact that the national land policy enabled speculative investments aiming to access agricultural support payments from the EU. For the region in Bulgaria, a lack of proper incentives and support policy for high-quality agricultural production was mentioned as a driver for agricultural land abandonment.

Stakeholders from the region in Romania mentioned that existing rural development policies in Romania failed to address factors that reinforced the trend towards older farmers and a dwindling agricultural labour force. It was also noted that the drop in participation in the agri-environment measures for HNV grassland in the period 2014-2020 may have increased land abandonment. Furthermore, the case study reported major delays with setting up a functional land administration/cadastral system, although the post-communist process of land privatisation and restitution is nearly completed (case study report for Braşov county, Romania).

*Drivers of agricultural land abandonment in the future*

Socio-economic drivers, both at farm level and broader, were mentioned most frequently in relation to the risk of abandonment of agricultural land in the near future (25 and 33 responses, respectively, out of 89 in total). A decrease in the number of livestock and limited market options for products from livestock farming were mentioned as drivers for all case study regions, except for the regions in Hungary, Portugal and Romania. For the regions in Italy and France this was explained by a declining demand for meat due to a change in diets. The low profitability of farming due to declining land quality, low yields and high costs of cultivation and limited accessibility were mentioned for all case study regions as drivers in the future. The decrease in population of young farmers and an ageing population in rural areas, with the consequent lack of labour force, were expected to increase abandonment of agricultural land in the future in the case study regions in Portugal, Bulgaria, Latvia, Hungary, Spain and Romania. This is particular the case for traditional smallholder farms in Portugal and Romania, for which a lack of competitiveness is exacerbated by desertification.

New drivers of agricultural land abandonment in the next ten years were mostly broader socio-economic drivers and drivers from natural constraints (eight and ten responses respectively out of 27). In the first group, distortions in the market for agricultural products were mentioned as new drivers for the region in Latvia due to the availability of more completive produce from other EU countries with intensive agricultural land use. Competition from countries outside Europe was mentioned as a constraint on agricultural production in the region in Italy. A lack of alternative crops was mentioned for the Soria region in Spain. Drivers concerning the land market include increasing land prices in Latvia because foreigners buy agricultural land at higher prices than Latvian property owners. For the Normandie region in France, respondents indicated that the abandonment of agricultural land is not expected to accelerate, because of an increasing interest in land for diversification to new forms of agriculture and for biomass crops for energy and other non-food uses.

New drivers mentioned from natural constraints were mainly related to climate change, with insufficient rainfall during the growing season, uneven distribution of rainfall, extremely high temperatures, drought, water stress and high temperature limiting rainfed agriculture in several regions. According to some respondents there is a need for new technologies and other crop types adapted to the new climate conditions.

*Development of drivers*

Respondents from all case study regions expected drivers for agricultural land abandonment to increase in the future (six or more responses per region). Climate change, declining land productivity, advance of desertification and land degradation were mentioned as drivers from natural constraints. Rural depopulation, shortage of labour force, ageing population, low prices for products on agricultural markets, international competition, infrastructural developments, land take for urban use and infrastructure, and afforestation were mentioned as broader socio-economic drivers. As socio-economic drivers at farm level, decreasing profitability, fragmentation of holdings, increase in production costs, and ageing of farm holders were thought likely to become more pronounced.

The drivers from policy that were mentioned to increase land abandonment were the decreasing support for young farmers under rural development plans (case study region in Bulgaria), a diminished interest in agricultural use of the land due to obligations from environmental regulations (case study region in Latvia) and reduced support from the CAP (case study region in Spain).

Respondents also mentioned trends leading to a decrease in agricultural land abandonment, mostly referring to broader socio-economic drivers. These include a strategic interest at national level in self-sufficiency for food production, and renewable energy production as an opportunity to revitalise rural areas (case study regions in Croatia, Italy). A renewed interest from citizens and foreigners in small-scale farming and living in rural areas were mentioned for the case study regions in Portugal, Latvia and Italy. Respondents from the regions in Bulgaria, Latvia, Spain and France reported a trend of increasing size of farm holdings, in some regions along with an increasing demand for agricultural land. For the case study region in Hungary, problems with land ownership are decreasing. In the case study regions in Bulgaria and Spain, an increasing farm size leading to higher profitability of farms in the regions in Bulgaria and Spain. Also mentioned as factors diminishing agricultural land abandonment were an increase in regional income levels enabling part-time farmers to keep agricultural land in good condition and increased knowledge and entrepreneurial activity of farmers (case study region in Latvia).

## 3.4 Conclusions: classification of hotspot regions according to main drivers that lead to lands becoming unused, abandoned and degraded

The literature review on agricultural land in the EU becoming unused, abandoned or degraded highlights that these transitions are caused by combinations of drivers which develop(ed) from different historical and geopolitical contexts. Industrialisation, the development of markets for agricultural products, and urbanisation characterised changes in agricultural land use in Western Europe. In Central and Eastern Europe, the change of political systems after the breakdown of the Soviet Union triggered abandonment of agricultural land, mainly due to the reform of the agricultural sector and the redistribution of land.

Agricultural land abandonment can be triggered by unfavourable agro-ecological conditions, socio-economic drivers operating at the level of farm holdings and regions. Drivers from policy appeared less prominent. The main policy influencing the use and management of agricultural land is the CAP. This policy can both reduce and increase drivers of agricultural land abandonment. An increasing effect was attributed to definitions of agricultural land by Member States that determine eligibility for direct payments.

In the EU-28, 29% of the agricultural area is marginal, occurring mainly in deep rural and rural areas (Elbersen et al., 2018). Mechanisation and modernisation of agricultural practice has induced abandonment in these areas as it is not possible to deploy these practices. Mountain areas are particularly sensitive to agricultural land abandonment.

Socio-cultural motivations may explain the maintenance of agriculture in regions where it is not economically viable, sometimes manifesting in hidden land abandonment. Productivity gains in some areas may lead to the abandonment of agricultural land in other areas, and employment opportunities in other sectors may reduce agricultural land use. Declines in rural population are a key driver of agricultural land abandonment in many parts of the EU, not only in the CEE countries. Accessibility and the level of rural infrastructure appear to be key factors for maintaining land in agricultural use and keeping population in rural areas.

In the case study regions, less than 5% of the agricultural area appeared to have been subject to forms of abandonment. The land that was abandoned in the past 20 years was mostly in use as arable land, permanent grassland, or was marginal land. These types of land are also considered likely to become abandoned in the near future. Abandoned land transformed into shrubs and combinations with trees or grassland. This leads to an increased risk of forest fires and soil erosion in some regions.

Specific locations where agricultural land was abandoned are in hilly or mountainous areas in remote locations, or in protected areas under the Natura 2000 regulation. Agricultural land near urban centres are also subject to abandonment in some areas, where conversion to built-up land is generating benefits and populations are leaving in search for employment.

The main drivers for agricultural land becoming unused or abandoned are of socio-economic character, operating either at the level of the farm holding or of the region. The most important drivers at farm level are the profitability of holdings, the productivity of the land for crops and livestock, production costs, fragmentation of farmland, and issues with land tenure and ownership. Depopulation of rural areas was the most frequently mentioned driver at the regional level, in all cases associated with an ageing population of landowners that remains. These trends were reported to lead to shortage of both skilled and unskilled agricultural labour, an uneven distribution of income, employment and investments in the region, and rural areas characterised by higher levels of poverty. A lack of transport infrastructure and public services in rural areas characterises several case study regions.

Agriculture as an economic sector is becoming less profitable in all case study regions except one. This increases the trend of young people leaving rural areas. Interest in agricultural land was reported for investment, construction, recreational use and afforestation.

In contrast to what the literature reports, natural constraints for agricultural land use and land degradation were not the most important drivers for agricultural land abandonment in the case study regions, although they were mentioned to occur in all regions. Adverse climate and unsuitable soil properties or terrain for agricultural use were the most frequently mentioned factors. In some regions land degradation reinforces abandonment of agricultural land or is expected to do so in the future under changing climate conditions. The types of land degradation reported are induced by use and management of agricultural land in place (soil erosion, soil organic matter decline) or originate from external sources (contamination, salinisation due to sea-level rise). In only a few case study regions does agricultural land abandonment lead to land degradation, taking the form of wildfires and soil erosion.

Few drivers from policy for agricultural land abandonment were identified in the case study regions. Those mentioned concern the possibility to obtain agricultural support payments under the CAP and the lack or failure of national policies to support agricultural production and rural development. A deficient land administration or cadastral system was mentioned for several regions.

The current socio-economic drivers leading to agricultural land becoming abandoned, unused or degraded in the case study regions are mostly expected to continue or increase in the future. New drivers come from distortions in agricultural markets due to competition from EU countries with intensive agriculture or from countries outside Europe. Climate change is expected to constrain rainfed agriculture in several case study regions, in particular on marginal land.

The case studies also revealed decreasing trends of land abandonment due to a strategic interest in self-sufficiency for food production in some regions, and in renewable energy production as an opportunity to revitalise rural areas. In some regions there is a renewed interest for agriculture and an increasing demand for agricultural land due to increasing levels of regional income and enlargement of farm holdings.

# 4 OPTIONS AND IMPEDIMENTS FOR USE OF UNUSED, ABANDONED AND DEGRADED LANDS FOR BIOMASS CROPPING FOR BIOFUELS AND OTHER USES

**Chapter aim and contents:**
This chapter presents the main findings from the literature review and the regional case studies regarding the types of non-food biomass crops and the barriers and opportunities for growing them on unused, abandoned and degraded lands. These barriers and opportunities are important to take into account when making policy recommendations for growing these crops.

## 4.1 Introduction and approach

Sustainability in relation to non-food biomass cropping on unused, abandoned and/or degraded lands is an important issue in the policy and scientific debate. When looking at land uses for non-food cropping, several studies indicate sustainability risks such as a loss of ecosystem services (Bindraban et al., 2009; Fargione, 2010; Berzky et al., 2011; Immerzeel, 2014; Plieninger and Gaertner, 2011), competition with food production (Royal Society, 2008; Salomon et al, 2010; Harvey and Pilgrim, 2011), and GHG emissions (Valin et al., 2015; Frank et al., 2013; Lapola, 2010; Laborde, et al., 2011; Daioglou et al., 2020). However, many other studies claim that win-win situations can be created with the production of non-food crops on unused, abandoned and/or degraded lands (Dauber et al., 2012; Cossel et al., 2019; Smeets et al., 2009; Dale, 2010; Fernando, 2005; Zegada-Lizarazu et al. 2010; Zimmermann et al., 2012; Haughton et al., 2016).

In this chapter the main outcome of a literature review and the regional case studies is presented regarding the types of non-food biomass crops and the barriers and opportunities for growing them on unused, abandoned and degraded lands.

## 4.2 Bringing unused, abandoned and degraded lands back into agricultural production – opportunities and barriers

The options for creating environmental co-benefits from the production of industrial crops on unused, abandoned and/or degraded lands depend very much on what type of land conversions are involved, time between lack of use and conversion to new crops, type of crops used (perennials or annuals), management practices, and the presence of other uses and ecosystem services (Pedroli et al., 2011; EEA, 2013 and ETC-SIA, 2013; Immerzeel et al., 2014).

The additional demand for biomass cropping comes from markets which are influenced by policies and societal ambitions to decarbonise the economy through shifting from a fossil to a renewable resources based economy, the bioeconomy. It is therefore crucial that biomass produced to supply the renewable bioeconomy does not create additional $CO_2$ emissions through direct and indirect land use changes, but rather leads to an additional mitigation of emissions and capturing of $CO_2$. The focus on unused, abandoned and marginal land in RED II is based on the expectation that it will help avoid indirect land use changes and related $CO_2$ emissions and loss of biodiversity while satisfying the additional demand for biomass. The literature review and case studies presented here focus on the barriers and opportunities for converting unused, abandoned and/or degraded lands to dedicated cropping for energy and other non-food uses in the bioeconomy. This includes an overview of the sustainability risks and opportunities found in literature.

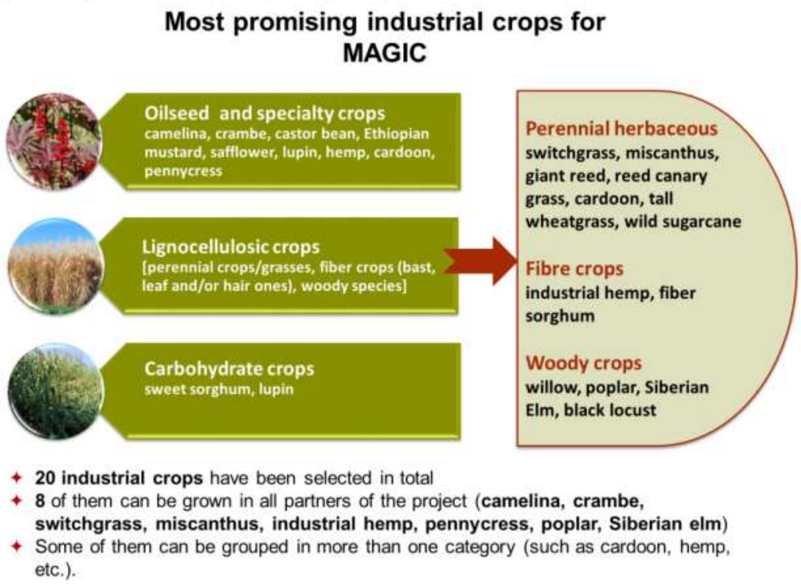
## 4.3 Sustainable cropping for biofuels and other non-food uses on unused, abandoned and degraded lands

*4.3.1 Agronomic suitability of potential crops for biofuels and other non-food uses in EU-28*

When looking at the barriers and opportunities of dedicated cropping for energy and other non-food uses, a distinction needs to be made between:
annual arable crops (for example, maize, oil seed rape, sunflower) that are used for food and feed production and also for producing first generation biofuels; these are most often grown on good agricultural land where they provide economic yields (Elbersen et al., 2013; Michel et al., 2012); and
industrial biomass crops, which are mostly perennial herbaceous or woody crops (Figure 4.1) and are not used for food or feed (for example, miscanthus, SRC willow or poplar, some forms of agroforestry)

The potential for displacement of food or feed production is mainly related to the first group of crops when sold for use as feedstock for first generation biofuels.

Figure 4.1 Most promising industrial crops for marginal lands in Europe.




Source: MAGIC D1.3 (Alexopoulou, 2018).

For industrial biomass crops, there are many crops and species that can cope with marginal production circumstances where natural constraints adversely affect the agricultural use and yield potential (see Chapter 3). This also applies to certain agroforestry systems that can be used for the combined production of food and biomass for energy and other non-food uses, particularly in marginal situations with limited water availability. Therefore, these types of crops and cropping systems are of interest to be grown on unused, abandoned and degraded lands as these lands often have marginal characteristics (Immerzeel et al., 2014; Dale, 2010; Cossel et al., 2019; Ciria et al., 2019; Gerwin et al., 2018; Alexopoulou, 2018).

There is increasing evidence that there are several types and species of non-food crops that can cope better with marginal soil and climatic conditions then average (mostly rotational) food crops (Cossel et al., 2019; Ciria, 2019; Pulighe et al., 2016; Lewandowski et al., 2016; Ramirez et al., 2017; Ciria et al., 2020). Many of these crops are tested in marginal circumstances in the EU H2020 project, MAGIC.

There are several reasons why perennial biomass crops cope better with marginal circumstances. Compared to annual crops, these perennials do not require soil tillage and sowing each year. This facilitates their growth under more difficult topographic circumstances such as steep slopes, heavy clay, wet soils, and stoniness. The perennial crops are also deeper rooting than rotational arable crops, which stimulates the building up of below ground biomass (McCalmont et al., 2017; Chimento et al., 2014) and facilitates access to water resources (once the plants are established). Miscanthus and switchgrass are also more water efficient[17]. Several biomass crops (for example, giant reed, cardoon, and kenaf) are more drought tolerant then most food crops, which enables them to survive better during long periods of drought. There are also examples of biomass crops, such as willow, poplar and reed canary grass, that can cope well with excessive soil moisture which makes them suited to grow in marginal lands with limited soil drainage and water logging. Marginal lands are also often characterised by low fertility levels. Research has shown that both miscanthus and switchgrass can cope well with low nutrient levels because of their efficient use of nutrients, due to efficient remobilisation of nutrient reserves to the root system of the plant before it is harvested (in winter), making the nutrients available for the next year's yield (Lasorella et al.,2011; Haines et al., 2015).

#### *4.3.2 Sustainability and co-benefits of potential crops for biofuels and other non-food uses*

### *Soil*

There is little doubt that intensification of agriculture has had strong adverse effects on soil quality (Jones et al., 2012, Panagos et al., 2015). This also applies to converting unused lands to biomass cropping, because introducing a cropping activity will always imply more soil disturbance and therefore higher risk for soil erosion and loss of nutrients and carbon (Verheijen et al., 2009). With permanent crops (perennials), once established, disturbance is less frequent than with rotational arable crops where field preparation occurs at least annually.

In contrast to rotational arable crops, perennial lignocellulosic crops have been shown to be effective in enhancing soil structure, building up soil organic carbon (SOC), improving the water holding capacity of the soil and reducing erosion, when compared to annual crops (Lewandowski, 2015; Cossel, 2019, Pencaldi and Trindade, 2020; McCalmont et al., 2017). The main reasons for this are lower levels of mechanisation (and thus soil disturbance) and year-round soil coverage of perennial crops, and deeper and well-branched rooting (Cossel et al., 2020; McCalmont et al., 2017; Emmerling and Pude, 2017; Pancalci and Trindade, 2020; Chimento et al., 2014; Fernando et al., 2018; Carvalho et al., 2017). According to Kuzyakov and Domanski (2000) and Chimento et al. (2016), an additional reason for miscanthus' ability to build up carbon in the soil is that it allocates high proportions of the assimilated

[17] These belong to the C4 photosynthetic group, and are therefore more water efficient, as they transpire less water per unit biomass (Ramirez et al., 2017; Cossel, 2019; Lewandowski, 2015).

carbon below ground as a carbon reservoir for growth in the spring. This was confirmed by Chimento et al. (2016) and in field trials for miscanthus, switchgrass, giant reed and three woody crops (willow, poplar and black locust) that, compared to grain maize, on average built up 45% more SOC in the root zone. A meta-analysis study (Agostini et al., 2015) showed SOC storage for herbaceous perennials (miscanthus and switchgrass) of between 1.14 to 1.88 mg C ha/year and for woody perennials (willow and poplar) a range of 0.63 to 0.72 mg C ha/year. However, these authors emphasise that long-term field trial data (>25 years) are missing and is needed to confirm the long-term sustainable soil carbon enrichment (because the stability of recently built up SOC stores is uncertain).

The effect of perennials on building up SOC is particularly large in marginal land with low SOC levels (Tilman et al., 2009; Pencaldi and Trindade, 2020; Whittaker et al., 2018). However, if biomass crops are established on land that already has high SOC levels, such as long-abandoned land with dense shrub and/or forest vegetation coverage or wetlands, this may lead to a serious decline in carbon (both above and below soil). In these situations, it is very difficult to build carbon up again in a short period of time (Fargione, 2008; Robertson et al., 2017; Daiaglou et al., 2020; Whittaker et al., 2018).

Jones et al. (2015) confirmed that the effect on soil carbon by perennials is very much dependent on the land use before the perennial plantation is established, in the case of conversion of permanent grassland and arable land to a miscanthus plantation. Clearing and tillage of grasslands for miscanthus cultivation results in SOC losses that can only be restored after several years of miscanthus yields. This restoration period is variable and depends on the yield evolution of the Miscanthus. A full restoration of the SOC within the plantation's lifetime may be challenging, particularly on low-yielding soils (Jones et al., 2015; Richards et al., 2017).

Continuous ground cover, low levels of soil disturbance, and the extensive rooting systems of perennial crops, including trees in agroforestry systems, are also reasons why they are very effective in reducing soil erosion. Torralba et al. (2016) showed that, compared to single forestry or pasture systems, agroforestry showed significantly more benefits in relation to erosion control and overall maintenance of soil fertility. The main reason is that agroforestry systems are efficient in reducing surface run-off of soils. Moreno and Pulido (2009) measured the effect of tree cover density in a dehesa agroforestry system on soil erosion. They showed that medium tree cover (55% tree cover) still has an erosion rate of 5.2 gr/m2/y, almost as high as for treeless pastures, while if the tree cover is above 80% the erosion rate declines to 0.9 gr/m2/y directly under the canopy and on average to 3.1 gr/m2/y in the field. The linear elements (of trees or shrubs) in agroforestry systems are wind breaks, reducing wind erosion and increasing soil fertility (Chifflot et al., 2005; Moreno, 2007; Smith et al., 2012).

### *Water quality*

Imbalanced fertiliser application, either mineral or organic, is a large problem is several EU regions because of the transfer of excessive nutrients to ground and surface waters (leaching/run-off). All field preparation, crop treatments and harvesting activities that involve heavy soil disturbance (for example, ploughing, tilling, or disking) or leave the soil bare for a period of time, may enhance the turnover of nutrients. This increases the potential risk of losing nitrogenous and phosphorus compounds, through surface runoff and soil erosion, to water resources where it may lead to eutrophication of ground and surface water resources.

Several studies have shown a combination of factors that explain very low nutrient leaching to water by perennial biomass crops. The deep and well-branched roots of these perennials mean that they hold large amounts of water and nutrients, the so-called 'plant root sink for nitrogen', which in row crops would more easily be lost through run-off and leaching. Other factors responsible for high nutrient use efficiency and low fertilisation requirements in many different perennial biomass crops are increased nitrogen uptake from air and/or through fine root systems, and the translocation of nutrients to the root system before the crop is harvested (in spring) (Aronsson and Bergstrom, 2001; Ruf et al., 2017; Cossel, 2020; Robertson et al., 2017; Jach-Smith and Jackson, 2018). In perennials, water transpiration rates are higher than for most annual crops and this also reduces water availability for drainage and nutrient leaching. Cacho et al. (2018) suggests perennials like switchgrass, miscanthus, big bluestem grass (Andropogon gerardi), prairie cordgrass (Spartina) are examples of grasses which create a dense soil cover and are therefore very effective in reducing water run-off and erosion and nutrient leaching to ground water.

Lower nitrogen leaching in perennials, compared to several different annual crops, was also reported by McIsaac et al. (2010), Ferchaud and Mary (2016), Smith et al. (2013); Robertson et al. (2017), and Sharma and Chaubey (2017). Acharya and Blanco-Canqui (2018) showed that SRC of willow and poplar reduced nitrogen leaching by between 70% and 98%, compared to rotational cropping systems with cereals, corn and soya. They also found that the phosphate leaching differences between perennials and rotational arable systems are much smaller. From these studies one can conclude that it is less damaging to water quality to grow perennial biomass than annual arable crops on abandoned land.

Evidence for adverse effects of agroforestry systems on water quality is scarce because, as several studies indicate (Kay et al., 2017; Torralba et al.,2016; Nair et al., 2005), the use of herbicides, pesticides and nutrient inputs is generally lower in agroforestry systems compared to mono-cultural cropping systems and intensive grazing systems. In addition to lower nutrient use, when compared to treeless systems agroforestry systems have more complete absorption of nutrients in the whole system. Trees take up the leached nutrients not used by the crops or the pasture. The effect of complete absorption is particularly strong in arid soils where water scarcity forces trees to root deeper. Several studies (for example, Kay et al., 2017; Lehman, 1999; Nair and Kalmbacher, 2005; Nair et al., 2005; Schultz et al., 2004) provide evidence that agroforestry systems are more efficient in reducing nutrient losses to surface and ground waters.

*Water quantity*

Many studies have shown that perennial biomass crops are more efficient in terms of water use, compared to most rotational arable crops, because they transpire less water per unit of biomass (Ramirez et al., 2017; Cossel et al., 2019; Lewandowski, 2015; Pancaldi and Trindade, 2020). According to the review by Pancaldi and Trindade (2020), for different perennial biomass crops the per hectare water needs are generally equal or outweigh annual crops such as maize, wheat and sorghum under similar growth circumstances. This is also because perennials have a longer growing season than annual crops which enables them to transpire water over a longer time period. In general, woody perennial crops and herbaceous perennial biomass crops of $C_4$ photosynthetic group (for example, miscanthus, switchgrass, tall wheat grass, wild sugarcane) are the most water-use efficient, certainly compared to annual crops (Robertson, 2011). The biomass produced per amount of water is higher, but if the total biomass produced is larger per hectare the total amount of water per hectare also increases. If there is enough water available, this is not a problem. $C_4$ crops are then the better option for water-efficient biomass production (Mehmood et al., 2017; Robertson et al.,2011). But under more arid circumstances, a C4 perennial is likely to have a larger effect on water source depletion then a $C_3$ perennial (giant reed, reed canary grass, cardoon) or common food crop. This occurs in a normal rainfed situation.

When irrigation is used, it will become an issue in both in rotational arable and in perennials, whether used for food and non-food, when it takes place in landscapes that have aridity and/or salinisation problems. Irrigation under these circumstances may lead to depletion of natural water sources and increased salinisation. This will also have adverse effects on the natural system. Introducing new biomass plantations is therefore not recommended in semi-arid and arid situations, particularly when these new plantations are irrigated. The situation becomes even less sustainable if the biomass plantations replace more deeply rooted woodlands or forests (de Fraiture and Berndes, 2009).

There are many biomass crops, both perennials and industrial oil crops (producing non-edible oils), that are drought tolerant. They may not produce optimal yields under these circumstances, but they will perform better than a conventional food crop and will survive in a wider range of rainfed situations (Mehmood et al., 2017; Robertson et al., 2017; Shafiei-Koij et al., 2019; Parvathaneni et al., 2017; Alexopoulou et al., 2018). For perennials this is due to factors such as the long growing season which enables them to have a prolonged evapotranspiration period, and their improvement of soil structures which increases the soil's infiltration and water storage capacity.

Another advantage is that for non-food crops there is the option to irrigate with waste waters, which is prohibited for crops used for food and feed purposes. In this case, perennial biomass crops can be used not only as a source of biomass, but may also provide water filtration services to purify polluted water.

When looking at water use in agroforestry, it is important to note that in the Mediterranean these systems have been particularly developed for farming in arid circumstances. Agroforestry entails the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal production systems to create shading which reduces the water loss through evaporation and enables higher water-use efficiency (Cannell et al., 1996; Lefroy et al., 1999; Nair, 2007; Torralba et al., 2016; Plieninger et al., 2015; Rigueiro-Rodríguez et al., 2009). The deep rooting system in trees and shrubs used in agroforestry also ensure that these systems cope well with the long drought periods typical of Mediterranean climates.

### *Air quality and climate mitigation*

The performance of GHG efficiency in biomass crops used for bioenergy and other non-food uses is an important consideration, particularly as one of the main reasons to grow these crops is to shift to a bio-based economy to reduce net GHG emissions overall. The most critical GHG emissions for these crops relate to nitrous oxide ($N_2O$) and carbon dioxide ($CO_2$) in the cropping phase.

The second largest source of direct GHG emissions in agriculture[18] is through $N_2O$ emissions from agricultural soil. Emissions are related to application of fertilisers, manure and other biosolids that, due to nitrification and denitrification in the field, form $N_2O$ (and NOx) that is released into the air. Lower manure and fertiliser application levels will reduce $N_2O$ emissions. Given this, it is no surprise that perennial biomass crops that require lower rates and less frequent applications of fertiliser perform better than annual crops in terms of $N_2O$ emissions. This was confirmed in a review of 28 publications by Whitaker et al. (2018) on $N_2O$ emissions from perennials (miscanthus, switchgrass, poplar and willow). It concluded that emissions vary widely, due to factors such as prior land use (arable land with annuals and permanent grassland), historic and current fertiliser rates, and time since the perennials were planted. There is a clear distinction in $N_2O$ emissions in perennials between the first two years of establishment and after three years of the plantation. High $N_2O$ emissions are caused by denitrification associated with high soil nitrate levels following soil tillage, herbicide application (to remove existing vegetation), increased residue decomposition, and/or fertilisation of the previous crop. Once the perennial is established (after two years) the $N_2O$ emissions are clearly much lower in perennial crops then in annual crops (Don et al., 2012; Drewer et al., 2012; Gauder et al., 2012; Gelfand et al., 2016).

Robertson et al. (2011) outline reasons for higher $N_2O$ emissions in annual crops, especially grain crops, including the low nitrogen efficiency of annual grain crops compared to their nitrogen demand. In temperate climates, there is a long period of absence of plants and thus plant uptake of nitrogen. This can be partly improved by including winter cover crops and advanced fertiliser management. In contrast, for perennials the nitrogen cycling and efficiency is much better. First, because they have a year-round cover, at least one to two years after establishment. Second, they have an overall lower nitrogen demand then grains. Most perennials translocate the nitrogen to the root zone in winter before the leaves fall off and harvesting is done in early spring.

As in all other agricultural sectors, energy use in mechanisation, and in the production of inputs (for example, fertilisers, pesticides) goes together with GHG emissions. Therefore, any farming activity requiring energy, through use of mechanisation or other mechanical support, and any input uses requiring large energy inputs for their production, leads to GHG emissions (mostly as $CO_2$). It is also logical that cropping systems that require lower mechanisation, like perennial systems, have lower $CO_2$ emissions then annual crops. Combined with the ability of perennial crops, including trees, to capture SOC, it is logical to assume that perennial biomass crops have a better net GHG performance then annual crops, although not better than leaving unused and abandoned lands undisturbed.

The ability of agroforestry systems to sequester carbon depends on tree species and tree density, but also the type of agroforestry system (trees with pasture or trees with permanent or annual crops). According to Rigueiro-Rodriguez et al. (2009) the sequestration capacity increases with the tree density, until the density becomes too high and there is competition between trees for the same resources.

Valin et al. (2015) undertook an extensive modelling study to assess the direct and indirect land use emissions for different crops to biofuel pathways. This showed that advanced biofuels have negative

[18] After methane, which comes mostly from livestock systems.

land use change emissions if produced from short rotation coppice (-29 $gCO_2e$/MJ biofuel consumed) or perennials (-12 $gCO_2e$/MJ), mainly because of the increase in the carbon stock on land that is converted to produce these higher carbon stock crops. Whitaker (2015) indicates that although our understanding at the system level of the GHG balance of dedicated perennials on abandoned, degraded and marginal lands is still limited, evidence so far indicates that the use of perennials can provide significant GHG savings compared to fossil fuel alternatives, provided reasonable yields are reached and low carbon soils are used.

*Biodiversity and ecosystem services*

Trying to assess the effects of any change in land use on biodiversity and the environment as a whole is extremely difficult because of imperfect knowledge. It is unclear how organisms are distributed in the landscape, how they function, and how management practices on the land affect them (Carey, 2015). For biodiversity conservation there are four landscape measures of crucial importance: the amount and quality of habitat, spatial configuration of the habitat within the landscape, and landscape permeability. If these factors are disrupted through changes in land cover and/or land management, through, for example, the introduction of biomass cropping, this may, depending on the size of the changes and the type and presence of biota, eventually lead to what Bertzky et al. (2011) call edge effects. These include lower species population sizes and composition, the invasion of disturbance-adapted species which dominate over rarer and threatened species, and overall habitat quality losses through, for example, lower humidity in the soil or lower air moisture and loss of living biomass.

The question is very much what biodiversity was present in the unused land before it was converted to biomass cropping and, once the crop is established, how it contributes to the four landscape measures. If the abandoned land has become an important haven for valuable species with conservation value, it is clear that conversion of these lands into biomass crops plantations leads to a loss of biodiversity. This will be most likely if these unused lands overlap with HNV farmland and/or Natura 2000 areas. In these cases it is better to choose to bring back traditional extensive farming practices or rewilding of the land than to bring it back into agricultural production, as this will lead to a loss of habitats (Allen et al., 2013). On the other hand, the introduction of biomass crops, particularly perennials, can also provide opportunities to improve the landscape measures supporting local biodiversity. This may be the case if there is little diversity in the surrounding landscape and newly introduced biomass fields provide new habitats to species to shelter, roost and feed (Pedroli et al., 2012; Dauber et al., 2010). Pincaldi and Trindade (2020) point to studies that claim that degraded lands that are converted to dedicated perennial crops will gain in biodiversity (Dauber et al., 2010; Meehan et al., 2010; Robertson et al., 2011; Chauvat et al., 2014).

Once a biomass cropping plantation is established, studies suggest that many biodiversity effects can be expected. Werling et al. (2014) demonstrated an overall wider species diversity in perennial biomass crops compared to more monotonous annual cropping systems. Similar conclusions were reached for bird diversity (Meehan et al., 2010; Londo, 2002), and diversity in insect communities (Gardiner et al., 2010; Bennett et al., 2014; Haughton et al., 2016. Haughton et al. (2009) reported a greater abundance of butterflies in field margins around miscanthus and SRC compared to arable crops. Soils under miscanthus showed an enhanced diversity of earthworm communities and a more balanced species composition (Felten and Emmerling, 2011). The ecosystem service of pollination is also enhanced by perennials (Bennett and Isaacs, 2014; Carlsson et al., 2017; Liere et al., 2015).

Manning et al. (2014) provide options to apply wildlife friendly practices in biomass plantations including agroforestry systems. They also suggest that new bioenergy plantations are located in a more strategic way that considers landscape context and is sensitive to how they affect biodiversity and ecosystem services. This involves planning the spatial arrangement of bioenergy plantations so that they interact positively with other landscape units. It also requires an understanding of how the impact of bioenergy crops on biodiversity and food security varies depending upon their biological and environmental context. In general, greater habitat diversity is associated with greater bird biodiversity (for example, Aebischer and Ward, 1997; Burel et al., 1998; Evans et al., 1995; Hurford, 1997; Robinson, Wilson and Crick, 2001). Any agricultural monoculture, be it arable or grassland, reduces habitat diversity and has the potential to damage bird populations. The effects of monoculture may operate temporally as well as spatially, for example causing rapid changes in resource availability depending on the stage of crop development or cultivation (Holland et al., 2002).

According to Moreno-Marcos and Pulido (2008), mature dehesas are among the most biodiverse man-made landscapes in Europe. Several studies identified by Rigueiro-Rodriguez (2009) show an increase in biodiversity (species numbers) when moving from open grasslands to agroforestry (for example, Cuthbertson and McAdam, 1996; Dennis et al., 1996; Burgess, 1999). The spatial heterogeneity resulting from the combination of pastures and/or crops with trees in agroforestry leads to diversity in structures at the plot and landscape scales. Due to this heterogeneity, agroforestry systems provide food, shelter, habitat and other resources to a wide diversity of species (Rigueiro-Rodriguez et al., 2009; Moreno et al., 2013; Hartel et al., 2013). In an agroforestry landscape there are therefore more ecological niches created by the variety of light conditions, temperature, wind, and soil cover.

Agroforestry also performs better in species richness compared to forest systems, which is not surprising as the reference scenario is likely to be dominated by production forests which are relatively species poor, with relatively low diversity in ecological niches. Furthermore, higher biodiversity levels occur, compared to closed forest ecosystems, particularly in agroforestry systems that have large old trees that are known to act as 'ecological keystone structures' (Plieninger et al., 2015; Manning et al., 2006; Hartel et al., 2014).

## 4.4 Opportunities and barriers for crops for energy and other non-food uses on unused, abandoned and degraded lands

### *4.4.1 Socio-economic barriers and opportunities*

The overall advantage of growing dedicated biomass crops for energy and other non-food purposes on unused, abandoned and degraded lands is avoiding competing with current food or feed production. Beside this, the introduction of biomass crops on unused lands may lead to additional income, create new employment, and can therefore improve overall rural development. This not only applies to employment creation on the farm/land, but also job creation further up the supply chain, particularly if the biomass is processed locally (Thornley, 2008; Valentine, 2012). It may also help to diversify the income of farmers and create local access to new and clean energy resources.

Given these advantages, one would expect large-scale uptake of dedicated biomass cropping on unused, abandoned and degraded lands. In practice this is not the case. So far very little evidence exists of the uptake of biomass cropping in general, let alone on unused lands. Lewandowski et al. (2016) estimated that for miscanthus, considered to be the most promising biomass crop (EC, 2018; Van de Weijde et al., 2017), only 20,000 ha are currently grown in the EU-28. The FSS data confirm 514,260 ha of SRC plantations in the total EU-28 for 2016, the only category of woody perennial biomass that is now separately registered in agricultural statistics. This is a very small area, amounting to only 0.3% of the UAA in the EU. To what extent these crops were grown on formerly unused, abandoned or degraded land cannot be determined from the statistics.

There are several reasons for the low uptake so far of dedicated biomass crops. A key aspect is uncertainty about its financial return, as the market demand for biomass crops is generally not well developed. This specifically concerns lignocellulosic biomass crops most suited to being grown on abandoned and degraded land. Mehmood et al. (2017) show that the cost of biofuels based on perennial grasses is still too high and cannot compete with fossil-based fuels. This disparity is further challenged by the lower yield levels of these crops when grown on unused lands which are generally of lower quality than agricultural land still in use. Cossel et al. (2019a), for example, indicate that a minimum yield of 11 tons of dry mass per hectare is required to make biogas production from miscanthus economically viable, but such a yield may not be realistic on marginal land. Similarly, the OPTIMA project (Soldatos, 2015) found that biomass crops grown on marginal lands with a yield below 10 tons of dry mass per hectare were not expected to be economically viable. Cossel et al. (2019a) and Mehmood et al. (2017) therefore emphasise the importance of also paying for ecosystem services delivered by perennial biomass crops when grown on unused, abandoned and/or degraded lands, in order to improve the economic performance and therefore uptake.

As well as the low yield and related economic challenges, unused, abandoned and certainly degraded lands can present many technical challenges to making the land suitable (again) for biomass cropping. Helliwell (2018) indicates that this usually requires large investments in, for example, removing the biomass that has grown through natural succession, improving the soil conditions in terms of nutrients and water-holding capacity, and arranging access to irrigation water in cases of arid environments. Making such investments is usually not very appealing to farmers, particularly when the expectations for good economic returns from the new crops are low.

Another factor limiting the uptake of biomass crops is the lack of knowledge and experience among farmers with these often-novel crops (Cossel et al., 2019a; Helliwell, 2017; Adams and Lindegaard, 2016).

For annual industrial oil crops, particularly those that may deliver specialty oils with specific high-value characteristics of interest to the biochemical industries, the economic viability may be better, even at low yields. This particularly applies to oil crops such as crambe, camelina, castor bean, Ethiopian mustard (Alexopoulou et al., 2018).

The establishment of agroforestry systems on unused, abandoned and degraded land may offer several opportunities. The creation of new agroforestry systems can be designed to yield different types of products both from the trees and the crops or grasslands they are combined with. As such they may also give additional income, employment and diversification of income opportunities. Graves et al. (2007), for example, showed that agroforestry systems can increase overall yields up to 40%

relative to monocultures in both arable and forestry systems. Kay et al. (2017) compared agroforestry and non-agroforestry systems and showed that the total annual yields of the harvested biomass in agroforestry (mainly crop yield and prunings) were lower than in single agricultural systems. However, the opposite applied to agroforestry systems in the Mediterranean.

### *4.4.2 Factors that enable or hamper the use of agricultural land for biomass production*

A study of renewable energy production on the farm identified six factors that affect farmers' choices on biomass for heat, power and fuel. These are summarised in Table 4.1, along with evidence from the case studies.

Table 4.1 Factors that enable (E) or hamper (H) the use of agricultural land for biomass for energy or other non-food uses production

| Factor | EIP-Agri | Case studies *(with examples)* |
|---|---|---|
| **Economic and financial** | **(E)** Stable financial instruments and transparency; regional scale business models; collective approaches could be useful (in synergy with sustainable agricultural goals).<br>**(H)** High costs of equipment and financing. | **(E)** Market prices and diversification of income were key reasons for adoption of biomass cropping (All case studies).<br>**(H)** High investment cost (Latvia, Croatia), unstable market (Spain, Hungary). |
| **Technical** | **(E)** Investment in biogas storage capacity on farms. Pre-treatment technologies and costs need further development.<br>**(H)** Other outputs of biogas plant (heat, digestate as fertiliser or purified biomethane) require multiple markets. Complex to match seasonality of biomass supplies to energy demand. | **(E)** Availability of biomass processing plants and supply chain (Romania).<br>**(H)** Lack of biomass processing plants and supply chain (Hungary, Croatia). Absence of support for testing technologies (Latvia). Lack of technical knowledge and expert advice (Croatia). |
| **Societal** | **(E)** Social acceptance can be enhanced if benefits are demonstrated. Inclusive business models in regions can increase support.<br>**(E/H)** Landscape impacts require attention. | **(H)** Lack of trust and cooperation within supply chain (Hungary). Conflict over use of food crops for energy (France, Croatia). Not enough use of agricultural residues instead (France). |
| **Regulatory** | **(E)** Stability in regulatory frameworks is needed, and a framework for sustainability of bioenergy. | **(E)** Local policy to replace coal with new biomass power plant (Portugal)<br>**(H)** Unclear government policy on non-food industrial crops (Croatia). |
| **Competition for natural resources** | **(E/H)** Sustainability of increased feedstock production is a key issue, including how to avoid competition with food production. | |

Sources: adapted from EIP-Agri (2019) and case studies for this report.

Both the literature and the case studies suggest that any scope for increasing bio-energy cropping is largely dependent on the market, which in turn is influenced by the presence of an effective supply chain, including the availability of processing facilities nearby (especially for heavy or bulky crops). A recent study pointed out that farmers growing SRC and energy grasses need certainty, and few will risk a 20-year investment unless the returns are better than those from other crop options (Rokwood, 2015b). The case studies suggest that, when farmers do introduce different crops, annual food crops, which can also be used for bioenergy (for example, rapeseed oil) or afforestation (not necessarily for energy production), are a more common choice than dedicated energy crops. Expanding bioenergy without monitoring and good governance of land use would risk significant conflict with sustainable food supply, resource use and biodiversity. Bioenergy policies need to consider regional conditions and priorities along with the role of agricultural (crops and livestock) and forestry sectors (Faaij, 2018). Some case studies did report emerging societal conflicts around the cultivation of food crops for energy generation, the use of agricultural land (not buildings) for solar or wind power, and the need to make better use of waste biomass (for example, crop residues). The importance of economic factors was summed up by the case study in Hungary: 'The whole idea can't work unless the value chain including the processing line is built up. A market must be created for the utilisation of biomass growth.'

#### *4.4.3 Evidence from the case studies on barriers and opportunities*

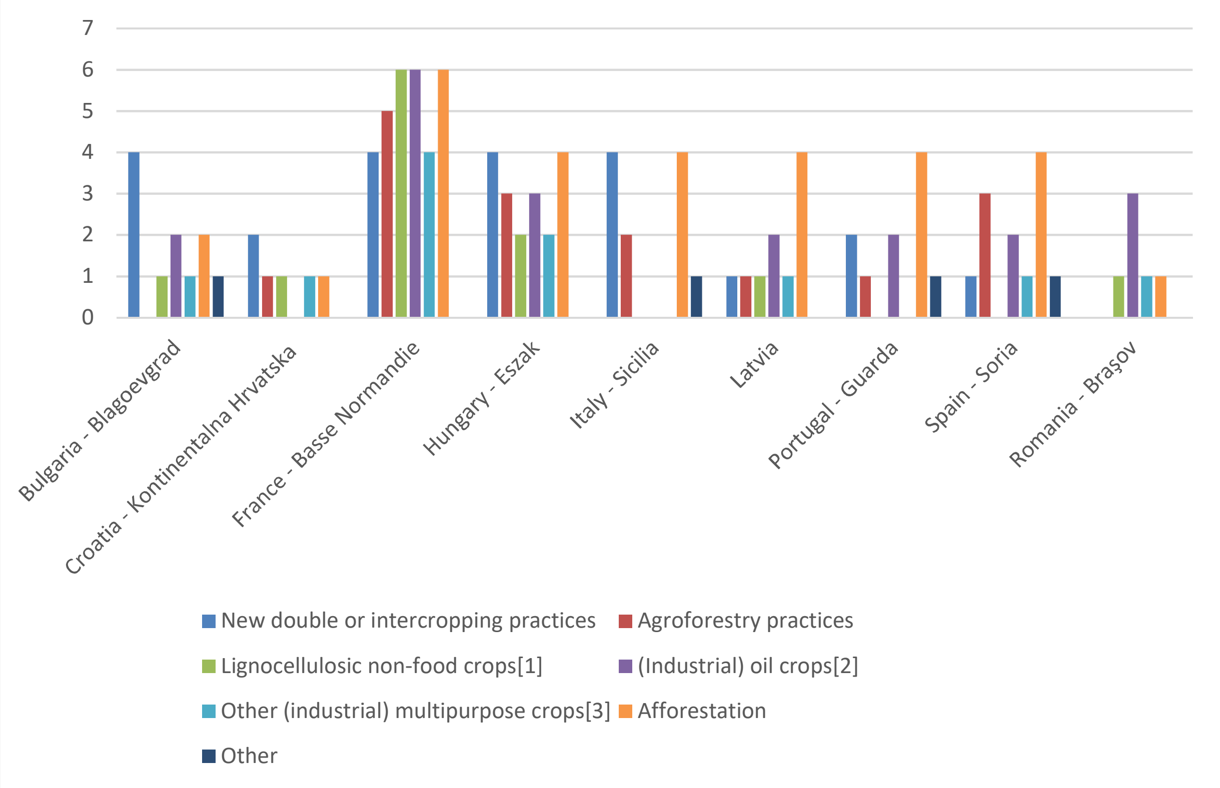
In the nine case studies, interviews were used to collect data on recent changes (in last 5 to 10 years) in agricultural land in terms of crop management and the reasons for this (for example, responding to markets) such as for example through the introduction of new/novel or cropping systems. It was also discussed whether farmers/land managers are considering alternative ways of using their land (for example, for horse paddocks, solar PV panels, rewilding, flood management) and the reasons for this. Finally the status of land being abandoned was discussed and whether it could be brought back to agricultural production, how if so and why if not.

*Recent changes in agricultural land uses and cropping systems*

Figure 4.2 shows that there are several new land management systems, crops and uses introduced in most regions. Overall, the introduction of these is not on a large scale, but was worth mentioning by the experts interviewed. The most commonly seen new land use is afforestation which can be a result of spontaneous vegetation growth of deliberate afforestation. This land cover change is important in almost all case study regions, except Kontinentalna in Croatia. Least common are lignocellulosic crops and industrial multipurpose crops. New double or intercropping practices are relatively common in Blagoevgrad, Kontinentalna, Basse Normandie, Eszak, and Sicily and much less in the other regions. The region where the most frequent shifts towards new crops take place is Basse Normandie in France.

From the experts interviewed there are expectations that some of the new crops, land uses and land management practices may help to prevent land becoming unused/abandoned (Figure 4.2). The average score of all nine case studies is highest for afforestation, followed by the introduction of new double and intercropping practices and then for lignocellulosic crop introduction. Afforestation score particularly more often in Sicilia and Guarda. New double cropping and intercropping practices are relatively more often mentioned in Blagoevgrad, Sicialy and Latvia. In Sicily these are only used in flat lands, where they are seen to help avoid abandonment because they increase yields. The introduction of industrial oil crops are seen as most effective in reducing abandonment in Soria. The contribution of lignocellulosic crops as a measure to prevent land abandonment is particularly supported by several experts in Basse Normandie, but also in Latvia and Soria. The opposite is the case for Guarda in Portugal and Sicily where it is not mentioned at all. The introduction of agroforestry practices as a measure to prevent abandonment were mentioned particularly often in Basse-Normandie. Trust in multipurpose industrial crops is only seen in Latvia and Spain.

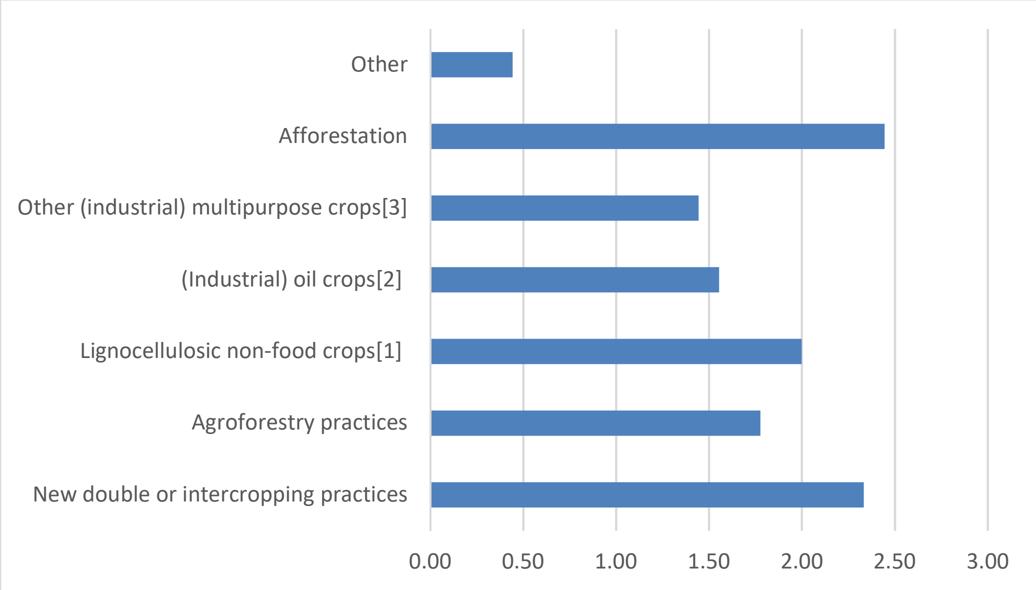
Figure 4.2 Responses to interview question: 'Are farmers/agricultural land managers in the region choosing different cropping management systems, types of agriculture and/or new crops compared to the systems and types applied in the past 5-10 years?'




Notes: [1] for example, miscanthus, switchgrass, reed canary grass, giant reed, SRC willow, SRC poplar, SRC eucalyptus, tall wheat grass, Siberian elm. [2] for example, rape, sunflower, soya, castor bean, camelina, crambe, pennycress, safflower, Ethiopian mustard. [3] for example, sunhemp, lupin, cardoon, biomass sorghum, cub plant.

In the Kontinentalna region in Croatia, and also in other regions in Bulgaria, Romania, and Latvia, farmers are seen to be choosing new crops compared to those grown 10 years ago. They strive for greater diversity of new crops and there is a widely observed change from cereals to more (industrial) oil crops (sunflower, soy, rapeseed) which may serve as food, but also for 1G biofuel production. In Croatia, the emergence of new crops is mainly driven by interest from younger farmers that see the need to diversify and respond to the market, and among farmers for which farming is a secondary activity. Therefore, novelties such as pumpkin, garlic, lavender, asparagus, aronia (*Aronia melanocarpa*) industrial hemp have appeared. There is also an increase in permanent crops in organic production, driven mostly by favourable payments under Measure 11 of rural development.

Figure 4.3 Average number of responses for all nine case studies to interview question: 'Do these types of agriculture or cropping systems lead to abandonment, or could they prevent abandonment?'




Areas under certain traditional crops such as tobacco and sugar beet in Croatia, Bulgaria, and Romania are decreasing and need to be replaced by novel crops, including the oil crops previously mentioned, but more specialty crops like saffron, raspberries, strawberries are also appearing in Eszak in Bulgaria.

In Sicily, like in Croatia, organic agriculture is mentioned by some experts as a fast-growing system which may also help prevent abandonment. The reasons given for this growth in Sicily were the need to make a difference on the market and get better prices to overcome competition; and the inclination to use more environmentally friendly cultivation techniques. This is a cultural leap that has led many farmers to reduce the use of pesticides and chemical fertilisers and go organic.

Afforestation is perceived very mixed. It is a very common land cover shift in all regions. In most regions it is also seen as an activity that can help prevent abandonment. An exception is Latvia, where it is rather seen as an activity leading to abandonment. This is logical when only agricultural land abandonment is considered, but overall abandonment of rural areas may be diminished by it. In Sicily, the approach to afforestation is changing towards the use of more endemic species. Previously afforestation was practiced with coniferous plantations, which are not endogenous. In Portugal, afforestation is still more focused on exotic species, particularly eucalyptus and pine. Eucalyptus is mostly produced for the paper industry, while pine has more multipurpose uses. In all regions where afforestation of agricultural land is significant it is encouraged through Rural Development Programme (RDP) measures. Lately these measures also support restoration and improved forest management interventions, such as replacing firebreaks.

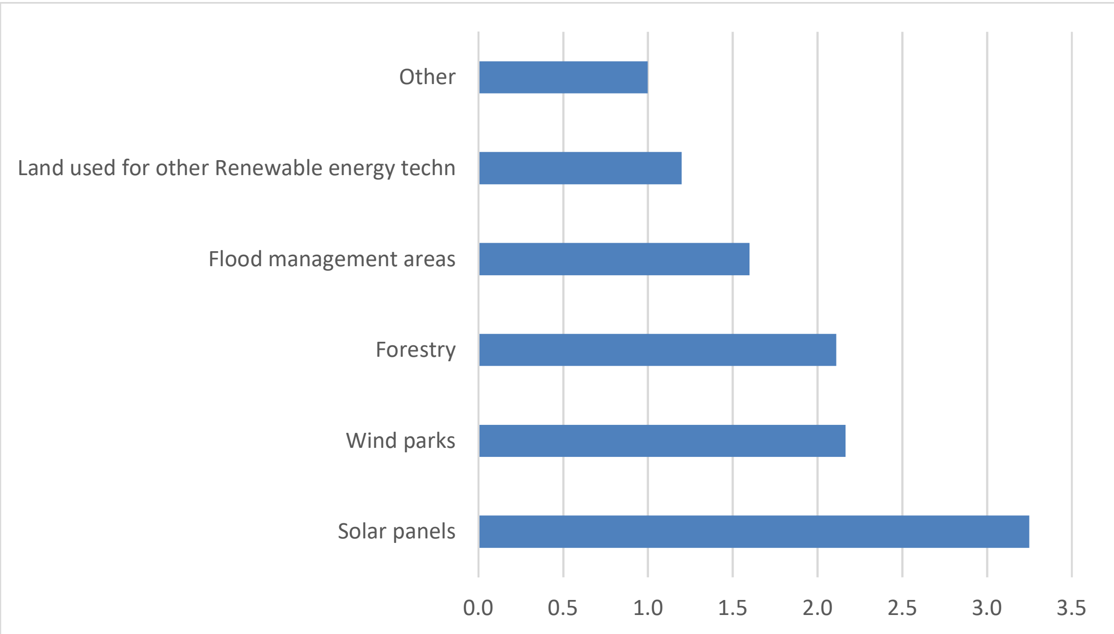
Some alternative land use strategies were also mentioned in some regions, such as in Basse Normandie where there was an increase in alfalfa which is beneficial to soil regeneration and soybean. This fits within the agricultural strategy 'La nouvelle politique agricole de la Région Normandie', (Normandie Region, 2016) in which farmers are encouraged to learn to mix crop and livestock farming and increase their own protein production for local livestock farming.

In the Guarda region of Portugal, there is a further intensification in farming, particularly in the lower flat parts of the region. In general, irrigated crops are expanding (in orchards in the south of the region) and mechanisation and professionalisation of the sector has taken place with the help of national and EU subsidies. Cultures that are expanding are berries, raspberry, blueberry, blackberry, arbutus, almond, walnuts, chestnut, quince, apple, cherry, peach, plums. In the more mountainous parts of Guarda in the north, agricultural land abandonment and afforestation continues. Similar developments are seen in the flat and coastal parts of Sicily, where there is a mention of increasing production of subtropical products, such as mango. Increases are also seen in the specialised production of almonds and olives.

#### *4.4.4 Shifts to non-agricultural land uses*

The experts in the case study areas were also asked whether shifts to other non-agricultural land uses had been observed in recent years, such as towards solar panels, forestry, other forms of renewable energy production, or other land uses. The responses in Figure 4.4 indicate that solar panels were seen most often and are developing in all case study regions, except for Guarda. Wind parks are also often mentioned but not seen in all the regions. In Basse Normandie, Soria and Sicily they were most developed.

Figure 4.4 Average number of responses to types of non-agricultural land uses that were seen introduced in recent years in the different regional case studies.




Experts in Sicily confirm a strong spread of solar panels for about ten years, but constraints have now been introduced, which make investing in the sector less profitable. Generally, solar energy is produced on rented land. Photovoltaics is the choice of entrepreneurs who want to reduce investments and risks and want to receive an income for no cost. It is not the choice of active agricultural entrepreneurs who invest and believe in their business. Typically, farmers who lend their land to photovoltaics companies are those who own marginal or unproductive lands. The farmers involved have two main concerns: 1) there is uncertainty about the management and related costs of waste disposal at the end of the contract; and 2) there is also uncertainty as to whether the rent is actually paid to the farmer. In other regions concerns are also raised by several experts about the creation of solar panels and PV parks. They suggest that policies should direct these as much as possible to rooftops rather than to agricultural lands, even if those lands are under threat of abandonment.

In the Kontinentalna region in Croatia, some solar panel development is seen on agricultural land, but these are more typical to Jadranska Hrvatska, while in Kontinentalna Hrvatska this mostly happens on small areas and rooftops. However, more serious developments are expected in near future, and there is much interest from investors. Wind parks or plans for wind parks in Kontinentalna Hrvatska are not known.

Forestry through afforestation happens or has happened in all case regions although not specifically targeted to biomass production for energy. In some regions this is related to the afforestation support in RDP. In other regions, forestry formation is more of a spontaneous process on long-term abandoned lands, particularly seen in the case studies in Croatia, Bulgaria, Romania. In Croatia, the interviewed representative of the farmers' association estimates that there is around 200,000-300,000 ha of forest on agricultural land as a result of previous land abandonment. There is also growing interest in short rotation coppice production, but this is not considered forestry. This estimation is in line with the statistical data for Croatia, which reveal a large increase in forest area from 2006 to 2018, by 279,834 ha or 11.3%[19].

However, the answers given indicate that more recently, in most of the case study regions, forestry is not taken up by farmers themselves as an option to diversify farming income. It is in Eszak, but in Basse Normandie, Sicily and Guarda it seems not to be a practice to which many farmers switch.

In a couple of regions, there is also mention of increasing introduction of biogas installations on farms, such as in Sicily, Kontinentalna and Basse-Normandie. In Basse-Normandie, biogas installations ('installations de méthanisation agricole') are mobilising more agricultural areas for crop production for co-digestion. Rotations incorporating main crops are sometimes less present than crops produced through intercropping. Silage maize as well as grasslands are sometimes diverted from their primary food role to supply to biogas installations. A regional reflection is underway on what should be regarded 'good agricultural practices' in the context of anaerobic digestion as part of the Normandy Methanization Plan.

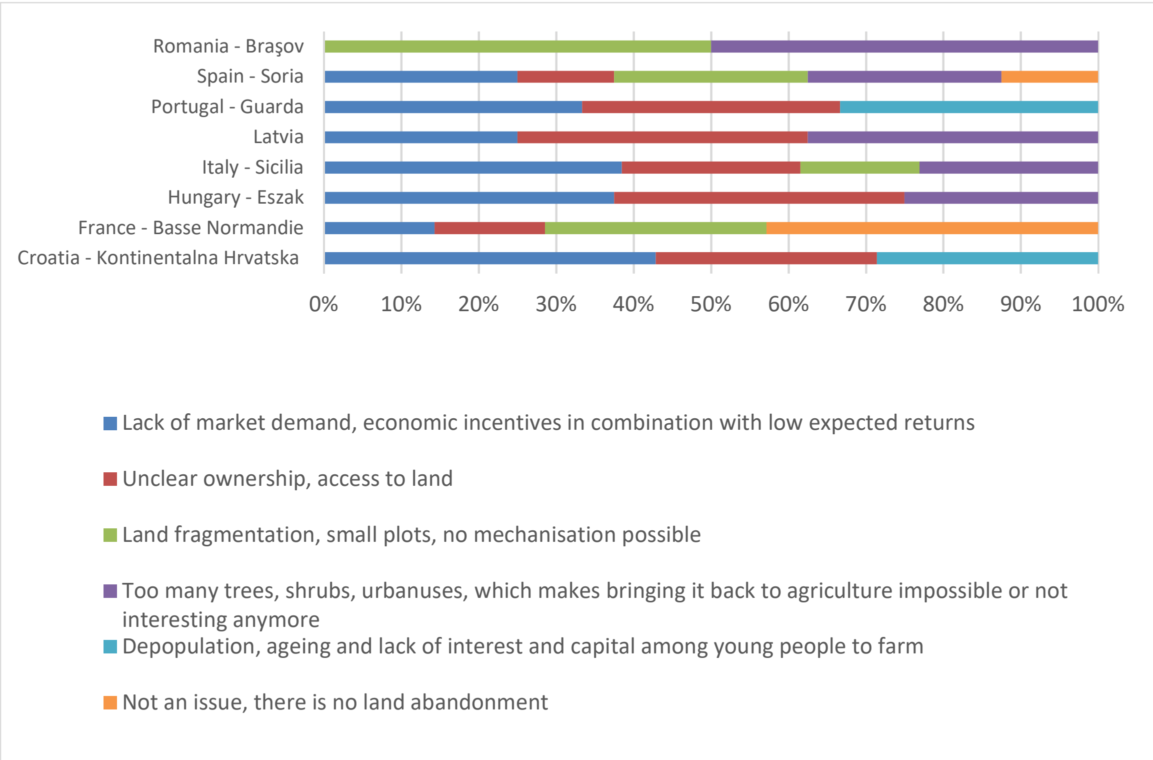
The most important reason mentioned in all case study regions for taking up new non-agricultural farming activities (see Table 4.1) is economic, the wish to both increase and diversify farm income. In some regions, such as in Kontinentalna and Eszak, there is specific mention of climate change effects which increase the urgency to increase income from non-agricultural activities.

[19] CBS Table 3. Forest land areas in ha, Croatia (Površine šumskog zemljišta u hektarima, Republika Hrvatska). Reference code: SUM3_HR

#### *4.4.5 Options for bringing back abandoned land in agricultural use*

First the experts were asked why abandoned lands have not been brought back into production until now. Answers to this question are summarized in Figure 4.5. Lack of market demand or low economic returns was the most frequent answer, followed by reasons related to unclear land ownership or access to land. In Basse Normandie, land abandonment is considered less of an issue than in the other regions. One overall reason mentioned in all case study regions is the lack of economic and market incentives making it unattractive to bring lands back into production. This, combined with the fact that bringing back these lands is costly and challenging, and the general marginal conditions in terms of biophysical constraints and the fragmented nature of such lands, make creating positive returns very challenging. Another very important issue, especially in Guarda, Latvia, Eszak and Croatia, is unclear land access rights. The specific contexts of the nine case study areas becomes clearer from the answers of several of the experts (see **Box 4.1**). The third main reason was that abandoned land was already covered with vegetation and it made no sense anymore to remove it and convert it back to agricultural use. The latter answer was only given in Eszak, Sicily, Latvia, Soria and Brasov. In Soria and particularly Basse-Normandie there were also respondents that said that there was no land abandonment in their region.

Figure 4.5 Answers given to the question 'With regard to land that has been abandoned, why haven't such lands been brought back into production?'



**Box 4.1 Examples of experts' answers to the question: 'With regard to land that has been abandoned, why haven't such lands been brought back into production?'**

**Sicily:**

'The settlement of young people in agriculture is high in Sicily, also thanks to the RDP. However, RDP is only partially successful, because the CAP follows an old-fashioned market logic. When the subsidies stop, young people will leave the countryside again, because the CAP subsidies didn't improve infrastructure, didn't build social capital. Once the land is abandoned in Sicily it is very difficult to bring it back into production. For example, the vegetation of abandoned forest areas grows in an uncontrolled way, and after a while it is very difficult to even enter it, you have to enter with bulldozers. After a wildfire, land restoration is very difficult. Farms often do not have the economic means to invest in it.'

'Abandoned land is often silent – the owners are unknown, perhaps they are people who have emigrated or have inherited their land without knowing it. They often are plots that were once used as pasture, but for low-scale, artisanal herding, which has now disappeared. The owners have lost the motivation to manage the land.'

**Croatia**:

'In general, people have skills to produce crops, but they do not know how to better market their product and create added value. The market is not reliable, there is a lot of insecurity, especially due to imports in recent years. Substantial expenditures that farmers must provide for the state, including taxes and different fees and payments, so that when all this is deducted, the profit is negligible and for many agriculture is not profitable. The situation somewhat improved with access to EU funds, subsidies, and markets (response from farmers' association) but not everyone knew how to create an advantage from this. The policies – direct payments, green payment, practice for environment – have contributed to keep some the land in production that would be otherwise abandoned.'

'The issue of agricultural land should not only be observed through the Ministry of Agriculture, but also Ministry of Environment, Ministry of Spatial Planning, and there is no policy coordination. The cadastre and land books are not in line. [With the] law on inheritance – deceased people are sometimes the owners, or the parcel is divided into ten parts. People in some areas choose to live in cities or chose occupations outside farming.'

The largest land abandonment occurred after the war (1991-95) in former Yugoslavia, when part of the population left, returning to their fields much later or never. In the eastern part of the region, a good part of these areas were brought back to production, but in the west significant areas are still abandoned and today covered with forest vegetation. Land in the eastern part is more fertile and easier to cultivate due to larger parcels, so production is more profitable.

' Most of the abandoned land is state owned. It is therefore not surprising that in 2018, changes in the Law on Agricultural Land (OG 20/18, 115/18, 98/19) transferred the authority for state-owned land management from the Agency on Agricultural Land to the local authorities (JLS) which should manage the land according to a programme for state agricultural land disposal, developed by each JLS and approved by Ministry of Agriculture. The Law was intended to decentralise land management, but it made an administrative maze. At the time of the case study, from a total of 555 JLS in Croatia (428 municipalities and 127 towns), 430 developed programmes had been submitted and 253 approved. Since the adoption of the Law, 40 tenders for state-owned land have been published, with only two being approved. Reallocation of state-owned land has been a sensitive topic, which has created uncertainties in the land market and, consequently, agricultural products market. Reallocation of state-owned land has generally favoured large agricultural enterprises.'

**Latvia**:

Some land had been put into the Land Reserve Fund to finalise the land reform. While the land is in the Fund, it is illegal to manage it and the municipality has been prevented from renting it out or managing it themselves. The future land use status of these lands was expected to change once the land reform has been finalised. As it has not been finalised many agricultural lands have remained abandoned.

Some landowners believed that agricultural land transformation is a complicated process and therefore do not transform their overgrown lands into forest land. They believe that paying a double tax for unmanaged agricultural land is much cheaper than the cost of land transformation, and are reluctant to initialise the cumbersome transformation process.
Many landowners might regard forests as a better form of investment that will have greater future returns compared to conventional agriculture. Several respondents observed afforestation and forestry as a preferred type of agricultural land

management, particularly among foreign investors. Transformation of agricultural land into forest land is also seen as opportunity to avoid paying a double tax for unmanaged agricultural land. Forests are also seen a more secure option for long-term investment and source of income for future generations.

**Guarda**

'There are no young people left and there is no capital to invest. Also the owners or heirs of the lands have passed away, and neither share the land between them nor ensure it is used again. The lack of a cadastre aggravates this problem. Irresponsible land abandonment only started to be prosecuted after the deadly 2017 wildfires. A lack of profitability is not necessarily leading to abandonment since the livelihoods of these owners is guaranteed through other income sources.'

**Blagoevgrad**

The land was largely abandoned during the transition period of the 1990s. With the introduction of CAP payments after Bulgaria joined the EU in 2007, land started to be used again. First, the highest quality lands were put back into use, but over time more and more lower quality lands are now being restored as orchards, vineyards and crop fields. Least used is the low-quality land category of communal property (either state or municipal). The latter is used only for extensive livestock grazing, which in most places is insufficient to keep them in optimal biodiversity quality as pastures.

The first programming period of the RDP was launched in 2007-2013. This has had a positive impact on agriculture. During this period, many young farmers and small semi-subsistence farms were supported in the region. The farmers have seen the opportunity to improve their life and farming activities and modernise their farms by purchasing trailers, vehicles up to 3.5 tonnes, small tractors, and other second-hand or new equipment. The introduction of direct area payments increased the interest in grasslands of both livestock farmers and other farmers (for subsidies). In the Gotse Delchev-Garmen-Satovcha region some tobacco producers converted to field vegetables, but no economic alternative to tobacco has so far been found. Around 20% of all farms in the region are small farms and the RDP support is vital for them. Land previously belonging to agro-industrial complexes, which is remote and has no access to infrastructure (roads, irrigation, and so on,) is currently not under cultivation. Another issue is the recently introduced requirement to prove the right to use certain land ('legal basis for land use') for direct payments and RDP support, since the land in the region is very fragmented and owned by many owners. Parts of those lands are given as so-called 'white spots' to the farmers, while other parts are abandoned. This policy was introduced to provide a legal basis for farmers managing that land to claim CAP Pillar 1 subsidies even if they are not the actual owners.

The traditional tobacco production in Gotse Delchev municipality has been drastically reduced for several reasons: a worldwide reduction in smoking, large decrease in income from this crop (which was a labour intensive crop) and the abolishment of support under CAP from 2020. Climate change and unprofitable tobacco cultivation have led to land abandonment, and no alternative income has been found. There were trials with herbs, hazelnuts and lavender, but the climatic conditions and soils are not suitable for these crops. About 3% of the area with tobacco is currently abandoned. As an alternative, permanent crops are beginning to emerge, such as raspberries, hazelnuts, nuts and grasslands. Small livestock farms are also disappearing, with the inability of older farmers to cope with the new requirements, and because of the aging population. Modern farms supported by the RDP have emerged. Many high mountainous small-sized and fragmented plots have become abandoned and self-afforested.

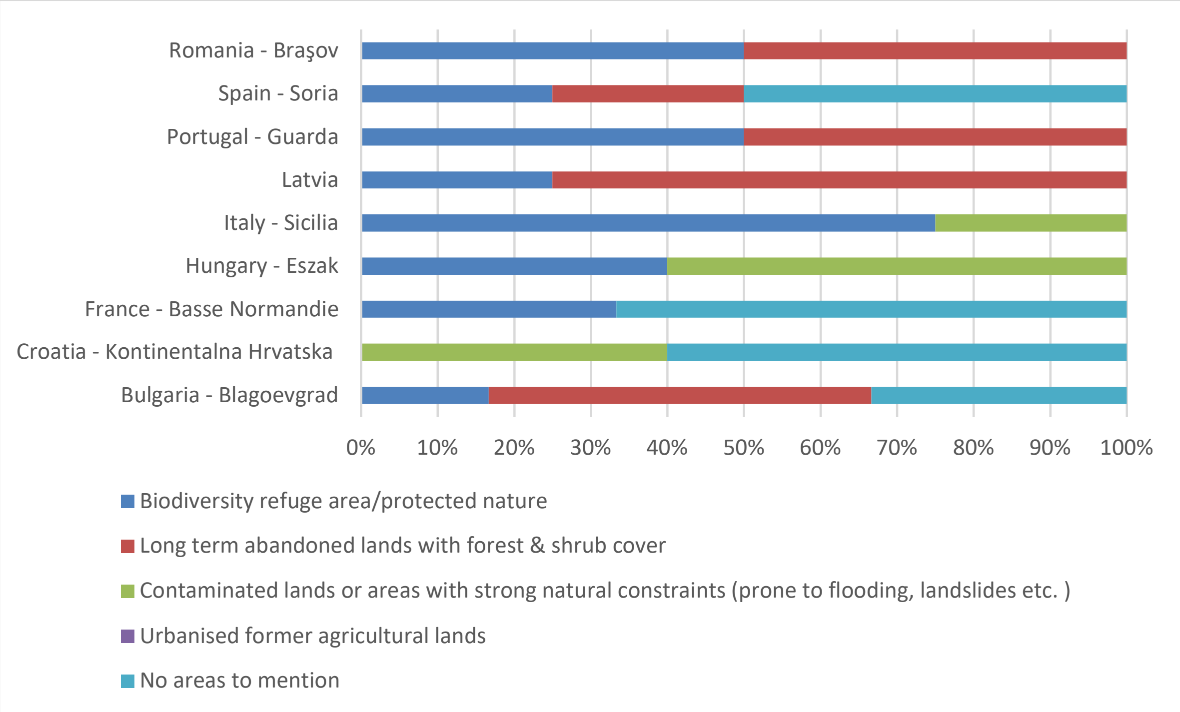
**Brasov**

The abandonment of small-scale arable plots is a long-term trend in Braşov county and is considered to be irreversible. These small-scale plots were cultivated by subsistence / semi-subsistence small holdings and were used mainly for growing potatoes. They were often situated in the hilly / mountain areas and were intrinsically less productive than the arable land at lower altitude in the plain areas of the county. Furthermore, most of the arable plots that were abandoned have reverted to grassland and in many cases have continued to be used periodically / intermittently grazed and therefore more a case of 'changed land use' (or in some cases 'semi or hidden abandonment') rather than 'actual abandonment'.
' major changes in hay-making have taken place and continue to take place on small farms whereby mechanised hay-making has almost completely replaced manual hay-making. Consequently, those grasslands abandoned in the hilly mountain areas because of steep slopes or inaccessibility are very unlikely to be brought back into production because a) they are simply not suited to mechanical hay-making and b) there is less and less labour available for hand-mowing and manual hay-making'

Source: case studies

With the responses in the case study regions it was also discussed whether there are areas for which it would be inappropriate to bring the back into production (Figure 4.6). The most common types mentioned were biodiversity rich/protected nature areas and areas that had been abandoned for too long and where the heavy shrub and forest cover would not allow it to be brought back to agricultural use. In Soria, Basse Normandie, Kontinentalna and Blagoevgrad, experts could not think of any type of area. In some regions there was also mention of contaminated lands or lands with strong natural constraints that could not be brought back into agricultural use. Further detailed answers from some respondents are presented in **Box 4.2**.

Figure 4.6 Answers given to the question ‘Are there areas for which it would be inappropriate to bring the back into production?’



**Box 4.2 Examples of expert's detailed answers to the question: 'Are there areas for which it would be inappropriate to bring them back into production?'**

**Sicily:**
'Unfortunately biodiversity rich areas have been severely damaged in recent years by pig farms. There has been a lack of coordination among policies which led to contradictions. We went from a strong environmental sensitivity in the 1980s, when protected areas were established, to years when they were not funded. The core of the protected areas must remain untouched, but other parts are compatible with agronomic and grazing activities, obviously within limits.'

**Soria**:
'It seems quite reasonable to me that not all lands have to go back to agricultural production because, currently, these marginal lands also play a role as a refuge for wildlife, promoting biodiversity, among other things. Although those externalities are difficult to quantify'.

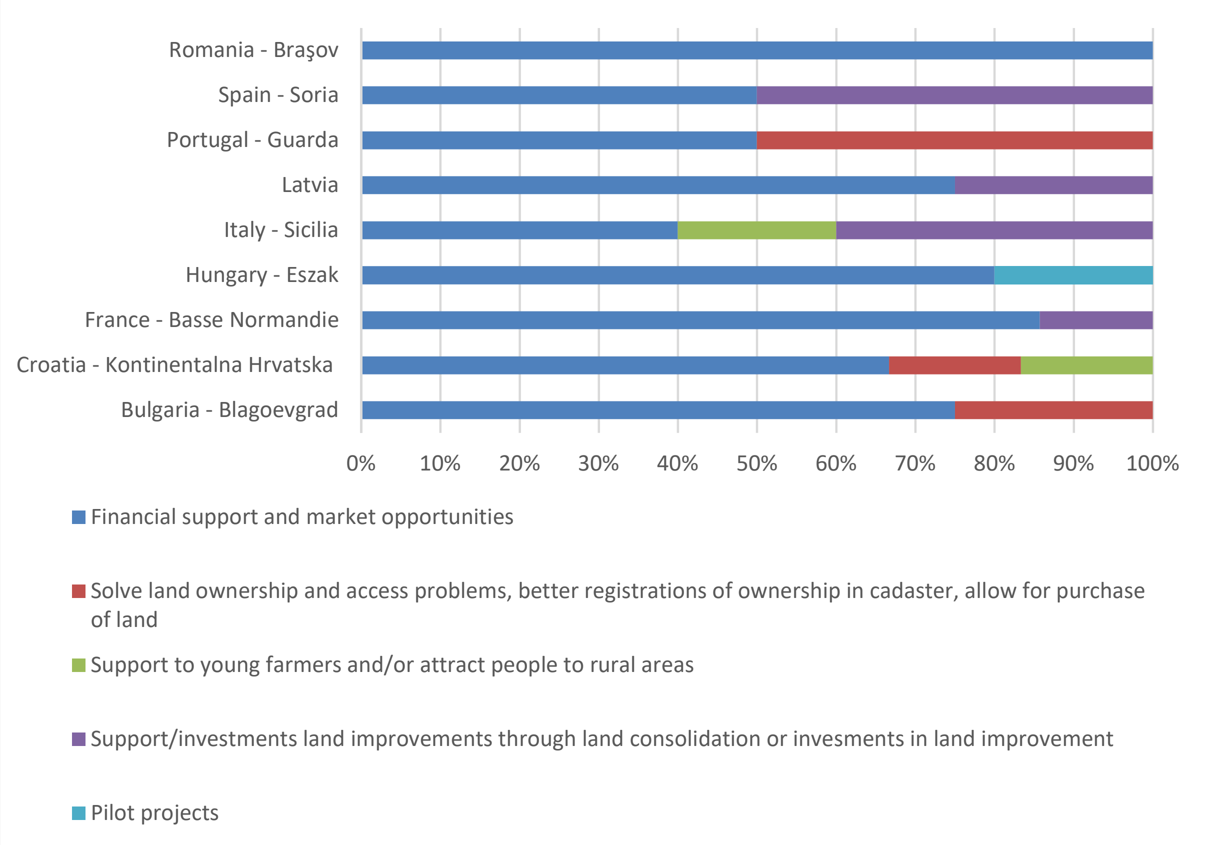
**Kontinentalna:**
Regarding the question on areas that are inappropriate to bring into production, the Ministry of Environment and Energy indicated that it depends what kind of system/habitat is in place now and to what do we want to convert it. Returning HNV grassland, high developed forest stands, and biodiverse wetlands to arable land could have adverse effects on nature and is not desirable. From the nature protection perspective, returning arable land that is currently meadow and grassland is also not a favoured option, but revitalisation of grasslands that were not managed and overgrown with invasive species is considered good and desirable practice.

***Brasov***
' Those abandoned grasslands will not return to agriculture. Nature has covered them in trees and they are already more useful to local people for firewood than hay. As access to the forest is more and more strictly controlled these alternative sources of firewood will become more appreciated.'

Source: case studies

The last question asked was about what factors that would lead or persuade land managers or other groups to bring land back into productive use (Figure 4.7). The most commonly mentioned factors related to market incentives and financial support. Practically all respondents agree that only if prices paid for agricultural products increase and/or support measures, including those arranged through CAP, are taken will it become more attractive to start using abandoned lands again. Another factor mentioned in three of the nine regions is the issue of officially clarifying the ownership and/or right to use and obligation to maintain land. The mechanisms behind this issue are, however, different between the regions.

Figure 4.7 Responses of experts in all nine case studies to the question: 'What factors would lead/persuade land managers/other groups to bring land back into productive use in the region?




In the Guarda region in Portugal, incomplete land ownership registration in the cadastre is seen as a counter-productive issue that needs to be resolved. Because only part of the agricultural land is registered in the cadastre, ownership remains unclear, land managers cannot be forced to maintain their land to at least prevent shrub invasion that increases the risk of wild fires, but nor do they need to pay taxes on the land. Incomplete registration is a sensitive political issue that has dragged on for a long time, but has not been resolved. Incomplete cadastre registration is also an issue in the Croatian region of Kontinentalna (see **Box 4.1**). This is combined with the large historical land reforms after the end of the communist period and the 1991-95 war in former Yugoslavia, when part of the population left, returning much later or never. In the eastern part of the Kontinentalna region a large share of the agricultural lands, which are generally of good quality, were brought back to production. Lands in the west of the region remain abandoned and are now covered with shrub and forest vegetation. Many of these abandoned lands are state-owned (see **Box 4.1**) and only very recently has political action begun to reorganise the access and/or ownership and use of these lands.

In Bulgaria similar problems occur regarding land access, due to a lack of clarity in the relationship between owners of the agricultural land and its users/tenants. A major issues for tenants is to have a legal basis for their use of the land. Part of the land that is currently not used is of good quality, but there is no legal basis for its use, and people who wish to cultivate it cannot rent it for longer than a year. This often prevents them making the necessary investments and applying the good agricultural practices needed for long-term conservation of the soil (**Box 4.1**).

**Box 4.3 Examples of experts' detailed answers to the question: 'What factors would lead/persuade land managers/other groups to bring land back into productive use in the region?**

**Sicily:**
'We need an ecological transition, but to do this we need to have a strategy beyond following the market. There are areas that have value beyond market value. Much agricultural biodiversity is permanently being lost, and agricultural biodiversity is important because it guarantees resilience, reduces the need for pesticides, and so on. We need strong policies to protect crops that perhaps have a low return on investment from an economic point of view, but a high value on other levels.'

'For years we have developed school canteens. We have used niche products, which have as their only outlet the local market. We used them to replace food products from far away. We have built a local protected proximity market. This required months and years of work. If this mechanism were to be disseminated at regional and national level, for example for public hospitals, canteens, and so on, a radical transformation of the agri-food processes could take place, towards a nutritionally correct diet that respects the environment and the economy, and contributes to food sovereignty.'

'The goal is to find solutions that provide young people with incentives to become farmers, in exchange for protecting biodiversity and implementing agro-ecological practices. We need European structural policies to encourage young people to become farmers, and this should be done not only with subsidies but also with other forms of incentives (for example, tax breaks, ensuring education for farmers'children, and so on). But today this cannot be done, because it would be considered state aid. This is why agricultural policy cannot work, and why Europe has entered a crisis.'

**Soria**:
'[We need] less environmental obstacles and legislation favourable to the undertaking of parallel activities, as in other EU countries. There are not policy measures in Soria province or region that can constrain or limit land from becoming unused, abandoned and/or degraded and that promote or lead to land being taken out of agriculture production.'

Source: case studies

In the Soria region of Spain, investments in land consolidation and in land improvements were also seen as a factor that could help. In Sicily and Croatia, the need to focus support on young farmers is emphasised (see **Box 4.3**).

#### *4.4.6 Interest in introduction of crops for energy and non-food uses on unused, abandoned and degraded lands*

In almost all regions respondents have different and sometimes contrasting opinions on the issue of whether introduction of crops for energy and other non-food uses are appropriate. In Croatia, for example, some see non-food industrial crops as a great opportunity to diversify agricultural production and generate additional income and employment, while others emphasise the importance of keeping agricultural land for agriculture and see other crops only as an option where food production is not possible. The latter argue that as the country (read Croatia) is not self-sufficient in food production the focus should be on food, and energy crops should only be used as a supplement to crop residues in case of conversion to bioenergy. However, crops for energy and other non-food uses could be an interesting option particularly for 'absent' landowners that have emigrated from rural areas or have other job opportunities than agriculture.

Problems identified with the cultivation of non-food industrial crops in the nine case studies are: current low economic viability of such crops, inability to place the product on market, no interest from relevant institutions, unclear policy for implementation, high investment, many uncertainties, and a lack of knowledge and support.

## 4.5 Conclusions

Overall, it is clear that bringing unused, abandoned and degraded lands back into use is a challenge. In both the EU-wide literature and statistics, little evidence exists of the wider uptake of biomass cropping in general, let alone on types of unused, abandoned or degraded lands. This is reinforced by the nine case studies.

On the other hand, it can also be concluded that the establishment of perennial and agroforestry systems on unused, abandoned and degraded lands can create more co-benefits in relation to soil, water, GHG mitigation and biodiversity. This does not apply in most cases to the establishment of annual crops on these lands. However, the effect of annual, perennial and agroforestry systems still remains dependent on the specific environmental and landscape context. The development of a more standardised environmental impact evaluation system linked to stimulation schemes and certification systems is therefore recommended.

In the case studies, no mention is made of the development of dedicated biomass cropping for energy and other non-food purposes on unused, abandoned and degraded lands. There is mention of cropping activity for first generation biofuels, mostly oil crops like rape and sunflower, but this takes place on good-quality arable land also used for food production. Mention is also made of crop production on normal arable lands of crops like maize, used for co-digestion in biogas plants. There is little evidence of interest in dedicated biomass crops on low-productivity lands typically under threat of abandonment or abandoned, except for some indication of trials. A key reason given in literature and by many experts in the case studies is uncertainty about financial return, particularly because the market demand for biomass crops is generally not well developed. This specifically concerns lignocellulosic biomass crops most suited to be grown on abandoned and degraded lands.

Another issue found in the literature and confirmed in the case studies is that there are many technical challenges to solve to make the land suitable (again) for agricultural use, including for biomass cropping. This usually requires large investments which are usually not appealing to farmers, particularly when the low expectations for good economic returns for the crops, whether for non-food or food applications.

The socio-economic opportunities of introducing new biomass crops on marginal lands were clearly mentioned in the literature and indicate that biomass crops on unused lands may lead to additional income, create new employment, and can therefore improve overall rural development. It may also help diversify farmers' incomes and create local access to new and clean energy resources. The case studies confirm the need for alternative land use activities within and outside agriculture, although experts differ on whether bringing abandoned agricultural lands back into use is a realistic option, including in relation to introducing new biomass crops. From all the case study regions, it is clear that there is no simple solution. A wide range of new developments is seen in the uptake of new crops, new land management and cropping systems, and new non-agricultural land uses. What is clear from all the case studies however, that there is an overall urgent need to find new solutions to ensure that agricultural activities can continue to exist, farm incomes are maintained, and diversified, and further land abandonment is prevented.

Although it seems that biomass crops are an interesting option for unused, abandoned and degraded lands, there is still little evidence of the use of these crops on such lands. At this moment it therefore remains more of a theoretical potential. One of the reasons for this is related to the many socio-economic barriers. Beside the socio-economic barriers and opportunities linked to the introduction of biomass crops, barriers and opportunities in terms of environmental risks and opportunities were also investigated. These barriers and opportunities are different depending on the type of biomass crop, in combination with the type of land conversions that are possible. The effects on environmental quality, biodiversity, and ecosystem services depend on the types of land use changes induced and the type of biomass crops and land management practices used. Annex VII provides a condensed summary of the main barriers and opportunities in relation to different types of biomass crops and land use conversions.

# 5 ROLE OF POLICY IN MAINTAINING LAND UNDER AGRICULTURAL PRODUCTION, BRINGING IT BACK INTO ACTIVE USE AND STIMULATING BIOMASS CROPPING FOR NON-FOOD PURPOSES

**Chapter aim and contents:**
This chapter identifies policy measures that have the greatest potential to reverse the trend of agricultural land becoming unused, abandoned and degraded, as well as to reclaim such land and put it back under active production for cropped feedstock for energy use.

It first provides an overview of the range of EU and national policies that in principle can influence the processes driving land abandonment and degradation (Section 5.2). It then looks in more detail at specific EU and national policy instruments that have been shown through the literature and the case studies to work in practice to help counter the drivers that lead to both intended and unintended abandonment, semi-abandonment or land degradation (Section 5.3) and to bring land back into agricultural production from an abandoned or degraded state, where it is appropriate and sustainable to do so (Section 5.4). Third, it examines the policy and other levers that would be required to encourage this land to be used to produce cropped feedstocks for energy and other non-food purposes where this is deemed to be a priority (Section 5.5). The chapter concludes with a summary of the issues arising with the implementation of the current suite of policies. Recommendations on how to address these can be found in Chapter 7.

## 5.1 Introduction

There are a number of reasons that land moves out of active agricultural management and use. In some situations, these changes in land use are the result of deliberate decisions to reallocate the land for other purposes that are deemed to have greater economic, social or even environmental or climate value. This includes reallocating agricultural land for infrastructure development (buildings, roads, urban expansion, tourist developments, and so on) but also converting agricultural land to forests (for commercial, environmental and increasingly climate reasons) as well as into nature reserves or wetland areas for environmental purposes. Although policies often play an important role in influencing these changes in land use, these are not the focus of this study and are not considered further.

In other situations, land leaves agricultural use through a less direct route, becoming degraded, semi-abandoned or fully abandoned over a period of time, and it is these changes in land use and management that are the focus of this study. This chapter therefore examines the key policy instruments/mechanisms that are currently in use or under development that have the greatest potential to counter the drivers of land degradation and abandonment, alongside those that can incentivise land managers to bring land back into production from an abandoned or degraded state.

Having land in a state that can legally and physically be used for agricultural production, however, does not mean it will necessarily be used to produce cropped feedstocks for energy or other non-food purposes. Indeed, it is clear from former chapters that this rarely happens in practice. This decision is in the gift of the land manager. The final section explores the role of policy in encouraging the production of cropped feedstocks for energy and other non-food uses where it is appropriate and sustainable to do so.

The findings are based on an assessment of EU, national and regional policy instruments, including consideration of how EU policy instruments are implemented at the national/regional level. The analysis has been informed by a review of the legislative texts, a literature review focusing on their role in influencing land at risk of leaving production and returning to active use, as well as information provided in the nine case studies.

## 5.2 Role of EU and national policies in countering land degradation and land abandonment

A number of policy instruments were identified that theoretically have the potential to counter the process of land abandonment – either through maintaining land under active agricultural use or incentivising it to come back into production. These include:

- Policies providing funding to rural areas, farms and rural enterprises and rural land in the form of payments for land management as well as investments in physical and non-physical infrastructure, such as the Common Agricultural Policy (CAP) – both Pillar 1 and Pillar 2 – the Structural Funds, the LIFE Programme as well as national initiatives.
- Legislation addressing farm structure and land tenure issues – mainly national policies which vary depending on the issues and priorities of the country concerned.
- Land use/development control policies – mainly national legislation but also the implementation of EU legislation such as the Environmental Impact Assessment (EIA) Directives.
- National financial instruments, such as those used to support young people to enter into or continue in farming.
- Environmental and climate policies (for example, the Nature Directives, the Floods Directive, the Renewable Energy Directive, LULUCF Regulation, Effort Sharing Regulation, mainly via the national strategies and plans that are put in place to achieve their objectives (for example, the National Energy and Climate Plans and Prioritised Action Frameworks), but also (in the case of RED) by providing an additional stimulus to produce low ILUC biofuel crops on abandoned or degraded land.
- State aid rules relating to certain agricultural and forest investments.

Table 16.1 in Annex IX sets out the EU policies that in principle could have a role in countering land abandonment with an explanation of how this might occur. In practice, however, the literature review and case studies show that relatively few of these play a significant role. The most influential is the CAP, in conjunction with some national policies. Most of the other EU policies, particularly the climate and environmental policies, generally exert an influence more indirectly through the impacts arising from the national strategies and plans that are put in place to achieve their objectives.

It is important to note that very few policies address land degradation or land abandonment as their primary focus, with the exception of the CAP payments to areas facing natural constraints (ANC) and national measures in some countries addressing farm structure and tenure issues.

Instead, most policies that have the potential to play a role in helping counter the drivers of land abandonment or support land coming back into agricultural production seek to address the socio-economic drivers affecting farm viability and the effects of broader rural socio-economic trends on the agricultural sector. These policies are therefore concerned with supporting the viability of the agricultural sector as a whole, maintaining the diversity of farming types and structures, and in some cases seeking to maintain specific forms of production as well as addressing issues of generational renewal and land tenure. They are rarely targeted at hotspots of abandonment.

The sustainable management of this land is not a key consideration of the majority of policy tools identified as helping avoid land abandonment, given their socio-economic focus. Exceptions are those that encourage particular types of land use or land management for environmental or climate purposes, such as the agri-environment-climate or organic farming measures under Pillar 2 of the CAP. The cross-compliance standards attached to agricultural land in receipt of payments under the CAP seek to avoid the degradation of land receiving these payments, although standards and their enforcement are very variable between Member States (see, for example, ECA, 2016; Frelih-Larsen et al., 2017).

Finally, it should be noted that only a few policy measures promote the use of agricultural land for cropped biomass feedstock production for energy and other uses, and those that do rarely focus on abandoned land.

More detail on the key policies identified as helping counter land degradation and land abandonment is set out in Sections 5.3 and 5.4. The role of policy in promoting the use of agricultural land for producing biomass for energy and other non-food uses is explored further in Section 5.5.

## 5.3 Role of policy in maintaining land under agricultural use

A review of the literature, supplemented by evidence from the nine case studies, showed that the main EU policy that helps constrain land leaving agricultural production by countering the drivers of land degradation and land abandonment is the CAP. The key CAP measures identified as exerting an influence were:

- Pillar 1 direct payments, including the Basic Payment Scheme/Single Area Payment, voluntary coupled support (VCS) as well as the additional payments for young farmers.
- Pillar 2 measures, particularly:
    - Compensation payments to farmers in areas facing natural constraints (ANC);
    - The agri-environment-climate measures (AECM) – mainly protecting extensively grazed areas;
    - Organic farming payments;
    - Natura 2000 compensation payments;
    - Investments in tangible and intangible assets on farms;

  - Start-up aid for young farmers and small farms;
  - Support for farm diversification; and
  - Support to revitalise rural areas.

In reality, however, whether or not these measures have more than a very marginal effect on maintaining land in agricultural production depends on a range of factors, including:

- National circumstances and economic conditions – for example, relatively low CAP payments can make a significant difference to the decision to stop farming or not in Member States where agricultural incomes and land prices are low (for example, many of the Central and Eastern, and Mediterranean Member States as well as in more marginal upland areas in other parts of the EU), but are likely to have far less of an effect in other countries and locations.
- Decisions made by Member States about payment rates on land of different productive potential and how the value of these compares to average returns per hectare, which can vary significantly.
- The eligibility rules set by Member States for particular CAP instruments and measures, as well as those that stipulate which land is eligible for CAP support.
- The choice of which CAP Pillar 2 measures to implement, the budget allocated to these and how they are designed and targeted (the area of land they cover and whether or not this is land that is at risk of abandonment).

An array of national policies were also identified in the case studies as playing a role in maintaining agricultural land under active management, some of which complement the CAP policy measures in place and others which are nationally distinctive and intended to address the issues and priorities of the country concerned. The scale and significance of their effect also varies considerably depending on the modalities for their implementation. These generally address the broader regional socio-economic drivers of abandonment (such as encouraging young farmers to enter agriculture to try and counter rural outmigration and an ageing farmer profile), as well as farm structure and land tenure issues. These can take the form of incentives, taxes, land use planning policies, and processes that seek to overcome land tenure issues. They can be characterised into four groups:

- Legislation to maintain agricultural land in active productive use;
- Legislation addressing farm structure and land tenure issues, including those arising from inheritance;
- Financial instruments, such as land taxes or preferential rates for loans; and
- Land use/development control and land zoning policies

The ways in which the CAP and the range of national policy measures exert an influence on land abandonment are varied, with different policy measures playing different roles at different scales and with different degrees of specificity. The role of each of the main types of policy instrument is set out below.

#### *5.3.1 The Common Agricultural Policy*

The key CAP interventions identified as playing a role in constraining land leaving agricultural production are outlined below, along with information on the ways in which they counter the key drivers of land abandonment and degradation, the scale of their influence, and the extent to which they include requirements for the sustainable management of agricultural land.

*CAP direct payments and payments to ANCs*

The Pillar 1 Basic Payment Scheme (BPS) or, in some Member States, the Single Area Payment Scheme (SAPS), as well as the Pillar 2 payments for ANC are key measures highlighted in both the literature and the case studies as helping maintain land under agricultural use. They tend to combat the risk of land becoming abandoned primarily on land that is marginally productive. They do this by increasing the viability of farming in general terms (Ecorys et al, 2016; European Commission, 2013). However, since 2005, when most CAP Pillar 1 payments were decoupled from production, there has been no obligation to produce crops or livestock on agricultural land receiving CAP payments, although it must be maintained in a state suitable for grazing or cultivation via so-called 'cross-compliance' requirements. These cross-compliance measures require land managers to maintain agricultural land in 'good agricultural and environmental condition' and can therefore reduce the risks of land degradation and abandonment, even if the land is not actively used for production (Keenleyside and Tucker, 2010; Filho et al., 2017). In some Member States, VCS is also thought to play a role by providing additional payments to grazing livestock in economically vulnerable farming systems (Alliance Environnement, 2019; Baldock and Mottershead, 2017).

The *BPS/SAPS* is not a targeted measure. It is available to all agricultural land that meets the eligibility criteria and therefore systematically supports land being maintained in a state that can be used for agricultural activities in all regions of the EU, not just those areas that are at risk of becoming unused and abandoned. In 2018, BPS/SAPS annual payments[20] covered 87% of the 162 million hectares of UAA in the EU27[21]. Its influence on land abandonment occurs where conditions make agriculture less viable, with marginal regions that have large areas of less productive land (typically grasslands) the most heavily affected (Anguiano et al., 2008; Brady et al, 2017). A number of studies that have attempted to model the impact of direct payments on production have shown that, in aggregate, direct payments help to keep land in agricultural production across the EU and, while land abandonment still occurs in practice, it is likely that more land would have been abandoned had direct payments not been in place (Brady et al, 2017; Uthes et al., 2011). Research in Central and Eastern European countries has shown that the (usually higher) share of CAP payments in farm income has influenced the maintenance of agricultural land and that, where reduced levels of support from the CAP for extensive farming occurred, a higher level of land abandonment was reported (Terres et al., 2013).

However, because land does not have to be under active management to be in receipt of BPS/SAPS, in places where land is more marginal economically and where those owning the land have other sources of employment, semi-abandonment can still occur to a significant extent. The BPS/SAPS does not ensure that agricultural land is managed sustainably, beyond adhering to cross-compliance requirements, which vary between Member States and whose enforcement is also variable (see, for example, ECA, 2016; Frelih-Larsen et al., 2017). The proposals for the next programming period of the CAP aim to strengthen these to some degree, although this has been contentious during the negotiations so far (Bas-Defossez and Meredith, 2019).

[20] Including the Small Farmers Scheme which is an alternative to BPS/SAPS in some Member States.
[21] Data for 2018 from the CAP Indicators data portal – these figures exclude the UK: https://agridata.ec.europa.eu/extensions/DataPortal/cmef_indicators.html-

However, the literature also shows that implementation choices made by Member States on eligibility rules[22] for CAP direct payments may lead to agricultural land being excluded from support and so becoming unused and subsequently abandoned. CAP legislation allows Member States to define several eligibility criteria for direct payments in ways that deliberately include marginal and other farmland at risk of abandonment or, alternatively, to define these rules to exclude some of this land. The ineligibility of particular types of land for CAP direct payments diminishes the force of the CAP as a magnet to keep land in agricultural use rather than acting as an active lever to push land out of production (although this may be the longer-term effect in practice).

In Bulgaria, for example, the permissible threshold of tree density for land eligible for CAP support was increased in the current programming period (2014-2020) from 50 trees/ha to 100 trees/ha, which led to a 55% increase in the area of eligible permanent grasslands in LPIS by 2019. Despite this, the current definition excludes grasslands with scrubby vegetation from the SAPS since Bulgaria chose not to extend their definition of eligible permanent grassland to include areas that are used for grazing as part of established local practices, permissible since 2013 (see Table 2.2 in Chapter 2). Because the economic viability of farming on most agricultural land in Bulgaria depends on CAP support, eligibility or non-eligibility for such support is potentially a significant factor preventing or leading to land abandonment.

Payments to *areas facing natural and other specific constraints* are available under both Pillars of the CAP, although in the 2014-2020 period Member States have chosen to implement the measure predominantly under Pillar 2. The aim of the ANC measure is to 'contribute to maintaining the countryside as well as to maintaining and promoting sustainable farming systems' by 'encouraging continued use of agricultural land' (Regulation (EU) 1305/2013, recital 25). In 2019, 57.9% of UAA in the EU-27 was designated as ANC, ranging from 2.5% in Denmark to 100% in Luxembourg and Malta[23]. Of this, 17.1% is designated as 'mountain' ANC, 32.6% as 'areas other than mountains facing natural constraints' and 8.1% as areas affected by other 'specific constraints'. The scale of disadvantage in different parts of the EU varies considerably even within these areas. Payments per hectare also vary greatly between Member States, but provide additional non-market, annual area-based payments to encourage continued use of agricultural land in mountain areas or in other areas facing natural or other specific constraints (such as steep slopes or poor soils) and act as a form of broadly targeted direct payment. These payments support agricultural incomes and improve the economic viability of farms in these areas and, although supporting evidence is lacking, it is expected that the measure reduces the rate of abandonment of such farmland as well as inhibiting afforestation or other competing land uses (Alliance Environnement, 2019; Louwagie et al., 2011).

All case studies highlighted the ANC measure as important for reducing the risk of abandonment in these areas. This is reinforced by examples from Alliance Environnement (2019) which showed that

---

[22] This includes rules on: maintaining an agricultural area in a suitable state for grazing or cultivation; minimum activities required on agricultural areas naturally kept in a state suitable for grazing or cultivation; defining 'permanent grassland and permanent pasture' in a way that includes pastureland with shrubs and/or trees which can be grazed, and other grazing land where grasses are traditionally not predominant; and ensuring landscape features are eligible for direct payments.

[23] CAP Context Indicator C.32, 2019 update: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/cap-context-indicators-table_2019_en.pdf

ANC payments had helped maintain HNV farmland in agricultural use in France and avoided the abandonment of grassland in Hungary and Ireland and on steep mountain slopes in Romania. Although there are no explicit environmental criteria attached to the payments, in some cases they help maintain extensive areas of HNV and the associated environmental and climate benefits they bring. However, the payments may also provide sufficient liquidity for farmers to carry out agricultural improvements on this land and can lead to overgrazing, which can have negative environmental impacts (Elbersen et al., 2014).

*Voluntary coupled support* is optional for Member States and provides support for specific crops or types of livestock in 'specific sectors or regions facing particular situations where specific types of farming or specific agricultural sectors are particularly important for economic, environmental and/or social reasons' (Regulation (EU) 1307/13, Recital 49). In practice all Member States apart from Germany have used VCS to varying degrees. It has been suggested that well-designed coupled payments may offer a useful way of providing extra income support for economically vulnerable livestock farming, including mountain dairy farms (Keenleyside and Tucker, 2010), although this type of targeting is not required and is very variable in practice.

Approximately 10% of the direct payments budget is used to provide coupled support. It is heavily used to support livestock production. Figures from 2020 show that the beef and veal sector receives most support under VCS (40%), followed by milk and milk products (21%), and sheep and goat meat (13%) (European Commission, 2020). In 2020, 39% of bovine animals were supported through VCS and 54% of sheep and goats[24]. However, it also supports a variety of crops, accounting for the remaining 27% of support[25]. Evidence of its impact on land abandonment is limited. Brady et al. (2017) concluded that VCS support for beef, sheep and goats and dairy was maintaining livestock production in areas where it would otherwise disappear, although whether this land would be abandoned or not is unclear. In three of the case studies, VCS is highlighted as an important supplementary payment to the BPS/SAPS for keeping land under agricultural production, helping maintain cattle, sheep and goats in mountainous areas in Bulgaria, sheep in Spain and grazing livestock in Hungary (although in this case the payments are available everywhere, not targeted to areas at risk of abandonment). One other example where VCS has been shown to help avoid land moving out of agricultural production that has been identified in the literature include two VCS schemes in Spain – one focused on nut production which may contribute to avoiding abandonment of terraces in mountainous areas, and one in Andalucía for extensive livestock systems which contributes to maintaining grassland systems on steep parcels which might otherwise be abandoned (Alliance Environnement, 2019). However, it should be noted that VCS payments do not require the sustainable management of agricultural land (beyond complying with cross-compliance regulations) and therefore payments can be made even if the land is unsustainably managed or degraded.

Finally, the *green direct payments* are considered to reduce the risk of land degradation (mainly soils) as some of the forms of management that have been required have led to improved management of

[24] Based on Eurostat 2019 figures of 77 million bovine animals in the EU-27 ((apro_mt_lscatl) and Eurostat 2015 figures of 63 million sheep and 12.4 million goats in the EU-27 (apro_mt_lssheep) and (apro_mt_lsgoat)
[25] 2020 figures show 11.16% of support went to protein crops, 4.31% to fruit and vegetables, 4.28% to sugar beet and the remaining 7.06% to crops such as cereals, olive oil, rice, grain legumes, starch potato, nuts, seeds, hops, hemp, oilseeds, silkworm and flax.

the land, for example, fallow introduced under crop diversification and ecological focus areas (EFA), and green cover and nitrogen fixing crops introduced under EFA (flagged in the Bulgarian case study).

*CAP environmental area payments (Pillar 2)*

The AECM plays a role, in combination with other CAP area payments and other Pillar 2 investment measures, in mitigating land abandonment by providing agricultural holdings with additional income for carrying out particular management, including on more economically marginal farms (Lasanta and Laguna, 2007; Calvo-Iglesias et al., 2009; Schröder, 2011). The scale and extent of this effect depends on the design and targeting of the agri-environment-schemes that are put in place in Member States as well as the payment levels and not all sub-measures will play a role. In most of the case studies, the AECM was specifically highlighted as an important means of supplementing farm income and helping maintain land under agricultural production, particularly in extensive grassland areas, as a means of protecting those grasslands which are of high biodiversity value.

For example, in Bulgaria the AECM provides support for the maintenance and restoration of HNV grasslands, with the main aim of preventing the loss of HNV grasslands from abandonment or intensification of agricultural activities. Funding is also available under a further scheme, the 'Pastoralism scheme' to maintain traditional grazing management in two national parks, on land in which is not eligible for Pillar 1 direct payments. In this case, the AECM support is critical to maintain these systems on which management had ceased prior to the introduction of the AECM. In Basse-Normandie in France, two management actions[26] specifically aim to limit scrub encroachment on agricultural land, thereby limiting the semi-abandonment of these areas. In Sicily (Italy), an AEC scheme on 'conservation and management of traditional landscape and terraced areas to reduce erosion and hydrogeological instability' helps both to prevent land degradation in the form of soil erosion, landslides and wildfires, as well protecting areas characterised by manna ash trees, in the hilly and mountainous areas of north-western Sicily, where cultural landscapes are at risk of disappearing.

Evidence from some of the case studies identified the *organic farming measure*, which supports the conversion or maintenance of organic farming, as helping enhance income for certified organic producers on poor as well as productive land. It was also identified as helping promote economic growth, increase farm profitability and provide new employment opportunities in rural areas, both on and off farm. It can contribute to efforts to minimise land abandonment, especially where organic farming is promoted on marginal and less profitable land. In some situations, it may also help prevent land degradation through supporting environmentally friendly production methods. Four of the case studies identified this measure as important for maintaining land under sustainable management (Bulgaria, Spain, Italy, Latvia). In the Spanish region of Soria there is an additional focus on encouraging young people and women into organic farming (as set out in the Strategic Plan for organic production in Castilla y Léon), which also aims to help counter issues of rural depopulation. However, the scale of influence of this measure is relatively low. Organic agriculture covers only 8% of UAA in 2018 (12.98 million ha), and the CAP organic farming measure provides support for 65% of this area (8.5 million

[26] These are OUVERT_01 and OUVERT_02.

ha)[27], with significant variations between Member States. In addition, much of the area supported under this measure will not be at risk of abandonment. Nonetheless the recent EU Green Deal target under the Farm to Fork and Biodiversity Strategies to increase the area under organic production to 25% by 2030 is likely to stimulate more land becoming organic (although not all of this land will require funding via the CAP to make this transition).

*Natura 2000 compensation payments* for restrictions attributable to the Birds and Habitats Directives play a role in the 2014-20 CAP in maintaining agricultural production on these areas. However, uptake of the measure is low, occurring in only 13 Member States and an estimated 7.9% of the total UAA in Natura 2000 areas (Alliance Environnement, 2019). A study in Germany concluded that if productivity impairments are not fully compensated, this could lead to the abandonment of farming in marginal Natura 2000 areas (Koemlea et al., 2019). The measure was highlighted in the case studies in Bulgaria and Sicily (Italy) as helping with the economic viability of farms within protected areas, which might otherwise be neglected and lose their biodiversity value.

### *CAP investment aid/grants (Pillar 2)*

Investment aid for tangible and intangible assets on farms provides support for a wide range of investments to improve or maintain the economic viability of farm businesses. As such it can be an important means of improving the overall economic performance of farms, thereby keeping them in production. This was highlighted in the Italian and Croatian case studies. In France, preferential conditions are placed on investment support for young farmers (for example, priority access in the selection process) as a means of incentivising young farmers to get into agriculture. In Baden Wurttemberg in Germany, the small farm investments programme is directly focused on supporting smaller producers in grazing areas at risk of abandonment, with investments mainly covering stables for cattle and machinery for steep slopes (Alliance Environnment, 2019).

The farm and business development measure was highlighted in many of the case studies as a further CAP measure than has been used to strengthen the economic viability of farms. Business start-up support for young farmers is addressed below, but in Bulgaria and Croatia, the measure is used to provide start-up support to small farmers to strengthen their viability. In Sicily (Italy), the sub-measure for farm diversification is used to provide alternative income streams for farm households, which are highlighted as important for enabling them to stay on the land, although it does not necessarily mean that the land is maintained in active management. The measure targets young farmers and women and promotes diversification into: renewable energy production; rural tourism; ICT activities and e-commerce; services for farms and for the rural population; and transformation of primary products into products with greater added value and their marketing.

### *Support for young farmers (Pillar 1 and Pillar 2)*

Support available under both CAP Pillar 1 and Pillar 2 has been identified as being used in the case study regions to encourage young farmers to take up farming as a way of addressing one of the drivers of land abandonment – an ageing farming population as a result of the outmigration of young people from rural areas. These are sometimes used alongside national measures (see below).

[27] CAP Dashboard: Organic Production - (EU27) - European Union 27 (excluding UK) https://agridata.ec.europa.eu/extensions/DashboardIndicators/OrganicProduction.html?select=EU27_FLAG,1

It is compulsory under the CAP (Pillar 1) to provide additional decoupled payments to young farmers, allocating up to 2% of their national ceiling for this purpose. The objective of the measure is centred on improving the competitiveness of the farming sector, rather than encouraging generational renewal. Nonetheless, as an additional source of income, not dependent on level of production or market prices, it can also play a role in encouraging young people to take up farming in areas where rural depopulation is a driver of abandonment. These payments are often used in conjunction with other Pillar 2 payments and sometimes national measures, as seen in a number of the case studies. An ECA report (ECA, 2017), however, found that the aid provided was often not targeted on the basis of a sound needs assessment which means that support is provided in a standardised way rather than focusing on places where the need is greatest. In addition, the report found that data on the income and viability of the supported holdings are not collected, which makes assessment of the effectiveness of this measure problematic.

The other key CAP measure used to encourage young people to take up farming is the Pillar 2 start-up aid for young farmers. Funding is often provided as a lump sum payment, subject to the completion of a business plan and sometimes an interest subsidy on a loan (ECA, 2017). Five of the nine case study countries highlighted this as an important measure in the regions investigated (Bulgaria, France, Italy, Spain, Portugal). In Bulgaria, this measure has encouraged young farmers in the municipality to rent and start cultivating abandoned land in lowland areas, areas close to urban areas, mountainous areas and border areas. Young farmers with more financial resources have rented land from numerous owners who have stopped cultivating their small, fragmented land plots due to a lack of profitability and manual labour. Those with more limited resources are renting smaller areas for vegetables. It has also helped young people inheriting even a few acres of land to cultivate it. Despite this, in Bulgaria, some interviewees identified decreases in the level of funding for young farmers under Pillar 2 measures as an issue with knock-on effects on the areas of land becoming abandoned.

Two case studies also highlighted the targeting of other CAP measures to prioritise young farmers. Young farmers are prioritised in the application process for the CAP investment measure in Basse Normandie (France), and the farm diversification measure is targeted at young farmers in Sicily (Italy).

However, in all the case studies it was noted that the measures in place were insufficient to address the issues faced by young farmers (for example, lack of knowledge, capital and access to land). A recent evaluation of the impact of the CAP on generational renewal showed that CAP support for young farmers both in the past and currently has had a variable impact in addressing the very powerful drivers influencing generational renewal in agriculture, such as farm structural adjustments and wider socio-economic dynamics (CCRI, OIR and ADE, 2019). Evidence for the 2014-2020 period highlighted that despite some positive examples, in areas that are marginal economically, 'the impact of the measures may be dwarfed by negative influences including socio-cultural and wider economic disincentives to farm or to remain in rural areas' (CCRI, OIR and ADE, 2019). This report concludes that 'the indirect effect of the young farmer measures upon local economies and rural employment appears weak but positive, particularly in the most remote and marginal rural areas. However, these impacts are likely much less than the impacts of other measures in the Pillar 2 menu which target these goals directly, as well as the indirect impacts of Pillar 1 and ANC aids which provide more significant general support to maintain farming in these areas'.

*Support to revitalise rural areas*

A significant driver of abandonment in many countries is the continuing outmigration of people, particularly women and younger generations, from rural households to look for employment in nearby urban centres and further afield. The CAP ‘basic services and village renewal’ support measure has been used in two of the case studies (Romania and Croatia) to try to limit outmigration by providing investments and services in local villages/communities to improve the quality of life in these areas, thereby seeking to address the socio-demographic factors driving the under-utilisation and abandonment of agricultural land. There is little available evidence to show if these measures are successful in achieving their goals, given the strength of these socio-demographic drivers.

A handful of other CAP Pillar 2 measures were identified in the case studies as helping minimise the risk of abandonment, although there is little evidence to demonstrate their impact in practice. These include:

- The restoration of agricultural production potential after damage caused by natural/climate events which is intended to prevent abandonment after such events – highlighted in the Croatian and Portuguese case studies.
- The establishment of producer and interbranch organisations – highlighted in the Croatian case study as being used to help increase the negotiation power of individual producers, thereby enhancing their ability to access markets and remain competitive.

### *5.3.2 National policy measures*

A mix of national policies were identified which have been used to help maintain land under agricultural production. These tend to address the broader regional or national socio-economic drivers of land abandonment and degradation identified in Chapter 3, such as ageing and declining rural populations, issues with successors and inheritance, and land fragmentation, rather than being targeted specifically at abandonment. The four groups of policy measures identified earlier are addressed in the following.

*Legislation to maintain agricultural land in productive use*

A number of the case studies highlighted national laws that set out rules about how agricultural land should be managed. These generally require agricultural land to be kept under active management and in good agricultural condition, thereby protecting productive land from potential degradation and where degradation exists, ensuring that this is addressed (Hungary, Croatia, Romania). This is separate to rules that apply under the CAP. These rules are considered by the case study experts to be an important means of requiring farmers to keep their land under productive use and in a non-degraded state. However, it is unclear how effective these laws are in practice. The example from Romania demonstrates that the implementation of the Land Fund Law has been problematic. The Law states that owners of agricultural land are obliged to ensure it is cultivated and its soils are protected. Although it is not known to what extent this has helped avoid land becoming abandoned, it has led to land becoming semi-abandoned or in a state of ‘transitional abandonment’ as ongoing conflicts over land ownership with respect to the active management of the land leave areas of land unmanaged.

Incomplete cadastres can also lead to problems with maintaining land in productive use. For example, in Portugal, only a proportion of agricultural land is registered in the official cadastre which makes it impossible to require landowners to maintain their lands, particularly in relation to scrub encroachment that increases the risk of wildfires. Incomplete registration of land in cadastres is also an issue in Croatia (see **Box 5.1**).

**Box 5.1 Examples of laws in place to promote the active use of productive agricultural land**

In **Hungary**, the Land Protection Act imposes a cultivation obligation on all landowners in keeping with the type of land cultivated. This is a very important basic principle in the legal system. The Land Market Act reconfirms these obligations, stipulating that when agricultural land is sold and purchased, the owner must cultivate the land for five years after the purchase and must keep it in his/her own use.

The National Land Fund Act in **Hungary** also sets out rules on the management of state-owned land, which means that state-owned agricultural land is generally kept under active agricultural management. New land is constantly coming under state control, for example through inheritance or land exchange. Although these areas may look as if they are abandoned in their transitional state, they are quickly allocated to some form of land use through the National Land Fund Centre.

In **Croatia**, the Law on Agricultural Land aims to protect agricultural land as a valuable natural resource and to promote or enable its use for agricultural production. It regulates a range of issues related to agricultural land, including its protection, use, how state-owned land is allocated to farmers, and changes in land use. It requires agricultural land to be kept in a condition suitable for agricultural production and protected from any damage that would reduce the agronomic value of the land (for example, via maintaining soil quality). In practice, however, the effectiveness of this law is reduced because land ownership is often unclear, and not fully registered in the cadastre.

In **Romania**, the Land Fund Law (18/1991) establishes a regulatory framework for the re-privatisation and restitution of land after the collapse of communism, including the restitution of agricultural land from collective and state farms. The legislation has many stated purposes – one of which is to ensure the 'protection and improvement of land' through its continued use. Article 53 requires that 'All owners of agricultural lands are obliged to ensure their cultivation and soil protection'. If a landowner does not comply with this, the law includes provision for the local authority to impose an annual fine (Article 54) and after a period of two years to take possession of the land (Article 55). Although it is not clear to what extent Article 53 specifically reduced the risk of abandonment, it is widely acknowledged that it been misused by local government officials to acquire land for their own personal interests and benefit (Mihalcea et al., 2015; Stahl et al., 2016).

Its flawed design and implementation led to instability, incoherence and unjustified delays in the land privatisation and restitution process (Rusu et al., 2011). In particular, it created the phenomenon of so-called 'transitional abandonment', which in Romania has mainly been associated with agricultural land being temporarily under-utilised or taken out of production due to land-related disputes and conflicts. According to Rusu et al. (2011), multiple forms of dispute and conflict have arisen from implementation of the Law, including:

- Ownership conflicts between state and private, common or collective owners;
- Boundary conflicts;
- Ownership conflicts linked to inheritance;
- Disputes over the value of land;
- Ownership conflicts due to lack of land registration;
- Disputes over payments for using/buying land;
- Evictions by landowners; and
- Illegal evictions by state officials acting in their private interest.
- These disputes continue and the issues with the design of the Law are yet to be addressed.

Source: case studies

### *Legislation addressing farm structure and land tenure issues*

Many Member States, especially Mediterranean or CEE countries, continue to face issues with land structure and tenure, both as a result of ongoing issues surrounding uncertainty about ownership or as a result of inheritance rules. Indeed, land tenure issues were among the most frequently identified drivers of land abandonment highlighted in the case studies (see Chapter 3). Land ownership issues arise both as a result of the post-communist land privatisation/restitution process, but also due to incomplete land registration/cadastral problems (see also **Box 5.3**). Ongoing issues with creating a comprehensive land cadastre were highlighted in the Portuguese, Romanian and Croatian case studies, where administrative, IT and institutional weaknesses are hampering progress. Significant efforts are taking place in Bulgaria, Croatia and Hungary to consolidate fragmented parcels of land, many of which are unused or abandoned. However, in some cases these efforts are having limited effect due to tensions with other policies in place (for example, inheritance laws in Hungary). The effectiveness of these policies is also hampered by lack of enforcement (for example, in Croatia). **Box 5.2** and **Box 5.3** provide some examples.

### Box 5.2 Examples of national policies to address farm structure and tenure issues

**Bulgaria: 'White spots' policy and land consolidation policy**
This policy, part of the law on ownership and use of farmland, provides for the administrative allocation of unused and/or unclaimed agricultural lands. It was introduced to provide the legal basis for land users of this land to claim CAP support. The policy requires landowners to submit an annual declaration of their intention to use the agricultural land they own. If no declaration is submitted, local authorities can allocate the land to other users who wish to cultivate it. The users pay a rent to the municipality and the municipality pays the rent to the owners. Between 4,600-4,900 ha have been maintained in agricultural use as a result of this measure. It also includes a provision to reduce land ownership fragmentation. This allows landowners that own over 10% of land in a particular area to put forward a land consolidation plan to decrease ownership fragmentation. This must be approved by local authorities. In practice this provision is used more in areas where land is more fertile than for land in marginal areas, which continues to become abandoned.

**Croatia: Law on Agricultural Land and 2015 Land Consolidation Law**
The Law on Agricultural Land aims to protect agricultural land as a valuable natural resource and to promote or enable its use for agricultural production. It regulates a range of issues related to agricultural land, including its protection, use, the allocation of state-owned land to farmers, and changes in land use. However, the process of selling state-owned land in practice is not well organised and tends to favour large companies (see Box 4.1).

The 2015 Land Consolidation Law aims to consolidate parcels and cadastre units into larger entities to improve their economic efficiency, create more favourable conditions for agricultural production, as well as to establish agricultural roads, and improve water structures and other land development activities related to the agriculture sector. The intention was to increase the area of agricultural holdings by about 300,000 ha over a five-year period, but this has not happened. A previous Law (1987) with the same aim led to an increase in the area of land registered as under agricultural use by 822,704 ha by 1991. However, the current law is proving very challenging to be enforced, mainly due to problems in tracing the remaining landowners (often people who left the land and emigrated two or three generations back) and having to use land books from the Austro-Hungarian Empire, since during the planned economy land books were not used.

**Hungary: Proposed package of policies to address issues of 'undivided common ownership' of land**
A particular land ownership/property rights issue exists in Hungary relating to the 'undivided common form of ownership'. This means small areas of land may have multiple co-owners (for example, one 8.5 ha parcel of land had 1,573 owners). Many of the co-owners do not manage the land and are often unknown, for example the title deed is missing, the owners cannot be identified, or the data are out of date or incomplete. This issue affects almost half of the agricultural area – 2.4 million ha – and more than one million properties. To avoid the issues that arise when people try to cultivate land without official permission in order to access CAP subsidies, the proposed law on agricultural land consolidation offers a number of ways of terminating the joint ownership of these areas of land. However, land under this form of ownership continues as the law on inheritance remains unchanged. This states that, unless stipulated otherwise, when an agricultural landowner dies, the land is divided between the heirs. It is not common practice to make a will in Hungary, and it is estimated that only 5% of farmers do so. The tensions between inheritance rules and the Law on Agricultural Land Consolidation was identified by many interviewees as one of the biggest issues hampering the efficient use of agricultural land in Hungary.

Source: case studies

**Box 5.3 Romanian programme to create a general cadastre for all private agricultural holdings**

Cadastral measurement and registration of the ownership of restituted land has proceeded very slowly in Romania, with much conflict and dispute. It has also been a very expensive process for landowners.

A large-scale pilot programme to introduce a general cadastre for private agricultural holdings (based on the so-called 'Land Book' system for land registration and titling) was first supported by the World Bank from 1997-2006. This pilot was rolled out into a national programme for 2015-2023 which provides for the cadastral registration of all properties throughout Romania, 'free of charge' to owners. This includes:

- Identifying property owners;
- Performing cadastral measurements;
- Collecting property title documents;
- Integrating and processing data and drafting cadastral documents;
- Public display of cadastral documents;
- Registering and resolving rectification requests filed by owners;
- Updating cadastral documents; and
- Digitalising existing hand-written records.

Successful implementation of the National Land Book and Cadastre Programme aims to make significant progress towards the development of a fully functional land market in Romania based upon formal, transparent and trustworthy transactions. It should make it easier to investigate the legal status of land and other properties and thereby make it safer to acquire them. It would also help to speed up remaining restitution claims by providing significantly more accurate information regarding property locations, thereby reducing title challenges and boundary disputes. This in turn should help to help prevent land from becoming unused and reduce the risk of transitional (or actual) abandonment.

Unfortunately, after five years of implementation, this national programme is clearly failing and a further European Regional Development Fund (ERDF) co-funded project (worth a total of €312 million) has recently been launched to focus on building the necessary administrative capacity in 23% of the rural regions where the registration of around 5.8 million ha is most hampered by poor socio-economic conditions, outdated IT, systems and institutional issues.

Source: case studies

### *Land use/development control and land zoning policies*

Spatial planning and zoning policies can be used to help maintain land under agricultural use by seeking to protect it from built development. These policies exist in many Member States. The main example identified in the case studies was in France. Here, development is generally not permitted on agricultural land (unless it is construction linked to agricultural activities). In Basse Normandie, the bocage landscape (composed of hedges and trees) is protected by local development plans (*plan local d'urbanisme* - PLU) within the framework of the Green and Blue Network initiative (*Trame verte et bleue*), and thus protected as a non-productive area. The *trame verte et bleue* is a policy tool that combines biodiversity conservation and land-use planning, whose purpose is to maintain and strengthen green infrastructure into planning tools and development projects. It does this by strengthening and creating ecological terrestrial and aquatic corridors and enabling built development to be planned in a way that achieves ecological coherence at a local level.

### *Taxation and financial instruments*

Evidence of the use of these types of instruments was found only in two of the case studies. In Italy, a programme has been in place for more than 50 years under which a public body, ISMEA[28], provides subsidised mortgages for young people who want to become farmers. This is intended to counter land abandonment, depreciation of the value of land, and help decrease land fragmentation. The programme provides a mortgage with very low interest rates whereby ISMEA buys the land on behalf

[28] Istituto di Servizi per il Mercato Agricolo Alimentare (Institute for Agricultural Food Market Services).

of young farmers and retains ownership until the mortgage is paid back over a period of time (the maximum is 30 years). The land cannot be sold for the first five years and the farmer is required to use it for agricultural purposes and to manage it directly.

The second example comes from France. In order to promote young people setting up in agriculture and encourage certain types of farming practices, young farmers (and also organic farmers) can be totally or partially exempt from paying property taxes on the part of their land that is not built on. Young farmers can apply for a 50% tax relief at the national level and an additional 50% tax relief can be granted by local authorities, depending on the municipality. This does not just relate to land being brought back from an abandoned state but can be applied on such land.

However, examples from the case studies also show that taxation can also work counter to maintaining land under agricultural production. For example, in Latvia situations were identified where landowners were allowing trees to encroach onto agricultural land to avoid taxes on agricultural land (see Box 5.5). In Portugal, an issue was identified with people not claiming ownership of land in order to avoid paying taxes, having the land registered in the cadastre, and then being obliged to maintain it under active management.

## 5.4 Role of policy in stimulating land to be brought back into agricultural production

It is important to highlight that it is not necessarily appropriate, for environmental and/or economic reasons, to bring back into production all land that is degraded or has been abandoned. Much land that is abandoned consists of small individual parcels scattered across an area which would not necessarily be economic to bring back into production. In other situations, land may be of high biodiversity value, in the process to reverting to forest over time, with associated climate and other environmental benefits, or may be fulfilling other important socio-economic and environmental functions and delivering ecosystem services, such as flood control and management. A precursor to any decision to bring land back into agricultural production therefore should be an assessment of the benefits and costs of doing so, taking into account the ecosystems services that are currently and could potentially be delivered in the future. This is necessary to ensure that vital ecosystem services are not lost in the process.

In addition, even where land is brought back into agricultural production, this will not necessarily be appropriate for growing biomass feedstocks for energy and other non-food uses. Chapter 4 set out the types of land that might be used to grow different types of crops for these purposes sustainably. There may also be barriers to the use of previously abandoned land for these purposes, including lack of competitiveness for reasons including remoteness and/or low yields, as well as issues relating to markets, infrastructure and supply chains. This is explored further in Section 5.5, which looks at the role of policy for incentivising biomass cropping for energy and other non-food uses.

This section focuses on those policies that have been identified in the literature and the case studies as being in place to proactively bring land back into active agricultural production, irrespective of the crop that is subsequently grown on this land.

The evidence gathered for this study shows that both national policy measures and certain CAP measures have been used to bring abandoned or unused land back into production. These policy measures generally work alongside those that seek to maintain land in production, and in a number of Member States the same policies are used for both purposes.

#### *5.4.1 The Common Agricultural Policy*

A number of CAP measures can and have been used by Member States to help bring land back into production. In the past, when CAP Pillar 1 direct payments became available on accession of the central and eastern European Member States to the EU, this encouraged land back into production on a significant scale, as the payments helped increase economic returns and improved income security which had been seriously disrupted. The payments helped farmers to reintroduce long-term management on temporarily abandoned land and land where ownership changes had been very disruptive (Anguiano et al., 2008). Some HNV pastures, for example, in parts of southern and eastern Europe were already suffering major abandonment and a dramatic decline in livestock numbers, but decoupled direct payments helped, by allowing mowing as an alternative to grazing, to meet CAP cross-compliance requirements (Keenleyside and Tucker, 2010). In some of the case studies (for example, Bulgaria and Latvia), these payments, in conjunction with ANC payments, are still seen as an important incentive to bring land back into active management. Much of the national legislation in place in these countries to bring unused and abandoned land back into production also seeks to make sure that these areas are eligible for CAP direct payments.

However, there is also a range of CAP Pillar 2 measures that can be used to support the process of bringing land back into production. Unlike Pillar 1 direct payments, these measures also seek to ensure that the land is managed for particular environmental or climate purposes. These areas of land would therefore not necessarily be appropriate for biomass cropping unless the crops used were able to deliver significant environmental and climate benefits (see Chapter 4). These measures include the investments aid measure (for both productive and non-productive investments), the AECM and the Natura 2000 compensation measure. These measures are used in a targeted way and with often limited budgets, therefore their influence is at a small scale, although locally this can be very significant. **Box 5.4** provides examples of how these Pillar 2 measures have been used in locally specific situations.

**Box 5.4 The use of CAP Pillar 2 measures to bring land back into agricultural production**

**Investment measures:**
In Sicily (Italy) the non-productive investment measure is used to provide funding to bring back into production abandoned land through restoring traditional agricultural landscapes that are of high cultural and environmental value, as well as reducing soil erosion and hydrogeological instability triggered by land abandonment. The funding covers planting or slope recovery interventions to reduce erosion and hydrogeological instability, and actions to restore terraces and trees.

In Bulgaria in 2014, investment support was used to convert 5.4 ha of abandoned land into organic cherry orchards, thus helping to expand the harvest season and increase the farms profitability. The organic cherry producer used the funds to extend his farm by bringing abandoned land back into production as well as diversify the mix of cherry varieties grown in order to guard against risks relating to climate change.

**Agri-environment-climate measures:**
In Bulgaria, the 'traditional practices for seasonal grazing' AECM was introduced to support traditional grazing practices in two national parks where agricultural activities were not otherwise permitted. These areas were not eligible for SAPS or any other area-based payments. The measure was introduced in 2008 to bring the remote alpine grasslands back into production and now is used to maintain these practices to prevent abandonment and biodiversity losses. Uptake has increased over time. In 2018, there were 154 beneficiaries covering 11,189 ha in the region. In 2019, there were 184 beneficiaries covering 14,516 ha.

In Finland, the CAP's agri-environment and non-productive investment measures have been used in conjunction with LIFE and Interreg funding to restore management in threatened coastal meadows. Here, a group of priority habitats found around the coastlines of the Baltic Sea that had been grazed since prehistoric times were in unfavourable status, primarily due to the abandonment of traditional low-intensity grazing. The combination of measures supported the restoration and reinstatement of grazing on several hundred hectares of coastal meadows.

**Natura 2000 compensation measure:**
The Bulgarian case study noted that some of the restrictions imposed on land use and management through the implementation of the Birds and Habitats Directives had led to land leaving active management. This CAP measure has helped bring some of these Natura 2000 grasslands back under active management.

**Restoration of agricultural production potential damaged by natural disasters and introduction of appropriate prevention measures**
In Croatia, this measure has been used to support the removal of mines on agricultural land in war-affected areas to restore the productive potential of such land and prevent the longer-term abandonment of agricultural holdings in these areas.

Source: Case studies; ENRD good practice examples (see: https://enrd.ec.europa.eu/projects-practice_en); Alliance Environnement, 2019.

### *5.4.2 National policies*

In terms of the national policies identified, these emerged primarily from the case studies, with few examples found in the literature. This highlighted a mix of policy tools in operation, including taxes, land auctions, spatial planning tools, and the development of processes for transferring land that has been abandoned to new owners/managers (for example, the use of pre-emption rights, land associations and land banks). The national measures identified above to address land structure and tenure issues also are often used to help bring land back into active management. Most of these policies either apply at a fairly local scale and deal with small areas of land or are in place but hardly used in practice. **Box 5.5** sets out examples of the national policy tools identified in the case studies.

**Box 5.5 National policy tools to stimulate land being brought back into active agricultural use**

**Latvia** has a political objective to return unused agricultural land to production. There are a couple of national policies used to achieve this:

- Law permitting the **lease/auction** of land owned by the municipality to revitalise land that is currently uncultivated or degraded. The municipality often ends up being responsible for managing land plots which have no official owners, where legal processes are ongoing, or where the owner dies and nobody inherits the land. There can be situations where the court gives the municipality the right to sell or lease such land. The practice works successfully, because in some regions, farmers lack agricultural land and they are keen to lease uncultivated land.
- Latvia also applies an additional **tax** on agricultural land that is unmanaged or untidy to disincentivise this. The basic tax on all land is 1.5% of the cadastral value of the land, which is doubled if deemed to be unmanaged/untidy. According to case study respondents, this is having the desired effect, but there are some exceptions where landowners prefer to pay the higher tax, viewing the land as a long-term investment, whether used or not. In some cases, growing trees on agricultural land is seen as a more secure long-term investment option, also providing a source of income for future generations. Where this takes place land will lose its agricultural status.

In **Italy (Sicily)** there are two policies currently under development:

- **A land association** – in the Madonie mountains – which would act as an intermediary between owners of agricultural land and young people willing to bring it back into production.
- A **regional land bank** is being put in place, under a national law that requires municipalities to create an inventory of their abandoned land and rent it to farmers aged between 18-40 years old. The aim is to improve the management of agricultural land and create jobs.

In **France**, there is a specific national process for bringing agricultural land back into production (SAFER **pre-emption rights** for agricultural land). An individual can request to manage an area of land that has been abandoned or under-utilised for more than three years – the landowner is notified and given a year to start cultivation. If this does not happen then the applicant is authorised to manage the land. Pre-emption rights to address land abandonment issues also exist in other countries, such as **Spain (Galicia)** and **Lithuania** (van Holst, 2011), but are rarely exercised.

**France** also uses **spatial planning tools,** for example development control rules that aim to avoid urban development projects impacting on agricultural land. In cases where development is approved on agricultural land, payments are required to compensate for the impacts ('collective compensation') – one example of possible collective compensation is to encourage abandoned/unused/degraded land to be brought back into production.

In **Croatia** the **Law on Agricultural Land** permits the Ministry of Agriculture to lease land that is not being used for agricultural production or kept in a state suitable for agricultural production and is owned by individuals who cannot be identified, to individuals who want to use it for agricultural production for a duration of up to ten years. This does not change the ownership rights of the land, it cannot be used for perennial crops, and agricultural buildings cannot be erected.

Source: case studies

## 5.5 Role of policy in incentivising biomass production on agricultural land

Bringing abandoned land into active agricultural use does not mean that it will necessarily be used to cultivate cropped feedstocks for energy and other non-food purposes. This decision is in the hands of the land manager and is influenced by a range of factors, with policy being only one of these.

There will be many cases where biomass cropping is not a viable use for abandoned, unused or degraded land, for a variety of reasons (see also Chapter 4). First, it may simply be uneconomic to grow biomass crops in situations where:

- natural constraints (soil, water availability, slope, altitude) limit potential productivity and raising this would require significant interventions which are costly and/or may conflict with other environmental or climate objectives. This constraint applies more strongly to annual oil, starch and sugar crops which require good agricultural land, than to perennial woody crops such as SRC and agroforestry (see Section 4.2 for the cultivation requirements of different biomass crops for energy and other non-food uses);
- land where farm structures preclude the use of specific parcels for a sufficiently long time period to provide a return on the investment in perennial biomass cropping; and
- where the lack of local markets, access problems or transport costs to processing facilities make biomass cropping economically unsustainable. The length of the production cycle of perennial biomass crops may heighten the level of economic risk (Clancy et al., 2012).

Second, there will be some abandoned land which should be allocated to other uses, not to biomass cropping, for reasons of environmental sustainability. These include:

- HNV pasturelands where restoration of the previous livestock management is feasible and alternative uses would damage their biodiversity conservation status: for example, grassland, heathland, steppe grazed/browsed woodland and long-established locally adapted agroforestry habitats (including but not limited to Annex 1 habitats and Natura 2000 sites dependent on or associated with specific types of agricultural management).
- Other nature conservation and protected areas.
- Undrained peatlands (unless used for paludiculture biomass crops).

Without spatially explicit information on the bio-physical and other structural characteristics of abandoned or degraded land, which is beyond the scope of this study, it is not possible to identify the extent or location of abandoned land where biomass cropping is a viable option. However, analysis of the drivers of land abandonment (see Section 4.4) indicates that overall there is likely to be a large overlap of abandoned land and the marginal conditions typical of areas where natural constraints impact on agricultural production.

There is very little evidence on biomass cropping specifically on previously abandoned or degraded land, and the following summary refers to biomass cropping on agricultural land generally. At the farm level the potential for growing biomass crops is affected by economic risks and uncertainties (variability in production costs, yields, market prices and especially the opportunity cost of alternative land uses); access to appropriate infrastructure and processing facilities; social factors (grower acceptance and resistance to long-term land use change); and the institutional and policy context (Allen et al., 2014; Clancy et al., 2012; DECC, 2012; Di Corato et al., 2013; Faaij, 2018). The market for energy crops shows huge variation across the EU countries (Rokwood, 2015a) (see Section 4.4 for further discussion of socio-economic factors).

Three studies illustrate the complexity and interaction of factors affecting farmer adoption of energy cropping on productive agricultural land, marginal land and abandoned land:

- A review of 25 years of UK perennial energy crops policy concluded that perennial biomass crops for energy have not fulfilled their potential on productive agricultural land. Obstacles to progress included: the lack of long term supportive policy; the failure of headline projects and organisations (which undermined grower confidence); long-term perennial crops being less competitive than annual crops; scheme bureaucracy; over-ambitious projects; and large-scale support schemes favouring imported rather than domestic biomass supplies (Adams and Lindegaard, 2016). An on-farm survey of arable farmers in England found that the main reasons for not growing dedicated energy crops were the impact on land quality, lack of appropriate machinery and the length of time to commit to this land use and achieve a financial return and profitability. The authors noted that previous research found that even where arable farmers are interested in energy crops, they are unlikely to convert large areas to them (Glithero et al. 2013).

- A study of marginal land in the Mediterranean concluded that the cultivation of energy crops 'still remains uncertain and less attractive without incentive mechanisms, tax credits and exemptions, or long-term pricing schemes' (Pulighe et al., 2019).
- A study of the establishment of short rotation crop systems (SRC) on abandoned agricultural land in the Latgale region of Latvia showed the dependence on policies guiding land acquisition and agricultural land use, as well as social and economic policies. Currently barriers include: lack of land management by absentee landowners (and ineffective tax measures for unmanaged agricultural land); afforestation measures offering better value than woody crops; insufficient support for small/medium farms and for young farmers planting SRC on abandoned agricultural land; low uptake of payments to improve land that is capable of growing SRC; and social exclusion and marginalisation of the rural population in the region (Abolina and Luzadis, 2015).

These studies illustrate the importance of a supportive policy framework, but despite national efforts (in particular in Sweden and the UK), and EC-supported research and pilot projects (Faaij, 2006) dedicated perennial energy crop production remains a minority land use in the EU. After 40 years of R&D the SRC sector accounted for just 514,260 ha in the EU-28 in 2016 (Eurostat FSS data). Evidence from the case studies shows that over the past five to ten years, where farmers have diversified their cropping into energy crop production, this has been only on a limited scale, and predominantly into familiar production systems: agroforestry in France, Portugal, Spain and Hungary; rapeseed in France and Hungary (which also recorded oil pumpkin). Six of the nine case studies reported no interest so far in more novel energy crops, but there had been some diversification into SRC willow/poplar in Hungary, miscanthus in Croatia (where there was considerable interest in industrial hemp and solar panels), industrial soy and sorghum (Hungary) and hemp/flax in France. Where other renewable energy production on agricultural land has increased, this is mainly solar panels, initiated by policy incentives to the photovoltaic sector which leased farmland (see Section 4.3).

### *5.5.1 Types of policy support for growing energy crops*

It is not possible to identify where polices promoting biomass cropping for energy or other non-food uses have been applied specifically to abandoned, degraded or marginal land. Therefore, the remainder of this section looks at the role of policy on agricultural land in general, irrespective of its current status or use.

Policy support for biomass crop cultivation for energy and other non-food uses can be direct/push (for example, supply-side support to incentivise growing perennial energy crops) or indirect/pull (for example, demand-side support for capital investment or energy generation), and the two need to be balanced to link supply with end-user markets (Adams and Lindegaard, 2016).

The key policy instruments and the way they influence biomass cropping for energy and other non-food uses are set out below. An important caveat is that in order to ensure sustainability, the socio-economic and environmental/climate suitability of agricultural land parcels should be assessed prior to its use for this purpose and that any biomass crops are managed sustainably to optimise the generation of ecosystem services.

*The Common Agricultural Policy*
The CAP has enabled the production of energy crops and SRC on agricultural land since 1992, through area-based direct payments under Pillar 1 and indirectly through a range of optional rural development measures under Pillar 2. The form and scope of the CAP support has changed considerably over time.

*Direct payments under Pillar 1:* Wholly funded by the European Agricultural Guidance and Guarantee Fund (EAGGF), almost all direct payments are now de-coupled annual payments per hectare of eligible agricultural land[29]. All annual oil, starch or sugar crops can be grown on agricultural land in receipt of CAP payments irrespective of their end use – for food, energy or other non-food uses. In 2009, land growing SRC became eligible for the main SPS claimed by most farmers[30]. In the 2014-20 CAP Member States could choose to pay additional VCS payments per hectare for SRC[31] and, together with agroforestry[32], it was also one of the options under the Pillar 1 greening requirement to manage an area equivalent to a proportion of the farm's arable land as EFA[33]. Only six Member States recorded farmers choosing SRC as an EFA option in 2018[34]. The legislative proposals for the next CAP programming period include an option for Member States to grant VCS for SRC and other non-food crops with potential to substitute fossil materials[35].

*Rural development measures under Pillar 2:* In Pillar 2 of the 2014-20 CAP almost all the measures are optional for Member States, and there are just two relevant measures. There is a specific reference to biomass production in the co-operation measure, which was introduced in 2014 under the EU priority for fostering innovation, cooperation, and development of the knowledge base in rural areas. Funding is available to support cooperation among supply chain actors for the sustainable provision of biomass for use in food and energy production and industrial processes[36], for example through operational groups (innovation projects financed through the RDPs). Topics might include, for example, testing of novel techniques; innovative harvesting and conditioning machinery for biomass production from short-rotation coppice; testing options for small-scale on-farm use of woody side streams for energy self-consumption; producing charcoal/pellets on the farm; exploring technological options for mobile heating units (for example, for seasonal grain drying); and groups of farmers working together on

[29] Meaning that there is no requirement for agricultural production, only an obligation to maintain the land in good agricultural and environmental condition.
[30] Reg 73/2009 Art.34.
[31] Reg 1307/2013 Art.52.
[32] Only agroforestry that is or has been supported under the CAP Pillar 2 measure is eligible (Reg 1307/2013 Art.46(2)e.
[33] Reg 1307/2013 Art.52.
[34] Austria, Denmark, Latvia, Poland and Slovakia (all at 1% of total EFA) and Sweden (at 2% of total EFA). Source: https://agridata.ec.europa.eu/extensions/DashboardIndicators/Biodiversity.html?select=EU27_FLAG,1 (accessed 2 September 2020).
[35] COM(2018) 392 final Art. 30.
[36] Reg 1305/2013 Art.35(2)h.

larger scale integrated renewable energy generation installations with the potential to provide multiple benefits for the local population (EIP-AGRI, 2019). The second relevant measure is a sub-measure (within the suite of forest measures in Pillar 2) providing support for the costs of establishment and initial maintenance of agroforestry systems. These systems vary considerably and the woody component may not be used for bioenergy.

Despite the availability of different forms of CAP support for nearly 30 years, research suggests that CAP payments do not appear to have had a significant influence on farmers' adoption of energy crops (Bartolini and Viaggi, 2012; Giannoccaro et al, 2009). It is relevant to bear in mind that when Member State or regional CAP managing authorities and farmers make decisions about support for biomass cropping, they do so within a context where:

- the policy drivers of afforestation (LULUCF, payments under the CAP and state aid) are generally stronger, more familiar and better established than drivers of biomass cropping;
- for the land manager, biomass cropping falls between very short arable rotations and long forestry rotations and requires a different set of skills and business plan. The introduction and management of agroforestry systems requires considerable investment and specific knowledge to integrate trees into existing cropping systems;
- the detailed decisions made by Member States or regional authorities will determine whether the available CAP measures are used to address the drivers of land abandonment and to create a more favourable environment for biomass cropping. Under the present CAP, all Pillar 2 measures are optional for land managers and most are optional for Member States (except for the AECM and LEADER measures).

*Structural fund policies*

In addition to the EAFRD, three other EU structural and investment funds are of potential relevance to energy crop supply chains: the ERDF, European Social Fund, and the Cohesion Fund. Key enabling technologies (KETs) are one of the investment priorities for the ERDF, which could support 'technological and applied research, pilot lines, early product validation actions, advanced manufacturing capabilities' (EC, 2014, cited in Scarlat et al. (2014)). For example, in Andalusia, Spain, an investment of €450,000 in nearly 2MW of biomass boilers in municipal dependencies was enabled with funding from the ERDF, the provincial council and participating municipalities (Rokwood, 2015a).

*RED II*

This specifies that to be classified as low ILUC, biomass renewable energy should come from unused, abandoned, degraded lands (according to the definitions in the regulation), but the effect so far is unclear and probably limited by the lack of a stable, economically attractive market.

*National policies*

It is beyond the scope of this study to review individual EU-28 policy incentives for energy cropping, but a 2006 study of bioenergy in Europe, considering both agricultural and forest energy crops, concluded that much was achieved for bioenergy in the 1990s, and *'the stronger the national policy in terms of support and legal embedding, the more substantial the results were'*. Examples included a carbon tax, and the development of the SRC willow production and combined heat and power (CHP) markets in Sweden; financial support for biodiesel and CHP in Germany; a straw utilisation programme in Denmark; and a CHP programme in Austria, which strengthened the position of the bioenergy sector in these countries and industries (Faaij, 2006).

A study of the impact of incentive programmes on returns from willow biomass cropping in the US showed that establishment grants of 75% of cost provided high returns on medium to high-productivity land, but annual payments over 5–15 years had little impact on profitability for growers and were costly to fund (Buchholz and Volk, 2012). Low cost start-up loans were one of the least expensive approaches for medium to high-productivity land, but the only incentive that made low-yielding sites profitable was an output subsidy of $50 per oven-dried metric ton, which was more expensive than other incentives. The authors concluded that effective financial incentives must be well designed and monitored to reach the target audience (Buchholz and Volk, 2012). A recent study of the wider bio-based economy in the EU concluded that financial policy instruments are the dominant support for the development of the bioeconomy (Elbersen et al., 2020).

Therefore, rather than focusing just on 'push' policies (for example, CAP measures enabling farmers to grow biomass crops and providing investment support for agroforestry) complementary action is needed to improve 'pull policies' that will stimulate a biomass market that can compete with alternative, more economically attractive crops. This includes a need to:

- Improve biomass energy value chains, access to markets and technological innovations (for example, in the use of crop and other residues).
- Create market demand for sustainable biomass for advanced biofuels and non-food uses.
- Develop a certification policy for sustainable biomass for energy and non-food uses that comes from specific perennial land management systems such as agroforestry and SRC.
- Pay for additional ecosystem system services and biodiversity delivered by existing and newly developed sustainable perennial biomass crops and agroforestry (landscape heterogeneity, biodiversity, carbon capture in above ground biomass), for example through EAFRD environmental land management measures in the CAP.

## 5.6 Conclusions

The way in which policy addresses land degradation and abandonment is mostly indirect and arises from a combination of different policies working together. The policies identified as having a particular influence were various instruments and measures under the CAP (both Pillar 1 and 2) and an array of national policies (including taxes, financial instruments, spatial planning policies and processes for land registration and to address land structure and tenure issues).

Other EU policies, such as those relating to renewable energy, climate, and environment, are likely to have an influence both through the policy signals they send about priorities as well as the national strategies put in place to implement them on the ground. However, their influence appears to be secondary to the policies identified above and they are rarely identified in the literature or the case studies.

Avoiding land abandonment is rarely the primary objective of the policy measures identified, with the exception of the ANC measure under the CAP. They primarily influence land abandonment by attempting to address the broader socio-economic issues facing either the agricultural sector or rural areas – for example seeking to maintain farm incomes, address farm structure and tenure issues, or avoid rural depopulation and promote generational renewal. In some cases, they also seek to influence the way land is managed, either through protecting areas of high biodiversity value or through maintaining or encouraging more sustainable forms of land management and the protection of natural resources (mainly Pillar 2 measures).

These policy measures operate at different scales and have varying degrees of influence on land degradation and abandonment depending on the way they are designed and implemented within Member States. In relation to the CAP, Member States have a high degree of flexibility in designing and implementing the interventions under both Pillar 1 and Pillar 2. This includes their eligibility criteria, payment rates, the funding allocated to them, and for Pillar 2, which measures to use and how these are targeted. In the future it is intended that Member States will have even greater flexibility which will also allow them to target Pillar 1 measures to address identified policies and needs.

National policies have evolved to address the specific issues faced nationally, regionally and locally. In particular, the case studies highlighted the special circumstances facing central and eastern European countries, particularly in addressing land structure and tenure issues arising from the process of land restitution.

In practice, however, the current policy mix is often insufficient to counter the broader socio-economic drivers of land abandonment, such as those leading to rural depopulation. These wider rural issues deserve more attention alongside support at the farm level and attempts to address farm structure and tenure issues if the most socio-economically vulnerable farming systems are to be maintained. The extent to which this is possible will vary regionally and depend on the relative economic buoyancy of the economy more generally.

In terms of bringing land back into agricultural production, there does not appear to be a widely applied process available that allows for an assessment of whether or not this is desirable from an environmental or climate perspective, since the decision lies purely in the hands of the landowner. The exception to this is the EIA requirements[37] although the threshold criteria adopted in most Member States as well as issues of enforcement effectively exempt most such changes from an EIA in practice (COWI, 2009b; King, 2010). Although the RED II includes sustainability criteria whereby bioenergy crops cannot be considered low ILUC if grown on land identified as biodiverse or carbon-rich according to the criteria set out in the implementing regulation, it assumes that crops planted on abandoned or degraded land would automatically meet these sustainability criteria. However, this is not necessarily the case. It is important to recognise that some land that has become abandoned over time will be delivering greater societal benefits in its new and less managed state (for example, for biodiversity, climate, flood protection, or even through other economic activities such as hunting) and it would therefore be inappropriate to bring this back into agricultural use. The absence of an effective EU system for screening the environmental effects of bringing land back into agricultural production is a current policy gap.

[37] In relation to agricultural land, the EIA Directive requires Member States to put in place rules for carrying out EIAs in certain circumstances, including the restructuring of agricultural land and the conversion of uncultivated or semi-natural habitats to intensive agricultural management.

Maintaining or bringing back land into agricultural production in a way that is sustainable and does not lead to land degradation is only one side of the coin. Once it is available for production, decisions about whether or not to plant biomass crops for energy or other non-food purposes also rest with the land manager. The factors determining these decisions are varied but tend to be primarily market-related. Although there are some policy measures (mainly under the CAP) that promote the production of biomass crops for energy, the policies available to those in the agricultural sector apply equally no matter what type of crop is produced. The key role of policy here is to ensure that agricultural production is carried out in a way that also delivers public goods: in other words, that the way crops are grown is sustainable, protecting natural resources and delivering a mix of ecosystem services.

The policy recommendations that follow from this chapter are presented in Chapter 7.

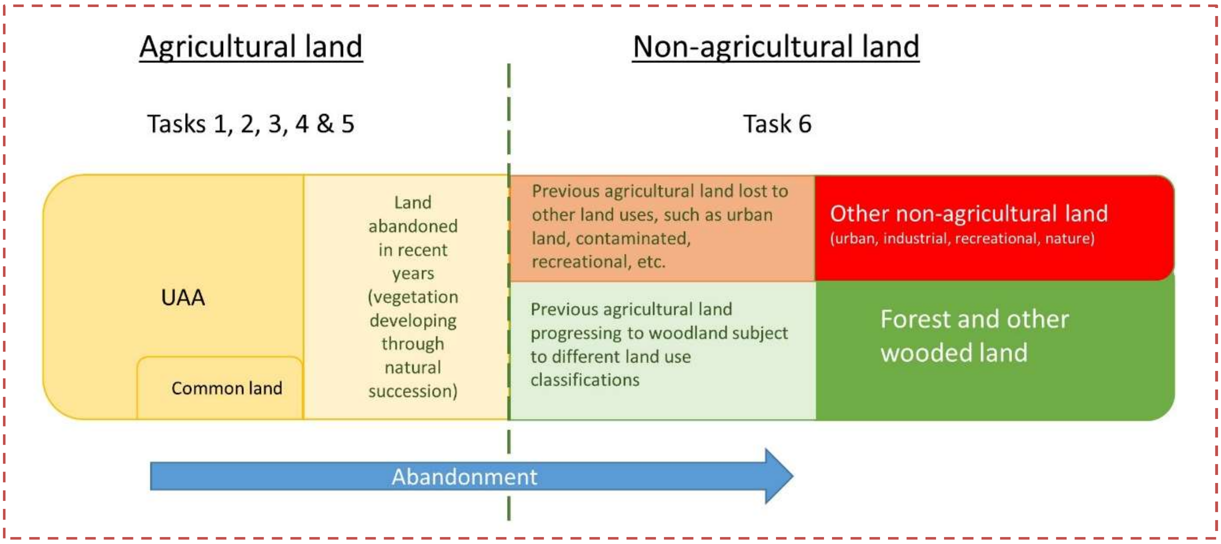
# 6 NON-AGRICULTURAL AREAS AND OPTIONS FOR BIOMASS CROPPING

**Chapter aim and contents:**
This chapter provides an overview of different types of non-agricultural land potentially suitable for producing biomass crops for energy and other non-food uses. Based on recent statistical data and literature, it identifies different non-agricultural land categories and assess the order of magnitude of these areas of land within the EU-28. It also outlines the outcomes of an analysis identifying the barriers and opportunities for growing biomass crops on these different land use types. Finally, three case studies provide in-depth insights into the potential for biomass crop production on the three most promising non-agricultural land use types.

## 6.1 General introduction and approach

Before analysing categories of non-agricultural land, it is important to arrive at a clear definition. When agricultural land is abandoned, this happens mostly through a gradual process. This makes it somewhat arbitrary to decide when exactly it becomes non-agricultural land. While Chapters 2, 3, 4 and 5 focus on agricultural lands that has been abandoned recently, here the focus is on non-agricultural land and agricultural land that has been out of production for a long time and therefore progressed to non-agricultural uses (the focus of Task 6 in this study).Forest land is excluded from the analysis. The boundary between agricultural and non-agricultural land lies in the status of transformation (see Figure 6.1).

Figure 6.1 Boundaries and status of transformation of (former) agricultural land




The following approach was used to further specify the different categories of non-agricultural land that could potentially be used to produce biomass crops for energy and other non-food uses:

**Expert consultation to construct a longlist.** Experts with experience in agriculture, forestry, EU biofuel policy, EU environmental policy, sustainable biomass certification, and land use change were consulted to brainstorm a longlist of potential non-agricultural land use categories. These were then reviewed by experts in the rest of the project team.

**Estimation of the theoretical potential available area in the EU-28**. For each category, the (maximum) theoretical potential of land area availability was estimated based on a literature search of scientific papers, databases, news articles, and other sources.

**Estimation of the available area in the EU-28.** For each category, the potential available area that is realistically available was estimated by considering competing uses or other factors that would limit the maximum theoretical potential.

**Creation of shortlist of categories.** The longlist was filtered to create a shortlist of categories based on size of availability, feasibility, and potential co-benefits (economic, environmental, and so on) identified in literature.

**Identification of opportunities and barriers**. For each shortlisted category, opportunities and barriers were identified through a literature search focusing on policy, funding options, co-benefits, pilot projects or existing initiatives, and positive public perception. The assessment was based on expert judgement.

**Identification of three categories for in-depth case study analysis.** Three shortlisted land use categories were selected for in-depth analysis on their technical and economic feasibility for biomass production, and to identify existing policies that could form barriers or stimulate the use of these lands for biomass cropping.

## 6.2 Non-agricultural land use categories

From the initial expert consultation, 28 categories of non-agricultural land use were identified to construct the longlist (see Annex X Non-agricultural land). Some of these include previous agricultural land that is now abandoned and may overlap with land categories from other chapters. We left these categories in the list as the input on policy recommendations could also be used in Chapter 5. The longlist was pared down by removing land types that were deemed too small in area, too low in practical feasibility, potentially interfering with ongoing activities, or if developing dedicated biomass cropping was not expected to be financially viable in the coming decades (see Annex VI for selection criteria). The result was a shortlist of 13 categories of non-agricultural land (Table 6.1), including the order of magnitude of available land area and the most relevant regions within the EU-28. The size ranges are defined as: *low (*0-10,000 ha); *medium (*10,000-100,000 ha); and *high (*>100,000 ha).[38] These refer to the potential of currently available land; for example, the closed landfills category includes landfills that are currently closed and excludes landfills to be closed in the future. Many land categories share common characteristics or are part of the same sector and can therefore be grouped into four aggregate groups: (1) brownfield land; (2) abandoned agricultural land; (3) infrastructure landscaping; and (4) combined business.

[38] The uncertainty of these ranges is high as the estimation from theoretical potential available area to potentially available area was determined by expert judgement.

Table 6.1 List of identified non-agricultural land categories suitable for biomass cropping for energy and other non-food uses, and scale of area available in the EU

| Category group | Category | Description | Land availability* | Most relevant regions |
|---|---|---|---|---|
| **Brownfields** | Closed landfills | Former landfills that are not operational | High | DE, IT, UK, GR[39] |
| | Closed coal mines | Former opencast coal mines that are not operational | Low | PL, DE, BG, RO[40] |
| | Closed quarries | Former aggregate mines that are not operational | Medium | PL, DE, FR, UK, IT[41] |
| | Closed mining waste facilities | Tailings and waste from extractive mining | High | CY, CZ, EE, EL, ES, FI[42] |
| | Brownfields general | Previously developed or derelict land, including contaminated land | High | EU-28 |
| **Abandoned agricultural land** | Desertified land | Degraded land in drylands, including former agricultural land | Medium | PT, ES, EL, IT[43] |
| | Saline land | Degraded land due to soil salinisation | High | FR, ES, HU[44] |
| **Infrastructure landscaping** | Roadside | Reserved area on the sides of paved roads | High | EU-28 |
| | Railside | Reserved area on the sides of railroads | Medium | GE, FR, PO, IT, UK, ES[45] |
| | Green city planning | Planned green spaces in urban areas | High | EU-28 |
| **Combined business** | PV farms | Agriphotovoltaics (combines biomass production with utility scale PV farms) | High | GE, IT, UK, FR, ES, NL, BE[46] |
| | Airports | Reserved and uninhabitable area not needed for airport operations | Medium | EU-28 |
| | Military terrain | Land for military training not necessary for permanent operations | High | EU-28 |

Notes: * low (0-10,000 ha); medium (10,000-100,000 ha); high (>100,000 ha).

## 6.3 Opportunity and barrier analysis

The successful implementation of biomass crop production is influenced by factors that could stimulate or hinder the process. These opportunities and barriers can be grouped into six categories:

[39] European Enhanced Landfill Mining Consortium, 'Landfills in Europe.' https://eurelco.org/wp-content/uploads/2018/09/landfill-situation-eu-28-eurelco.pdf
[40] European Commission, (2018), 'EU coal regions: opportunities and challenges ahead.' https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/eu-coal-regions-opportunities-and-challenges-ahead
[41] UEPG, (2017), 'Estimates of aggregates production data.' http://www.uepg.eu/statistics/estimates-of-production-data/data-2017
[42] European Commission, 'Closed and abandoned waste facilities.' https://ec.europa.eu/environment/waste/mining/implementation.htm
[43] Courthouse News, (2019), 'EU warned to do more on desertification.' https://www.courthousenews.com/eu-warned-to-do-more-on-desertification
[44] JRC, (2008), 'Saline and sodic soils in the European Union.' https://esdac.jrc.ec.europa.eu/images/eusoils_old/Library/Themes/Salinization/Resources/salinisation.pdf
[45] Statista, (2017), 'Total length of the railway lines in use in Europe.' https://www.statista.com/statistics/451500/length-of-railway-lines-in-use-in-europe
[46] EurObserv'ER, (2019), 'Photovoltaic barometer.' https://www.eurobserv-er.org/photovoltaic-barometer-2019

**Economic.** Opportunities are related to profitability from the cultivation of bioenergy crops or available funding opportunities, for example, PV farms where energy crops could be cultivated on unused land to generate additional income. Barriers are related to the high cost of cultivation or investments needed, or the unprofitability of cultivation, for example, rail-side and roadside strips cover long distances but are narrow, and therefore potentially difficult and expensive to manage and harvest.

**Policy and regulation.** Opportunities are related to policy or strategic plans that accelerate or are synergistic with bioenergy crop cultivation, for example, land rehabilitation policy and greening initiatives. Barriers include policy or regulations that hinder or limit agricultural activities on this land category, for example, permitting restrictions or land classification/planning.

**Public perception.** Opportunities are related to positive public perception, for example, contaminated land being rehabilitated or closing coal mines. Barriers are related to negative public perception, for example, cultivation for bioenergy competing with nature protection or recreational uses.

**Ongoing initiatives.** Opportunities are related to instances where production of biomass crops leads to synergies (besides economic benefits) with existing projects or initiatives, for example, EU land rehabilitation projects. Barriers are related to biomass crops competing with other initiatives, for example, rehabilitation projects focused on increasing biodiversity rather than cultivation of single or few crops.

**Environment.** Opportunities are related to cultivation having a positive impact on the local ecosystem or soil quality, for example, degraded land is restored. Barriers are related to environmental limitations that make cultivation challenging, for example, low productivity of crops on contaminated land.

**Other.** These can vary depending on the land use category. Annex X, Table 2, gives details of the relevant opportunities and barriers in this category.

The opportunities and barriers identified for each non-agricultural land category are summarised in Table 6.2 and detailed analysis included in Annex X, Table 17.2. The plus-sign (+) indicates an opportunity and the minus-sign (-) indicates a barrier. In cases where both an opportunity and barrier are identified within a group of categories, a slash mark (/) is used. The table is not exhaustive and includes the opportunities and barriers most apparent in literature and from expert judgement (see also references to Table 17.2 in Annex X). It resulted in a scoring matrix for the opportunities and barriers for the land categories selected for further analysis.

Table 6.2 Summary of opportunities and barriers for non-agricultural land categories

| Category group | Category | Economic | Policy and regulation | Ongoing initiatives | Environment | Public perception | Other |
|---|---|---|---|---|---|---|---|
| Brownfield land | Closed landfills | + | + | +/- | ++/- | ++ | |
| | Closed coal mines | ++/- | | + | ++/- | ++ | |
| | Closed quarries | +/- | | +/- | ++/- | | |
| | Closed mining waste facilities | +/- | - | ++ | ++/- | ++ | |
| | Brownfields general | +/- | | + | ++/- | ++ | |
| Abandoned agricultural land | Desertified land | +/- | | +/- | - | | |
| | Saline land | +/- | | + | +/- | | |
| Infrastructure landscaping | Roadside | - - | | +/- | | | |
| | Railside | - - | | +/- | | | |
| | Green cities | | +/- | +/- | + | | |
| Combined business | Utility scale PV | +/- | | ++ | | | - |
| | Airports | ++ | - | - | + | | |
| | Military terrain | ++ | - | | | | + |

## 6.4 Case studies: three promising types of non-agricultural land use

Three land categories were selected for a deeper analysis of the barriers and opportunities regarding biomass cropping opportunities. The selection was based on a number of factors, including high land availability, promising opportunities and practical feasibility for biomass production. For each case study, several (industry) experts were interviewed and relevant literature reviewed.

### *6.4.1 Case study 1: Bioenergy crops on airport land*

*General context*

Airports generally own a large area of land around the operational aviation zone that is not used for other activities for a range of reasons, mostly safety related. For example, aviation safety rules prohibit tall objects or buildings to be built near landing and taking off zones. Sound pollution makes the area near an airport uninhabitable and unsuitable for most economic activities. But there are options, like agriculture, that can utilise this area effectively. Agriculture on airport land is called airport farming, and is a well-known practice in the USA. Experts[47] suggest that about half of US airports have some sort of farming on their lands or nearby aviation operations. There appears to be no specific preference for biomass crop production for non-food uses on airport land, as currently most airport farming includes food/fodder crops (for example, corn, soy, beans, wheat). However, research has shown that airplane fumes can lead to pollution on or in crops which could make food production unviable. Logistically, it

[47] Experts from the Wisconsin Department of Transportation and the Bureau of Aeronautics were consulted.

should be straightforward to connect airport land to existing agricultural supply chains. Most airports in the EU are already surrounded by land on which agriculture is carried out.

The changes in land use can have a substantial effect on the local biodiversity. This relationship needs to be assessed carefully to ensure minimal interaction with wildlife. One of the most prominent barriers for airport farming is attracting wildlife and the potential corresponding increase of wildlife collision (EASA, 2018). Airports are spatially planned to create clearance, specifying object-free areas around instruments, lights and runways. The buffer size of these areas depends on the overall design and size of the airport. Different regulations apply for large (international) airports versus smaller (national) airports. For example, large airplanes require bigger buffer zones and two intersecting runways are required to have undisturbed sight lines alongside each other. Smaller airports might be more suitable for energy crop production due to having proportionally more area available.

*Order of magnitude estimate for EU potential*

For this case study, a spatial analysis based on OpenStreetMap and CLC was carried out to estimate the maximum potential area for airport farming in the EU-28. Data on airports (class 1.2.4) in CLC (Copernicus Global Land Service) indicate that airports in the EU-28 cover about 3,000 km$^2$. However, this mostly refers to the area covered by buildings and landing strips, land that cannot be used. In a more detailed analysis, using OpenStreetMap, the total area in the EU-28 belonging to airports[48] amounts to 5,500 km$^2$ in EU-28. Of this, the total non-impervious land was estimated to be roughly 4,300 km$^2$, or about 430,530 ha. Annex XII, Table 19.1 gives an overview of the breakdown for each Member State. On average, about 21.8% of the total airport area is impervious (covered by buildings and roads) and thus not suitable for agricultural activity. There are significant differences in the ratio of operational area per total airport area between Member States, ranging from 6.7% (Latvia) to 36.1% imperviousness (Luxembourg). Smaller airports are expected to have less air traffic and a larger ratio of operational area per total airport area. Therefore, smaller airports might be more suitable for airport farming (and biomass cropping).

*Preferred characteristics for energy crops*

To prevent the blocking of sight lines, a maximum height of crops on airports of about two metres is acceptable according to experts. The crops ideally should not produce substantial (loose) plant matter, in order to avoid this being blown onto the runways. Another preferred characteristic is low attractiveness to animals that pose a high risk of collision. This must be assessed locally for different airports, as climates and biodiversity differ between regions. The agricultural operations needed for cultivation should also be evaluated to reduce additional wildlife being attracted to the airport.

Airport-owned land might not always be most optimally fertile. Therefore, crops that can cope well with marginal circumstances like low soil fertility, limited water requirements, and specific pollution levels (for example, de-icing, potassium acetate, propylene glycol and hydrocarbons) are more suitable for airport farming. In relation to these pollutants, it might also be useful to take the bioremediation capability of different crops into account in the crop selection for airport farming.

[48] Excluding small airports where landing strips consist of grassland cover.

*Practical examples*

There are not many specific examples of airport farming in the EU-28, although it is expected that many airports have some sort of farming near them. Several examples are found outside the EU. Airport farming is usually done on airport-owned land away from the aviation operations. A safe distance from aviation operations should be maintained to control the risks of collision and leftover agriculture debris. Airport farming could thus seem to be an unnecessary hazard to aviation operations. However, there are some cases that have a direct benefit to aviation. One example is Adelaide Airport in Australia, which uses agricultural practices to lower the air temperature for aviation operations (see Figure 6.2)[49]. The trial site is four hectares in size and located 600 metres south of the airport's main runway. Different types of grass species were considered (including tall fescue, couch and kikuyu) but Lucerne showed the highest impact on temperature dampening. Lucerne can also be cut into hay and sold as a premium feed for livestock, provided pollution stays below acceptable levels, otherwise the biomass can be used for energy and other non-food products. Lucerne also appears to deter birds, which pose a great risk of collision with planes. The total water requirements in this pilot project are not yet known.

Figure 6.2 Airport farming can lower air temperature on hot days. Adelaide Airport, Australia.

Source: SA Water.

Another example is East Midlands Airport in the UK, which has planted an onsite willow farm to produce biofuel (and biogas) for the terminal building biomass boiler.[50] Using these fuels helps the airport to meet their sustainability goals. A feasibility study for energy crop production on airports and other non-traditional land in Michigan was performed by the Michigan State University in 2010.[51] This underlined the international priority of utilising (infrastructural) land for energy crops production, while not competing with food production.

[49] ABC News, 'Lucerne hay grown near Adelaide Airport runway helps aircraft take off, and provides cash crop', April 2019, https://www.abc.net.au/news/rural/2019-04-10/livestock-feed-crop-cools-down-adelaide-airport/10962938

[50] GreenAIR online.com, 'UK airport to plant its own willow farm to produce biofuel for terminal building biomass boiler', April 2010, https://www.greenaironline.com/news.php?viewStory=796

[51] Gould, C.M., (2010), 'Exploring the feasibility of growing, harvesting and utilizing bioenergy crops on non-traditional cropland in Michigan', Michigan State University, https://www.canr.msu.edu/uploads/files/Final%20Report%20Phase%20I.pdf

*Barriers*

New agricultural practices at airports are expected to change the local biodiversity. How strong this effect will be depends on the type of crop and a combination of factors at landscape scale (for example, other land uses and the presence of habitats around the airport). This biodiversity change could lead to a higher prevalence of wildlife, which brings the risk of wildlife collision with aviation. Airports in different European regions have different types of wildlife that pose a high risk of collision. For example, at Schiphol Airport geese pose the highest risk due to their weight and size. Wildlife collisions can lead to serious damage of airplanes and helicopters, and even fatal incidents (EASA, 2008). Wildlife management is therefore essential for airports to ensure safe aviation operation, with avoiding and minimising the risk of wildlife collision an integral part of airport planning.

Land before and after runways must be kept clear of objects to avoid obstructed sight lines. Radio signals, instruments and critical airport infrastructure must also be kept clear[52] and other activities are not permitted nearby in order to prevent damage. This is a barrier for agriculture using high crops or involving bulky machinery. Another barrier for airport farming is the necessity for access routes for, for example, emergency vehicles. This could result in the division of available farmland into small patches, which could reduce yield or increase costs.

Furthermore, there is a risk of agricultural waste ending up on the runways, which could damage or hamper airplanes. Foreign object debris (FOD) on runways is a danger and should be avoided. It is unlikely, however, that organic FOD like mud or small pieces of plants would cause severe damage. Airports previously allowing airport farming have agreed strict protocols with farmers on clean farming operations.

*Opportunities*

Most airports have a type of grass covering the unused land around the runway and buildings.[53] This grass needs to be maintained yearly to ensure that it does not attract wildlife or grow too tall.[54] This brings a maintenance cost for airports. Cut grass could decompose if left on the ground, leading to carbon emissions. Instead of grass and maintenance costs, a more valuable crop that sequesters carbon could be planted. This could have direct positive effects for the airport in terms of biomass and GHG emission compensation. Airport farming also adds a new revenue stream for the airport, and its operational costs could (partially) replace the previous maintenance costs. Revenue could either come from the rent a farmer pays to the airport, or from the sale of the produced biomass feedstock. Airport farming can thus be financially attractive. Commercial viability is an important factor for additional activities, especially to larger airports, as they often act as a real estate developer.

Growing crops on airport land could have a range of potential benefits to the local environment. Plants have a dampening effect on the local temperature and can absorb heavy rainfall. In addition, they

[52] For example, in Europe, 150 metres either side of runways must be kept clear of all objects except airport infrastructure.

[53] This holds for airports in moderate climates. In dry regions, sand, scrubs or rock is mostly seen as land cover.

[54] Around 30 cm is the preferred length for grass on airport. Longer grass attracts rodents and predators, shorter grass attracts large birds.

could help prevent soil loss through wind erosion. For airports that suffer from extreme weather events like heavy rainfall or high temperatures, airport farming may be beneficial to their aviation operations because the crops could reduce the likelihood of adverse effects of these weather events. Extremely high temperatures can force airports to cancel flights due to a significant reduction in lift. This has occurred in South Australia and was the main reason for Adelaide Airport to start experimenting with Lucerne crop cultivation to help cool the air.

Most airports are already surrounded by agriculture, which eases the expansion of agriculture to airport-owned land and it makes the airport land more easily accessible, which is a great logistical opportunity. This opportunity may only be valid if the nearby farmer/owner of the land agrees to take on the management of the airport land.

Lastly, airport farming can help reduce the adverse effects of aviation operations. Noise pollution and chemical pollution are substantial issues which can be reduced by the sound dampening and remediating effect of some crops (Nunes et al., 2011).

*Summary of main barriers and opportunities*

| Barriers | Opportunities |
|---|---|
| **Airport farming poses an additional risk to aviation.** | Airport farming could be financially attractive to airports due to several reasons. |
| **Airport farming can attract wildlife to airport land which is a substantial threat for aviation due to wildlife collision damage.** | Crops on airports could remediate several adverse effects of aviation operation, such as sound and chemical pollution. |
| | Available land on airports is comparatively large and easily accessible, which makes bioenergy production more feasible. |
| | Airport farming could dampen the negative effects of extreme weather events, reducing financial loss of delayed or cancelled aviation operations. |

*Policy recommendations*

- The European Aviation Safety Agency (EASA) should be consulted on policy on airport farming in Europe, as they are the main authority for aviation safety.
- Every modification to airport land is carefully evaluated by the EASA. Airport farming could lead to an increase in wildlife as plants attract wildlife. Wildlife attraction and risk assessment differs across different countries, climates, areas and crops. It is necessary to look at the local characteristics before judging the wildlife risk. Monitoring and precautionary measures are crucial in order to track wildlife interaction over time and intervene pro-actively when needed.
- Distinguishing regulations for large versus medium or small airports is useful, as large (international) airports follow a stricter set of rules on aviation operations, maintenance and safety.
- Standards on airport farming need to include methods to minimise the impacts of farming activity and debris. A clean and efficient operation is vital to ensure a safe aviation environment. After harvesting, the biomass should be taken away quickly. Throughout the process, debris should not linger on runways or airport grounds.
- The US Federal Aviation Administration (FAA) requires airports to lease the land through a public bidding process. Farming is mostly done by an adjacent farmer, and through a short-

term lease agreement, preferably a yearly contract in order to stay flexible. This could be a template for the European setting.

- Effective wildlife management is required to minimise wildlife collisions. The cost of wildlife control and potential accidents should be weighed against the income produced by the crops when deciding whether to allow farming on the airport (USDA, 2005).

#### *6.4.2 Case study: energy crops in utility scale PV systems*

##### *General context*

Agrophotovoltaics (APV) is the process of combining agricultural practices with photovoltaic electricity production on the same surface area[55]. APV systems consist of PV arrays[56] installed at an elevated height to make normal agricultural operations at ground level possible. This dual use increases the value of land because it generates a higher total income per area.[57] Pilot projects in Europe have observed a slight decrease in biomass production for most crops in the APV setup, compared to a reference case. This is because the PV panels use part of the sunlight, which could otherwise be captured by the crops via photosynthesis. However, due to the shading effect and tendency to reduce evaporation, the PV arrays can also have a positive effect on crop growth.

Existing utility scale ground-mounted PV systems[58] in Europe are often optimised for maximum power production. The PV arrays are generally installed facing south and with minimal space in between, capturing sunlight optimally. In these installations the PV arrays are often separated by a few metres of cleared space, enabling installation and maintenance. In this configuration roughly 50% of the surface area is covered by the PV arrays. They are most often mounted on metal and concrete structures and alleviated two to four metres above the ground.[59] Recently, PV developers in Europe have experienced more societal resistance to large PV systems, due to a lack of ecological integration and adverse impacts on the landscape. This topic has recently received more attention in the Dutch PV sector. A new initiative in the Netherlands, the Code of Conduct Solar PV on Land, aims for ecological integration of all new installations. The initiative was signed by several environmental organisations and the Dutch PV industry association.[60] Modifications to the mounting system (infrastructure) for large PV systems are needed to enable (energy) crop agriculture. Although there are some commercial APV systems worldwide, in Europe the installation of APV systems is mostly not yet financially viable due to high investment costs and unfavourable (financial) policies (Weselek et al., 2019). European pilot studies show great opportunities for APV systems for society, but with a need for dual land use.

##### *Order of magnitude estimate for EU potential*

The potential area for energy crop production in APV systems in the EU-28 is estimated to be about 500,000 ha, based on the following calculations. As of 2019, about 150 GWp of PV had been installed

[55] In some sources the term ‘agrivoltaics’ is also used.
[56] Commonly understood as solar panels
[57] According to experts associated with the Heggelbach APV pilot study, and literature: https://www.ise.fraunhofer.de/en/press-media/press-releases/2019/agrophotovoltaics-hight-harvesting-yield-in-hot-summer-of-2018.html
[58] For readability, ‘large PV systems’ is used to describe ‘utility scale ground-mounted PV systems’.
[59] Expert interview: TKI Urban Energy, Holland Solar.
[60] *‘Gedragscode zon op land*’, Holland Solar, 2019, https://hollandsolar.nl/gedragscodezonopland

in the EU-28 (GMO Solar Power 2019-2023). On average, about one third (50 GWp) of this consists of large PV systems. Large PV systems have a power density of about 0.5 MW per ha[61], so currently about one million hectares is used by large PV systems. Project developers for new large PV systems might be interested in the integration of energy crop farming, but it is highly unlikely that existing large PV systems can be adjusted to facilitate this, according to PV industry specialists. Most installed large PV systems are not suitable for ex-post integration of energy crops with corresponding agricultural practices. Despite fluctuations in the annual installed capacity, the total installed capacity in the EU-28 is expected to exceed 300GWp in the coming decade, even assuming the most conservative scenarios. Based on this expected trend, we assume half of the area currently taken up by large PV systems could be used as (new) agrophotovoltaics systems in the near future. This means that one out of four hectares of large PV systems in future will be APV systems, which requires a very substantial development and implementation of APV systems in the coming years. Such development remains debatable.

*Preferred characteristics for energy crops*

PV arrays block a significant part of the sunlight, causing shade. Energy crops that grow well in shade or diffuse light are therefore preferable in APV systems. Ease of production is also an important factor. Crops that require less frequent agricultural operations, such as perennial crops, are preferred because operations near or under PV arrays bring an associated risk of damaging the PV system. Agricultural operations generally entail seeding, cutting and ploughing. Heavy machinery and farming equipment are normally required for these activities. The types of crops cultivated in APV facilities worldwide are all food crops and consist of winter wheat, maize, watermelon, potato, onion, rice, and more (Weselek, 2019). At the time of writing, we are not aware of an APV facility cultivating energy crops.

Figure 6.4 Configuration of PV arrays in APV Research Plant in Heggelbach, Germany.

Figure 6.3 Raspberry farm with PV arrays as protective roof. Babberich, the Netherlands.

*Practical examples*

There have been several APV pilot studies. For example, one in Heggelbach, Germany, run by Fraunhofer ISE, aims to learn about the interaction between bioenergy and solar energy in different

[61] Global Market Outlook for Solar Power 2019–2023. https://www.solarpowereurope.org/wp-content/uploads/2019/05/SolarPower-Europe-Global-Market-Outlook-2019-2023.pdf

set-ups, such as the one in Figure 6.4[62]. Preliminary results show that vegetation behind PV arrays have a cooling effect and can therefore be beneficial for the PV efficiency. Some crops also tend to grow better in shady conditions, which the PV arrays naturally create.

In Babberich in the Netherlands, an APV pilot project is currently underway at a raspberry farm.[63] Different types of PV technologies are being tested as a protective roof for raspberry farming (Figure 6.3). The preliminary results show a slight decrease in the production of berries, but this decrease is minimised with the semi-transparent PV technology. In the reference case, berry farmers use plastic covers to establish diffuse light conditions. These covers need to be replaced and can be destroyed by storms, generating a substantial waste stream.

*Barriers*
A potential barrier for the integration of agriculture and large PV systems is the risk of damage to the PV equipment. In addition, a more spacious setup for the PV arrays to enable agricultural practices will lead to a lower surface power (production) density. This means a lower yield of solar PV electricity production per hectare. Because the cost of land is an important cost component for large PV systems, this could be a serious barrier. To make energy crop APV financially feasible, the extra revenue stream from the energy crop production would have to outweigh the loss in PV electricity.

Currently, electricity from APV systems does not enjoy feed-in tariffs in the EU-28, except in France, which makes APV not price competitive in the EU-28.[64] The cost price (LCOE) of electricity from APV systems is currently between 7-10 eurocents per kwh, which is significantly higher than the average LCOE for state-of-the-art (utility scale) ground-mounted PV systems (under 5 eurocents per kwh) (Jäger-Waldau, 2019). Extra infrastructural components in APV systems such as steel beams and concrete poles are the main reasons for the increased costs of the electricity produced. Additionally, there could be higher transaction costs for APV systems compared to the usual large PV systems, as more (and different) players need to interact and collaborate, which could incur more management costs. The ownership of land can also be an issue and a potential barrier for energy crop production in APV. Owners would have to allow for APV to be integrated into the agricultural operations of the farmer. From the perspective of PV developers, energy crop farmers would have to be invited to integrate agricultural operations onto their (leased) land.

Finally, the recent growth in societal resistance to large PV systems due to a lack of ecological integration and adverse landscape impacts, could also be valid for APV systems. APV systems do integrate with agricultural lands, but can change the landscape aesthetics significantly.

*Opportunities*
The integration of energy crops into large PV systems can increase the value of land, which is a great opportunity in densely populated areas in the EU-28. The dual land use provides an extra revenue stream which could improve the economics of both large PV systems and energy crop farming. The total operational costs will probably be lower, since some of the cost components can be shared.[64]

[62] APV Research Plant (2016), Fraunhofer ISE, http://www.agrophotovoltaik.de/english/research-site
[63] 'Frambozen gedijen onder zonnepanelen', Nieuwe Oogst (2019), Zachtfruitteler Piet Albers, https://www.nieuweoogst.nl/nieuws/2019/09/27/frambozen-gedijen-onder-zonnepanelen
[64] According to experts associated with Heggelbach APV pilot study.

APV systems could therefore have a dampening effect on the farmer's financial risks of crop failure. Vegetation cooling the PV arrays from behind improves PV efficiency[65], and PV arrays can protect crops from direct sunlight and from extreme drought, heat, hail and rain. An associated opportunity in this beneficial interaction is that PV arrays are likely to have a dampening effect on the farmer's risks of crop failure, since PV arrays can shield crops from extreme drought, heat, hail and rain. Some APV pilot projects experiment with food crops that require diffuse light in ideal growing circumstances. Results show that some crops perform better under (semi-transparent) PV arrays compared to a reference case without a roof. Currently these crops are grown under a plastic cover to create diffuse light. These covers need to be replaced (bi-)yearly and can be damaged by storms.

APV systems could also offer ecological value, such as the protection of pollinator health by providing a temporary resting place and food source. Furthermore, APV systems could potentially be used as a cost-effective method to restore degraded soil, in arid or semi-arid land. The protective characteristics of PV arrays (shade, evaporation reduction, and so on) can lead to an improved growing environment. Although the extra construction material like steel beams and concrete inflicts a significant higher carbon footprint per kWh of produced PV electricity, overall this could be counteracted by the ability of carbon capturing by the crop in an APV system. Thus, from a system perspective, an APV system with energy crops could have a lower carbon footprint than a usual large PV system.

*Summary of main barriers and opportunities*

| Barriers | Opportunities |
|---|---|
| **The investment costs of APV costs are significantly higher than utility-scale PV systems.** | APV systems show great potential to increase the value of land. |
| **Electricity from APV systems is currently not price competitive due to higher installation cost.** | The area potential for APV in EU-28 is large, around half a million hectares. |
| **Uncertainty about the ownership of land can hinder the implementation of APV systems.** | APV could be used to restore degraded soils, on arid or semi-arid land. |
| | PV arrays can protect crops from direct sunlight and from extreme drought, heat, hail and rain. APV systems could therefore reduce the farmer's risks of crop failure. |
| | Vegetation cooling the PV arrays from below improves PV efficiency.[65] |
| | From a system perspective, an APV system with energy crops could have a lower carbon footprint than a usual large PV system. |

*Policy recommendations*

- Target PV developers with new policies rather than farmers, as this is expected to be more fruitful.[66] Usually farmers follow market trends and APV electricity currently is not price competitive.

[65] 'Effect of Temperature', PVeducation.org, https://www.pveducation.org/pvcdrom/solar-cell-operation/effect-of-temperature
[66] According to experts associated with Heggelbach APV pilot study.

- To make APV competitive, stimulating policies and quality standards are needed to subsidise electricity from APV systems in the first phases of technological development. This could make large-scale APV commercially viable and possibly independent of subsidy schemes in future.
- Standards and quality norming are needed to establish trust and avoid safety issues of APV systems. Fraunhofer ISE is working on an APV standard, due in summer 2020, which needs international support and governmental approval to be fully effective.
- Create more financial incentives (instruments) in the PV market to integrate agricultural operations into large PV systems, as these incentives seem to be lacking. To establish this, legislative guidance around ownership or collaboration between PV developers and farmers could be useful.
- Offer legislative guidance around ownership of land or facilitate collaboration between PV developers and farmers. From the perspective of PV developers, farmers would have to be invited to integrate agricultural operations onto their (leased) land.
- The lack of ecological integration into conventional large PV systems and landscape impacts have led to recently societal resistance. Anticipating this trend by endorsing recent efforts around new guidelines or European policy is recommended. APV systems may have less public resistance in the EU-28. This has not yet been studied.

### *6.4.3 Case study: energy crops on closed landfills*

*General context*

Growing energy crops on closed landfills can be financially viable, scalable and could aid in the remediation of contaminated soils. Without the need for (semi-)permanent infrastructure, it can also serve as a temporary short to mid-term activity, while waiting for possible remediation or removal plans for the landfill.

The total land area of closed landfills is expected to be large but scattered. According to Eurostat data, the EU-28 has about 1,483 closed landfill sites.[67] About 87% (1,293) of these contain non-hazardous waste, 4% (61) contain hazardous waste, and 9% (131) were used to dispose inert waste. Older landfills tend to be filled with municipal solid waste and often lack any environmental protection technology (Hernández Parrodi et al., 2019). As landfilling is considered to be the least preferable option for waste disposal, it should be limited to the necessary minimum.[68] It is expected that the remaining operational landfills will close in the coming decades. The need for landfilling is also expected to reduce, as clear targets for waste reduction, management and recycling are set in the revised legislative proposal on waste.[69]

The most common way of closing a landfill has been to cover the surface with a layer of clay, sand or dirt. Closures of modern landfills, after the EU Landfill Directive of 1999/31/EC, have additional

[67] Eurostat, 'Number and capacity of recovery and disposal facilities by NUTS 2 regions [env_wasfac].' https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wasfac&lang=en

[68] European Commission on Environment and Waste. https://ec.europa.eu/environment/waste/landfill_index.htm

[69] European Commission, Review of Waste Policy and Legislation. https://ec.europa.eu/environment/waste/target_review.htm

requirements to reduce negative effects on the environment. After closure, a landfill site often needs to be monitored for decades to ensure environmental safety. There are a few options for closed landfills, from doing nothing, remediation activities, to landfill mining (for recovering resources).

The Landfill Directive allows the EU-28 to organise their own waste management and organisational bodies to manage the responsibilities on waste disposal. Therefore, maintenance, monitoring, and control of landfills and its potential hazards can be performed by different parties alongside the (former) operator of the landfill. The distribution of these tasks can be different for each Member State, but in most cases the responsibility is placed with local governments. Temporary use of the area is possible and can increase economic and societal value, until the local government decides on the final outcome of a closed landfill (for example, remediation or incineration) (van Liedekerke et al., 2014). A viable and scalable option for temporary use is the production of energy crops on top of the cover layer.

*Order of magnitude estimate for EU potential*

The EU-28 has about 1,483 closed landfill sites, according to Eurostat data in 2016. Some sources indicate a higher number of closed landfills, in the range of 150,000-500,000.[Error! Bookmark not defined.] Many of these are historic[70] and have been closed for many decades or even centuries. Some of the closed landfills have been reclaimed by urban areas, recreational areas, restored to natural land, or are now part of the built environment. This is understandable since many landfills are situated in semi-urban areas.[71] For reasons of simplicity and reliability, the order of magnitude estimate for the EU potential of energy crops on closed landfills is based on the Eurostat data. Using insights from the Public Waste Agency of Flanders (OVAM), 40% of closed landfills are smaller than 1 ha, 50% are average-sized (1-10 ha) and 10% are large (over 10 ha) (OVAM, 2013). Assuming an average size of 3 ha per closed landfill, this implies a total potential of about 4,500 ha in the EU-28. However, the OVAM numbers are based on modern and old landfills combined. Also, being a comparatively small country, it is unlikely the proportions of the Belgium case represent the situation in the rest of Europe accurately.

The largest landfill in Europe was Malagrotta in Italy, at around 275 ha, which was closed in 2013.[72] The Vinča landfill, situated next to Belgrade, is about 68 ha.[73] Large landfills are most commercially attractive for energy crop production due to scaling advantages. Due to a lack of accurate estimates for the surface area of the average modern (closed) landfill in the EU-28, we estimate it to be about 10 ha, in line with the sizing groups of OVAM (2013). The order of magnitude estimate for the EU-28 potential for energy crops on closed landfills is thus about 15,000 ha. When including all currently open landfills into the equation as well (6,043 in total), the potential is about 60,000 ha.

*Preferred characteristics for energy crops*

There are several specific landfill features that could determine the selection of appropriate crops to grow on closed landfill sites. Ideally, energy crop production on closed landfills is a temporary measure

---

[70] In line with the Environment Agency for England, the definition for historic landfills is: 'A historic (closed) landfill site is one where there is no Pollution Prevention and Control permit or waste management licence currently in force'.

[71] EU Landfill Policy and LF Directive (2019). https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1551688415.pdf

[72] Size of largest landfills as of 2019: https://www.statista.com/statistics/530481/largest-dump-sites-worldwide

[73] https://www.energoinfo.com/listing/call-for-final-bids-for-belgrades-largest-landfill-vinca

until permanent remediation can be carried out effectively. Water and groundwater access might be problematic, since landfill sites are often situated in an elevated position in the landscape, can contain a membrane, and are therefore dependent on rainfall. Also, the soil can be contaminated which can affect crop growth.

The selected crops should therefore be tolerant to certain contaminants and, if possible, they may also function to bioremediate certain polluting substances from the sites. Perennial crops may be preferred on landfills that cannot afford topsoil losses (due to erosion or ploughing) in order to protect the landfill's cover layer. Perennial crops can increase biological carbon sequestration and reduce waterway pollution through preventing agricultural runoff. An important feature in the selection of crops is the compatibility with the local processing industry to add further value to the crop. Landfill sites mainly are situated near urban or industrial areas. Previously, energy producers have considered miscanthus produced on landfills as feedstock for bioenergy.

*Practical examples*

There are several ongoing pilot projects, such as NEW MINE[74], RAWFILL[75] and COCOON[76], on remediating or recycling closed landfills. These efforts have mainly focused on methodologies for enhanced landfill mining and not on the integration of energy crop production on top of the cover layer. However, plants are considered one of the low-cost remediation strategies for landfills with low to medium concentrations of pollutants, so that the phytotoxicity remains low and crops/plants can grow. Furthermore, the plant yield can serve as a temporary source of income until other measures are taken.

Figure 6.5 FCC Environment reaps energy from landfill sites

[74] NEW-MINE: https://new-mine.eu/project
[75] RAWFILL: https://www.nweurope.eu/projects/project-search/supporting-a-new-circular-economy-for-raw-materials-recovered-from-landfills
[76] Consortium for a Coherent European Landfill Management Strategy: https://www.interregeurope.eu/cocoon

Waste companies such as FCC[77] have already demonstrated the feasibility of energy crop production on closed landfills through projects growing miscanthus in the UK to supply the DRAX power plant (Figure 6.5)[78]. Alongside pilot studies, studies have been undertaken of energy crops on landfills, such as by Pivato, Garbo, and Moretto (2018). They found that energy crop production is slightly economic attractive and can decrease the leaching of pollutants due to enhanced evapotranspiration.

*Barriers*

A potential barrier to the production of energy crops on closed landfills is the existence of other plans for these landfills, such as remediation or enhanced landfill mining. As Europe works towards a more circular economy, there is an increasing push for policies such as a 'regulatory framework for enhanced landfill mining as to permit the retrieval of secondary raw materials that are present in existing landfills' (Hernández Parrodi et al., 2019). Energy crop production can still take place, but as a temporary use. Energy crops could still be grown after secondary raw materials are removed from landfills, but this is not always likely, as the land could then also become available for other purposes.

A practical barrier could be the degree of dispersion of landfills over a region or country. Agricultural farms (economically optimised) can have large plots of land, often several tens of hectares and in the vicinity of other plots of agricultural land and related infrastructure. Landfills are rather dispersed, and most are only a few hectares in size. Crops on landfills could therefore have higher operational costs than crops on agricultural land, resulting in a reduced business case. As well as to potential higher operational costs, bioenergy production installations usually require considerable and constant supplies of feedstock. If the biomass is too dispersed and spread over large distances, logistics and transport costs are likely to increase.

The cover layer of closed landfills might be contaminated by pollutants such as heavy metals which can negatively affect the biomass chemistry and restrict suitability for bioenergy or biofuel application (Dastyar et al., 2019). Non-food applications of the biomass may be the only feasible option. Another barrier to the cultivation of energy crops is the potential absence of fertile soil in the cover layer. The soil might need treatment to improve its quality and ensure sufficient yields, which would inflict extra costs. With persistent low-quality soil, yields could fall short and impact on the economic feasibility.

*Opportunities*

The cultivation of bioenergy crops on closed landfills has several opportunities or unique selling points. First, landfills are marginal lands with serious restrictions in new (spatial) zoning plans. As food production is not allowed on former landfills due to safety regulations, and the construction of new permanent buildings might be dangerous due to instability and contaminated soil, energy crop production might be one of the most useful temporary purposes for closed landfills. It does not hinder a potential future decision for enhanced resource mining or remediation of that landfill, as very limited infrastructural modifications are needed, if any.

[77] FCC Environment is one of the UK's leading waste and resource management companies.

[78] Energy Crops Harvested from FCC Landfill Sites (2013). https://waste-management-world.com/a/energy-crops-harvested-from-fcc-landfill-sites

Infrastructure for supplying biomass feedstock to the rest of its supply chain is essential to keep transport costs low and landfills are most likely well integrated with road infrastructure since they needed to be accessed by lorries carrying waste to landfill sites.

There are scientific insights on the remediation effect of biomass on contaminated lands (Pivato, Garbo, and Moretto, 2018; Garbo et al., 2017). As well as the gradual extraction of pollutants, vegetation could also decrease the leaching of polluted water due to enhanced evapotranspiration.

*Summary of main barriers and opportunities*

| Barriers | Opportunities |
|---|---|
| **Soil pollutants and poor soil quality could lead to low yields or biomass quality issues.** | Energy crop production on closed landfills is an ideal temporarily use until more permanent solutions are found for remediation. |
| **Operational costs are expected to be relatively high due to smaller and sub-optimal geometry of the patches and necessary soil fertility treatment.** | The accessibility of closed landfills is a great benefit to their integration into supply chains. |
| | Energy crops could remediate the soil and prevent or decrease environmental risks associated with closed landfills like leakage. |

*Policy recommendations*

- The EC has acknowledged that a vision for managing Europe's landfills is required. The COCOON project (under INTERREG Europe), among other things, proposes improvements to existing policy instruments to stimulate landfill mining. There is merit in ensuring energy crop production is included in this European effort as a temporary option for closed landfills which are currently not being used for other purposes.
- There is currently no uniform European governance structure on the ownership, maintenance, monitoring, and control of landfills in the EU-28 Member States. In many EU countries the execution and costs for monitoring a closed landfill are publicly managed. The introduction of a European governance structure could therefore ease the utilisation of the closed landfills.
- Establishing a value chain for the biomass produced on closed landfills is crucial for commercial viability. Policy instruments could aid in establishing this.
- European landfill management could offer opportunities for circular economy and additional land potential to avoid competition with current food/feed production.
- The pollutants in the soil cover layer of closed landfills can be taken up by crops. The current quality criteria for new biomass feedstocks might be a barrier for demand for landfill biomass, as heavy metals or other pollutants could be taken up by the energy crop. The possibilities for leeway in this legislation to remove this barrier could be assessed, recognising the differences in quality criteria needed for food crops and non-food crops.

# 7 MAIN CONCLUSIONS AND RECOMMENDATIONS

## 7.1 Introduction

This chapter presents the study's main conclusions, following up systematically on the six study objectives:

- To provide, based on most recent statistical and scientific data, the area of UAA in all EU-28 countries at present and an evaluation of how this area has evolved since 1975.
- To provide the most recent statistical data, scientific and EU case study evidence on declines in agricultural land in the EU countries and the reasons why agricultural land becomes unused, abandoned and degraded.
- To support the Commission in proposing policies that can reverse this trend of agricultural land becoming unused, abandoned and degraded.
- To support the Commission in proposing policies aimed at reclaiming unused, abandoned and degraded agricultural land and putting it under active biomass production for energy and other non-food uses.
- To review recent data and scientific evidence to identify different types of non-agricultural land in the EU that could potentially be used for active biomass production for energy and other non-food uses.
- To support the Commission in proposing policies aiming at reclaiming non-agricultural land for active biomass production for energy and other non-food uses.

## 7.2 Actual UAA and changes in UAA since 1975

Here we present the results under the first study objectives, to provide, based on most recent statistical and scientific data, the current area of UAA in all EU-28 countries and an evaluation of how this area has evolved since 1975; and to provide the most recent statistical data, scientific and EU case study evidence on declines in agricultural land in the EU countries.

According to the Eurostat-FSS definition, the UAA is 'the total area taken up by arable land, permanent grassland, permanent crops and kitchen gardens used by the holding, regardless of the type of tenure or of whether it is used as a part of common land'. AA consists of the UAA plus NUAA and SAA. The FA is the largest area, and consists of AA plus wooded area (WA) and other land (FA9), which is farmland occupied by buildings, farmyards, tracks, ponds, and so on.

In spite of the changes in definitions and recording of data on the various components of UAA over time, and the variations permitted to Member States for recording certain agricultural land categories, the FSS database is a relatively uniform source of data that can be accessed to determine the actual UAA for EU countries and regions and historic changes in UAA. However, for data on UAA for some countries' pre-EU accession period, we also used FAOSTAT data. FAOSTAT data on agricultural lands follow a relatively similar definition as Eurostat FSS for the sub-categories of UAA. Since Member States are also responsible for providing data to FAO, it is likely that they are based on similar national data sources as used to report data to Eurostat.

Other EU-wide data sources, such as FADN, IACS-LPIS and spatial sources, were considered less suitable to obtain data on actual UAA. FADN has a much lower representation of small farms, IACS-LPIS registers AA, but is not consistent with the FSS definitions applied for UAA sub-categories, and representation of farmland is limited to potentially CAP-eligible areas.

The best source of information to determine actual UAA and historical changes in UAA in the total EU-28 at the country and region level is therefore the Eurostat FSS database, in conjunction with FAOSTAT data. Analysing these data allowed the following conclusions to be reached regarding UAA.

*Actual UAA and changes in UAA 2005-2016*
In the period between 2005 and 2016, actual UAA remained relatively stable, with an average level of 1,737,200 $km^2$, with a peak in 2010 of 1,758,150 $km^2$. The FA and AA showed a slight decline in this period, of -2% and -1%, respectively. The difference between the UAA and the AA suggests that around 5% of farmland is unused agricultural land, defined by Eurostat as 'common land that is unused'. The difference of around 15% between the AA and the FA is mostly made up of wooded areas, which also include SRC areas, and other land, which is occupied by buildings, farmyards, tracks, ponds, but does not belong to the farm area.

In this 10-year period, within the UAA arable land and permanent cropland declined in both absolute and relative terms, while the permanent grassland area increased, at least until 2010. This does not reflect a real increase in permanent grasslands, but rather be a result of an adjustment in 2010 in the inclusion of common land in FSS. Since common land often coincides with permanent grasslands this leads to large increases in this area, in especially Bulgaria, Greece, Croatia, Austria, Romania, Ireland and the UK. Therefore apparent changes in permanent pasture area need to be treated with great caution and changes in UAA data as a whole either side of 2010 are less accurate for this reason alone. However, data since 2010 might be more reliable.

For this same 2005-2016 period, the changes in UAA at country or regional levels were more extreme than for the EU-28 as a whole. The largest declines in UAA (more than 10%) occurred in Cyprus (-26%) and Austria (-18%). Countries with more modest declines were Romania, Spain, Netherlands, Sweden, Belgium, Czechia, Denmark, Germany, Italy, Poland, Portugal and Finland. The largest increases in UAA (more than 10%) were in Bulgaria (64%), Estonia (20%), Ireland (16%), Greece (14%), Croatia (60%) and Latvia (13%). Smaller increases were seen for France, Lithuania, Luxembourg, Slovenia, Slovakia, the UK, Hungary, and Malta. Countries with declining arable and permanent cropland areas are more common than countries with declines in permanent grassland areas. The declines in the first two categories are likely to be more reliable than the increases in permanent grasslands, for the reasons outlined above.

*Long-term changes in UAA 1975-2016*
The total decline in UAA between 1975 and 2016 for all EU-28 countries (for three Baltic States, between 1990 and 2016), amounts to almost 360,000 $km^2$. This relates to 18% of the UAA area in 1975. Declines were seen in all countries in this period. The largest declines occurred in Bulgaria (-25%), Czechia (-23%), Estonia (-27%), Greece (-20%), Spain (-27%), Croatia (-30%), Italy (-29%), Cyprus (-38%), Latvia (-24%), Hungary (-31%), Poland (-25%), Slovenia (-45%) and Slovakia (-35%). Medium declines in

UAA (> -20% to -10%) occurred in Belgium, Denmark, Germany, Ireland, France, Lithuania, Malta, Netherlands, Austria, Romania, Finland, Sweden and the UK. Small declines in UAA (-10% to 0%) occurred in Luxembourg and Portugal. At the regional level the largest declines (>-25%) were seen in northern Sweden, Estonia, Galicia, Madrid, Valencia, Alicante, Castellon, Provence-Alpes, Languedoc-Roussillon, most Italian regions, southern Austrian regions, and all regions in Slovakia, Hungary, Bulgaria, Slovenia and Croatia.

Industrialisation, the development of markets for agricultural products, and urbanisation characterised changes in agricultural land use in most non-CEE EU countries. In most of the CEE countries the decline was particularly large between 1990-2005, directly after the conversion from communist to market economies, when large state farms ceased to exist, markets collapsed, and agricultural production decreased tremendously. It takes a long time to bring these lands back into agricultural use by either returning the land to its original owner, or renting or selling it to people/companies who want to farm it. This gradual process of returning land to agricultural use and accession to EU explains most of the large increase in UAA in some CEE countries in the 2005-2016 period, such as in Bulgaria, Estonia, Croatia and Latvia, but also at more modest level in Lithuania, Slovenia, Slovakia, and Hungary. Over the whole 1975-2016 period, the decline in UAA is still large in these countries, indicating that a large propotion of land has not been brought back to agriculture and could have become forest with or without productive management, shrubland with no use, nature conservation areas, or urban areas.

## 7.3 Main drivers for land abandonment in agricultural lands in EU-28

Here we present the results under the second study objective, which is to provide literature and EU case study evidence on drivers for declines in agricultural land in the EU-28 and the reasons why agricultural land becomes unused, abandoned and degraded.

The literature review suggests that these transitions in land use are caused by combinations of drivers which develop(ed) from different historical and geopolitical contexts. In Western Europe the main socio-economic contexts in which abandonment took place were industrialisation, the development of markets for agricultural products, and urbanisation which led to changes in agricultural land use and demographic changes in rural areas. In Central and Eastern Europe, the change of political systems after the collapse of the Soviet Union triggered abandonment of agricultural land, mainly due to reform of the agricultural sector and the redistribution of land. After this the access to the EU agricultural markets influenced the agricultural land use strongly.

When looking specifically at drivers for agricultural land abandonment we found more widely applicable drivers of agricultural land abandonment which are unfavourable agro-ecological conditions and socio-economic drivers operating at the level of farm holdings and regions. In the EU-28, 29% of the agricultural area is marginal, occurring mainly in rural areas. Mechanisation and modernisation of agricultural practice has induced abandonment in areas where it was not possible to deploy these. Mountain areas are particularly sensitive to agricultural land abandonment.

From the literature it also became clear that socio-cultural motivations explain on the one side the maintenance of agriculture in regions where it is not economically viable, sometimes manifesting in hidden land abandonment, while on the other side productivity gains elsewhere and employment opportunities in other sectors may lead to the abandonment of agricultural land and reduction of agricultural land use. Declines in rural population are a key driver of agricultural land abandonment in many parts of the EU, not only in the CEE countries. Accessibility and the level of rural infrastructure were other key factors for maintaining land in agricultural use and keeping populations in rural areas.

Drivers from policy appeared less prominent, except for the CAP, the main policy influencing the use and management of agricultural land. This policy can both reduce and increase drivers of agricultural land abandonment. An increasing effect was attributed to definitions of agricultural land by Member States that determine eligibility for direct payments.

In the nine regional case studies interviewed experts estimated that in most cases less than 5% of the agricultural area appeared to have been subject to forms of abandonment. The land that was abandoned in the past 20 years was mostly in use as arable land or permanent grassland, and it was often marginal land. This explains why specific locations experienced more abandonment, such as hilly or mountainous areas in remote locations or in protected areas under the Natura 2000 regulation. These types of land were also considered likely to become abandoned in the near future. The vegetation development seen after abandonment was of shrubs and combinations with trees or grassland. Some case studies confirmed that agricultural land near urban centres is also subject to abandonment in some rural areas, where conversion to built-up land is generating benefits and the population is leaving in search for employment.

The nine case studies suggest that the main drivers for agricultural land becoming unused or abandoned were socio-economic in character, operating either at the level of the farm holding or the region. The most important drivers at the farm level are the profitability of holdings, the productivity of the land for crops and livestock, production costs, fragmentation of farmland, and issues with land tenure and ownership. Agriculture as an economic sector is becoming less profitable in all case study regions except the Basse-Normandie region. This enhances the trend of young people leaving rural areas. Interest in agricultural land was reported for investment, construction, recreational use and afforestation. Depopulation of rural areas was the most frequently mentioned driver at the regional level, in all cases associated with an ageing population of landowners that remain. These were reported to lead to a shortage of both skilled and unskilled agricultural labour, an uneven distribution of income, employment and investments in the region and poverty.

In contrast to what the literature reports, natural constraints for agricultural land use and land degradation were not the most important drivers for agricultural land abandonment in the case study regions, although they were mentioned in all regions. In some regions, land degradation was mentioned as reinforcing abandonment, or being expected to do so in the future under changing climate conditions. In some regions land degradation was reported to be induced by use and management of agricultural land in place (soil erosion, soil organic matter decline) or originate from external sources (contamination, salinisation due to sea level rise). In only a few case study regions does agricultural land abandonment lead to land degradation, in the form of wildfires and soil erosion.

Also, in the case study regions few drivers from policy for agricultural land abandonment were identified, but if mentioned they related to support payments under the CAP. In principle it was acknowledged that they did help keeping land in agricultural production. At the same time it was also mentioned that national policies to support agricultural production and rural development were not sufficient to keep all agricultural land in production. Also, a deficient land administration or cadastral system was mentioned in several regions as a reason why lands are becoming unused or are not brought back into agricultural use.

In most case study regions, the drivers described for land becoming unused, abandoned and degraded are expected to continue in the future. In Sicily and Soria the expectation was also for decreasing trends of land abandonment due to a strategic interest in self-sufficiency for food production, and in renewable energy production as an opportunity to revitalise rural areas.

## 7.4 Data gaps and data needs for detecting land abandonment

The only data source that maps abandonment status of lands directly (by surveyors on the ground) is LUCAS. In the LUCAS system one category of land registered as a separate land cover class is 'fallow and abandoned land'. 'Fallow' land includes all crop land not included in the crop rotation for at least one year. 'Abandoned lands' are defined as 'all agricultural land that is set aside for a long-term'. LUCAS also registers agricultural land, and since the survey is repeated every three to five years trends in agricultural land use can also be detected. LUCAS data is however, limited in that it is point information collected in a sample. This point information is scaled-up to a total area share per region (NUTS 1,2 3 levels). The precise location of the abandoned lands is not mapped in LUCAS. It therefore gives a good indication of how much land abandonment there is roughly per region, country and land cover class, but does not map the precise location of abandoned lands or the spatial extent.

A check on registration of unused, abandoned or degraded lands in the case study regions showed that fallow land is the only unused category registered in most national agricultural statistical sources and refers to the fallow land that is part of the rotation. Registration of this category is logical as it also needs to be reported as a separate category to Eurostat for FSS. In Latvia and the Bulgarian Blagoevgrad region the share of land that could be categorized as 'unused' could be estimated by subtracting the area that was registered as 'agricultural land' and 'used agricultural land'. In data this could be done. This explicit registration of used land is in line with what Eurostat also asks Member States to report to make a distinction between AA and UAA, but Eurostat-FSS defines this difference as 'unused common land' only, while in the 2 example case studies is refers to all agricultural land irrelevant of whether it is common land. In the Romanian Brasov region the registration of 'Degraded and unproductive lands' was reported. It is likely that part of this land overlaps with the REDII definition of degraded land. The registration of this type of land was not seen in the other case studies.
Overall, we conclude that unused, abandoned and degraded lands, certainly as defined in the REDII are not registered in any EU wide or national data sources.

The main reason for not registering land that goes out of production and becomes abandoned or degraded is because it then also loses agricultural land status and is therefore no longer registered in agricultural statistics. The only unused land categories for which data are collected refer to lands that are temporary out of use, such as fallow land or unused lands. However, if they are unused for a couple of years the lands lose agricultural status and are often no longer registered. Wider land use statistics may still cover these lands, and register them according to what land use or land cover it has become. This can be forest, urban, nature conservation area, lands with shrubs, or bare land. It then becomes very challenging to understand whether these lands relate to former abandoned or degraded agricultural lands. Land use and land cover data is therefore needed, on which spatial flow analysis needs to be undertaken.

The Corine Land Cover flow analysis example, enabling the comparison of land use in a precise location in different time periods, yielded some information on the types of conversions from agricultural land to other land covers. The limitation of the CLC flow analysis is that it only identifies flows that are dominant in terms of land cover, those that are large in area coverage. Small area changes are missed. This is related to the coarse spatial resolution of the satellite data that CLC uses, that have a minimum mapping unit of 25 ha and which means that detailed spatial information is lost. Therefore, small abandoned fields become part of the mosaic classes in CLC, making their identification from the CLC impossible if additional data are not used.

Another reason why data detecting abandoned lands are missing is because it involves a gradual process of transition from agricultural land to shrubs and eventually forest. It is therefore very difficult to determine when land has become abandoned completely or when it is still managed, if trying to detect abandonment based on land cover data alone. Usually a combination of statistical and different spatial data sources is needed from different time periods providing information on land use, land management and land cover.

In spite of this there are options to improve the detection and registration of abandoned and unused lands. To identify farmland abandonment and also land degradation the parcel level should be the starting point as this is the spatial level at which this process takes place. One parcel can be abandoned, while the next is managed regularly and sustainably. From this perspective, some recommendations are made and presented in the next section.

## 7.5 Barriers and opportunities for growing biomass crops for energy and other non-food uses in unused, abandoned and degraded agricultural lands

Here, we present the main conclusions regarding the types of non-food biomass crops and the barriers and opportunities for growing them on unused, abandoned and degraded lands. These barriers and opportunities are important to take into account when making policy recommendations.

Socio-economic opportunities of introducing new biomass crops on unused, abandoned and degraded lands were clearly mentioned in literature and indicate that biomass crops on unused lands may lead to additional income, create new employment, and can therefore improve rural development overall. It may also help diversify the income of farmers and create local access to new and clean energy resources. In the case studies confirmed the need for alternative land use activities within and outside agriculture, although experts differ on whether bringing back into use unused, abandoned and degraded agricultural lands is realistic, or if introducing new biomass crops is either.

There is some development of SRC cropping in the EU (500,000 ha in 2016) but otherwise both in the EU wide literature and statistics little evidence exists of the wider uptake of biomass cropping in general let alone on types of unused, abandoned or degraded lands. The same applies to the situation reviewed in the 9 case studies. No mention is made of the development of dedicated biomass cropping for energy and other non-food purposes on unused, abandoned and degraded lands. Evidence for the interest in dedicated biomass crops for production in low productive lands typically under threat of abandonment or to become abandoned is hardly given in all case studies. A key reason given in literature, but also by many experts in the case studies, is uncertainty about its financial return, particularly because the market demand for biomass crops is generally not well developed. This specifically concerns lignocellulosic biomass crops most suited to be grown on abandoned and degraded lands.

Another issue found in literature and confirmed in the case studies is that there are many technical challenges to solve to make the land suitable (again) for agricultural use including for biomass cropping for non-food uses. This usually requires large investments which are usually not very interesting to farmers, particularly when the expectations for good economic returns for the crops, whether used for non-food or food applications are low.

Beside the socio-economic barriers and opportunities linked to the introduction of biomass crops, it was also investigated what barriers and opportunities were related to introduction of these biomass crops in terms of environmental risks and opportunities. The options for creating co-benefits from the production of industrial crops on unused, abandoned and/or degraded lands depend very much on what type of land conversions are involved, the time between lack of use and conversion to new crops, the type of crops used (perennials or annuals), the management practices, and the presence of other uses and ecosystem services before introduction of the new crop.

On bare (black)unused, abandoned, degraded lands the establishment of any crop that will create a soil cover will help stabilising the soil. However, perennial crops are more effective than annual crops in reducing soil erosion and building up soil carbon. The continuous ground coverage, the low soil disturbance, and the large rooting systems are reasons for this. The same applies for agroforestry systems, particularly those that combine trees with permanent crops and permanent grassland, but also those combined with annual crops. Agroforestry are better in erosion control and overall maintenance of the soil fertility then conventional single forestry, cropping or single pasture systems.

The effect on soil carbon of perennial biomass crops and agroforestry systems very much depends on the land use before. Clearing and tillage of grasslands long abandoned lands with dense shrub and/or forest vegetation coverage or wetlands, for the purpose of perennial biomass crops results in serious decline in carbon (both above and below soil). These carbon losses for which the restoration period is variable and depending on the yield may not be compensated within the plantation lifetime of the new perennial or agroforestry system.

Overall, perennial biomass crops have low lower soil disturbance, year-round soil coverage and deep rooting which explains very low nutrient leaching to water. The deep and well branched roots in all of these perennials make that they hold large amounts of water and nutrients. Many perennial biomass crops have an increased nitrogen uptake from air and/or through fine root system and/or translocation of nutrients to the root system before the crop is harvested. In perennials water transpiration rates are high and this reduces water drainage and leaching. Similarly, adverse water quality effects of agroforestry systems are very limited as in several studies it is indicated that the use of herbicides, pesticides and nutrient inputs is generally lower in agroforestry systems as compared to mono-cultural cropping systems and intensive grazing systems. Also the deep roots of the trees make that they hold large amounts of water and nutrients, also those nutrients that are leached to the deeper root zone of trees by the annual crops grown in combination.

Effects on water availability in drought prone areas from additional establishment of crops may increase unsustainable water use. This may happen when irrigation is used, but also in rainfed situations. This applies to annual crops and also perennials where deep rooting in rainfed conditions may also deplete ground water. On the other hand there are many annual and perennial non-food crops that can cope well with arid conditions and may grow where food crops are no longer an option. Furthermore, non-food crops can be irrigated with waste water. The best option however in arid circumstances is an agroforestry system since it entails integrating woody with crop and/or animal production systems to create shading which reduces the water loss through evaporation and enables higher efficiency in water use. The deep rooting system in trees and shrubs ensure that these systems cope well with long drought periods.

In terms of GHG efficiency the land-based emissions in the cropping phase need to be considered. Application of fertilisers, manure in annual crops that may occurrence of nitrification and denitrification in the field form $N_2O$ (and $NO_x$) that is released to the air are always higher than when lands are left unused. Furthermore, annual row crops, particularly in temperate climates, have a long period of absence of plants and thus plant uptake of nitrogen which increases $N_2O$ emissions further. For perennials and agroforestry systems, even though they require relatively low levels of fertilisation and mechanisation, still release nitrous oxide and $CO_2$ (through mechanisation) to the atmosphere during cropping. However, perennials including trees in agroforestry can compensate the emissions of GHG in the cropping phase through the strong capture of carbon below and above ground during the plantation phase and also through use as alternative to fossil feedstock to avoid fossil-based emissions.

The effects on biodiversity are very much landscape and habitat context related. It is however clear that any shift that takes place from unused status to an annual, perennial of agroforestry system will lead to higher input use and mechanisation. This will have negative implications for overall habitat quality in terms of soil, water quality on soil and water quality and subsequently soil organisms. A shift from vegetated abandoned lands to rotational arable will diminish shelter and breeding opportunities for mammals and birds and will diminish the floristic diversity that was present in the abandoned land. So any conversion from unused and abandoned lands to crop production systems should be avoided when located in nature protection and or high biodiversity areas, for example, Natura 2000 and HNV farmland. On the other hand, when new plantations can be created in a more strategic way that considers landscape and biodiversity context co-benefits may be possible. Some species (certain birds and small mammals) might profit from introduction of perennial and agroforestry systems particularly in typical open monotonous permanent grassland or arable landscapes as they provide additional new landscape structural diversity and shelter and nesting opportunities.

## 7.6 Key characteristics of non-agricultural lands suitable for crops for energy and other non-food uses

In this section we present the main conclusion regarding to objective of the study to review recent data and scientific evidence to identify different types of non-agricultural land in the EU that could potentially be used for active production of biomass for energy and other non-food uses. Non-agricultural land can cover a wide diversity of land including land that has gone out of agricultural production already for a longer period (> 20 years) and has therefore progressed to other non-agricultural land uses. What is excluded from the analysis here however is forest land.

The study started with the elaboration of a longlist of non-agricultural land categories suitable for biomass cropping for energy and other non-food uses with 28 categories. The longlist was pared down to a shortlist by removing land types that were deemed either too small in area, too low in practical feasibility, potentially interfering with ongoing activities or in the case that developing dedicated biomass cropping was not expected to become financially viable in the coming decades. The result was a shortlist of 13 categories of non-agricultural land that could be grouped into four aggregate groups, namely: (1) brownfield land, (2) abandoned agricultural land, (3) infrastructure landscaping and (4) combined business. For each shortlisted category, opportunities and barriers were identified through focusing on policy, funding options, co-benefits, pilot projects or existing initiatives, and positive public perception. Airport land, agrophotovoltaics (APV) which are biomass crops on utility scale PV systems and biomass cropping on closed landfills were eventually selected as most promising options. For these the main barriers and opportunities were reviewed through literature review and interviews with experts.

For **biomass cropping on airports** the main barriers identified were that farming activities poses an additional risk to aviation activities and cropping activities may attract certain biodiversity, birds and mammals they may increase collision risks with airplanes. As to the opportunities several were identified. Airport farming could bring additional financial income and available land on airports is comparatively large and easily accessible, which makes bioenergy production more (economically)feasible. Crops grown on airports could remediate several adverse effects of aviation operation, such as sound and chemical pollution. Crops on airport could also dampen the negative effects of extreme weather events (for example, high temperatures), reducing financial loss of delayed or cancelled aviation operations.

For **APV**, the main barriers identified were investment cost which are significantly higher than utility scale PV systems and therefore electricity from these is currently not price competitive and uncertainty about the ownership of land can hinder the implementation of APV systems. There were also many opportunities identified. APV systems show great potential to increase the value of land. The area potential for APV in the EU-28 is very large around 500,000 ha. APV could be used to restore degraded soils, on arid or semi-arid land. PV-arrays can protect crops from direct sunlight and from extreme drought, heat, hail and rain and could reduce the farmer's risks of crop failure. Vegetation cooling the PV arrays from behind improves PV efficiency and the combination with energy crops could have a lower carbon footprint than a usual large PV system.

For biomass cropping **on closed landfills** the barriers identified were, first, that present soil pollutants and poor soil quality could lead to low yields or biomass quality issues. Second, operational costs are expected to be relatively high due to smaller and sub-optimal geometry of the patches and necessary soil fertility treatment. The first opportunity is that biomass crop production on closed landfills is an ideal temporarily use until more permanent solutions are found for remediation. Second, accessibility of (closed) landfills is a great benefit to its integration into supply chains. Third, Energy crops could remediate the soil and prevent or decrease environmental risks associated with closed landfills like leakage.

## 7.7 Main recommendations for filling data gaps on UAA and unused, abandoned and degraded lands

Some improvements may still be made in the consistent registration of UAA in EU Member States. In the former we already concluded that still in the reporting by national statistical offices to Eurostat FSS inconsistencies occur particularly in relation to minimum and maximum tree cover rules and also in relation to categories of agroforestry areas. It is therefore recommended that further uniformity in tree cover levels between EU Member States determining the difference between forests and agricultural areas is created. With this improvement it would also be strongly recommended to define more clearly agroforestry areas and develop clear agreement on how to register them in FSS. Either as a separate category of agricultural land or as part of the different sub-categories, but for this, clear rules need to be established for which type of agroforestry area is registered under which subcategory of UAA (arable, permanent crops or permanent grasslands).

As to unused, abandoned and degraded lands we concluded that these are not registered in any EU wide or national data sources. This brings us to make the following recommendations:

- Absence of management for several years in a row is recommended to be registered for lands in the agricultural domain, also when they become unused for a long time and lose their official agricultural land use status (e.g. in terms of eligibility for CAP). This can be done in existing national data sources, which are also used as a basis for national reporting to Eurostat for FSS. At this moment absence of certain management practices such as ploughing for the registration of permanent grassland are already applied and this can also be done for management in cropping lands.

- Degraded lands within and outside agricultural lands need to be registered in statistical or spatial data sources. Heavily eroded lands can be detected more easily using high temporal and spatial resolution sensor data. In Romania degraded lands are already registered by the statistical office and other countries may follow this example.

- A good indirect indicator of marginality and land degradation in arable lands is yield. Detailed yearly and regional level (preferable at LAU level) registrations of yields per hectare are very informative and can help identify regions where agricultural marginalisation may lead to (further) abandonment and where measure may be taken to support and turn this process around.

To identify farmland abandonment and also land degradation the parcel level should be the starting point as this is the spatial level at which this process takes place. From this perspective, some recommendations can be made to improve detection and registration of unused and abandoned agricultural lands:

- Use the existing IACS-LPIS framework and data stored in the LPIS by the Member State paying agencies. The annual update cycle of IACS data together with the high spatial accuracy and land-use information (e.g. crop type) stored in IACS-LPIS make this database potentially very valuable for the identification of unused, abandoned and degraded lands. The information registered at a yearly basis already enables paying agencies to trace crop cultivation and therefore also the absence of it over time. In practice such analysis is already applied in order to detect permanent grassland as grasslands can only be classified as permanent if it has grass cover for 5 years consecutive years. For this reason, and also to check eligibility of specific parcels of land for different types of CAP payments paying agencies can monitor the use and maintenance of agricultural fields through the comparison of registrations of land uses/crops in IACS in different years. However, there is no obligation on farmers to use productively the land on which they claim CAP direct payments, they simply have to comply with GAEC cross-compliance standards, for example maintaining minimum soil cover and retaining certain landscape features. This makes it difficult to identify land that is temporarily unused or in transition to abandonment simply by using IACS data.
- Combine the use of the LPIS reference layers with high spatial and temporal resolution information from satellites to measure within field vegetation development, through NDVI, and management activity or rather the lack of it. In the last couple of years much progress is being made with identifying crop types, land management through RS and aerial photographic interpretation. Higher temporal and spatial resolution images in combination with better interpretation methods and big data processing technologies enable us to identify within parcel activities in fields. In the MAGIC project a methodology is being developed to identify land abandonment using radar data to detect management activities in fields. The method is still in development, but showing promising results in relation to detecting management of land or absence of it.

## 7.8 Main conclusions and recommendations on policy improvements for maintaining land under agricultural production and bringing it back into active use

From an analysis of the literature and the case study reports it is clear that preventing land abandonment or bringing land that has been abandoned back into production is rarely a direct objective of policies. Rather, the way in which policy addresses these issues is mostly indirect through policies that affect some of the drivers of land abandonment, but not necessarily targeted at areas facing land abandonment specifically.

The CAP was shown to have a particular influence (both Pillars) alongside a range of national policies (including taxes, financial instruments, spatial planning policies and processes for land registration and to address land structure and tenure issues). These measures have varying degrees of influence on land degradation and abandonment depending on the way they are designed, targeted and implemented within Member States.

The key issues identified in the analysis can be summarised as follows:

- The broader socio-economic drivers of land abandonment are often stronger than the policy measures in place that could address them. This is not helped by the fact that restraining abandonment is not necessarily an explicit or even implicit goal of such policy measures.
- Farm level economic drivers of abandonment are addressed to some extent through the existence of CAP direct payments and ANC measures that help maintain large areas of land in agricultural use that would otherwise move out of production, although they do not secure the sustainable management of these areas.
- The policy measures in place to counter rural depopulation and encourage generational renewal in agriculture operate at a very local scale and have limited funding allocated to them. At some point, if these wider rural issues are not addressed then the farm level payments and attempts to address farm structure and tenure issues will not be sufficient to maintain farming in systems that are the most socio-economically vulnerable. The extent to which this is the case will vary regionally and also depend on the relative economic buoyancy of the economy more generally.
- The way Member States choose to implement the available policy measures (in terms of funding allocation, design, eligibility criteria, targeting, payment levels) affects the impact that these can have on land degradation and land abandonment issues.
- National policies have evolved to address the specific issues faced nationally, regionally and locally. In particular, the case studies highlighted the special circumstances facing central and eastern European countries, particularly in addressing land structure and tenure issues arising from the process of land restitution.
- In some countries, tensions between policies have been identified, particularly between national policies to address farm structure and tenure and inheritance laws.
- Land registration and efforts to create complete cadastres remain incomplete in some countries, which leads to continued issues with identifying those responsible for the management of the land and the ability to require its sustainable management.
- There is no requirement for land that has been abandoned to be screened and assessed prior to coming back into agricultural production to assess the environmental / climate sustainability of doing so, unless it falls within the scope of the EIA Directive (and much agricultural land does not). The REDII appears to assume that crops planted on abandoned or degraded land would automatically be considered to be sustainable. This is not the case and assumes that abandoned land is to be considered as something negative that should be overcome, whereas in reality it may have evolved to deliver other valuable ecosystem services. The absence of an effective EU system for screening the environmental effects of bringing land back into agricultural production is a policy gap currently.

Given these issues a number of recommendations for policy improvements have been identified. These are set out below.

A key role that public policy has to play in relation to land management and land use is to support the delivery of public goods (i.e. those that cannot be provided by the market). In the face of the environmental and climate challenges facing the EU, it is of paramount importance that any policies influencing land use and management should seek to maintain and stimulate the sustainability of all land management practices on agricultural land, whether it is used to grow biomass for food or for energy and other non-food uses.

*Policy improvements for maintaining or bringing back land into agricultural production:*

- Member States should assess the areas that are currently abandoned or degraded or at risk of becoming so and identify which of these areas would be most suitable for biomass production for energy and other non-food uses. This assessment should consider the types of crops that would be appropriate, taking into account the environmental and climate implications and market feasibility. Policy interventions should only be made where it is clear that such intervention is required, that it is environmental sustainable to do so and to actively promote the sustainable management of such land.
- Member States should make sure that the drivers of land abandonment are well identified in the SWOT analyses of their CAP Strategic Plans and that analysis is carried out on which areas at risk it are most appropriate to maintain in agricultural use and which areas might be better used for other purposes (e.g. afforestation, rewilding, used for eco-tourism, hunting etc).
- Once the priorities have been identified, Member States should choose, design, tailor and target the appropriate mix of CAP interventions to address those issues, using the flexibilities permitted under the CAP to support the sustainable management of land, but also to address the wider societal issues of poverty and social exclusion in rural areas. In the latter situation, better integration of the CAP with funding from the Structural Funds as well as national measures could help draw down the level of resources required to address the issues.
- Greater use of innovative and locally-led approaches would be of value as a way of identifying and piloting novel solutions to the more intractable local problems in rural areas, for example using tools like LEADER, EIP Operational groups and the LIFE fund.
- Member States with incomplete systems of land registration should prioritise sorting this out so that it is clear who owns each parcel of land and that where issues of degradation, under-management and abandonment occur owners can be contacted to address the issues.
- All policies that deal with agricultural land (including CAP direct payments and the ANC measure) should make sure that sustainability criteria are in place and adequately enforced to require and stimulate land to be managed sustainably and that environmental degradation is avoided.

## 7.9 Main conclusions and policy recommendations for stimulating biomass cropping for energy and other non-food purposes on previously unused, abandoned and degraded lands

Decisions on whether land in agricultural production (either at risk of abandonment or recently brought back into production) should be used to produce biomass crops for energy or other non-food purposes are in the hands of the land manager and policy plays only a limited role. Agricultural payments have been decoupled from production since 2005 (with the exception of voluntary coupled support) in order to allow decisions on which crops to grow to be influenced by the market. The key role of policy should be to ensure that agricultural production is carried out in a way that also delivers public goods, in other words that the way crops are grown is sustainable, protecting natural resources and delivering a mix of ecosystem services.

Given this, the key policy improvements to incentivise biomass cropping for energy and non-food uses on agricultural land that has been brought back into production can be summarised as follows:

- The continuity of the EU's strategic priorities with respect to climate goals, the role of renewable energy in achieving emission reductions targets, and within this the role of biomass crops from agricultural land, remains important to provide consistent market signals that instil confidence in producers to produce crops for energy and other non-food uses.
- There should be better coherence at Member State and regional/local levels of local/regional/national renewable energy and climate policies with the CAP and with the Structural Funds.
- All interventions under the CAP should have sustainability criteria attached and area based support should only be made available where it leads to the sustainable management of agricultural land and, where it is needed, to enable environmentally and climate beneficial land use change that takes advantage of new markets – e.g. agroforestry and perennial crops in marginal areas (c.f. Chapter 4).
- Member States could make greater use of CAP rural development funds under Pillar 2 to provide support for biomass value chains at farm, local and regional levels through packages of investment, knowledge transfer and innovation support (including research/farmer/processor co-operation, pilot projects, farm exchanges etc).
- Although there is considerable interest in agroforestry systems, a relatively small amount of CAP support is provided in Member States currently to support these. Payments and advisory support for sustainable new agroforestry and the restoration/maintenance of existing agroforestry systems should be competitive with afforestation support at Member State level. Since agroforestry is an agricultural land use (rather than a forest measure) and has the potential to deliver multiple ecosystem services, it may also merit being included as part of the agricultural environmental interventions in the future CAP, rather than part of the suite of forest measures.
- Greater development of institutional capacity is required to provide technical advice on biomass cropping and processing/marketing and on targeting at land with minimal risk of ILUC or conflict with existing use.

## 7.10 Policy improvements to incentivise biomass cropping for energy and non-food uses on non-agricultural land

Based on the findings of the three case studies and the earlier sections in this chapter, several overarching policy recommendations are summarized in the following paragraph. These are recommendations that may be relevant to other non-agricultural land categories as well.

- At airports some non-agricultural land with existing vegetation needs active management to ensure safety for (nearby) various operations. The maintenance costs could be partially replaced by the agricultural costs in case of a dual function, possibly improving the economics of bioenergy crop production substantially.

- Effective wildlife management at airports is required to minimise wildlife collision with traffic of any kind or with wildlife interaction in case of an additional agricultural function. The effect on this from agriculture (including bioenergy crops) is to be assessed for each case individually and it is difficult to make any general predictions on success or mitigation measures.
- Bioenergy crop production on non-agricultural land often requires the collaboration between several industries or sectors that do not commonly interact. Policies enhancing sector collaboration are expected to aid in the implementation. Examples are financial benefits for consortia of companies from different sectors cooperating in giving land multiple functions, or legislative guidance in arranging (model) contracts for multiple uses of the same area.
- European certification for bioenergy crop production from (previously) non-agricultural lands could help in differentiating the biomass produced in these areas which could be a significant benefit in the market for green fuels.
- Use of some non-agricultural lands for agricultural purposes are prone to societal resistance due to a loss of vegetation or ecological integration or landscape impacts. In line with the ongoing initiatives to green European cities, (urban) non-agricultural lands could be made greener by bioenergy crops actually fulfilling two purposes.
- Some non-agricultural lands are only temporarily available for other purposes, but not for a long-term. Bioenergy crop production is a valuable and suitable activity for short to medium-long term land use and can therefore be an option in those cases, as long as done sustainably.
- Bioremediation of the soil is a promising side-effect of (bioenergy) crop production or agriculture and can lead to significant reductions in toxic compounds near logistic operations, waste facilities, chemical industries, and so on. As bioenergy crops will not be used for food, the permitted toxicity of these crops could be adjusted accordingly. This can be done after research has proven that using toxic feedstocks does not have substantial negative implications in energy production. Another form of bioremediation is the observed improvement of soil structure, making it more resilient against erosion. Therefore, bioenergy crop production might be more valuable on lands prone to erosion.

## REFERENCES

Abolina, E., Luzadis, V.A. (2015). 'Abandoned agricultural land and its potential for short rotation woody crops in Latvia.' *Land Use Policy*, 49, 435–445. https://doi.org/10.1016/j.landusepol.2015.08.022

Acharya, B.S. & Blanco-Canqui, H. (2018). 'Lignocellulosic-based bioenergy and water quality parameters: a review.' *GCB Bioenergy 10*, 1, 504–533. doi: 10.1111/gcbb.12508

Aebischer, N.J. and Ward, R.S., (1997). 'The distribution of corn buntings Miliaria calandra in Sussex in relation to crop type and invertebrate abundance.' In P.F. Donald, N.J. Aebischer, J.H. Bratton, S.M. Davies and P.V. Grice (eds) *The Ecology and Conservation of Corn Buntings Miliaria Calandra*, pp. 124-138. Peterborough: Joint Nature Conservation Committee.

Alcantara, C., Kuemmerle, T., Baumann, M., Bragina, E. V., Griffiths, P., Hostert, P., Radeloff, V.C. (2013). 'Mapping the extent of abandoned farmland in Central and Eastern Europe using MODIS time series satellite data.' *Environmental Research Letters*, 8(3). https://doi.org/10.1088/1748-9326/8/3/035035

Alexopoulou, E., Christou, M., and Eleftheriadis, I. (2018). 'Deliverable 1.5 Handbook with fact sheets of the existing resource-efficient industrial crops.' Athens: MAGIC H2020 project, Grant Agreement No. 727698.

Allen, B., Kretschmer, B., Baldock, D., Menadue, H., Nanni, S., and Tucker, G. (2014). 'Space for energy crops – assessing the potential contribution to Europe's energy future.' Report produced for BirdLife Europe, European Environmental Bureau and Transport and Environment London; IEEP.

Allen, B., Kretschmer, B., Kieve, D., Smith, C., and Baldock, D. (2013). 'Biofuels and ILUC – Q&A: Answers to common questions surrounding the ILUC debate.' Biofuel ExChange Briefing No 5. London: IEEP.

Alliance Environnement (2017). 'Evaluation study of the forestry measures under Rural Development.' Final Report, European Commission, DG Agriculture. https://ec.europa.eu/agriculture/sites/agriculture/files/forest/publications/pdf/eval-study-forestry-measures-report_en.pdf

Alliance Environnement (2017a). 'Literature reviews on the effects of farming practices associated with the CAP greening measures on climate and the environment, carried out for the Evaluation study of the payment for agricultural practices beneficial for the climate and the environment ('greening' of direct payments), ISBN 978-92-79- 73406-9.

Alliance Environnement. (2017b). 'Evaluation study of the payment for agricultural practices beneficial for the climate and the environment, Final Report, European Commission, DG Agriculture.' https://ec.europa.eu/agriculture/sites/agriculture/files/fullrep_en.pdf

Alliance Environnement. (2019). 'Evaluation of the impact of the CAP on habitats, landscapes, biodiversity.' Final Report for the EC Directorate-General for Agriculture and Rural Development. Lunel: Alliance Environnement.

Al-Riffai, P., Dimaranan, B, and Laborde, D. (2010). 'Global Trade and Environmental Impact Study of the EU Biofuels Mandate, Vol. 125.' Washington, DC: IFPRI.

ANCPI (2019). 'Cadastre – A Solid Foundation for Economic and Social Growth: The Romanian Experience.' Presentation by the National Agency for Cadastre and Land Registration to a plenary meeting and conference ('The Economic Impact of Cadastre for Society') of the Permanent Committee on Cadastre in the European Union (PCC) held on 6-7 June 2019 in Bucharest, Romania. Available at: https://eurogeographics.org/wp-content/uploads/2019/03/Romania-ANCPI-PCC-Bucharest.pdf

ANCPI (2020). Public information on the state of implementation of the 'National Land Book and Cadastre Programme 2015-2023', notably the local administrative units (LAUs) that have started their systematic cadastral registration. Available at: http://www.ancpi.ro/pnccf_docs2/index.php

Aronsson, P.G., and Bergstrom, L.F. (2001). 'Nitrate leaching from lysimeter-grown short rotation willow coppice in relation to N-application, irrigation and soil type.' *Biomass and Bioenergy*, 21, 155–164.

Baldock, D. & Mottershead, D.H. (2017). 'Towards an integrated approach to livestock farming, sustainable diets and the environment: challenges for the Common Agricultural Policy and the UK.' London: Institute for European Environmental Policy.

Bartolini, F. and Viaggi, D. (2012). 'An analysis of policy scenario effects on the adoption of energy production on the farm: A case study in Emilia–Romagna (Italy).' *Energy Policy*, 51, 454–464. https://doi.org/10.1016/j.enpol.2012.08.043

Bas-Defossez, F. and Meredith, S. (2019). 'CAP 2021- 27: A comparative analysis of the environmental performance of the COMENVI and COMAGRI reports on the Commission's proposals.' Report for NABU. London: IEEP.

Baumann, M., Kuemmerle, T., Elbakidze, M., Ozdogan, M., Radeloff, V. C., Keuler, N. S. and Hostert, P. (2011). 'Patterns and drivers of post-socialist farmland abandonment in Western Ukraine.' *Land Use Policy*, 28(3), 552–562. https://doi.org/10.1016/j.landusepol.2010.11.003 LK - https://wur.on.worldcat.org/oclc/5902879447

Bell, S., Montarzino, A., Aspinall, P., Penēze, Z. and Nikodemus, O. (2009). 'Rural Society, Social Inclusion and Landscape Change in Central and Eastern Europe: A Case Study of Latvia.' *Sociologia Ruralis*, 49(3), 295–326. https://doi.org/10.1111/j.1467-9523.2009.00480.x LK - https://wur.on.worldcat.org/oclc/5156923006

Bennett, A.B., and Isaacs, R. (2014). 'Landscape composition influences pollinators and pollination services in perennial biofuel plantings.' *Agriculture, Ecosystems & Environment*, 193, 1–8. doi: 10.1016/j.agee.2014.04.016

Bertzky, M., Kapos, V. and Scharlemann, J.P.W. (2011). 'Indirect land use change from biofuels production: implications for biodiversity.' JNCC Report No. 456. https://www.cbd.int/agriculture/2011-121/UNEP-WCMC-JNCC%20report-sep11-en.pdf

Bindraban, P.S., Bulte, E.H., and Conijn, S.G. (2009). 'Can large-scale biofuels production be sustainable by 2020?' *Agricultural Systems*, 101, 197-199.

Buchholz, T., Volk, T. (2013). 'Profitability of Willow Biomass Crops Affected by Incentive Programs.' *BioEnergy Research*, 6, 53–64. https://doi.org/10.1007/s12155-012-9234-y

Burel, F., Baudry, J., Butet, A., Clergeau, P., Delettre, Y., Le Coeur, D., Dubs, F., Morvan, N., Paillat, G., Petit, S., Thenail, C., Brunel, E. and Lefeuvre, J.-C. (1998). 'Comparative biodiversity along a gradient of agricultural landscapes.' *Acta Oecologica*, 19, 47-60.

Burgess, P.J. (1999). 'Effects of agroforestry on farm biodiversity in the UK.' *Scottish Forestry,* 53, 1, 24–27.

Cacho, J.F., Negri, M.C., Zumpf, C.R., and Campbell, P. (2018). 'Introducing perennial biomass crops into agricultural landscapes to address water quality challenges and provide other environmental services.' *Wiley Interdisciplinary Reviews*, 7, 2, e275. doi: 10.1002/wene.275

Cannell, M.G.R., Noordwijk, M.V.A.N., and Ong, C.K., (1996). 'The central agroforestry hypothesis: the trees must acquire resources that the crop would not otherwise acquire.' *Agroforestry Systems*, 24, 27–31. doi: http://dx.doi.org/10.1007/BF00129630

Carey, P.D., Griffiths, G.H., Carey, I.N., Butcher, B., Treweek, J., Charlton, M.B., Arnell, N.W., Sozanska-Stanton, M., Smith, P. and Tucker, G. (2015). 'Priority Habitats, Protected Sites and Climate Change: Three Investigations to Inform Policy and Management for Adaptation and Mitigation.' Defra, contract CR0439, pp 206

Carlsson, G., Mårtensson, L.M., Prade, T., Svensson, S.E., and Jensen, E S. (2017). 'Perennial species mixtures for multifunctional production of biomass on marginal land.' *GCB Bioenergy,* 9, 191–201. doi: 10.1111/gcbb.12373

Carvalho, J.L.N., Hudiburg, T.W., Franco, H.C.J., and DeLucia, E.H. (2017). 'Contribution of above- and belowground bioenergy crop residues to soil carbon.' *GCB Bioenergy*, 9, 8, 1333-1343. https://doi.org/10.1111/gcbb.12411

Castillo, C., Aliaga, E. C., Lavalle, C., and Llario, J. C. M. (2020). 'An assessment and spatial modelling of agricultural land abandonment in Spain (2015-2030).' *Sustainability* (Switzerland), 12(2). https://doi.org/10.3390/su12020560

Castillo, C., Kavalov, B., Diogo, V., Jacobs-Crisioni, C., Batista e Silva, F., and Lavalle, C. (2018). *JRC Policy Insights* – 'Agricultural land abandonment in the EU within 2015-2030.' Jrc113718, (October), 7. Retrieved from www.ec.europa.eu/jrc/en/publications%0Ahttps://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/agricultural-land-abandonment-eu-within-2015-2030%0Ahttps://ec.europa.eu/jrc/sites/jrcsh/files/jrc113718.pdf

CCRI, OIR and ADE. (2019). 'Evaluation of the impact of the CAP on generational renewal, local development and jobs in rural areas.' Report for the European Commission, Directorate-General for Agriculture and Rural Development. https://op.europa.eu/en/publication-detail/-/publication/4bd0b0a2-0503-11ea-8c1f-01aa75ed71a1

Ceausu, S., Hofmann, M., Navarro, L. M., Carver, S., Verburg, P.H. and Pereira, H.M. (2015). 'Mapping opportunities and challenges for rewilding in Europe.' *Conservation Biology*, 29(4), 1017–1027. https://doi.org/10.1111/cobi.12533

Ceotto, E., and Di Candilo, M. (2010). 'Sustainable bioenergy production, land and nitrogen use.' In Lichtfouse, E. (ed.) *Biodiversity, Biofuels, Agroforestry and Conservation Agriculture*. Berlin: Springer, pp. 101–122.

Chauvat, M., Perez, G., Hedde, M., and Lamy, I. (2014). 'Establishment of bioenergy crops on metal contaminated soils stimulates belowground fauna.' *Biomass Bioenergy* 62, 207–211. doi: 10.1016/j.biombioe.2014.01.042

Cherubini, F., Bird, N.D., Cowie, A., Jungmeier, G., Schlamadinger, B., and Woess-Gallasch, S. (2009). 'Energy- and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations.' *Resources, Conservation and Recycling*, 53, 8, 434–447.

Chimento, C., Almagro, M., and Amaducci, S. (2016). 'Carbon sequestration potential in perennial bioenergy crops: the importance of organic matter inputs and its physical protection.' *GCB Bioenergy*, 8, 111–121. doi: 10.1111/gcbb.12232

Ciria, C., Sanz, M., Carrasco, J., and Ciria, P. (2019). 'Identification of Arable Marginal Lands under Rainfed Conditions for Bioenergy Purposes in Spain.' *Sustainability*, 11, 1833. doi: 10.3390/su11071833

Clancy, D., Breen, J.P., Thorne, F. and Wallace, M. (2012). 'A stochastic analysis of the decision to produce biomass crops in Ireland.' *Biomass and Bioenergy*, 46, 353–365. https://doi.org/10.1016/j.biombioe.2012.08.005

Corbelle-Rico, E., Butsic, V., Enríquez-García, M. J. and Radeloff, V. C. (2015). 'Technology or policy? Drivers of land cover change in northwestern Spain before and after the accession to European Economic Community.' *Land Use Policy*, 45, 18–25. https://doi.org/10.1016/j.landusepol.2015.01.004 LK - https://wur.on.worldcat.org/oclc/5900996052

COWI. (2009a). 'Ex-post evaluation of projects and activities financed under the LIFE programme. Final Report. Part 1: Methodology and description of the LIFE programme and its policy context.' https://life.aeidl.be/environment/life/publications/lifepublications/evaluation/documents/life_finalreport_part1.pdf

COWI. (2009b). 'Study concerning the report on the application and effectiveness of the EIA Directive.' Final report, report to DG Environment, June 2009.

Cuthbertson, A., and McAdam, J. (1996). 'The effect of tree density and species on carabid beetles in a range of pasture-tree agroforestry systems on a lowland site.' *Agroforestry Forum*, 7, 3, 17-20.

Cvitanović, M., Blackburn, G. A. and Rudbeck Jepsen, M. (2016). 'Characteristics and drivers of forest cover change in the post-socialist era in Croatia: evidence from a mixed-methods approach.' *Regional Environmental Change*, 16(6), 1751–1763. https://doi.org/10.1007/s10113-016-0928-0 LK - https://wur.on.worldcat.org/oclc/6659535312

Daioglou, V., Doelman, J.C., Stehfest, E., Müller, C., Wicke, B., Faaij, A., et al. (2017). 'Greenhouse gas emission curves for advanced biofuel supply chains.' *Nature Climate Change* 7, 920–924.

Daioglou, V. Woltjer, G., Elbersen, B., Barberena Ibanez, G., Strengers, B., Sanches Gonzales, D., and Vuuren, van, D. (2020). 'Progress and barriers in understanding and preventing indirect land use change.' *Biofuels, Bioproducts and Biorefining*, 14, 5, 924-934. doi: 10.1002/bbb.2124

Dale, V., Kline, K., Wiens, J. and Fargione, J. (2010). 'Biofuels: Implications for Land Use and Biodiversity.' Biofuels and Sustainability Reports, 1-13. http://www.esa.org/biofuelsreports/

Dastyar, W. et al. (2019). 'Biofuel Production Using Thermochemical Conversion of Heavy Metal-Contaminated Biomass (HMCB) Harvested from Phytoextraction Process.' *Chemical Engineering Journal* 358, 759-785. http://dx.doi.org/10.1016/j.cej.2018.08.111

Dauber, J. and Miyake, S. (2016). 'To integrate or to segregate food crop and energy crop cultivation at the landscape scale? Perspectives on biodiversity conservation in agriculture in Europe.' *Energy, Sustainability and Society,* 6,25.

Dauber, J., Brown, C., Fernando, A., Finnan, J., Krasuska, E., Ponitka, J., Styles, D., Trän, D., Groenigen, K., Weih, M., and Zah, R. (2012). 'Bioenergy from 'surplus' land: environmental and socio-economic implications.' *BioRisk*, 7, 5-50.

Dauber, J., Jones, M.B., and Stout, J.C. (2010). 'The impact of biomass crop cultivation on temperate biodiversity.' *GCB Bioenergy* 2, 289–309. doi: 10.1111/j.1757-1707.2010.01058.x

DECC–DfT–DEFRA (2012). UK Bioenergy Strategy, London: Department of Energy and Climate Change, Department for Transport, Department of the Environment, Farming and Rural Affairs. https://www.gov.uk/government/publications/uk-bioenergy-strategy

De Fraiture, C. Giordano,M., and Liao, Y. (2008). 'Biofuels and implications for agricultural water use: blue impacts of green energy.' *Water Policy* 10. 67-81.

Dennis, P., Shellard, L.J.F., and Agnew, R.D.M. (1996). 'Shifts in arthropod species assemblages in relation to silvopastoral establishment in upland pastures.' *Agroforestry Forum*, 7, 3, 14-17.

Dıaz-Pines, E., Molina-Herrera, S., Dannenmann, M., et al. (2017). 'Nitrate leaching and soil nitrous oxide emissions diminish with time in a hybrid poplar short-rotation coppice in southern Germany.' *GCB Bioenergy*, 9, 613–626.

Di Corato, L., Gazheli, A. and Lagerkvist, C.J. (2013). 'Investing in energy forestry under uncertainty.' *Forest Policy and Economics*, 34, 56-64.

Dobre, R. (2018). 'Subvenția APIA pentru PÂRLOAGĂ! Care este noul termen de care trebuie să țineți cont!' *Agrointeligența* (6 February, 2018). Available at: https://agrointel.ro/92440/subventia-apia-pentru-parloaga-care-este-nou-termen-de-care-trebuie-sa-tineti-cont/

Dobre, R. (2020). 'CADASTRU GRATUIT 2020: Lista cu cele 261 de comune unde incep lucrarile de cadastrare.' *Agrointeligența* (10 August, 2020). Available at: https://agrointel.ro/152682/cadastru-gratuit-2020-lista-261-comune-august/

Don, A., Osborne, B., Hastings, A., et al. (2012). '*Land-use change to bioenergy production in Europe: implications for the greenhouse gas balance and soil carbon*.' *GCB Bioenergy*, 4, 372–391.

Drewer, J., Finch, J.W., Lloyd, C.R., Baggs, E.M., and Skiba, U. (2012). 'How do soil emissions of $N_2O$, CH4 and $CO_2$ from perennial bioenergy crops differ from arable annual crops?' *GCB Bioenergy*, 4, 408–419.

EASA. (2008). 'Bird Strike Damage and Windshield Bird Strike Final Report.' https://www.easa.europa.eu/sites/default/files/dfu/Final%20report%20Bird%20Strike%20Study.pdf

EC Directorate-General for Research and Innovation. (2018). 'A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment.' Updated Bioeconomy Strategy. Brussels: EC. doi: 10.2777/478385

ECA. (2016). 'Making cross-compliance more effective and achieving simplification remains challenging, Special Report No 26.' Brussels: ECA.

ECA. (2017). 'EU support to young farmers should be better targeted to foster effective generational renewal, Special Report No 10.' Brussels: ECA.

Ecorys, IEEP and WUR. (2016). 'Mapping and analysis of the implementation of the CAP.' Final Report for DG Agriculture and Rural Development.

EEA. (2019). 'Land and Soil in Europe.' *Soil Science* (Vol. 112). https://doi.org/10.1097/00010694-197108000-00011

EIP-AGRI (2019). 'Focus group enhancing production and use of renewable energy on the farm: final report October 2019.'

Eitelberg, D., van Vliet, J. and Verburg, P. (2015). 'A review of global potentially available cropland estimates and their consequences for model-based assessments.' *Global Change Biology,* 21, 1236–1248. doi: 10.1111/gcb.12733

Elbersen, B.S., Fritsche, U.R, Petersen, J-E, Lesschen, J.P., Böttcher, H. and Overmars, K. (2013). 'Assessing the effect of stricter sustainability criteria on EU biomass crop potential.' *Biofuels, Bioproducts & Biorefining (Biofpr) Journal*. Article first published online: 19 MAR 2013 | DOI: 10.1002/bbb.1396

Elbersen, B.S., Fritsche, U., Overmars, K., J.P. Lesschen, Staritsky, I., Ros, J., Zulka, K.P., Brodski, L., Eerens, H. and Hennenberg, K. (2013). 'Review of the EU bioenergy potential from a resource efficiency perspective.' A follow-up to EEA report No 7/2006. ETC-SIA technical report. (July 2013).

Elbersen, B., Beaufoy, G., Jones, G., Noij, G-J., Doorn, A., Breman, B. and Hazeu, G. (2014). 'Aspects of data on diverse relationships between agriculture and the environment.' Report for DG-Environment. Contract no. 07-0307/2012/633993/ETU/B1. Wageningen: Alterra.

Elbersen, B., Staritsky, I., Hengeveld, G., Jeurissen, L., Lesschen, J.P. and Panoutsou, C. (2015). 'Outlook of spatial biomass value chains in EU-28.' (September 2015). Biomass Policies, p.270.

Elbersen, B., Eupen, van, M., Mantel, S., Verzandvoort, S., Boogaard, H., Mucher, S., Cicarreli, T. & Elbersen, W., Bai, Z., Iqbal, Y., Cossel, M., Ian MCallum, I., Carrasco, J., Ciria Ramos, C., Monti, A., Scordia, D., Eleftheriadis, I. (2018). 'Deliverable 2.1 Definition and classification of marginal lands suitable for industrial crops in Europe.' MAGIC; GA-No.: 727698.

Elbersen, B., Eupen, van E., Mantel, S., Verzandvoort, S.., Boogaard, H., Mucher, S., Cicarreli, T., and Elbersen, W., Bai, Z., Iqbal, Y., Cossel, M., MCallum, I., Carrasco, J., Ciria Ramos, C., Monti, A., Scordia, D., Eleftheriadis, I. (2018). 'Deliverable 2.6: Methodological approaches to identify and map marginal land suitable for industrial crops in Europe.' MAGIC; GA-No.: 727698.

Elbersen, B.; Coninx, I; Hatvani, N.; Houtkamp, J.; Koos, A.; Kulmány, I; Mateffy, K.; van den Oever, M. & Vásáry, V. (2020). An overview of suitable regional policies to support bio-based business models. Deliverable 4.2. POWER4BIO. Grant Agreement no. 818351. H202-RUR-2018-2020.

Emmerling, C., and Pude, R. (2017). 'Introducing Miscanthus to the greening measures of the EU Common Agricultural Policy.' *GCB Bioenergy*, 9, 2, 274–279.

Estel, S., Kuemmerle, T., Alcántara, C., Levers, C., Prishchepov, A., & Hostert, P. (2015). Mapping farmland abandonment and recultivation across Europe using MODIS NDVI time series. Remote Sensing of Environment, 163, 312–325. https://doi.org/10.1016/j.rse.2015.03.028

Eupen, van, M., Hennekens, S. and Zervas, G. (2003). 'Developing a high nature value indicator.' Report for the European Environment Agency. Copenhagen. Further work of the EEA and JRC is documented under: http//eea.eionet.europa.eu/Public/irc/envirowindows/hnv/library

European Commission. (2013). 'CAP Towards 2020, Impact Assessment – Direct Payments, contribution to the Impact Assessment of the CAP towards 2020.' (COM(2011) 625 final). https://ec.europa.eu/agriculture/rica/pdf/PO0202_direct_payments.pdf

European Commission. (2020). 'COMMISSION IMPLEMENTING DECISION (EU) 2020/859 of 16 June 2020 excluding from European Union financing certain expenditure incurred by the Member States under the European Agricultural Guarantee Fund (EAGF) and under the European Agricultural Fund for Rural Development (EAFRD).' Official Journal of the European Union L 195 (19.6.2020), 59–93. Available at: https://eur-lex.europa.eu/eli/dec_impl/2020/859/oj

European Commission. (2020). 'Voluntary coupled support Review by the Member States of their support decisions applicable as from claim year 2020.' DG Agriculture and Rural Development Informative Note. Brussels: EC.

European Commission. (2018). 'Report from the Commission to the European Parliament and the Council.' https://eur-lex.europa.eu/legalcontent/EN/TXT/?qid=1490786763554&uri=COM:2017:152:FIN

European Environment Agency. (2013). 'Review of the EU bioenergy potential from a resource efficiency perspective.' Brussels: EEA.

Evans, A., Appleby, M., Dixon, J., Newbery, P. and Swales, V. (1995). 'What future for lowland farmland birds in the UK?' *RSPB Conservation Review*, 9, 32-40.

Faaij, A. (2006). 'Bio-energy in Europe: changing technology choices.' *Energy Policy,* 34, 322–342.

Faaij, A.P.C. (2018). 'Securing Sustainable Resource Availability of Biomass for Energy Applications in Europe.' Review of Recent Literature.

Fargione, J., Hill, J., Tilman, D., Polasky, S., and Hawthorne, P. (2008). 'Land clearing and the biofuel carbon debt.' *Science* 319, 1235–1238. doi: 10.1126/science.1152747

Fargione, J.E., Plevin, R.J. and Hill, J.D. (2010). 'The Ecological Impact of Biofuels.' *Annual Review of Ecology, Evolution, and Systematics*, 41, 1, 351–377.

Felten, D. and Emmerling, C. (2011). 'Effects of bioenergy crop cultivation on earthworm communities—A comparative study of perennial (Miscanthus) and annual crops with consideration of graded land-use intensity.' *Applied Soil Ecology*, 49, 167–177. https://doi.org/10.1016/j.apsoil.2011.06.001

Ferchaud, F., and Mary, B. (2016). 'Drainage and nitrate leaching assessed during 7 years under perennial and annual bioenergy crops.' *BioEnergy Research*, 9, 656–670.

Fernando, A. (2005). 'Fitorremediacao por Miscanthus x giganteus de solos contaminados com metais pesados.' PhD diss., Universidade Nova de Lisboa, Lisbon.

Fernando, A.L., Costa, J., Barbosa, B., Monti, A., and Rettenmaier, N. (2018). 'Environmental impact assessment of perennial crops cultivation on marginal soils in the Mediterranean Region.' *Biomass Bioenergy,* 111, 174–186. doi: 10.1016/j.biombioe.2017.04.005

Forsell, N., et al. (2016). 'Study on impacts on resource efficiency of future EU demand for bioenergy (ReceBio). Final report.' Project: ENV.F.1/ETU/2013/0033. Luxembourg: Publications Office of the European Union.

Frank, S. et al. (2013). 'How effective are the sustainability criteria accompanying the European Union 2020 biofuel targets?' *GCB Bioenergy*, 5, 3, 306–314. doi: http://dx.doi.org/10.1111/j.1757-1707.2012.01188.x

Frelih-Larsen, A., C. Bowyer, S. Albrecht, C. Keenleyside, M. Kemper, S. Nanni, S. Naumann, R., D. Mottershead, R. Landgrebe, E. Andersen, P. Banfi, S. Bell, I. Brémere, J. Cools, S. Herbert, A. Iles, E. Kampa, M. Kettunen, Z. Lukacova, G. Moreira, Z. Kiresiewa, J. Rouillard, J. Okx, M. Pantzar, K. Paquel, R. Pederson, A. Peepson, F. Pelsy, D. Petrovic, E. Psaila, B. Šarapatka, J. Sobocka, A.-C. Stan, J. Tarpey, and R. Vidaurre (2016). 'Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States.' Final Report to DG Environment. Berlin: Ecologic Institute.

Garbo, F., Lavagnolo, M.C., Malagoli, M., Schiavon, M., and Cossu, R. (2017). 'Different leachate phytotreatment systems using sunflowers.' *Waste Management* 59, 267–275. doi: https://doi.org/10.1016/j.wasman.2016.10.035

Gauder, M., Butterbach-Bahl, K., Graeff-Hoenninger, S., Claupein, W., and Wiegel, R. (2012). 'Soil-derived trace gas fluxes from different energy crops – results from a field experiment in Southwest Germany.' *GCB Bioenergy*, 4, 289–301.

Gelfand, I., Shcherbak, I., Millar, N., Kravchenko, A.N., and Robertson, G.P. (2016). 'Longterm nitrous oxide fluxes in annual and perennial agricultural and unmanaged ecosystems in the upper Midwest USA.' *Global Change Biology*, 22, 3594–3607.

Gerwin, W., Repmann, F., Spyridon, G., Despoina, V., Gounairs, N., Baumgarten, W., Christiane, V., Keramitzis, D., Kiourtsis, F., and Freese, D. (2018). 'Assessment and quantification of marginal lands for biomass production in Europe using soil quality indicators.' *Soil*, 4, 267–290.

Giannoccaro, G., Barbuto, A., Baselice, A. and Falcone, P.M., n.d. 'Farmers' Intention towards Energy Crops Adoption under Alternative Common Agricultural Policy: An Empirical Analysis in Andalusia, Spain.' 13.

Glithero, N.J., Wilson, P., Ramsden, S.J. (2013). Prospects for arable farm uptake of Short Rotation Coppice willow and miscanthus in England. Applied Energy 107, 209–218. https://doi.org/10.1016/j.apenergy.2013.02.032

'Global Market Outlook for Solar Power 2019 – 2023.' https://www.solarpowereurope.org/wp-content/uploads/2019/05/SolarPower-Europe-Global-Market-Outlook-2019-2023.pdf

Glover, J. D., Culman, S. W., Dupont, S. T., Broussard, W., Young, L., Mangan, M. E., et al. (2010). 'Harvested perennial grasslands provide ecological benchmarks for agricultural sustainability.' *Agriculture, Ecosystems and Environment*, 137, 3–12. doi: 10.1016/j.agee.2009.11.001

Graves, A.R., Burgess, P.J., Palma, J.H.N., Herzog, F., Moreno, G., Bertomeu, M., Dupraz, C., Liagre, F., Keesman, K., van der Werf, W., Koeffeman de Nooy and van den Briel, J.P. (2007). 'Development and application of bio-economic modelling to compare silvoarable, arable and forestry systems in three European countries.' *Ecological Engineering*, 29: 434–449.

Haines, S.A., Gehl, R., Havlin, J., and Ranney, T. (2015). 'Nitrogen and Phosphorus Fertilizer Effects on Establishment of Giant Miscanthus.' *BioEnergy Research*, 8, 17–27. doi: 10.1007/s12155-014-9499-4

Hart, K., Allen, B., Lindner, M., Keenleyside, C., Burgess, P., Eggers, J., Buckwell, A. (2013). 'Land as an Environmental Resource.' Report Prepared for DG Environment, Contract No ENV.B.1/ETU/2011/0029, London: Institute for European Environmental Policy.

Hartel, T., Dorresteijn, I., Klein, C., Máthé, O., Moga, C.I., Öllerer, K., Roellig, M., von Wehrden, H., Fischer, J., (2013). 'Wood-pastures in a traditional rural region of Eastern Europe: characteristics, management and status.' *Biological Conservation*, 166, 267–275.

Harvey, M. and Pilgrim, S., (2011). 'The new competition for land: Food, energy, and climate change.' *Food Policy*, 36, S40–S51.

Haughton, A.J., Bohan, D.A., Clark, S.J., Mallott, M.D., Mallott, V., Sage, R., et al. (2016). 'Dedicated biomass crops can enhance biodiversity in the arable landscape.' *GCB Bioenergy*, 8, 1071–1081. doi: 10.1111/gcbb.12312

Haughton, A.J., Bond, A. A. Lovett, T. Dockerty, G. Sünnenberg, S. J. Clark, D. A. Bohan, R. B. Sage, M. D. Mallott, V. E. Mallott, M. D. Cunningham, A. B. Riche, I. F. Shield, J. W. Finch, M. M. Turner and A. Karp. (2009). 'A novel, integrated approach to assessing social, economic and environmental implications of changing rural land-use: a case study of perennial biomass crops.' *Journal of Applied Ecology,* 46, 2, 315–322.

Helliwell, R. (2018). 'Where did the marginal land go? Farmers perspectives on marginal land and its implications for adoption of dedicated energy crops.' *Energy Policy*, 117, 166-172. doi: https://doi.org/10.1016/j.enpol.2018.03.011

Hernández Parrodi, J.C., et al. (2019). 'Integration of resource recovery into current waste management through (enhanced) landfill mining.' *Detritus* 8, 141-156. doi: https://doi.org/10.31025/2611-4135/2019.13884

Holland Solar (2019). 'Gedragscode zon op land' (in Dutch), https://hollandsolar.nl/gedragscodezonopland.

Holland, J.M., Southway, S., Ewald, J.A., Birkett, T. and Begbie, M. (2002). 'Invertebrate chick food for farmland birds: spatial and temporal variation in different crops.' *Aspects of Applied Biology*, 67, 27-34.

Hurford, C. (1997). 'Avian use of stubble and root crops in Wales during the 1993/94 and 1994/95 winters.' *Welsh Birds*, 1, 41-55.

IEEP. (2010). 'Manual of European Environmental Policy.' London: Institute for European Environmental Policy.

IEEP, Alterra. (2010). 'Reflecting Environmental Land Use Needs into EU Policy: Preserving and Enhancing the Environmental Benefits of 'Land Services': Soil Sealing, Biodiversity Corridors, intensification/Marginalisation of Land Use and Permanent Grassland.' Final Report to the European Commission, DG Environment on Contract ENVB1/ETU/2008/0030. Institute for European Environmental Policy/Alterra Wageningen UR.

Immerzeel, D.J. et al., 2014. 'Biodiversity impacts of bioenergy crop production: a state-of-the-art review.' *Global Change Biology Bioenergy*, 6, 3, 83–209. doi: http://doi.wiley.com/10.1111/gcbb.12067

Ioffe, G. and Nefedova, T. (2004). 'Marginal Farmland in European Russia.' *Eurasian Geography and Economics*, 45:1, 45-59 doi: http://dx.doi.org/10.2747/1538-7216.45.1.45

Jäger-Waldau, A., (2019). 'PV Status Report 2019.' EUR 29938EN. Luxembourg: Publications Office of the European Union. ISBN 978-92-76-12608-9, doi:10.2760/326629, JRC118058.

Jodl, S., Eppel-Hotz, A., and Kuhn, W. (2004). 'Miscanthus als nachwachsender Rohstoff: Ergebnisse aus 15-jähriger Forschungsarbeit in Kurzfassung, Bayerische Landesanst.' für Weinbau und Gartenbau, Abt. Landespflege.

Jones, N. M. (2015). 'Evaluation of effects of agri-environmental measures on rangeland degradation in two less favoured areas in Portugal.' PhD thesis, Wageningen University, Wageningen, 161 p. ISBN: 978-94-6257-461-8 https://library.wur.nl/WebQuery/wurpubs/fulltext/360283

Jones, A., P. Panagos, M. Erhard, G. Tóth, S. Barcelo, F. Bouraoui, C. Bosco, O. Dewitte, C. Gardi, J. Hervás, R. Hiederer, S. Jeffery, V. Penizek, T. Strassburger, A. Lükewille, L. Marmo, L. Montanarella, C. Olazábal, J.-E. Petersen, M. Van Den Eeckhaut, M. Van Liedekerke, F. Verheijen, E. Viestova, Y. Yigini, E. (2012). 'The state of soil in Europe: a contribution of the JRC to the European Environment Agency's environment state and outlook report - SOER 2010.' European Commission, JRC, Institute for Environmental Sustainability and European Environment Agency. Luxembourg: Publications Office.

Jones, M. B., Finnan, J. and Hodkinson, T. R. (2015). ‘Morphological and physiological traits for higher biomass production in perennial rhizomatous grasses grown on marginal land.’ *GCB Bioenergy*, 7, 375–385. doi: 10.1111/gcbb.12203.

Junginger, M. (2007). ‘Lessons from (European) bioenergy policies; results of a literature review for IEA Bioenergy Task 40.’ Utrecht : Utrecht University.

Kay, S., Crous-Duran, J., Garcia de Jalon, S., et al. (2017). ‘Spatial similarities between European agroforestry systems and ecosystem services at the landscape scale.’ *Agroforestry Systems*, 92, 1075–1089. doi: https://doi.org/10.1007/s10457-017-0132-3

Kazakov, Y., Hrystova, T. and Kazakova, S. (2000). ‘Drought tolerance of plants and the problem of its study.’ *Issues Biol. Ecol.*, 5, 3–12.

Keenleyside, C. and Tucker, G. M. (2010). ‘Farmland Abandonment in the EU: An Assessment of Trends and Prospects.’ Report prepared for WWF. London: Institute for European Environmental Policy.

King, M. (2010). ‘An investigation into policies affecting Europe’s semi-natural grasslands.’ A report commissioned by the Grassland Trust commissioned by the European Forum on Nature Conservation and pastoralism & co-funded by the European Commission (DG Environment).

Kosmas, C., Kairis, O., Karavitis, C., Acikalin, S., Alcalá, M., Alfama, P., Salvati, L. (2015). ‘An exploratory analysis of land abandonment drivers in areas prone to desertification.’ *Catena*, 128, 252–261. Doi: https://doi.org/10.1016/j.catena.2014.02.006 LK - https://wur.on.worldcat.org/oclc/5900113904

Krčílková, Š. and Janovská, V. (2016). ‘Land Tenure as a Factor Underlying Agricultural Landscape Changes in Europe: A Review.’ *Scientia Agriculturae Bohemica*, 47(2), 68–81. Doi: https://doi.org/10.1515/sab-2016-0011

Kuemmerle, T., Levers, C., Erb, K., Estel, S., Jepsen, M. R., Müller, D., Plutzar, C. Stürck, J., Verkerk, P., Verburg, P., Reenberg, A. (2016). ‘Hotspots of land use change in Europe.’ *Environmental Research Letters*, 11(6), 1–14. Doi: https://doi.org/10.1088/1748-9326/11/6/064020

Kuzyakov, Y., and Domanski, G. (2000). ‘Carbon input by plants into the soil: Review.’ *Journal of Plant Nutrition and Soil Science*, 163, 4, 421-431. https://doi.org/10.1002/1522-2624(200008)163:4<421::AID-JPLN421>3.0.CO;2-R.

Laborde, D. 2011. ‘Assessing the land use change consequences of European biofuel policies.’ Final report ATLASS consortium. Contract no. TRADE/07/A2; Washington, DC: IFPRI. http://trade.ec.europa.eu/doclib/docs/2011/october/tradoc_148289.pdf (accessed 1 July 2012)

Lapola, D.M.D. et al., (2010). ‘Indirect land-use changes can overcome carbon savings from biofuels in Brazil.’ *Proceedings of the National Academy of Sciences of the United States of America*, 107, 8, 3388–3393. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2840431&tool=pmcentrez&rendertype=abstract%5Cnhttp://www.pnas.org/content/107/8/3388.short

Lasanta, T. (2002). 'Los sistemas de gestión en el Pirineo central español durante el siglo XX: del aprovechamiento global de los recursos a la descoordinación espacial en los usos del suelo.' *Ager* 2, 173–195.

Lasanta, T., J. Arnáez, N. Pascual, P. Ruiz-Flaño, M.P. Errea, and N. Lana-Renault. (2017). 'Space–time process and drivers of land abandonment in Europe.' *CATENA*, 149, 3, 810-823. doi: https://doi.org/10.1016/j.catena.2016.02.024

Lasorella, M., Monti, A., Alexopoulou, E., Riche, A., Sharma, N., Cadoux, S., Diepen, C.A. van, Elbersen, B.S., Atzema, A.J., and Elbersen, H.W. (2011). 'Yield comparison between switchgrass and miscanthus based on multi-year side by side comparison in Europe.' Proceedings of the 19th European Biomass Conference and Exhibition, 6-10 June 2011, Berlin. doi: 10.5071/19thEUBCE2011-VP1.3.59

Leal Filho, W., M. Mandel, A. Quasem Al-Amin, A. Feher and C J.C. Jabbour. (2017). 'An assessment of the causes and consequences of agricultural land abandonment in Europe.' *International Journal of Sustainable Development & World Ecology*, 24, 6, 554-560. doi: 10.1080/13504509.2016.1240113.

Lefroy, E.C., Hobbs, R.J., Connor, M.H.O., and Pate, J.S. (1999). 'What can agriculture learn from natural ecosystems?' *Agroforestry Systems*, 45, 425–438. Doi: http://dx.doi.org/10.1023/A:1006293520726

Levers, C, Müller, D., Erb, K., Haberl H., Rudbeck Jepsen, M., Metzger, M. J., Meyfroidt, P., Plieninger, T., Plutzar, C., Stürck, J. Verburg, P.H., Verkerk, P. J., Kuemmerle, T. (2015). 'Archetypical patterns and trajectories of land systems in Europe.' *Regional Environmental Change*, pp. 1–18.

Lewandowski, I. (2016). 'The role of perennial biomass crops in a growing bioeconomy.' In S. Barth, D. Murphy-Bokern, O. Kalinina, G. Taylor, and M. Jones (eds.) *Perennial Biomass Crops for a Resource-constrained World,* 3–13. Cham: Springer Switzerland.

Lewandowski, I., Clifton-Brown, J., and Murphy-Bokern, D. (2015) 'Perennial biomass Crops for a Resource-Constrained world.' https://biomass2015.uni-hohenheim.de/fileadmin/einrichtungen/biomass2015/Biomass2015_Conference_Results_02.pdf

Liere, H., Kim, T.N., Werling, B.P., Meehan, T.D., Landis, D.A., and Gratton, C. (2015). 'Trophic cascades in agricultural landscapes: indirect effects of landscape composition on crop yield.' *Ecological Applications*, 25, 652–661. doi: 10.1890/14-0570.1

Lourenço, L. (2018). 'Forest fires in continental Portugal. Result of profound alterations in society and territorial consequences.' Http://Journals.Openedition.Org/Mediterranee, (130). Doi: https://doi.org/10.4000/MEDITERRANEE.9958

Manning, P., Taylor, G. and Hanley, M. (2015). 'Bioenergy, Food Production and Biodiversity – An Unlikely Alliance?' *GCB Bioenergy*, 7, 570–576. doi: 10.1111/gcbb.12173

MARD. (2020). 'Grupurile de producători recunoscute în România.' Ministry of Agriculture and Rural Development for Romania, Bucharest. Available at: https://www.madr.ro/docs/agricultura/grupurile-producatorilor-recunoscute-update-04.03.2020.pdf

McCalmont, J.P., Hastings, A., Mcnamara, N.P., Richter, G.M., Robson, P., Donnison, I.S., and Clifton-Brown, J. (2017). 'Environmental costs and benefits of growing Miscanthus for bioenergy in the UK.' *GCB Bioenergy*, 9, 489–507.

McIsaac, G.F., David, M.B., and Mitchell, C.A. (2010). 'Miscanthus and switchgrass production in central Illinois: impacts on hydrology and inorganic nitrogen leaching.' *Journal of Environmental Quality*, 39, 1790–1799. doi: 10.2134/jeq2009.0497

Meehan, T.D., Hurlbert, A.H., and Gratton, C. (2010). 'Bird communities in future bioenergy landscapes of the Upper Midwest.' *PNAS*, 107, 18533–18538. doi: 10.1073/pnas.1008475107

Mehmood, M.A., Ibrahim, M., Rashid, U., Nawaz, M., Ali, S., Hussain, A., et al. (2017). 'Biomass production for bioenergy using marginal lands.' *Sustainable Production and Consumption* 9, 3–21. doi: 10.1016/j.spc.2016.08.003

Michel, H. (2012). 'Editorial: The Nonsense of Biofuels.' *Angewandte Chemie*,51, 2516–2518.

Mihalcea, L., Radu, R.I. and Nastase, G. (2015). The Capitalisation of the Romanian Land Fund in the context of European Integration. In: Risk in Contemporary Economy, proceedings of an international conference organised by "Dunarea de Jos" University of Galati, Faculty of Economics and Business Administration, 526-533. Available at: https://ideas.repec.org/a/ddj/fserec/y2015p526-533.html

Moreno, G., and Pulido, F.J. (2009). 'The function, management and persistence of dehesas.' In Rigueiro-Rodríguez, A., Mosquera, M.R., and McAdam, J. (eds.) *Agroforestry in Europe. Current Status and Future Prospects.* Heidelberg: Springer, 127–160.

Mosquera-Losadaa, M.R., Santiago-Freijanesa, J., Rois-Díaza, M, Morenod, G., den Herder, M., Aldrey-Vázquez, J, Ferreiro-Domíngueza, N., Panteraf, A., Pisanellig, A., and Rigueiro-Rodrígueza, A., (2018). 'Agroforestry in Europe: A land management policy tool to combat climate change.' *Land Use Policy*, 78,. 603-613.

Nair, V.D., and Kalmbacher, R.S. (2005). 'Silvopasture as an approach to reducing nutrient loading of surface water from farms.' In Mosquera-Losada, M.R., McAdam, J., and Rigueiro-Rodríguez, A. (eds.) *Silvopastoralism and Sustainable Land Management*. Wallingford: CABI.

NIS (2020a). 'TEMPO-Online time series AGR101A - Land fund area by usage, ownership form, macroregions, development region and counties.' National Institute for Statistics - ROMANIA, Bucharest. Available at: http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table

NIS (2020b). 'TEMPO-Online time series AGR108A - Area cultivated with main crops by ownership form, macroregions, development regions and counties.' National Institute for Statistics - ROMANIA, Bucharest. Available at: http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table

Nunes, L., Stigter, T., Monteiro, J., and Teixeira, M. (2011). 'Environmental Impacts on Soil and Groundwater at Airports: Origin, Contaminants of Concern and Environmental Risks.' Journal of Environmental Monitoring, 13, 3026-39. doi: 10.1039/c1em10458f

OVAM. (2013). 'Potentieelbepaling Landfill Mining en saneringsnoodzaak stortplaatsen in Vlaanderen – Eindrapportage mei 2013.' https://www.ovam.be/sites/default/files/atoms/files/def-rapport-eddy.pdf

Panagos, P., Borelli, P., Poesen, J., Ballabio, C., Lugato, E., Meusburger, K., Montanarella, L. and Alewell, C. (2015). 'The new assessment of soil loss by water erosion in Europe.' *Environmental Science & Policy*, 54, 438-447. doi: https://doi.org/10.1016/j.envsci.2015.08.012

Panagos, P., Van Liedekerke, M., Jones, A. and Montanarella, L. (2012). 'European Soil Data Centre: Response to European policy support and public data requirements.' *Land Use Policy*, 29, 329–338. Doi: https://doi.org/10.1016/j.landusepol.2011.07.003

Pancaldi, F., and Trindade, L.M. (2020) 'Marginal Lands to Grow Novel Bio-Based Crops: A Plant Breeding Perspective.' *Frontiers in Plant Science*, 11, 227. doi: 10.3389/fpls.2020.00227

Paracchini, M.L., Petersen, J.E., Hogeveen, Y., Bamps, C., Burfield, I., and van Swaay, C. (2008). 'High nature value farmland in Europe. An estimate of the distribution patterns on the basis of land cover and biodiversity data.' European Commission, Joint Research Centre, Institute for Environment and Sustainability. EUR 23480 EN.

Parvathaneni, L., Prayaga, L., and Karusala, A. (2017). 'Selection of castor germplasm with important traits for drought tolerance under field conditions.' *Indian Journal of Plant Physiology*, 22, 3, 295–303. doi: 10.1007/s40502-017-0302-3

Pedroli, B., Elbersen, B., Frederiksen, P., Grandin, U., Heikkilä, R., Krogh, P.H, Izakovičová, Z., Johansen, A., Meiresonne, L., and Spijker, J. (2013). 'Is energy cropping in Europe compatible with biodiversity? Opportunities and threats to biodiversity from land-based production of biomass for bioenergy purposes.' *Biomass Bioenergy*, 55, 73–86.

Pivato, A., Garbo, F., Moretto, M., et al. (2018). 'Energy crops on landfills: functional, environmental, and costs analysis of different landfill configurations.' *Environmental Science and Pollution Research*, 25, 35936–35948. doi: https://doi.org/10.1007/s11356-018-1452-1

Plieninger, T., and Gaertner, M. (2011). 'Harnessing degraded lands for biodiversity conservation.' *Journal for Nature Conservation*, 19, 18-23.

Plieninger, T., Hartel, T., Martín-López, B., Beaufoy, G., Bergmeier, E., Kirby, K., Montero, M.J., Moreno, G., Oteros-Rozas, E., and Van Uytvanck, J. (2015). 'Wood-pastures of Europe: Geographic coverage, social-ecological values, conservation management, and policy implications.' *Biological Conservation* 190, 70-79. doi: http://dx.doi.org/10.1016/j.biocon.2015.05.014

Plutzar, C., Kroisleitner, C., Haberl, H., Fetzel, T., Bulgheroni, C., Beringer, T., Hostert, P., Kastner, T., Kuemmerle, T., Lauk, C., Levers, C., Lindner, M., Moser, D., Müller, D., Niedertscheider, M., Paracchini, M.L., Schaphoff, S., Verburg, P.H., Verkerk, P.J., Erb, K.H. (2016). 'Changes in the spatial patterns of human appropriation of net primary production (HANPP) in Europe 1990-2006.' *Regional Environmental Change*, 16(5), 1225–1238. Doi : https://doi.org/10.1007/s10113-015-0820-3 LK - https://wur.on.worldcat.org/oclc/6039644468

Pointereau, P., Coulon, F., Girard, P., Lambotte, M., Stuczynski, T., Sánchez Ortega, V., and Del Rio, A. (2008). 'Analysis of Farmland Abandonment and the Extent and Location of Agricultural Areas that are Actually Abandoned or are in Risk to be Abandoned.' EUR 23411EN – 2008, Institute for Environment and Sustainability, JRC.

Poláková, J., Tucker, G., Hart, K., Dwyer, J., and Rayment, M. (2011) 'Addressing biodiversity and habitat preservation through Measures applied under the Common Agricultural Policy'. Report Prepared for DG Agriculture and Rural Development, Contract No. 30-CE-0388497/00-44. London: Institute for European Environmental Policy.

Porder, S., A. Bento, A. Leip, L. A. Martinelli, J. Samseth, and T. Simpson. (2009). 'Toward an integrated assessment of biofuel technologies.' In Howarth, R.W., and Bringezu, S. (eds.) *Biofuels: environmental consequences and interactions with changing land use. Proceedings of the Scientific Committee on Problems of the Environment (SCOPE) International Biofuels Project Rapid Assessment, 22-25 September 2008,* Gummersbach, 233-248.

Pulighe, G., Bonati, G., Fabiani, S., Barsali, T., Lupia, F., Vanino, S., Nino, P., Arca, P., and Roggero, P.P. (2016). 'Assessment of the Agronomic Feasibility of Bioenergy Crop Cultivation on Marginal and Polluted Land: A GIS-Based Suitability Study from the Sulcis Area, Italy.' *Energies*, 9, 18.

Pulighe, G., Bonati, G., Colangeli, M., Morese, M.M., Traverso, L., Lupia, F., Khawaja, C., Janssen, R., Fava, F. (2019). 'Ongoing and emerging issues for sustainable bioenergy production on marginal lands in the Mediterranean regions.' *Renewable and Sustainable Energy Reviews*, 103, 58–70. Doi: https://doi.org/10.1016/j.rser.2018.12.043

Ramirez-Almeyda, J., Elbersen, B., Monti, M., Staritsky, I., Panoutsou, P., Alexopoulou, E, Schrijver, R, and Elbersen, W. (2017). 'Assessing the potentials for non-food crops.' In Panoutsou, C. and Langeveld, H. (eds.). *Modelling and Optimisation of Biomass Supply Chains. Top down and bottom up assessment for agricultural, forest and waste feedstock*. Elsevier, 219-251.

Richards, M., Pogson, M., Dondini, M., et al. (2017). 'High-resolution spatial modelling of greenhouse gas emissions from land-use change to energy crops in the United Kingdom.' *GCB Bioenergy*, 9, 627–644.

Rigueiro-Rodríguez, A., McAdam, J. and Mosquera-Losada, M.R. (Eds.) (2009). *Agroforestry in Europe. Current Status and Future Prospects.* Springer Science ISBN: 978-1-4020-8271-9.

Robertson, G. P., Hamilton, S. K., Barham, B. L., Dale, B. E., Izaurralde, R. C., Jackson, R. D., et al. (2017). 'Cellulosic biofuel contributions to a sustainable energy future: choices and outcomes.' *Science* 356, eaal2324. doi: 10.1126/science.aal2324

Robertson, G. P., Hamilton, S.K., Del Grosso, S.J., and Parton, W.J. (2011). 'The biogeochemistry of bioenergy landscapes: carbon, nitrogen, and water considerations.' *Ecological Applications*, 21, 1055–1067. doi: 10.1890/09-0456.1

Robinson, R.A., Wilson, J.D. and Crick, H.Q.P. (2001). 'The importance of arable habitat for farmland birds in grassland landscapes.' *Journal of Applied Ecology*, 38, 1059-1069.

Rokwood (2015a). 'Energy crops in Europe: best practice in SRP biomass from Germany, Ireland, Poland, Spain, Sweden & UK.'

Rokwood (2015b). 'Resource efficient production and utilization of woody biomass from SRPs: European Best Practice and Key Findings.'

Royal Society. (2008). 'Sustainable biofuels: prospects and challenges.' Policy document 01/08, January.

Ruf, T., Schmidt, A., Delfosse, P., and Emmerling, C. (2017). 'Harvest date of Miscanthus x giganteus affects nutrient cycling, biomass development and soil quality.' *Biomass Bioenergy*, 100, 62–73.

Rusu, M., Florian, V., Tudor, M., Chitea, M., Chitea, L. and Rosu, E. (2011). Land related disputes and conflicts in Romania, Agricultural Economics and Rural Development 8(1), 127–145. Available at: https://ideas.repec.org/a/iag/reviea/v8y2011i1p127-145.html

Săvulescu, I., Mihai, B., Vîrghileanu, M., Nistor, C. and Olariu, B. (2019). 'Mountain Arable Land Abandonment (1968–2018) in the Romanian Carpathians: Environmental Conflicts and Sustainability Issues.' *Sustainability*, 11, 6679. doi:10.3390/su11236679

Scarlat, N., Dallemand, J.-F., Monforti-Ferrario, F., Nita, V. (2015). 'The role of biomass and bioenergy in a future bioeconomy: Policies and facts.' *Environmental Development*, 15, 3–34. Doi : https://doi.org/10.1016/j.envdev.2015.03.006

Schneider, M., Blanchard, G., Levers, C. and Kuemmerle, T. (2015). 'Spatial Variation of Drivers of Agricultural Abandonment with Spatially Boosted Models.' *Procedia Environmental Sciences*, 27, 53–57. Doi: https://doi.org/10.1016/j.proenv.2015.07.114

Searchinger, T., Heimlich, R., Houghton, R. A., Dong, F., Elobeid, A., Fabiosa, J., et al. (2008). 'Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change.' *Science* 319, 5867, 1238-1240.

Shafiei-Koij, F., Mahdi Majidi, M., Mirlohi, A., Saeidi, G., Barthet, V.J., and Eskini, S. (2019). 'The Use of Wild Relatives of Safflower to Increase Genetic Diversity for Fatty Acid Composition and Drought Tolerance.' *Crop Science*, 59, 2109–2118 (2019). doi: 10.2135/cropsci2019.01.0068

Sharma, S., and Chaubey, I. (2017). 'Surface and subsurface transport of nitrate loss from the selected bioenergy crop fields: systematic review, analysis and future directions., *Agriculture-Basel*, 7, 27.

Silvis, H. and Voskuilen, M. (2018). 'Agricultural land prices in the EU in 2016.' Factsheet, Wageningen University & Research. https://edepot.wur.nl/446327

Smeets, E., Lewandowski, I. and Faaij, A. (2009). 'The economical and environmental performance of miscanthus and switchgrass production and supply chains in a European setting.' *Renewable and Sustainable Energy Reviews*, 13, 1230-1245.

Stahl, J., Sikor, T. and Dorondel, S. (2007). Transparency in Albanian and Romanian Land Administration. International Land Coalition, Rome. Available at: https://www.researchgate.net/publication/255609850_Transparency_in_Albanian_and_Romanian_Land_Administration_1

Stolte, J., Tesfai, M., Øygarden, L., Kvaernø, S., Keizer, J., and Verheijen, F. (2016). 'Soil threats in Europe: status, methods, drivers and effects on ecosystem services. A review report, deliverable 2.1 of the RECARE project.' https://doi.org/10.2788/488054

Stringer, L.C., and Harris, A. (2014). 'Land degradation in Dolj county, southern Romania: environmental changes, impacts and responses.' *Land Degradation & Development*, 25(1), 17–28. Doi: https://doi.org/10.1002/ldr.2260 LK - https://wur.on.worldcat.org/oclc/5534806671

Sutcliffe, L. et al (2015). 'Harnessing the biodiversity value of Central and Eastern European farmland.' *Diversity and Distributions*, 21, 722–730. Doi: https://doi.org/10.1111/ddi.12288.

Terres, J.M., Nisini, L. and Anguiano, E. (2013). 'Assessing the risk of farmland abandonment in the EU.' JRC78131 EUR 25783 EN ISBN 978-92-79-28281-2 (pdf) ISSN 1831-9424 (online) doi: LB-NA-25783-EN-N Luxembourg: Publications Office of the European Union, 2013, European Union.

Terres, J.M., Hagyo, A., Wania, A., Confalonieri, R., Jones, B. Van Diepen K., and Van Orshoven J. (2014). 'Scientific contribution on combining biophysical criteria underpinning the delineation of agricultural areas affected by specific constraints. Methodology and factsheets for plausible criteria combinations'. JRC92686. doi: 10.2788/844501.

Terres, J.M., Van Orshoven, J., Toth, T., Jones, R., Le-Bas, C., Nachtergaele, F., Rossiter, D., Schulte, R., Velthuizen, H. (2014b). ‘Updated common bio-physical criteria to define natural constraints for agriculture in Europe. Definition and scientific justification for the common biophysical criteria.’ JRC report EUR 26638 EN. Luxembourg: Publications Office of the European Union.

Terres, J. M., Scacchiafichi, L. N., Wania, A., Ambar, M., Anguiano, E., Buckwell, A., Zobena, A. (2015). ‘Farmland abandonment in Europe: Identification of drivers and indicators, and development of a composite indicator of risk’ https://wur.on.worldcat.org/oclc/7095073920. *Land Use Policy,* 49, 20–34.

Tilman, D., Socolow, R., Foley, J. A., Hill, J., Larson, E., Lynd, L., et al. (2009). ‘Beneficial biofuels—the food, energy, and environment trilemma.’ *Science* 325, 270–271. doi: 10.1126/science.1177970

Torralba, M., Fagerholma, M., Burgess, P., Moreno, G., and Plieninger, T. (2016). ‘Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis.’ *Agriculture, Ecosystems and Environment,* 230, 150–161.

Tóth, G., Adhikari, K., Várallyay, G., Tóth, T., Bódis, K. and Stolbovoy, V. (2008). ‘European Union Threats to Soil Quality in Europe.’ In: ‘Threats to Soil Quality in Europe’ (pp. 65–77). European Commission Joint Research Centre.

Toth, G., Hermann, T., Szatmari, G. and Pasztor, L. (2016). ‘Maps of heavy metals in the soils of the European Union and proposed priority areas for detailed assessment.’ *Science of the Total Environment,* 565, 1054–1062. http://dx.doi.org/10.1016/j.scitotenv.2016.05.115.

USDA National Wildlife Research Center (2005). ‘Wildlife Hazard Management at Airports: A Manual for Airport Personnel.’ https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1127&context=icwdm_usdanwrc

Valentine, J., Clifton-Brown, J., Hastings, A., Robson, P., Allison, G. and Smith, P. (2012). ‘Food vs. fuel: the use of land for lignocellulosic ‘next generation’ energy crops that minimize competition with primary food production.’ *GCB Bioenergy*, 4, 1–19. doi: 10.1111/j.1757-1707.2011.01111.x

Valin, H., Peters, D., van den Berg, M., Frank, S., Havlik, P., Forsell, N. et al. (2015). ‘The Land Use Change Impact of Biofuels Consumed in the EU: Quantification of Area and Greenhouse Gas Impacts.’ Utrecht: ECOFYS. p. 261.

Van der Sluis, T., Pedroli, B., Kristensen, S.B.P., Lavinia Cosor, G. and Pavlis, E. (2016). ‘Changing land use intensity in Europe - Recent processes in selected case studies.’ *Land Use Policy*, 57, 777–785. https://doi.org/10.1016/j.landusepol.2014.12.005 LK - https://wur.on.worldcat.org/oclc/6777550992

Van der Weijde, T., Kiesel, A., Iqbal, Y., Muylle, H., Dolstra, O., Visser, R.G.F., Lewandowski, I., and Trindade, L. M. (2017). ‘Evaluation of Miscanthus sinensis biomass quality as feedstock for conversion into different bioenergy products.’ *GCB Bioenergy*, 9(1), 176–190. https://doi.org/10.1111/gcbb.12355.

Van Eupen, M., Metzger, M.J., Perez-Soba, M, Verburg, P., van Doorn, A. and Bunce, R.G.H. (2012). 'A rural typology for strategic European policies.' *Land Use Policy*, 29, 473-482.

Van Holst, F. (2011). 'Comparative quick scan study: Pre-emption rights related to rural land.' The Netherlands: DLG.

Van Liedekerke, M., Prokop, G., Rabl-Berger, S., Kibblewhite, M., and Louwagie, G. (2014). 'Progress in the Management of Contaminated Sites in Europe. EUR 26376.' Luxembourg: Publications Office of the European Union (68 pp).

Van Vliet, J., de Groot, H. L. F., Rietveld, P. and Verburg, P. H. (2015). 'Manifestations and underlying drivers of agricultural land use change in Europe.' *Landscape and Urban Planning*, 133, 24–36. https://doi.org/10.1016/j.landurbplan.2014.09.001 LK - https://wur.on.worldcat.org/oclc/5627857093

Verburg, P.H. and Overmars, K.P. (2009). 'Combining top-down and bottom-up dynamics in land use modeling: exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model.' *Landscape Ecology*, 24(9): 1167-1181. http://dx.doi.org/10.1007/s10980-009-9355-7.

Verheijen, F.G.A., Jones, R.J.A., Rickson, R.J. and Smith, C.J. (2009). 'Tolerable versus actual soil erosion rates in Europe.' *Earth-Science Reviews*, 94 (1–4), 23–38.

Viedma, O., Moity, N. and Moreno, J. M. (2015). 'Changes in landscape fire-hazard during the second half of the 20th century: Agriculture abandonment and the changing role of driving factors.' *Agriculture, Ecosystems and Environment*, 207, 126–140. https://doi.org/10.1016/j.agee.2015.04.011 LK - https://wur.on.worldcat.org/oclc/5899886239

Vinogradovs, I., Nikodemus, O., Elferts, D. and Brūmelis, G. (2018). 'Assessment of site-specific drivers of farmland abandonment in mosaic-type landscapes: A case study in Vidzeme, Latvia.' *Agriculture, Ecosystems and Environment*, 253, 113–121. https://doi.org/10.1016/j.agee.2017.10.016 LK - https://wur.on.worldcat.org/oclc/7241033826

Von Cossel, M., I. Lewandowski, B. Elbersen, I. Staritsky, M. Van Eupen, Y. Iqbal, S. Mantel, D. Scordia, G. Testa, S. Luciano Cosentino, O. Maliarenko, I. Eleftheriadis, F. Zanetti, A. Monti, D. Lazdina, S. Neimane, I. Lamy, L. Ciadamidaro, M. Sanz, J.E. Carrasco, P. Ciria, I. McCallum, L.M. Trindade, E.N. van Loo, W. Elbersen, A.L. Fernando, E.G. Papazoglou and E. Alexopoulou (2019a). 'Marginal Agricultural Land Low-Input Systems for Biomass Production.' *Energies*, 12, 16, 3123. doi:10.3390/en12163123

Von Cossel; M, Wagner M.; Lask J.; Magenau E.; Bauerle A.; von Cossel V.; Warradh-Sagi K.; Elbersen B.; Staritsky I.; van Eupen M.; Iqbal Y.; Jablonowski N.D.; Happe S.; Fernando A.L.; Scordia D.; Cosentino S.L.; Wulfmeyer V.; Lewandowski I.; Winkler B. (2019b): Prospects of Bioenergy Cropping Systems for A More Social-Ecologically Sound Bioeconomy. DOI: 10.3390/agronomy9100605

Vorovencii, I. (2017). 'Analysis of changes in the Metropolitan Area of Brasov, Romania, using Landsat multitemporal satellite images.' *Environmental Engineering and Management Journal*, 16(2), 303-316.

Werling, B.P., Dickson, T.L., Isaacs, R., Gaines, H., Gratton, C., Gross, K.L., et al. (2014). 'Perennial grasslands enhance biodiversity and multiple ecosystem services in bioenergy landscapes.' *PNAS*, 111, 1652–1657. doi: 10.1073/pnas.1309492111

Weselek, A., Ehmann, A., Zikeli, S., Lewandowski, I., Schindele, S., and Högy, P. (2019): 'Agrophotovoltaic systems: applications, challenges, and opportunities. A review', *Agronomy for Sustainable Development*, 39, Article 35. https://doi.org/10.1007/s13593-019-0581-3

Whithaker, J., Field, J., Bernacchi, C., Cerri, C., Ceulemans, R., Davies, C., Delucia, E., Donnison, I., McCalmont, J., Paustian, K., Rowe, R., Smith, P., Thornley, P., and Mcnamara, N. (2018). 'Consensus, uncertainties and challenges for perennial bioenergy crops and land use.' *GCB Bioenergy*, 10, 3, 150–164, doi: 10.1111/gcbb.12488

Wiegmann, K., Hennenberg, K.J., and Fritsche, U.R. (2008). 'Degraded land and sustainable bioenergy feedstock production.' Paper presented at the Joint International Workshop on High Natural Value Criteria and Potential for Sustainable Use of Degraded Lands, Paris.

Zegada-Lizarazu, W., Elbersen, H., Cosentino, S., Zatta, A., Alexopoulou, E., and Monti, A. (2010). 'Agronomic aspects of future energy crops in Europe.' *Biofuels, Bioproducts and Biorefining,* 4, 674-691.

Zimmermann, J., Dauber, J., and Jones, M. (2012). 'Soil carbon sequestration during the establishment phase of Miscanthus x giganteus: a regional-scale study on commercial farms using 13C natural abundance.' *GCB Bioenergy*, 4, 453-461.

# 8 ANNEX I OVERVIEW OF STATISTICAL AND SPATIAL DATA SOURCES ON FARMLAND AT EU-WIDE LEVEL

## Eurostat – Farm Structure Survey (FSS)

Eurostat is the European statistical office that provides strict guideline to all MS on how they have to report their data to FSS. It ensures that there is regular data reporting according to a consistent methodology between all EU Member States. The data on farming are published through the Farm Structural Survey (FSS). It includes data on agricultural land collected at Member State and regional level.

The Eurostat Farm structure survey (FSS) is carried out by all European Union (EU) Member States. The FSS is conducted consistently throughout the EU with a common methodology on a regular basis and provides therefore comparable and representative statistics across countries and time, at regional levels (NUTS0- NUTS 3 level). Every 3 or 4 years the FSS is carried out as a sample survey, and once in ten years as a census. The last census was carried out in 2010. Sample surveys of 2003, 2005 and 2007 covered the EU-27 Member States. In 2013 and 2016, the survey covered the EU28 Member States (including Croatia) and other non-EU countries like Iceland, Norway, Switzerland, Montenegro, North Macedonia and Serbia.

The countries collect information from individual agricultural holdings and forward these to Eurostat. The information collected in the FSS covers all crop/land types on farm area, AA and UAA as presented in the tree in Figure 3.2. Also other data is collected through it like livestock numbers, rural development, management and farm labour input (including the age, gender and relationship to the holder of the agricultural holding). The basic unit underlying the FSS is the agricultural holding , although only those that meet the minimum requirements set in the Regulation (EC) No 1166/2008.

The definitions making up the UAA land use categories are presented in Section 2.1 of the main report (Table 2.1).

**Minimum size threshold[79]:**

Until the FSS 2007, in accordance with Article 6 of Regulation (EEC) No 571/88, the countries which applied a threshold of above one hectare of utilised agricultural area (UAA) committed themselves to fix this threshold at a level excluding only the smallest holdings, which together contributed 1 % or less to the total standard gross margin (SGM).

[79] Copied from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farm_structure_survey_%E2%80%93_survey_coverage#Thresholds_described_in_legislation.C2.A0

Table 8.1 Minimum farm and farm area coverage for registration in FSS before and after 2007

| Legal Act | Regulation (EEC) No 571/88 | Regulation (EC) No 1166/2008 |
|---|---|---|
| Population coverage | a) agricultural holdings where the agricultural area utilised for farming is one hectare or more; | |
| | b) agricultural holdings where the agricultural area utilised for farming is less than one hectare, if those holdings produce a certain proportion for sale or if their production unit exceeds certain physical thresholds. | |
| Condition(s) of coverage in case countries apply a threshold of above one hectare of utilised agricultural area | 99% of the total standard gross margin (SGM) | 98% or more of the total utilised agricultural area excluding common land and 98% or more of the total number of farm livestock units |
| Additional conditions of coverage | - | In any case, all agricultural holdings reaching one of the physical thresholds specified in Annex II shall be covered |

Following the entry into force of Regulation (EC) No 1166/2008, the minimum requirements for survey coverage from the 2009/2010 FSS onwards have been modified. Countries which used a survey threshold above one hectare of UAA were allowed to fix this threshold at a level that excludes only the smallest agricultural holdings which together contribute 2 % or less to the total UAA excluding common land, and 2 % or less to the total number of farm livestock units (LSU). In addition, in all cases, countries have to include in the survey populations all holdings which comply with at least one of the following set of physical thresholds, defined in Annex II of Regulation (EC) No 1166/2008:

- Utilised agricultural area (arable land, kitchen gardens, permanent grassland, permanent crops): 5 hectares
- Permanent outdoor crops (fruit, berry, citrus and olive plantations, vineyards and nurseries): 1 hectare
- Other intensive production:
    - Fresh vegetables, melons and strawberries, which are outdoors or under low (not accessible) protective cover: 0.5 hectares
    - Tobacco: 0.5 hectares
    - Hops: 0.5 hectares
    - Cotton: 0.5 hectares
- Crops under glass or other (accessible) protective cover:
    - Fresh vegetables, melons and strawberries: 0.1 hectares
    - Flowers and ornamental plants (excluding nurseries): 0.1 hectares
- Bovine animals (all): 10 heads
- Pigs (all): 50 heads
- Breeding sows: 10 heads
- Sheep (all): 20 heads

- Goats (all): 20 heads
- Poultry (all): 1 000 heads.

**Common land** can be defined as utilised agricultural area used by the agricultural holding but not belonging directly to it, i.e. on which common rights apply. In general terms, common land is utilised agricultural area (UAA) owned by a public authority (state, parish, etc.) over which another person is entitled to exercise rights of common, and these rights are generally exercisable in common with others. Common land is found in Mediterranean Member States (Greece, Spain, France, Italy, Cyprus and Portugal), in mountainous countries (Austria, Norway and Switzerland), in some East European countries (Bulgaria, Croatia, Hungary, Poland, Romania, Slovenia, Montenegro and Serbia), in countries which have extensive grassland areas (Ireland, United Kingdom and Iceland) and in Germany.

Common land consists mainly of permanent grassland, although it could also consist of horticulture or arable land. A large percentage of these areas is used for grazing animals. In common land units, the area used by each holding is not individualised but is counted as part of the utilised agricultural area (UAA) in the FSS database.

As to registration of common land in FSS not all countries register it in the same as part of UAA and some adjustments were introduced since 2010 (see Table 2) as some additional countries started registering it as part of the UAA. From Table 2.3 (in main report) it becomes clear that this can be quite significant areas (see Table 8.2). So this also creates inconsistencies between the definition and what is registered in FSS by every country.

Table 8.2 Different ways common land is registered in FSS

| Common land: | *Method A:* Area of common land rented by, or allotted to the agricultural holding (existence of written or oral agreement) (1) | *Method B:* Area of common land neither rented by, nor allotted to the agricultural holding: actual common land | | |
|---|---|---|---|---|
| | | *Option 1:* Allocated to agricultural holdings | *Option 2:* Common land units - local units managing the common land | *Option 3:* Common land units - aggregates of common land at regional level |
| included in FSS even before 2010 | Spain, Italy, Latvia, Poland | Germany (excl. Bavaria), Cyprus, Poland, Norway | Germany (excl. Bavaria), Spain, Italy, Cyprus, Austria, Portugal, Romania | - |
| included in FSS since 2010 (2) | Hungary, Iceland, Serbia | Croatia, Slovenia, Montenegro | Bulgaria, France, Serbia | Ireland, Greece, Croatia (2013 only), Hungary, United Kingdom |
| No common land | Belgium, Czech Republic, Denmark, Estonia, Lithuania, Luxembourg, Malta, Netherlands, Slovakia, Finland, Sweden | | | |

(1) Not considered common land in statistics
(2) Serbia carried out the 2010 FSS in 2012

One conclusion from this table is that there are a lot of inconsistencies and movements in data that almost certainly don't correspond to changes on the ground. Many statistical artefacts, including the important shift from estimates to more consistent use of EU methodology in several MS.

## DG-AGRI- Farm Accountancy Data Network (FADN)

Another relevant EC data source is the Farm Accountancy Data Network (FADN), that should be used with caution for determining the UAA, and comparing it to other data sources. The UAA for which data is collected in FADN is based on the same definition as applied in FSS but the limitation is however the low representation of small farms in the FADN sample, because farms have to be above an *economic size* threshold, which is also different per MS. This implies that it excludes parts of the UAA where small farms predominate. From the particular perspective of land abandonment this is even more of a limitation as we know that the drivers on farmland abandonment are most prominent in remote rural areas and in these type of areas there are relatively more farms with limited economic size and part-time farmers, particularly in the CEEC and Mediterranean countries. This implies a significant under-representation of farms and related UAA in areas with high risks of land abandonment.

In FADN individual farm data are collected combining land use and production information and land management. The UAA for which data is collected in FADN is based on a similar definition as applied in FSS. Data or farms is only registered in FADN when they comply to the above minimum *economic size* threshold (see Table 8.3).

Table 8.3 FADN includes farms which exceed a certain economic size and are defined as commercial. Because of the different farm structures in the European Union, it is necessary to specify separate thresholds for each Member State[80].

| Economic size thresholds (in 1000 EUR) applied by the Commission according to Regulation (EC) 1242/2008 from Year | 2017 |
|---|---|
| Belgium | 25 |
| Bulgaria | 4 |
| Czech Republic | 8 |
| Denmark | 15 |
| Germany (*) | 25 |
| Estonia | 4 |
| Ireland | 8 |
| Greece (*) | 4 |
| Spain | 8 |
| France (Guadeloupe) | 15 |
| France | 25 |
| France (La Réunion) | 15 |
| France (Martinique) | 15 |
| Croatia | 4 |

[80] http://ec.europa.eu/agriculture/rica/methodology1_en.cfm

| | |
|---|---|
| Italy | 8 |
| Cyprus | 4 |
| Latvia | 4 |
| Lithuania | 4 |
| Luxembourg | 25 |
| Hungary | 4 |
| Malta | 4 |
| Netherlands (*) | 25 |
| Austria | 15 |
| Poland | 4 |
| Portugal | 4 |
| Romania | 2 |
| Slovenia | 4 |
| Slovakia | 25 |
| Finland | 8 |
| Sweden | 15 |
| United Kingdom (Northern Ireland) | 15 |
| United Kingdom | 25 |

## Integrated Administration and Control System (IACS)

The Integrated Administration and Control System registers agricultural land use at the level of agricultural parcel on farms. Because the CAP payments can only be linked to agricultural land which is 'eligible', it only registers eligible land which implies that the UAA registered through IACS/LPIS is mostly smaller than in FSS as was already illustrated in section 2.2.

The Integrated Administration and Control System (IACS and its GIS, "the Land Parcel Identification System" (LPIS)) has been set up by all member states to manage the implementation of the Common Agricultural Policy. It is operationalized by the paying agencies of each member state. The IACS ensures that payments of the EU Common Agricultural Policy (CAP) are made correctly. LPIS identifies and quantifies agriculture land for the purpose of allocating CAP payments. The data is gathered each year through individual application forms that are filled out by every farmer claiming CAP payments. In IACS/LPIS the UAA definition applied is similar to that of Eurostat statistics and FADN sources, however again the representation of farms is different. This is because the CAP payments can only be linked to agricultural land which is 'eligible'. Therefore the CAP Regulation defines agricultural area and categorizes land for "eligible hectares".

## Spatial data

An overview of the most relevant spatial sources which provide data on agricultural land in the EU, both for current and for past situation are presented in in Table 8.4.

Table 8.4 Main spatial data sources providing information on agricultural land

| Data source | Description | Suitable for UAA and AA quantification? |
|---|---|---|
| **Land Use and Cover Area frame Survey (LUCAS)** | On a 2km grid sample points are selected and data on land use and land cover are collected. Sample points are classified into different categories of land use and land cover according to first and second dominant class per point. The classifications used are streamlined with other statistical standards, like the Farm Structure Survey and the EUNIS classification. | This database registers agricultural land following the EU-CAP definition. However, it is not a suitable source to obtain a good area estimate of the UAA or AA because it is sample based and registered information is aggregated and averaged to the sample grid. |
| **Corine Land Cover (1990, 2000, 2006, 2012, 2018)** | The land cover information is derived from high resolution satellite data (Landsat-TM) by computer assisted visual interpretation in combination with ancillary data. The final CLC database consists of a geographical database describing land cover/use in 44 classes grouped into a three level hierarchical structure. The CORINE land cover nomenclature has 5 major categories at the first level, 15 land cover categories at the second level and 44 categories at the third level. | Very suitable EU wide database for understanding land use and land cover changes in time as it has a full area coverage and is repeated every 6 years. However, data are aggregated and averaged to 100 meter grid, many land uses are registered as combined classes and minimal mappable units exclude the registration of land in small parcels.<br>Total agricultural lands registered in CLC never correspond to the total AA in FSS or IACS-LPIS. |
| **GlobCover** | The GlobCover Land Cover Map was created by the ESA's GlobCover Project. The map displays land classification information for most of the Earth's surface at a resolution of 300 meter (9 ha per pixel) and contains 22 different land cover types, which are based on the predominant type of vegetation found at that location. The thematic legend is intended to be compatible with the FAO Land Cover Classification System (LCCS) used for the GLC2000 global land cover map. The data was collected from the MERIS sensor on the ENVISAT satellite during 2009. | Similar to CLC, with smaller number of land cover classes registered. Good to help understand where land cover changes take place, provided the area they cover is large enough to fit the minimal mapping unit. |
| **CCI-Land Cover (1992-2015)[81]** | As a further improvement of the GlobCover map the the CCI-LC project delivers a new time series of 24 consistent global LC maps at 300 m | This data is suitable to detect changes in land use, management and also likely signs of abandonment through derived |

[81] See http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf

| Data source | Description | Suitable for UAA and AA quantification? |
|---|---|---|
| | spatial resolution on an annual basis from 1992 to 2015, including land surface seasonality products: greenness, seasonality, NDVI | indices such as NDVI and greenness. However it is not a suitable source to detect the total area size of UAA and AA. It is only suitable to help assess what happens within the land and where it is located. |
| **MODIS 2001-2017[82]** | Modis was used to create an overview of land abandonment in the pan-European region. Cropped-not-cropped areas within a time frame of 15 years where analysed, showing patterning of longer abandonment and short term (yearly) set aside production cycles | This data is suitable to detect changes in land use, management and also likely signs of abandonment. However it is not a suitable source to detect the total area size of UAA and AA. It is only suitable to help assess what happens within the land and where it is located. |
| **GFSAD 30 meter Cropland mask[83]** | Global Food Security-Support Analysis Data at 30 m (GFSAD30) is a NASA funded project to provide high resolution global cropland data and their water use that contributes towards global food security in the twenty-first century. The GFSAD30 products are derived through multi-sensor remote sensing data (e.g., Landsat, MODIS, AVHRR), secondary data, and field-plot data and aims at documenting cropland dynamics from 1990 to 2017. The GFSAD30 collection, based on Landsat data, currently provides cropland extent data across the globe for nominal year 2015 at 30 meter resolution. Additionally, the validation dataset used to conduct an independent accuracy assessment of global cropland extent is available. | Interesting source to obtain information on where cropland is and how it is managed. Not a suitable source to quantify the total UAA area. |
| **Sen2-Agri system (mainly for regional/case study applications)** | ESA's Sentinel-2 for Agriculture project provides the Satellite Sen2-Agri system. This is an operational standalone processing system generating agricultural products from Sentinel-2 (A&B) and Landsat 8 time series satellite information. The different products consist of: 1) monthly cloud- | This data is suitable to use for analysis of changes in land use and especially management and also likely signs of abandonment. However it is not a suitable source to detect the total area size of UAA and AA. It is only suitable to help |

[82] Levers et al http://iopscience.iop.org/article/10.1088/1748-9326/11/2/024015/pdf
[83] See e https://lpdaac.usgs.gov/about/news_archive/release_gfsad_30_meter_cropland_extent_products

| Data source | Description | Suitable for UAA and AA quantification? |
|---|---|---|
| | free composites of surface reflectance at 10 – 20 m resolution; 2) monthly dynamic cropland masks, delivered from the agricultural mid-season onwards; 3) cultivated crop type maps at 10 m resolution for main crop groups, delivered twice along agricultural seasons; 4) periodic vegetation status maps, NDVI and LAI, describing the vegetative development of crops each time a cloud-free observation is recorded. The Sen2-Agri system is free and open source | assess what happens within the land and where it is located. |

# 9 ANNEX II ACTUAL UAA IN EU COUNTRIES AND CHANGES IN TIME BASED ON FSS AND FAO DATA SOURCES

Table 9.1 UAA (Km2) 2005-2016 for EU28 Member States

| | 2005 | 2007 | 2010 | 2013 | 2016 | % change in UAA since 2005 | % change in AA since 2005 | % change in farm area since 2005 |
|---|---|---|---|---|---|---|---|---|
| Belgium | 1,386 | 1,374 | 1,358 | 1,308 | 1,354 | -2% | 1% | 0% |
| Bulgaria | 2,729 | 3,051 | 4,476 | 4,651 | 4,492 | 65% | 57% | 23% |
| Czechia | 3,558 | 3,518 | 3,484 | 3,491 | 3,455 | -3% | -3% | -5% |
| Denmark | 2,708 | 2,663 | 2,647 | 2,619 | 2,615 | -3% | -1% | 0% |
| Germany | 17,035 | 16,932 | 16,704 | 16,700 | 16,715 | -2% | -3% | -2% |
| Estonia | 829 | 907 | 941 | 958 | 995 | 20% | 13% | 6% |
| Ireland | 4,219 | 4,139 | 4,991 | 4,959 | 4,884 | 16% | 15% | 14% |
| Greece | 3,984 | 4,076 | 5,178 | 4,857 | 4,554 | 14% | 12% | 11% |
| Spain | 24,855 | 24,893 | 23,753 | 23,300 | 23,230 | -7% | -11% | -9% |
| France | 27,591 | 27,477 | 27,837 | 27,739 | 27,814 | 1% | 0% | 0% |
| Croatia* | | 979 | 1,316 | 1,571 | 1,563 | 60% | 49% | 41% |
| Italy | 12,708 | 12,744 | 12,856 | 12,099 | 12,598 | -1% | -1% | -7% |
| Cyprus | 152 | 146 | 118 | 109 | 112 | -26% | -32% | -32% |
| Latvia | 1,702 | 1,774 | 1,796 | 1,878 | 1,931 | 13% | 1% | 1% |
| Lithuania | 2,792 | 2,649 | 2,743 | 2,861 | 2,925 | 5% | 3% | 2% |
| Luxembourg | 129 | 131 | 131 | 131 | 131 | 1% | 1% | 0% |
| Hungary | 4,267 | 4,229 | 4,686 | 4,657 | 4,671 | 9% | 4% | 1% |
| Malta | 10 | 10 | 11 | 11 | 11 | 9% | 4% | 3% |
| Netherlands | 1,958 | 1,914 | 1,872 | 1,848 | 1,796 | -8% | -2% | -4% |
| Austria | 3,266 | 3,189 | 2,878 | 2,727 | 2,670 | -18% | -17% | -19% |
| Poland | 14,755 | 15,477 | 14,447 | 14,410 | 14,406 | -2% | -6% | -7% |
| Portugal | 3,680 | 3,473 | 3,668 | 3,642 | 3,642 | -1% | -3% | -2% |
| Romania | 13,907 | 13,753 | 13,306 | 13,056 | 12,503 | -10% | -11% | -10% |
| Slovenia | 485 | 489 | 483 | 486 | 488 | 1% | -5% | -2% |
| Slovakia | 1,879 | 1,937 | 1,896 | 1,902 | 1,890 | 1% | -1% | -1% |
| Finland | 2,264 | 2,292 | 2,291 | 2,258 | 2,194 | -3% | -11% | -14% |
| Sweden | 3,192 | 3,118 | 3,066 | 3,036 | 3,021 | -5% | -11% | -11% |
| United Kingdom | 15,957 | 16,043 | 16,882 | 17,096 | 16,394 | 3% | 7% | 12% |
| EU 28 | 171,996 | 173,376 | 175,815 | 174,358 | 173,052 | 1% | -1% | -2% |

*% change calculated for 2007-2016

Table 9.2 Permanent grassland and rough grazing (Km2) registered in FSS for 2005, 2013 and 2016 for EU28 Member States

| | Permanent grassland | | | Rough grazing | | |
|---|---|---|---|---|---|---|
| GEO/TIME | 2005 | 2013 | 2016 | 2005 | 2013 | 2016 |
| **Belgium** | 519 | 483 | 473 | 0 | 1 | 2 |
| **Bulgaria** | 74 | 571 | 594 | 33 | 632 | 507 |
| **Czechia** | 864 | 932 | 695 | 11 | 23 | 241 |
| **Denmark** | 193 | 103 | 149 | 5 | 29 | 36 |
| **Germany** | 4,773 | 4,411 | 4,506 | 156 | 191 | 171 |
| **Estonia** | 237 | 216 | 267 | 0 | 0 | 0 |
| **Ireland** | 2,614 | 3,042 | 3,979 | 451 | 873 | 444 |
| **Greece** | 278 | 216 | 118 | 546 | 1,879 | 1,734 |
| **Spain** | 2,801 | 2,981 | 2,868 | 5,852 | 4,675 | 4,458 |
| **France** | 6,830 | 6,434 | 6,842 | 1,301 | 1,808 | 1,554 |
| **Croatia** | | 167 | 146 | | 451 | 460 |
| **Italy** | 2,642 | 2,163 | 2,150 | 705 | 1,125 | 1,022 |
| **Cyprus** | 0 | 1 | 0 | 0 | 1 | 1 |
| **Latvia** | 104 | 173 | 147 | 495 | 399 | 424 |
| **Lithuania** | 891 | 488 | 568 | 0 | 12 | 17 |
| **Luxembourg** | 68 | 67 | 67 | 0 | 0 | 0 |
| **Hungary** | 260 | 49 | 26 | 208 | 654 | 641 |
| **Malta** | 0 | 0 | 0 | 0 | 0 | 0 |
| **Netherlands** | 775 | 722 | 691 | 33 | 51 | 39 |
| **Austria** | 947 | 858 | 836 | 841 | 435 | 416 |
| **Poland** | 2,176 | 2,967 | 2,908 | 844 | 31 | 62 |
| **Portugal** | 515 | 536 | 486 | 1,253 | 1,269 | 1,363 |
| **Romania** | 4,223 | 3,730 | 3,725 | 307 | 256 | 265 |
| **Slovenia** | 236 | 221 | 227 | 46 | 64 | 58 |
| **Slovakia** | 485 | 453 | 466 | 45 | 46 | 44 |
| **Finland** | 12 | 10 | 9 | 14 | 21 | 16 |
| **Sweden** | 464 | 400 | 404 | 46 | 48 | 48 |
| **United Kingdom** | 5,591 | 5,849 | 6,002 | 4,218 | 4,871 | 4,246 |

Table 9.3 Relative change in the area 2005-2016 in UAA, AA, Farmland, arable, permanent grassland and permanent crops. *Source: FSS data*

| GEO/TIME | Farm area | AA | UAA | Arable land | Permanent grassland | Permanent crops |
|---|---|---|---|---|---|---|
| Belgium | 0% | 1% | -2% | 1% | -8% | -3% |
| Bulgaria | 23% | 57% | 65% | 30% | 970% | 24% |
| Czechia | -5% | -3% | -3% | -6% | 8% | -6% |
| Denmark | 0% | -1% | -3% | -6% | 14% | 193% |
| Germany | -2% | -3% | -2% | -1% | -5% | 2% |
| Estonia | 6% | 13% | 20% | 17% | 28% | 18% |
| Ireland | 14% | 15% | 16% | -60% | 44% | -7% |
| Greece | 11% | 12% | 14% | -14% | 126% | -15% |
| Spain | -9% | -11% | -7% | -4% | -12% | -3% |
| France | | 0% | 1% | 0% | 6% | -13% |
| Croatia | 41% | 49% | 60% | 18% | 240% | 37% |
| Italy | -7% | -1% | -1% | 1% | -3% | -4% |
| Cyprus | -32% | -32% | -26% | -24% | 214% | -36% |
| Latvia | 1% | 1% | 13% | 19% | 6% | -70% |
| Lithuania | 2% | 3% | 5% | 14% | -14% | -10% |
| Luxembourg | 0% | 1% | 1% | 3% | -1% | -1% |
| Hungary | 1% | 4% | 9% | 6% | 47% | -10% |
| Malta | 3% | 4% | 9% | 11% | 0% | 20% |
| Netherlands | -4% | -2% | -8% | -8% | -10% | 18% |
| Austria | -19% | -17% | -18% | -4% | -30% | -2% |
| Poland | -7% | -6% | -2% | -4% | 5% | 19% |
| Portugal | -2% | -3% | -1% | -16% | 6% | 9% |
| Romania | -10% | -11% | -10% | -12% | -6% | -11% |
| Slovenia | -2% | -5% | 1% | 1% | 1% | -2% |
| Slovakia | -1% | -1% | 1% | 2% | -1% | -30% |
| Finland | -14% | -11% | -3% | -3% | 0% | -23% |
| Sweden | -11% | -11% | -5% | -4% | -11% | 3% |
| United Kingdom | 12% | 7% | 3% | -1% | 5% | 11% |
| EU 28 | **-2%** | **-1%** | **1%** | **-2%** | **6%** | **-3%** |

Table 9.4 UAA and NUAA in 2005 and 2016

| Km2 | UAA - 2005 | NUAA - 2005 | UAA - 2016 | NUAA - 2016 | % change UAA 2005-2016 | % change NUAA 2005-2016 |
|---|---|---|---|---|---|---|
| **BE - Belgium** | 1,386 | 25 | 1,354 | 7 | -2% | -70% |
| **BG - Bulgaria** | 2,729 | 160 | 4,492 | 16 | 65% | -90% |
| **CZ - Czechia** | 3,558 | 87 | 3,455 | 5 | -3% | -94% |
| **DK - Denmark** | 2,708 | 73 | 2,615 | 57 | -3% | -22% |
| **DE - Germany** | 17,035 | 417 | 16,715 | 26 | -2% | -94% |
| **EE - Estonia** | 829 | 97 | 995 | 4 | 20% | -96% |
| **IE - Ireland** | 4,219 | 158 | 4,884 | 52 | 16% | -67% |
| **EL - Greece** | 3,984 | 225 | 4,554 | 129 | 14% | -43% |
| **ES - Spain** | 24,855 | 3,404 | 23,230 | 221 | -7% | -94% |
| **FR - France** | 27,591 | 559 | 27,814 | 61 | 1% | -89% |
| **HR - Croatia** | 0 | 0 | 1,563 | 37 | | |
| **IT - Italy** | 12,708 | 1,325 | 12,598 | 454 | -1% | -66% |
| **CY - Cyprus** | 152 | 35 | 112 | 14 | -26% | -61% |
| **LV - Latvia** | 1,702 | 488 | 1,931 | 104 | 13% | -79% |
| **LT - Lithuania** | 2,792 | 131 | 2,925 | 22 | 5% | -83% |
| **LU - Luxembourg** | 129 | 1 | 131 | 0 | 1% | -70% |
| **HU - Hungary** | 4,267 | 480 | 4,671 | 53 | 9% | -89% |
| **MT - Malta** | 10 | 2 | 11 | 0 | 9% | -92% |
| **NL - Netherlands** | 1,958 | 42 | 1,796 | 1 | -8% | -97% |
| **AT - Austria** | 3,266 | 796 | 2,670 | 74 | -18% | -91% |
| **PL - Poland** | 14,755 | 1,584 | 14,406 | 138 | -2% | -91% |
| **PT - Portugal** | 3,680 | 249 | 3,642 | 98 | -1% | -60% |
| **RO - Romania** | 13,907 | 532 | 12,503 | 104 | -10% | -80% |
| **SI - Slovenia** | 485 | 59 | 488 | 15 | 1% | -75% |
| **SK - Slovakia** | 1,879 | 75 | 1,890 | 16 | 1% | -78% |
| **FI - Finland** | 2,264 | 940 | 2,194 | 0 | -3% | -100% |
| **SE - Sweden** | 3,192 | 211 | 3,021 | 0 | -5% | -100% |
| **UK - United Kingdom** | 15,957 | 329 | 16,394 | 743 | 3% | 126% |

Table 9.5 Development of UAA 1975-1990, 1991-2005, 2005-2016 & 1975-2016

| | 1975-1977 | 1990 | % change 1975-1990 | 1991 | 2005 | % change 1991-2005 | 2005 | 2016 | % change 2005-2016 | 1975/ 1990**** | 2016 | % change 1975/ 1990**** - 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Belgium** | 1,517 | 1,379 | -9% | 1,379 | 1,386 | 0% | 1,386 | 1,354 | -2% | 1,517 | 1,354 | -11% |
| **Bulgaria*** | 5,955 | 6,159 | 3% | 6,159 | 2,729 | -56% | 2,729 | 4,469 | 64% | 5,955 | 4,469 | -25% |
| **Czechia**** | 4,479 | 4,287 | -4% | 4,287 | 3,558 | -17% | 3,558 | 3,455 | -3% | 4,479 | 3,455 | -23% |
| **Denmark** | 2,933 | 2,787 | -5% | 2,787 | 2,708 | -3% | 2,708 | 2,615 | -3% | 2,933 | 2,615 | -11% |
| **Germany** | 18,794 | 17,503 | -7% | 17,503 | 17,035 | -3% | 17,035 | 16,715 | -2% | 13,268 | 16,715 | -11% |
| **Estonia****** | | 1,366 | | 1,366 | 829 | -39% | 829 | 995 | 20% | 1,366 | 995 | -27% |
| **Ireland** | 5,722 | 4,490 | -22% | 4,490 | 4,219 | -6% | 4,219 | 4,884 | 16% | 5,722 | 4,884 | -15% |
| **Greece** | 5,683 | 5,175 | -9% | 5,175 | 3,984 | -23% | 3,984 | 4,554 | 14% | 5,683 | 4,554 | -20% |
| **Spain** | 31,855 | 30,340 | -5% | 30,340 | 24,855 | -18% | 24,855 | 23,230 | -7% | 31,855 | 23,230 | -27% |
| **France** | 32,308 | 30,432 | -6% | 30,432 | 27,591 | -9% | 27,591 | 27,814 | 1% | 32,308 | 27,814 | -14% |
| **Croatia***** | 2,231 | 2,404 | 8% | 2,404 | 979 | -59% | 979 | 1,563 | 60% | 2,231 | 1,563 | -30% |
| **Italy** | 17,804 | 17,868 | 0% | 17,868 | 12,708 | -29% | 12,708 | 12,598 | -1% | 17,804 | 12,598 | -29% |
| **Cyprus*** | 180 | 141 | -22% | 141 | 152 | 7% | 152 | 112 | -26% | 180 | 112 | -38% |
| **Latvia****** | | 2,531 | | 2,531 | 1,702 | -33% | 1,702 | 1,931 | 13% | 2,531 | 1,931 | -24% |
| **Lithuania****** | | 3,513 | | 3,513 | 2,792 | -21% | 2,792 | 2,925 | 5% | 3,513 | 2,925 | -17% |
| **Luxembourg** | 132 | 126 | -4% | 126 | 129 | 2% | 129 | 131 | 1% | 132 | 131 | -1% |
| **Hungary*** | 6,770 | 6,466 | -4% | 6,466 | 4,267 | -34% | 4,267 | 4,671 | 9% | 6,770 | 4,671 | -31% |
| **Malta** | 13 | 11 | -15% | 11 | 10 | -7% | 10 | 11 | 8% | 13 | 11 | -14% |
| **Netherlands** | 2,084 | 1,995 | -4% | 1,995 | 1,958 | -2% | 1,958 | 1,796 | -8% | 2,084 | 1,796 | -14% |
| **Austria*** | 3,189 | 3,468 | 9% | 3,468 | 3,266 | -6% | 3,266 | 2,670 | -18% | 3,189 | 2,670 | -16% |
| **Poland*** | 19,224 | 18,623 | -3% | 19,197 | 14,755 | -23% | 14,755 | 14,406 | -2% | 19,224 | 14,406 | -25% |
| **Portugal*** | 3,956 | 4,070 | 3% | 4,070 | 3,680 | -10% | 3,680 | 3,642 | -1% | 3,956 | 3,642 | -8% |

| | 1975-1977 | 1990 | % change 1975-1990 | 1991 | 2005 | % change 1991-2005 | 2005 | 2016 | % change 2005-2016 | 1975/ 1990**** | 2016 | % change 1975/ 1990**** - 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Romania*** | 14,946 | 14,786 | -1% | 14,786 | 13,907 | -6% | 13,907 | 12,503 | -10% | 14,946 | 12,503 | -16% |
| **Slovenia***** | 891 | 842 | -5% | 842 | 485 | -42% | 485 | 488 | 1% | 891 | 488 | -45% |
| **Slovakia**** | 2,912 | 2,417 | -17% | 2,417 | 1,879 | -22% | 1,879 | 1,890 | 1% | 2,912 | 1,890 | -35% |
| **Finland*** | 2,614 | 2,549 | -2% | 2,549 | 2,299 | -10% | 2,299 | 2,233 | -3% | 2,614 | 2,233 | -15% |
| **Sweden*** | 3,726 | 3,387 | -9% | 3,387 | 3,192 | -6% | 3,192 | 3,013 | -6% | 3,726 | 3,013 | -19% |
| **United Kingdom** | 18,944 | 16,963 | -10% | 16,963 | 15,957 | -6% | 15,957 | 16,673 | 4% | 18,944 | 16,673 | -12% |

*Data used from FAOSTAT for 1975 and rest of years derived from Eurostat

**Data used from FAOSTAT from Former Czechoslovakia for 1975. Distribution over Czechia and Slovakia according to agricultural land use share in 1990

*** Data used for FAOSTAT from former Yuguslavia for 1975. Distribution over Croatia and Slovenia according to agricultural land use share in 1990 of the 6 countries in which it was split.

**** No data available for 1975 in FAOSTAT. Change in last column calculated for the period 1990-2016 instead of 1975-2016 as assessed for all other countries

Data source: Eurostat FSS data 1975-2016. If data missing FAOSTAT data were used

# 10 ANNEX III LAND COVER FLOW ANALYSIS CHANGE (LEAC) TO DETECT SIGNS OF LAND ABANDONMENT IN EU REGIONS

To understand from existing data sources what type of land cover changes are behind the declines in UAA a land cover flow analysis was done. This was done by comparing the CLC data layers at 100*100 m resolution from 2000 and 2018. We selected and grouped conversions from agricultural land to other land cover types using the classification of land cover flows (lcf) (conversions from one land cover type into another over a given period) according to the Land and Ecosystem Accounting system of the EEA (LEAC)[84] (Table 10.1).

Table 10.1 Grouped conversions from agricultural land based on the LEAC system used to detect changes between 2000 and 2018

| Grouped LEC conversions | LEAC conversions |
|---|---|
| **Internal conversion within agriculture** | • lcf41 Extension of set aside fallow land and pasture (Figure 10.2)<br>• lcf45 Conversion from arable land to permanent crops<br>• lcf46 Conversion from pasture to arable and permanent crops |
| **Sign of shift to agricultural land abandonment (Figure 10.1)** | • lcf61 Withdrawal of farming with significant woodland creation<br>• lcf62 Withdrawal of farming without significant woodland creation |
| **Loss agricultural area to Urbanisation (Figure 10.3)** | • lcf13 Development of green urban areas<br>• lcf22 Urban diffuse residential sprawl<br>• lcf31 Sprawl of industrial & commercial sites<br>• lcf32 Sprawl of transport networks<br>• lcf33 Sprawl of harbours<br>• lcf34 Sprawl of airports<br>• lcf35 Sprawl of mines and quarrying areas<br>• lcf36 Sprawl of dumpsites<br>• lcf37 Construction<br>• lcf38 Sprawl of sport and leisure facilities |
| **Longer term abandonment and afforestation (Figure 10.4)** | • lcf61 Withdrawal of farming with significant woodland creation |

A summary of the relative LEAC conversions from agricultural land per EU country is also presented in Table 10.2 in which LEAC conversions are also expressed in percentage of total AA in 2000.

Only 'Shift to agricultural land abandonment' in Table 10.1 and mapped in Figure 10.1 is considered 'real' agricultural land abandonment here. From the map in Figure 10.1 we conclude that this

[84] https://www.eea.europa.eu/data-and-maps/dashboards/land-cover-and-change-statistics

conversion is relatively large in the all regions on the Iberian Peninsula, Scotland, Wales, Southern England, Northwestern Ireland, Many regions in Germany, all regions in Finland, Estonia, Lavia, Centru in Romania, Southern provinces of Bulgaria (Sofia & Plovdiv).

To understand whether this process also involves a process towards more 'rewilding' a split is also made in shifts to agricultural land with (lcf61) and without forest formation (lcf62). From Table 10.2 it becomes clear that on average of EU-28 abandonment with and without forest formation occurs in more or less the same share. However, in some countries abandonment with forest formation indicating more to long term abandonment occurs, like e.g. in Finland, Lithuania, Latvia, Portugal takes place. While in other countries abandonment without forest formation is more seen such as in Austria, Bulgaria, Cyprus, Spain, Ireland, and UK.

Abandonment within and outside N2000 areas in Table 10.2. Overall in most EU countries the majority of this type of abandonment takes place outside N2000 (80% on average EU28).

The other classes of land cover flows in Table 10.1 are not considered signs of land abandonment, either because the destination land cover type is a form of agricultural land use (Internal conversions within agriculture), or because the conversion leads to urbanisation built-up land. The urbanisation of agricultural land has also been mapped in Figure 10.2.

The lcf41 involves an internal agricultural land use flow in which cropping land moves to a more extensive class which can be fallow, set-aside or pasture. This is indeed not an abandonment of the agricultural land, but could be considered as first signs of a process towards abandonment or hidden abandonment. This category has therefore been mapped in Figure 10.2 and shows largest concentrations of this process in Germany, UK, Estonia and Latvia.

The conversions to urban are mapped in Figure 10.3. It shows that overall the urbanisation of agricultural land is small in total agricultural conversions, it took place in 2% of the agricultural area. This urbanisation of agricultural land has been most strong in The Netherlands, Valencia, Murcia, Basque region, and around several of the larger cities. At national level these conversions are very small in absolute and relative terms, certainly compared to the conversions to abandonment and the internal conversions. However, at regional level these can be quite large, certainly around the big cities and in coastal regions.

The largest total conversions of agricultural land to abandonment between 2000 and 2018 were seen in Spain, Finland, Estonia, Latvia, Portugal, Austria, Ireland, UK and Romania. Largest conversions within agricultural lands towards more extensive land uses, such as set-aside, pasture and fallow, in Germany, Estonia, Ireland, Lithuania, Luxembourg, Latvia, Portugal, Romania and UK.

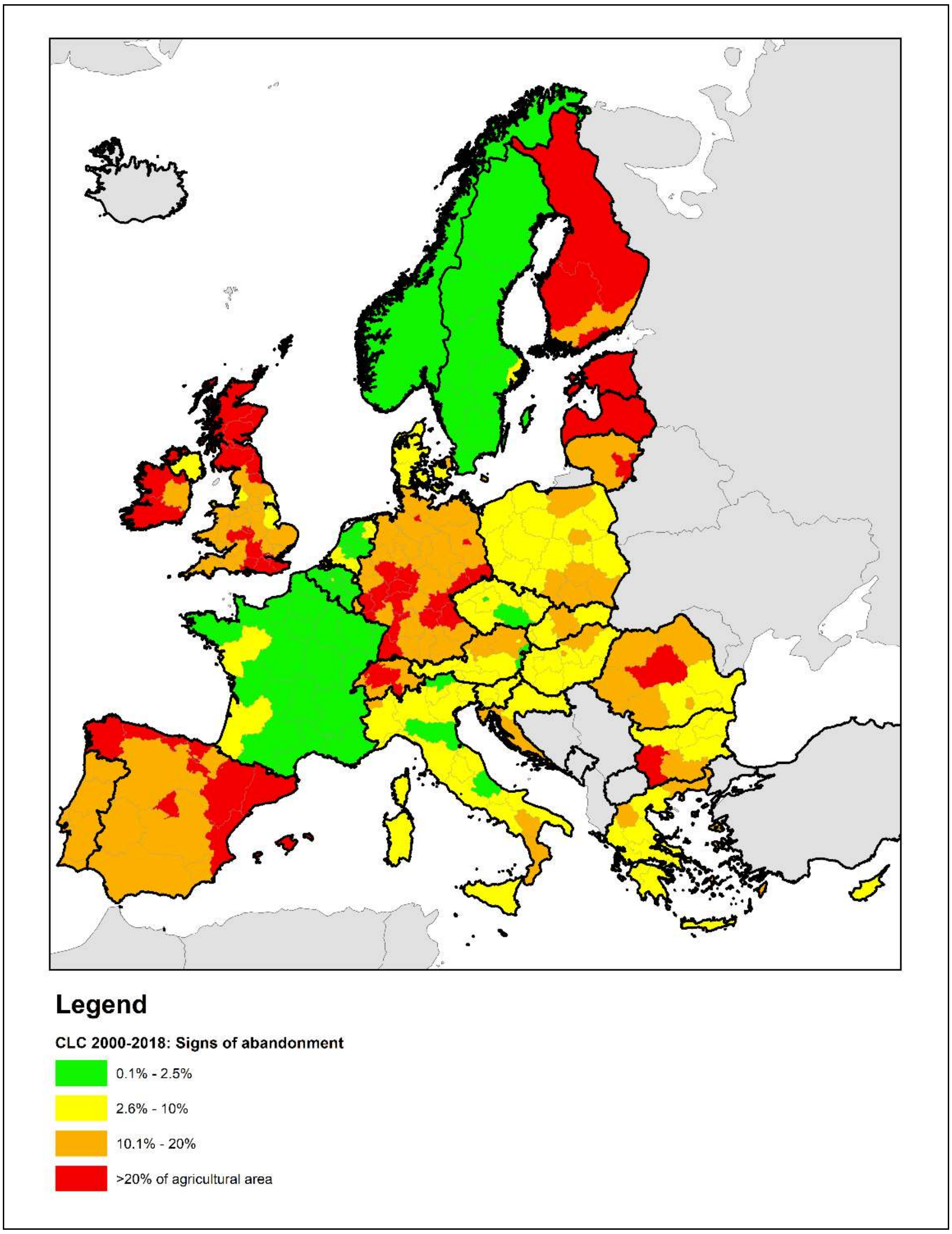



Figure 10.1 Land conversions with signs of shifts to land abandonment with reference to agricultural area in 2000 (lcf61 & lcf62). Data source: CLC 2000 and CLC 2018.

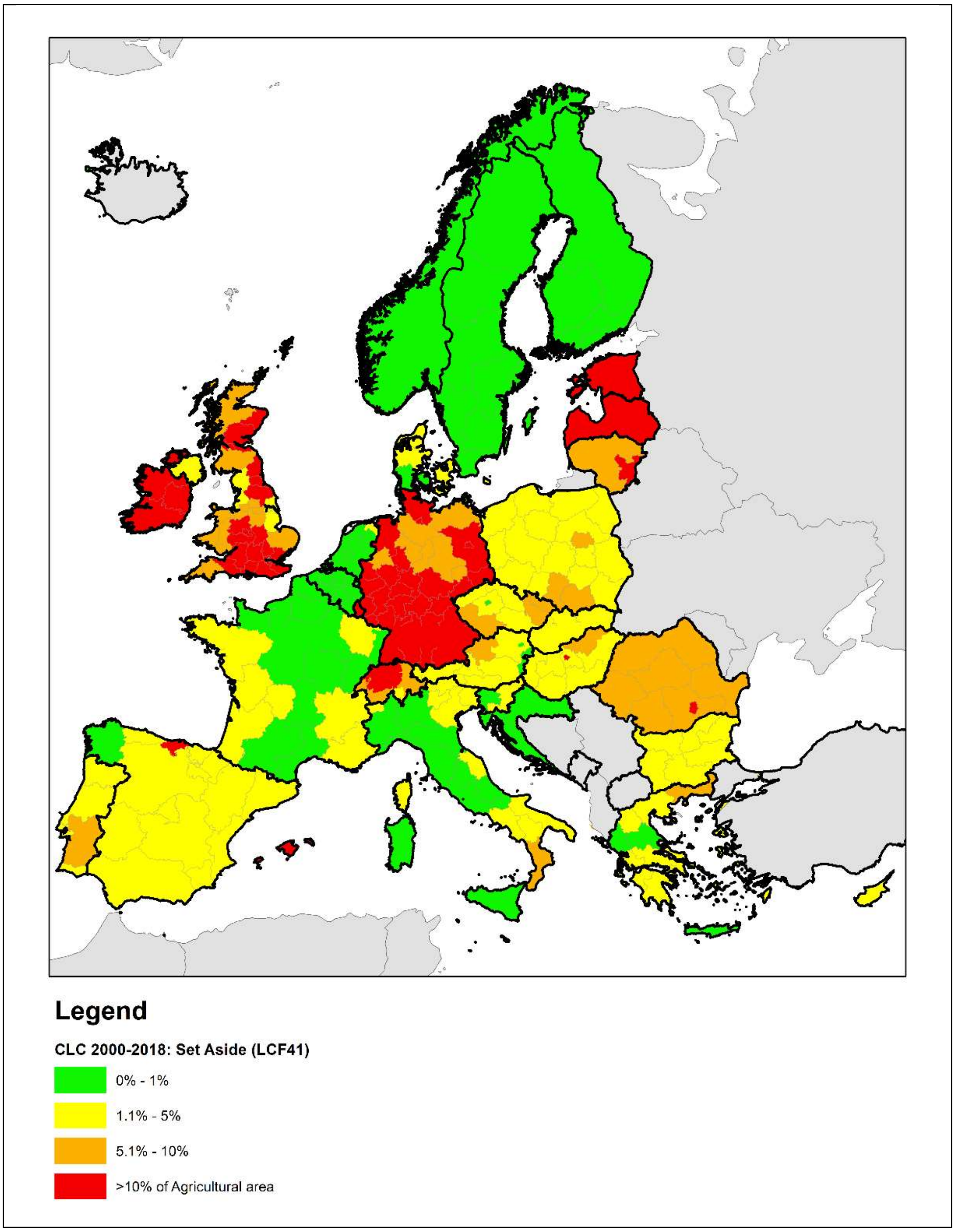



Figure 10.2 Land conversions from cropping to set-aside, fallow and pasture (lcf41) 2000-2018 with reference to agricultural area in 2000. Data source: CLC 2000 and CLC 2018

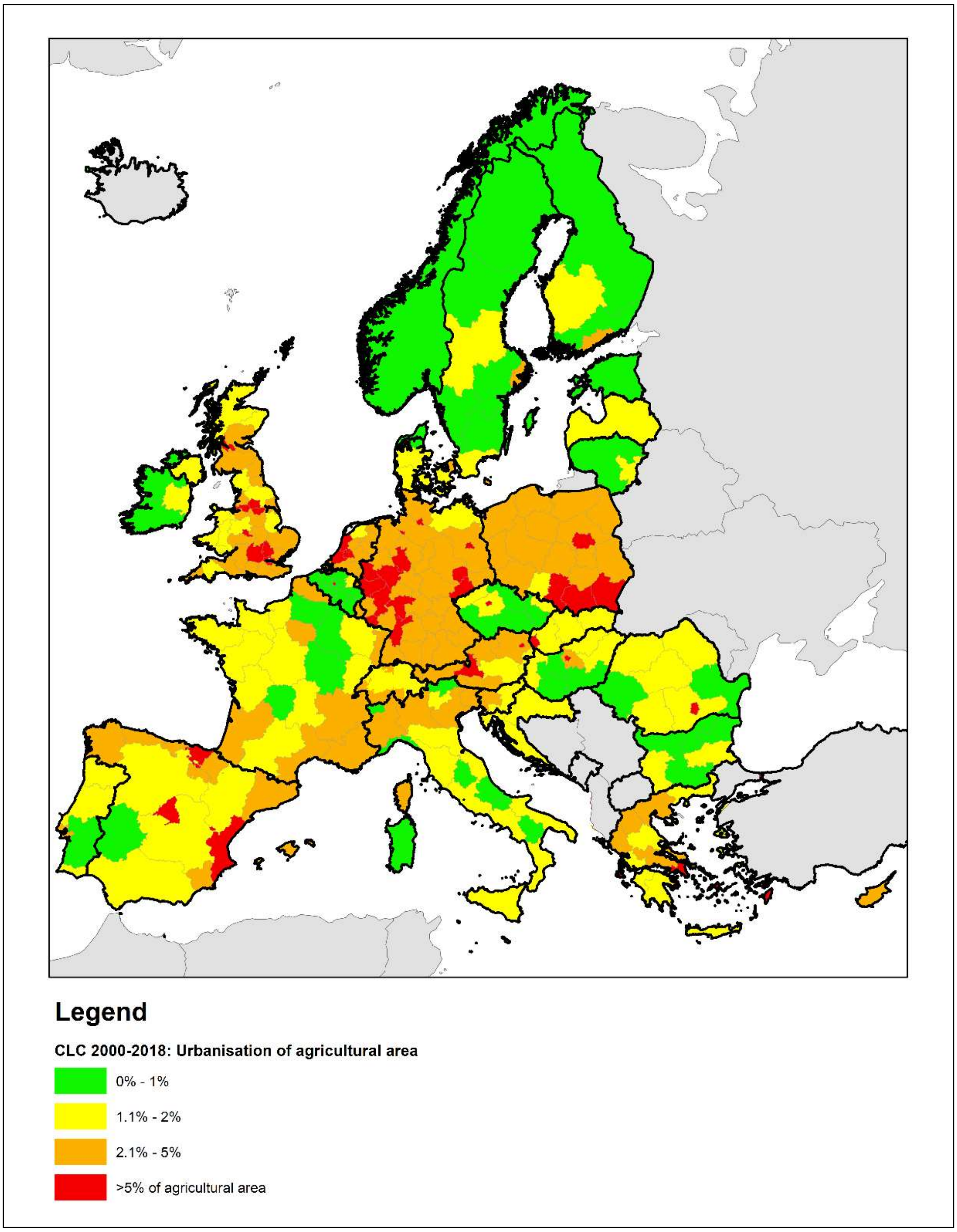



Figure 10.3 Land conversions from agricultural to urban 2000-2018 with reference to agricultural area in 2000. Data source: CLC 2000 and CLC 2018

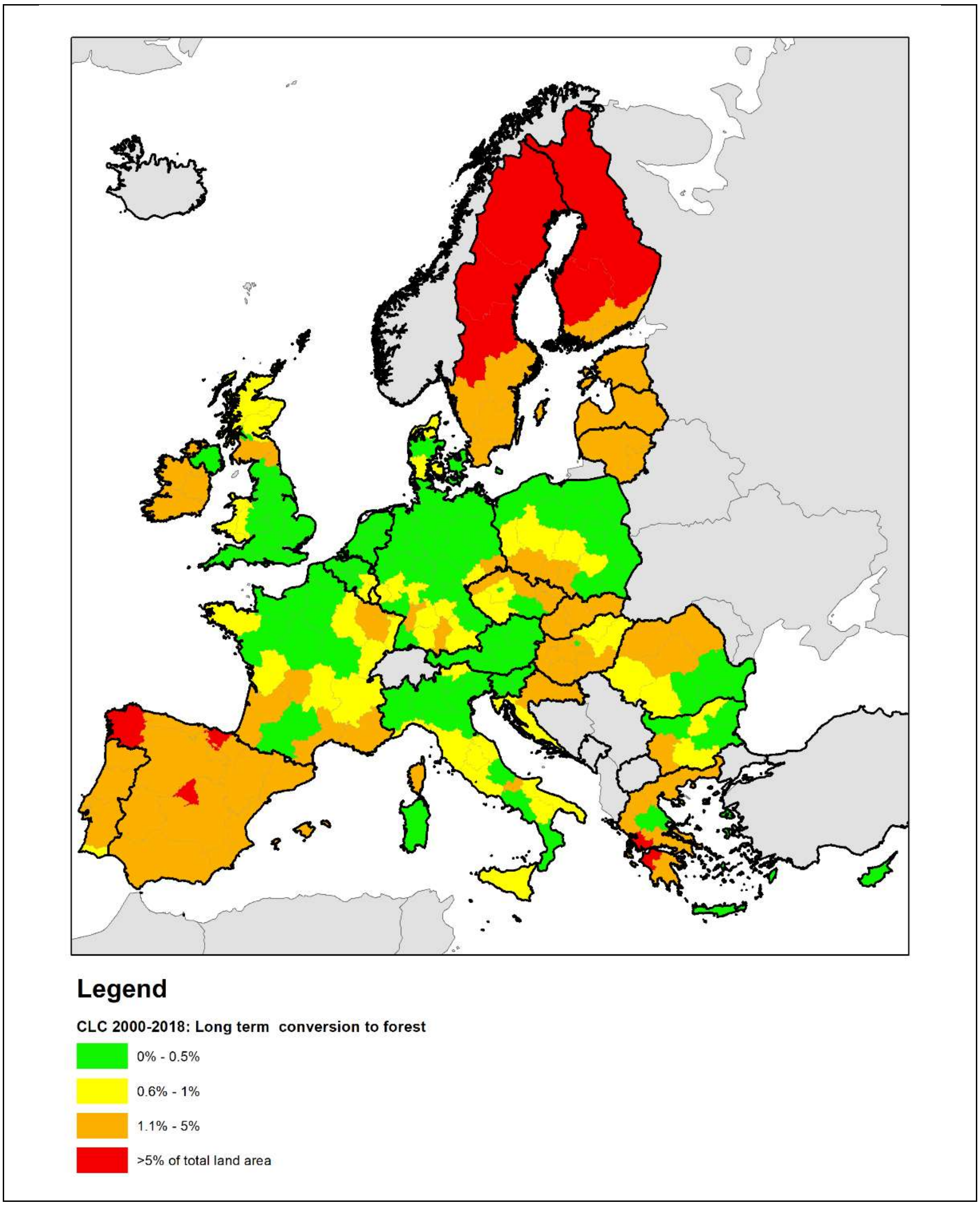



Figure 10.4 Land conversions from agricultural to forest (lcf 61 Abandonment of agriculture with forest formation) 2000-2018 with reference to agricultural area in 2000. Data source: CLC 2000 and CLC 2018

Table 10.2 Overview of relative landcover flows per EU country 2000-2018 with reference to agricultural area in 2000. Data source: CLC 2000 and CLC 2018

| Country | Agricultural Area (AA) 2000 (km2) | Extension of set-aside-fallow and pasture land (lcf41) 2000-2018 (% of AA) | Sign of shift to abandonment (lcf62) 2000-2018 (% of AA) | Sign of shift to abandonment (lcf62) in N2000 2000-2018 (% of AA) | Sign of shift to abandonment (lcf62) NO N2000 2000-2018 (% of AA) | Loss agricultural area to Urbanisation 2000-2018 (% of AA) | Longer term abandonment (Forest formation (lcf61) 2000-2018 (% of AA) | Total |
|---|---|---|---|---|---|---|---|---|
| Austria | 27,224 | 4.25% | 8.1% | 0.6% | 3.7% | 2.94% | 1.78% | 12.7% |
| Belgium | 17,617 | 0.16% | 0.5% | 0.0% | 0.1% | 0.77% | 0.16% | 1.2% |
| Bulgaria | 57,341 | 3.59% | 6.6% | 1.0% | 2.5% | 0.78% | 2.07% | 8.5% |
| Cyprus | 4,463 | 3.13% | 6.6% | 0.2% | 2.9% | 3.67% | 0.58% | 9.0% |
| Czechia | 45,244 | 0.39% | 6.9% | 0.0% | 0.4% | 0.88% | 0.35% | 5.7% |
| Germany | 214,012 | 0.59% | 0.9% | 0.3% | 0.3% | 3.47% | 3.93% | 20.1% |
| Denmark | 33,078 | 2.67% | 4.9% | 0.1% | 2.5% | 1.42% | 1.90% | 7.7% |
| Estonia | 14,753 | 2.87% | 8.3% | 0.2% | 2.7% | 0.83% | 3.90% | 20.8% |
| Greece | 52,742 | 3.00% | 45.0% | 0.5% | 2.5% | 2.51% | 1.85% | 9.8% |
| Spain | 254,281 | 9.50% | 1.0% | 1.9% | 7.5% | 1.83% | 6.02% | 20.1% |
| Finland | 29,351 | 7.24% | 5.8% | 0.1% | 7.2% | 0.96% | 13.59% | 21.8% |
| France | 329,073 | 0.31% | 9.0% | 0.1% | 0.3% | 1.68% | 0.38% | 3.2% |
| Croatia | 22,817 | 1.92% | 4.9% | 1.0% | 0.9% | 1.40% | 2.20% | 6.3% |
| Hungary | 62,864 | 1.29% | 9.2% | 0.3% | 1.0% | 0.96% | 3.26% | 8.0% |
| Ireland | 47,225 | 5.07% | 4.5% | 0.7% | 4.4% | 0.87% | 2.37% | 20.8% |
| Italy | 157,604 | 2.39% | 17.1% | 0.6% | 1.8% | 1.48% | 0.93% | 6.7% |
| Lithuania | 39,915 | 2.40% | 7.7% | 0.2% | 2.2% | 0.80% | 4.57% | 14.9% |
| Luxembourg | 1,424 | 2.04% | 5.6% | 0.5% | 1.5% | 3.31% | 2.96% | 19.6% |
| Latvia | 28,330 | 2.76% | 2.2% | 0.3% | 2.5% | 1.56% | 11.71% | 25.3% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Malta | 162 | 2.17% | 2.7% | 0.5% | 1.7% | 0.67% | 0.00% | 3.2% |
| Netherlands | 25,156 | 1.86% | 0.6% | 0.5% | 1.4% | 3.44% | 0.47% | 6.2% |
| Poland | 196,481 | 1.80% | 5.9% | 0.3% | 1.5% | 3.62% | 3.47% | 11.7% |
| Portugal | 43,939 | 4.31% | 13.4% | 0.9% | 3.4% | 1.02% | 5.12% | 16.5% |
| Romania | 134,952 | 4.94% | 8.3% | 1.2% | 3.7% | 1.20% | 2.63% | 15.5% |
| Sweden | 39,449 | 0.39% | 0.0% | 0.1% | 0.3% | 0.84% | 0.50% | 1.8% |
| Slovenia | 7,074 | 2.28% | 6.2% | 0.8% | 1.5% | 2.00% | 2.76% | 8.1% |
| Slovakia | 23,750 | 2.83% | 6.3% | 0.5% | 2.3% | 1.74% | 2.90% | 9.6% |
| United Kingdom | 143,135 | 4.06% | 23.3% | 0.5% | 3.6% | 2.65% | 2.67% | 19.2% |
| Grand Total | **2,053,460** | **3.10%** | **8.1%** | **0.6%** | **2.5%** | **2.00%** | **2.97%** | **12.5%** |

# 11 ANNEX IV COUNTRY FACT SHEETS ON ACTUAL UAA FROM EUROSTAT-FSS AND NATIONAL SOURCES COMPARED

National statistical offices or Ministries of Agriculture are usually in charge of reporting the agricultural land use data to Eurostat for FSS according to the uniform guidelines for EU countries. The data are collected and are based on census and sample data. Since the data collected at national or regional level are the source of Eurostat and national statistical data publications it is interesting to compare the totals reported for UAA by Eurostat and national statistical data sources (Table 11.1).

Table 11.1 UAA ($km^2$) reported in Eurostat-FSS and national data sources and relative differences for UAA data published by Eurostat and national sources

| Country | Data source | 2010 | 2013 | 2016 | % difference 2010 | % difference 2013 | % difference 2016 |
|---|---|---|---|---|---|---|---|
| Austria | Eurostat | 28,782 | 27,269 | 26,698 | -0.06% | -0.06% | -0.05% |
| Austria | STATcube | 28,799 | 27,286 | 26,712 | | | |
| Belgium | Eurostat | 13,580 | 13,079 | 13,543 | 0.17% | -2.19% | 0.25% |
| Belgium | STATBEL | 13,558 | 13,366 | 13,508 | | | |
| Bulgaria | Eurostat | 44,755 | 46,509 | 44,919 | | -7.40% | -11.79% |
| Bulgaria | NSI | - | 49,951 | 50,214 | | | |
| Germany | Eurostat | 167,040 | 166,996 | 167,153 | 0.00% | 0.00% | 0.34% |
| Germany | BMEL | 167,040 | 166,996 | 166,589 | | | |
| Spain | Eurostat | 237,527 | 233,002 | 232,297 | -0.49% | -0.96% | -0.98% |
| Spain | MAPA | 238,687 | 235,230 | 234,566 | | | |
| Finland | Eurostat | 22,910 | 22,576 | 21,942 | 1.29% | -0.05% | -3.66% |
| Finland | Luke | 22,615 | 22,587 | 22,745 | | | |
| France | Eurostat | 278,373 | 277,394 | 278,142 | -4.52% | -4.34% | -3.91% |
| France | Agreste | 290,957 | 289,438 | 289,015 | | | |
| Croatia | Eurostat | 13,160 | 15,712 | 15,630 | -4.14% | -1.79% | -0.54% |
| Croatia | CBS | 13,705 | 15,994 | 15,714 | | | |
| Italy | Eurostat | 128,561 | 120,989 | 125,982 | | -2.70% | 0.00% |
| Italy | I.Stat | - | 124,260 | 125,982 | | | |
| Latvia | Eurostat | 17,963 | 18,777 | 19,309 | -1.09% | 0.28% | -0.07% |
| Latvia | CSB Database | 18,159 | 18,725 | 19,323 | | | |
| Netherlands | Eurostat | 18,724 | 18,476 | 17,963 | 0.00% | 0.00% | -1.09% |
| Netherlands | CBS-Statline | 18,723 | 18,476 | 18,159 | | | |
| Slovakia | Eurostat | 18,955 | 19,016 | 18,898 | -1.40% | -1.41% | -1.54% |
| Slovakia | DATACube | 19,220 | 19,285 | 19,189 | | | |
| UK | Eurostat | 168,817 | 170,962 | 163,938 | -2.09% | -0.95% | -5.90% |
| UK | DEFRA | 172,341 | 172,591 | 173,603 | | | |

Overall the differences in UAA area published by Eurostat and national data sources are very small. However, there are exceptions for certain countries and for specific years. The biggest differences between Eurostat and national levels are seen in Bulgaria, France and UK.

To understand how differences occur between national and Eurostat data sources we discuss some national and regional examples in higher detail in the next sections.

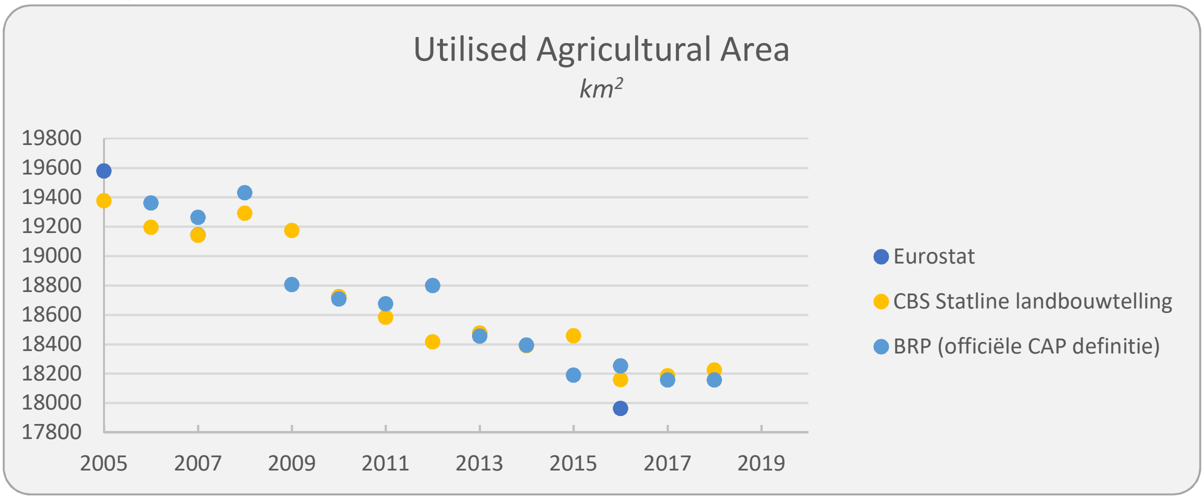
**Netherlands**

- UAA is reported in the 2 national data sources of CBS Statline and Dutch LPIS and can be compared to Eurostat-FSS statistics is presented.

- When looking at the absolute figures an average size for UAA can be calculated from the three statistical sources for the recent years 2015-2018. This average amounts to 17,963 km$^2$ for Eurostat and 18,308 for CBS Statline as the maximum. The Dutch LPIS average is in-between Eurostat and CBS Statline and amounts to 18,222 km$^2$.
- Differences in total UAA between the FSS and the 2 Dutch data sources are small.
- The total UAA consists of arable land, permanent grassland, permanent crops. Differences between FSS and the national data sources are relatively small for arable land, but larger for permanent grassland and even larger for permanent crops. The latter is related to a difference in definition between FSS and the CBS permanent crops.

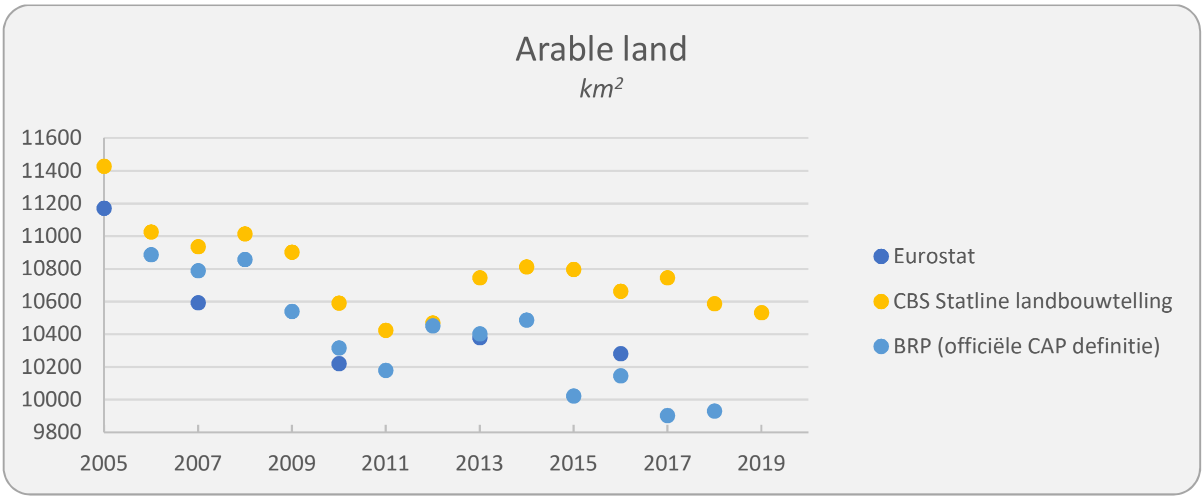
**Sources:**
Eurostat-FSS
CBS: https://www.cbs.nl/en-gb/economy/agriculture
Basis registratie percelen Nederland

**Utilised Agricultural Area (2005-2019) in Netherlands**



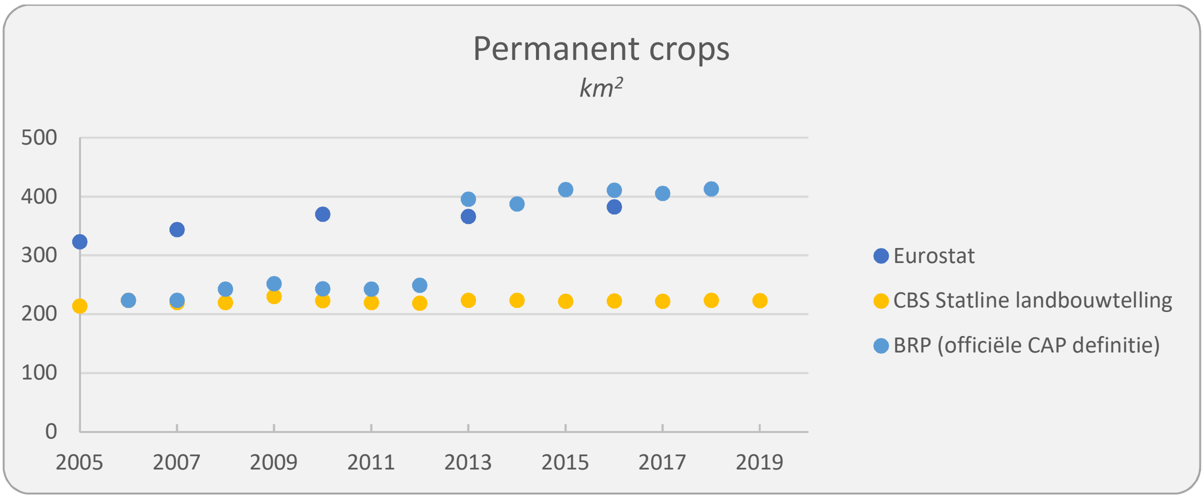

| year | Eurostat-FSS | CBS-Statline | BRP (NL-LPIS) | Difference % FSS-CBS | Difference % FSS - BRP |
|---|---|---|---|---|---|
| **2003** | 20,073 | 19457 | | 3.1% | .. |
| **2005** | 19581 | 19377 | | 1.0% | |
| **2007** | 19143 | 19143 | 19264 | 0.0% | -0.6% |
| **2013** | 18476 | 18476 | 18456 | 0.0% | 0.1% |
| **2016** | 17963 | 18159 | 18252 | -1.1% | -1.6% |

**Arable land (2005-2019) in Netherlands**



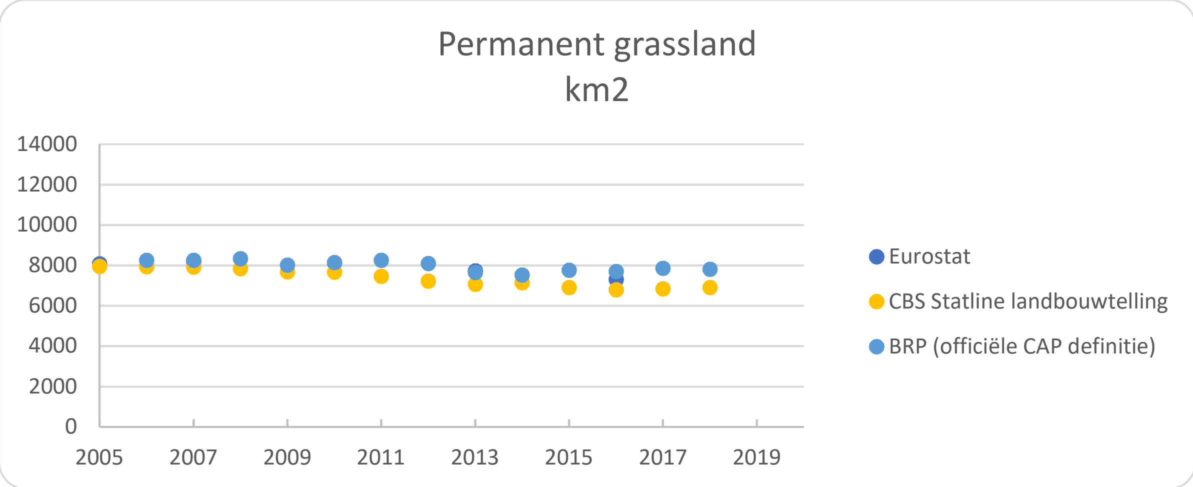

| year | Eurostat-FSS | CBS-Statline | BRP (NL-LPIS) | Difference % FSS-CBS | Difference % FSS - BRP |
|---|---|---|---|---|---|
| **2003** | 11,011 | 11288 | | -2.5% | .. |
| **2005** | 11170 | 11428 | | -2.3% | |
| **2007** | 10592 | 10936 | 10788 | -3.2% | -1.9% |
| **2013** | 10379 | 10745 | 10402 | -3.5% | -0.2% |
| **2016** | 10282 | 10664 | 10146 | -3.7% | 1.3% |

**Permanent crops (2005-2019) in Netherlands**




| year | Eurostat-FSS | CBS-Statline | BRP (NL-LPIS) | Difference % FSS-CBS | Difference % FSS - BRP |
|---|---|---|---|---|---|
| **2003** | 311 | 219 | | 29.6% | .. |
| **2005** | 323 | 214 | | 33.9% | |
| **2007** | 344 | 220 | 223 | 36.1% | 35.0% |
| **2013** | 366 | 224 | 395 | 39.0% | -7.9% |
| **2016** | 382 | 222 | 410 | 41.8% | -7.4% |

**Permanent grassland and meadows (2005-2019) in Netherlands**



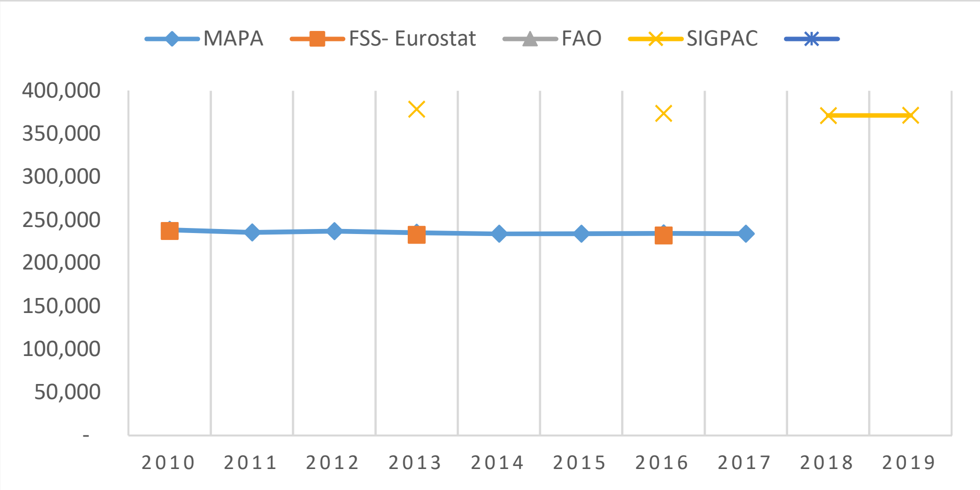

| year | Eurostat-FSS | CBS-Statline | BRP (NL-LPIS) | Difference % FSS-CBS | Difference % FSS - BRP |
|---|---|---|---|---|---|
| **2003** | 8,750 | 7567 | | 13.5% | .. |
| **2005** | 8087 | 7947 | | 1.7% | |
| **2007** | 8207 | 7916 | 8249 | 3.6% | -0.5% |
| **2013** | 7731 | 7058 | 7659 | 8.7% | 0.9% |
| **2016** | 7299 | 6803 | 7696 | 6.8% | -5.4% |

**Spain**

- UAA is reported in the 2 national data sources MAPA (Ministerio de Agricultura, Pesca i Alimentacion) and SIGPAC (Spanish LPIS) and can be compared to Eurostat-FSS statistics is presented.
- Absolute and relative differences for UAA between the FSS and MAPA data are small. The difference between FSS, MAPA and the SIGPAC are more large however.
- The total UAA consists of arable land, permanent grassland, permanent crops. Differences between FSS and the national data sources are very large for all categories. The latter is related to differences in definition between FSS and the subcategories of UAA.
- One large difference for between SIGPAC and FSS and MAPA is related to the definition change of permanent grassland in the CAP allowing for inclusion of areas with shrubs and trees in permanent grassland surface eligible for CAP payments. In the statistical sources, most of the grasslands with tree and shrub cover are registered as forest land, rather than as agricultural.
- Another large difference between what is registered as arable, permanent crop and permanent grassland may be related to the unclear definition of agroforestry land. In Spain large areas are covered with these dual systems in which trees are combined with arable, permanent crops and grazing. FSS does not register this class separately, nor has a definition for it.

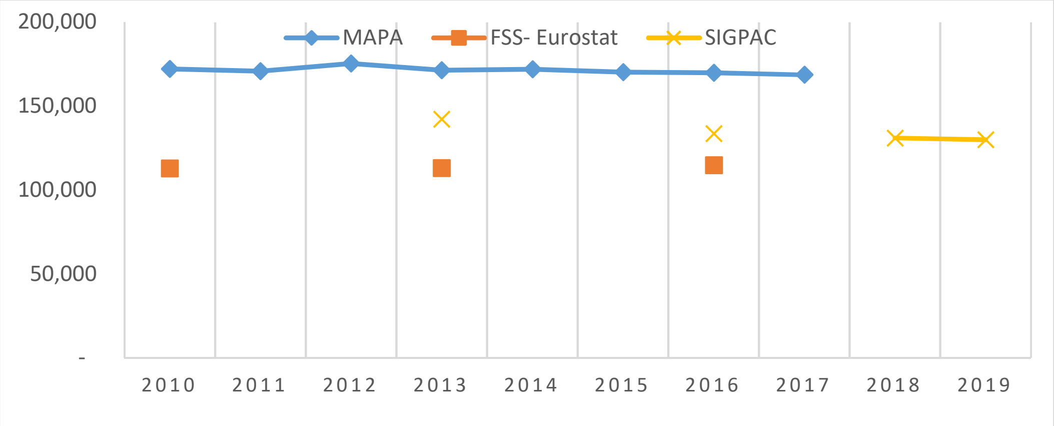
**Sources:**
Eurostat-FSS
Ministry of Agriculture, Fisheries and Food (MAPA) https://www.mapa.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/default.aspx SIGPAC

**Utilised Agricultural Area (2010-2016) in Spain**



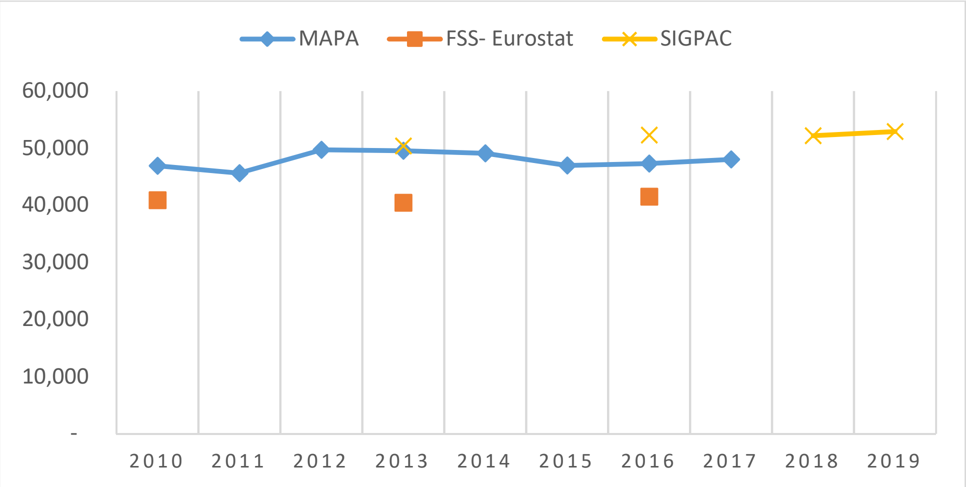

| year | Eurostat-FSS | CBS-Statline | BRP (NL-LPIS) | Difference % FSS-CBS | Difference % FSS - BRP |
|---|---|---|---|---|---|
| 2010 | 237,527 | 238,687 | .. | -0.49% | |
| 2013 | 233,002 | 235,230 | 378,784 | -0.96% | -62.57% |
| 2016 | 232,298 | 234,566 | 373,755 | -0.98% | -60.89% |

**Arable land (2010-2016) in Spain**



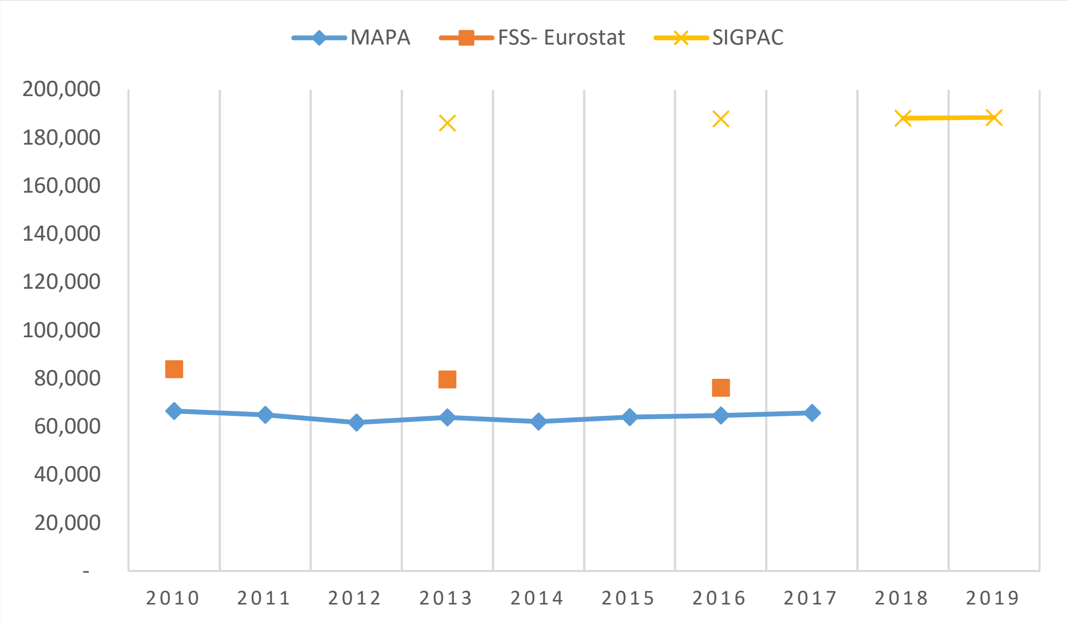

| year | Eurostat-FSS | MAPA | SIGPAC | Difference % FSS-MAPA | Difference % FSS - SIGPAC |
|---|---|---|---|---|---|
| 2010 | 112,860 | 172,214 | .. | -52.59% | |
| 2013 | 112,946 | 171,328 | 142,190 | -51.69% | -25.89% |
| 2016 | 114,629 | 169,852 | 133,498 | -48.18% | -16.46% |

**Permanent crops (2010-2016) Spain**




| year | Eurostat-FSS | MAPA | SIGPAC | Difference % FSS-MAPA | Difference % FSS - SIGPAC |
|---|---|---|---|---|---|
| 2010 | 40,862 | 46,930 | .. | -14.85% | |
| 2013 | 40,424 | 49,516 | 50,365 | -22.49% | -24.59% |
| 2016 | 41,497 | 47,311 | 52,298 | -14.01% | -26.03% |

**Permanent grassland and meadows (2010-2016) in Spain**



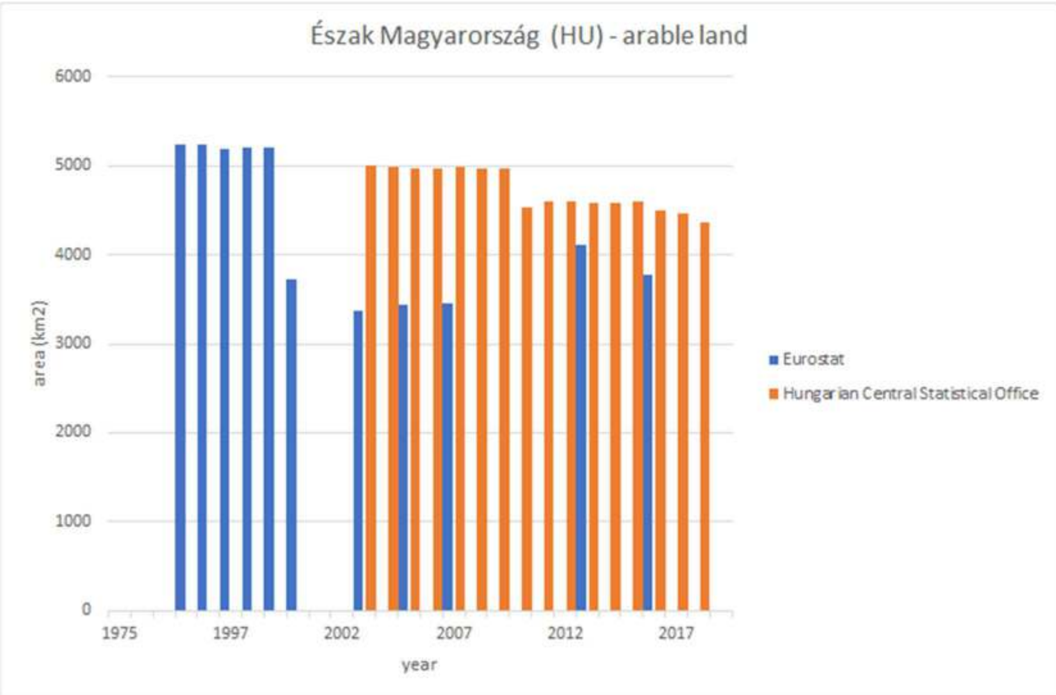

| year | Eurostat-FSS | MAPA | SIGPAC | Difference % FSS-MAPA | Difference % FSS - SIGPAC |
|---|---|---|---|---|---|
| **2010** | 83,774 | 66,474 | .. | 20.65% | |
| **2013** | 79,620 | 63,902 | 186,230 | 19.74% | -133.90% |
| **2016** | 76,160 | 64,714 | 187,959 | 15.03% | -146.79% |

**Észak Magyarország – Hungary**

- No registration of UAA available from the Hungarian Central Statistical Office because UAA is not defined in the Agricultural Census (although it is in the LPIS);
- Larger areas are in the database of the Hungarian Central Statistical Office than in Eurostat for all agricultural land use types. Differences are largest for arable land and permanent grassland, amounting to 1296-1635 km2 in the period 2003-2007. Differences are smaller in the years of Eurostat census 2013 and 2016 (11-19% of areas in Eurostat for arable land and 1-12% for permanent grassland).
- Access to LPIS for individual experts is not possible in Hungary; the Ministry of Agriculture shall be directly addressed with this issue by the Commission;
- Data on the area of (temporarily) unutilised land categories was not available from national/regional data sources.

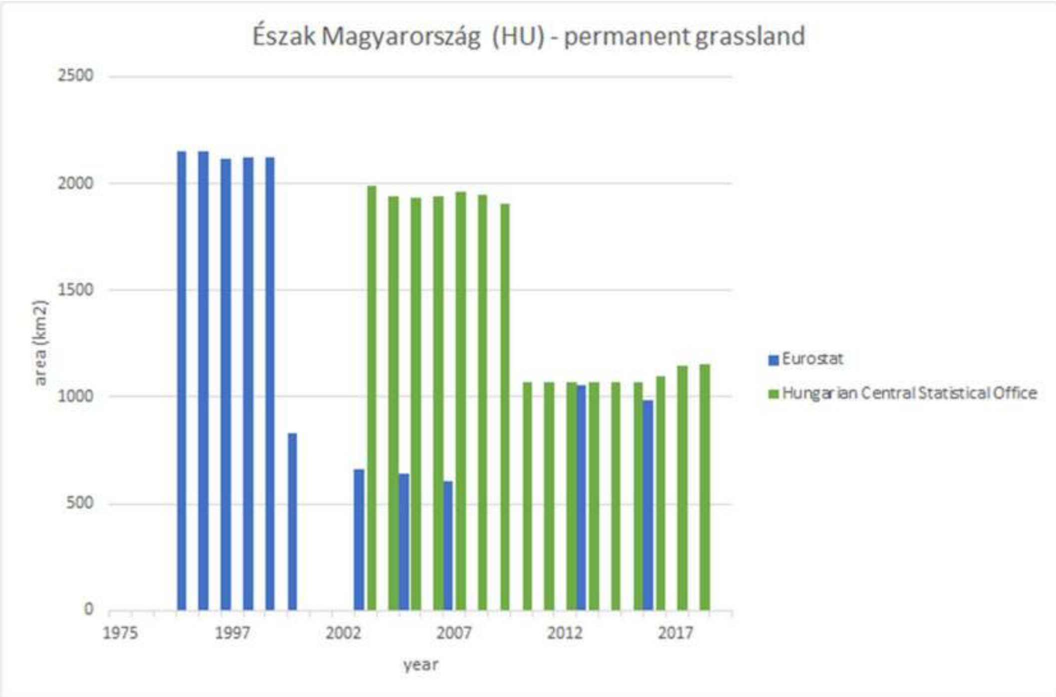
**Sources:**
Case study report for Észak Magyarország, Hungary
Eurostat

**Arable land**



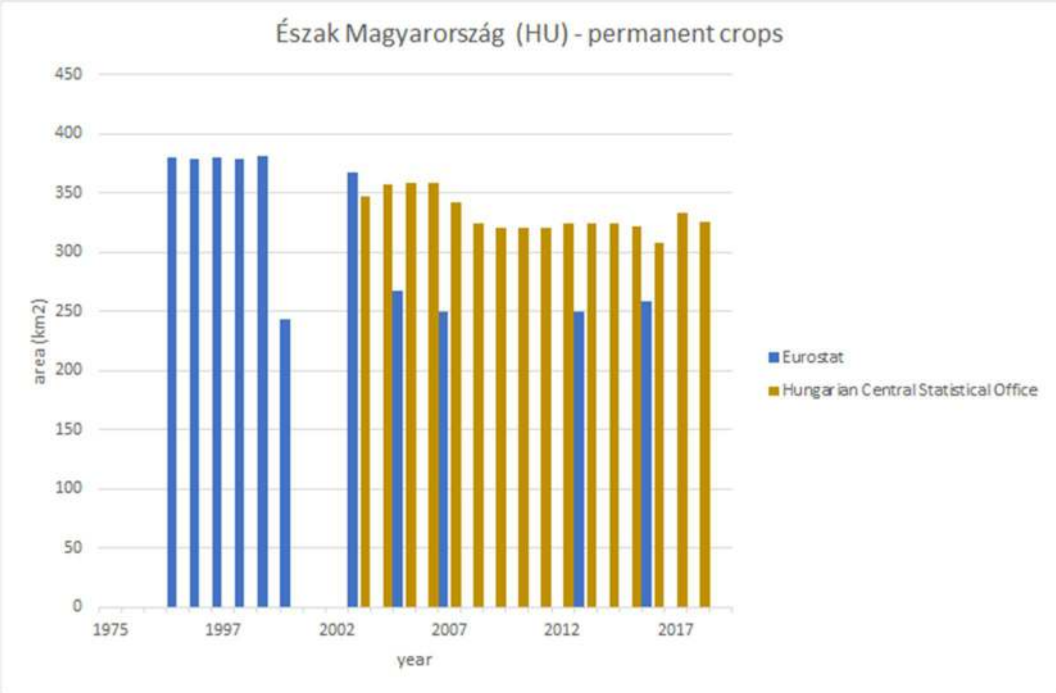

| year | Eurostat | Hungarian Central Statistical Office | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2003** | 3364 | 4999 | -1635 | -49% |
| **2005** | 3439 | 4965 | -1526 | -44% |
| **2007** | 3452 | 4980 | -1528 | -44% |
| **2013** | 4114 | 4585 | -471 | -11% |
| **2016** | 3782 | 4498 | -716 | -19% |

**Permanent grassland**




| year | Eurostat | Hungarian Central Statistical Office | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2003** | 663 | 1990 | -1327 | -200% |
| **2005** | 640 | 1936 | -1296 | -203% |
| **2007** | 608 | 1964 | -1356 | -223% |
| **2013** | 1059 | 1070 | -11 | -1% |
| **2016** | 983 | 1100 | -117 | -12% |

**Permanent crops**




| year | Eurostat | Hungarian Central Statistical Office | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2003** | 367 | 347 | 20 | 5% |
| **2005** | 268 | 358 | -90 | -34% |
| **2007** | 250 | 342 | -92 | -37% |
| **2013** | 250 | 325 | -75 | -30% |
| **2016** | 259 | 308 | -49 | -19% |

## Basse-Normandie – France

- Three national data sources are available on scale of agricultural land use: the statistical service of the Ministry of Agriculture in France (Agreste), the Land use Parcel Information System (LPIS) and Teruti-LUCAS, a point-based annual field survey.
- Only for the year 2013 data were available from Eurostat and one or more national data sources.
- Compared to Agreste, areas registered in Eurostat are 20% smaller for permanent grassland, but 21% larger for permanent crops.
- Compared to Teruti-LUCAS, areas registered in Eurostat are 23% larger for arable land, but 20% smaller for permanent grassland, and 136% smaller for permanent crops.
- Discrepancies in the area of permanent crops between Teruti-LUCAS (189 $km^2$ in 2013) and Agreste (63 $km^2$) remain unexplained. Both databases have a similar definition for this land use type.
- LPIS holds smaller areas for permanent crops and permanent grassland than the data sources from Teruti-LUCAS and Agreste. This may be explained by the listing of agricultural areas of farms having at least one plot receiving support from the 1st pillar of the CAP or subject to measures under the 2nd pillar.
- From 2012 to 2015, administrative data from the LPIS were used to inform the Teruti points located in agricultural plots. Nevertheless, there is still a difference between the two sources of data[1], which could not be explained from the definitions of the land use types.

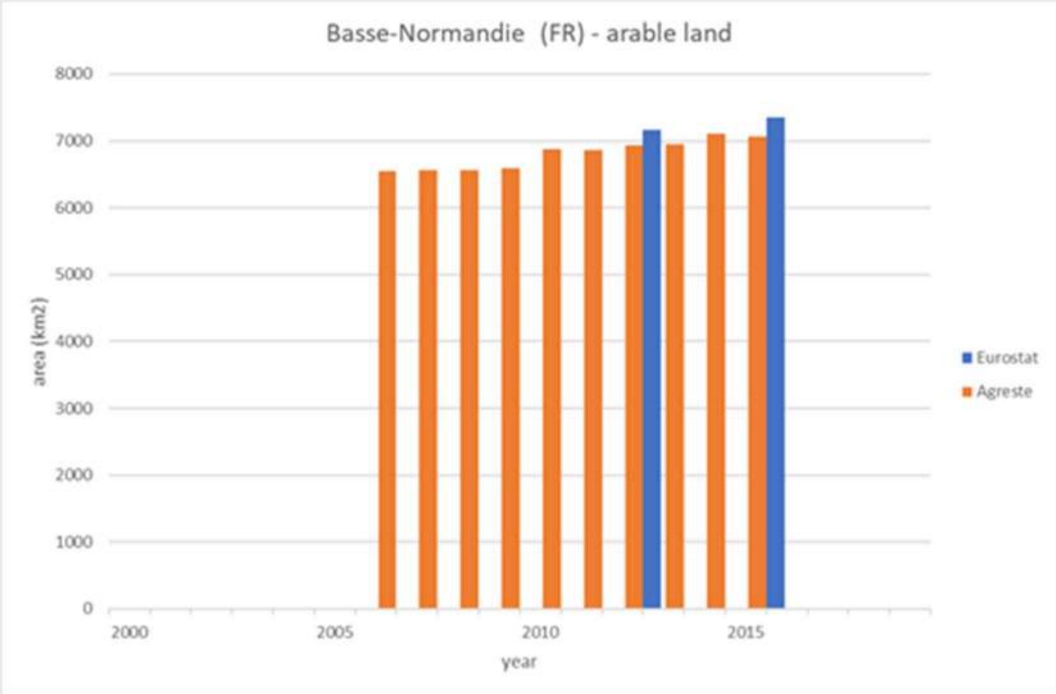
**Sources:**
Case study report for Basse-Normandie, France
Eurostat

**Utilised Agricultural Area (UAA)**

| year | Eurostat | Agreste | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 12075 | 12930 | -855 | -7% |

| year | Eurostat | Teruti-Lucas | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 12075 | 11566 | 509 | 4% |

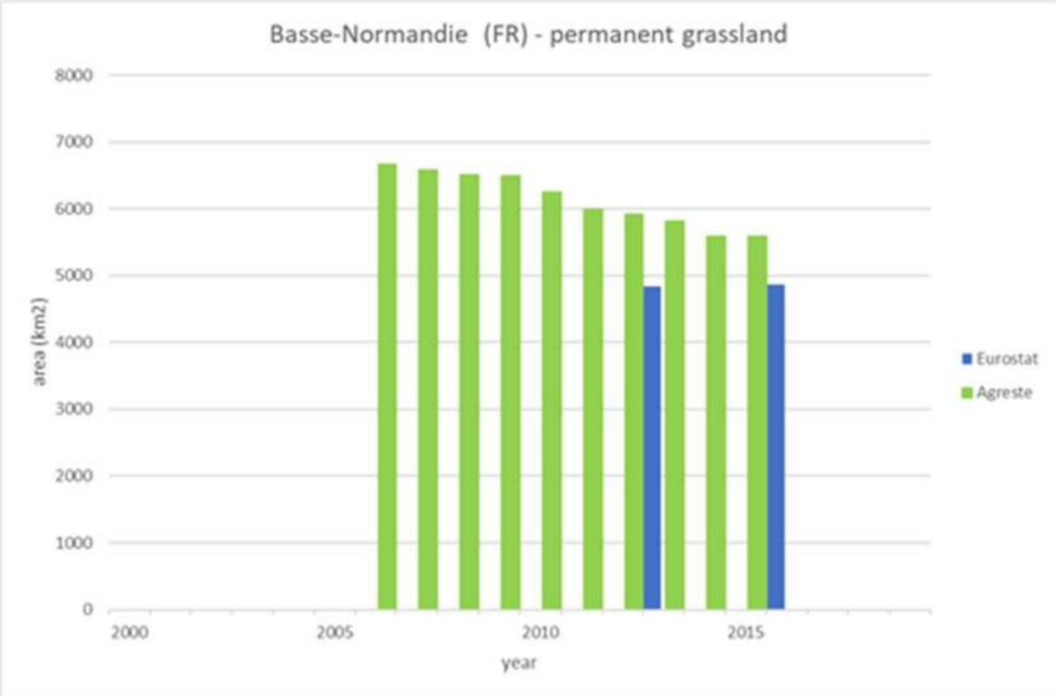
**Arable land**




| year | Eurostat | Agreste | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 7160 | 6947 | 213 | 3% |

| year | Eurostat | Teruti-Lucas | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 7160 | 5546 | 1614 | 23% |

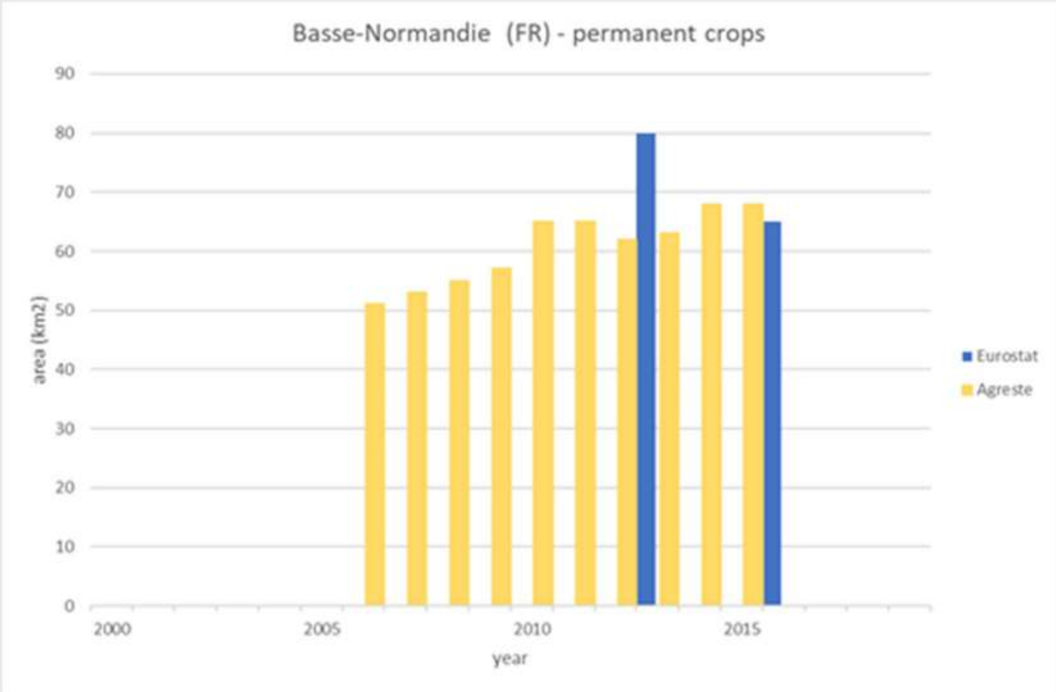
**Permanent grassland**




| year | Eurostat | Agreste | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 4834 | 5810 | -976 | -20% |

| year | Eurostat | Teruti-Lucas | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 4834 | 5802 | -968 | -20% |

**Permanent crops**




| year | Eurostat | Agreste | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 80 | 63 | 17 | 21% |

| year | Eurostat | Teruti-Lucas | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 80 | 189 | -109 | -136% |

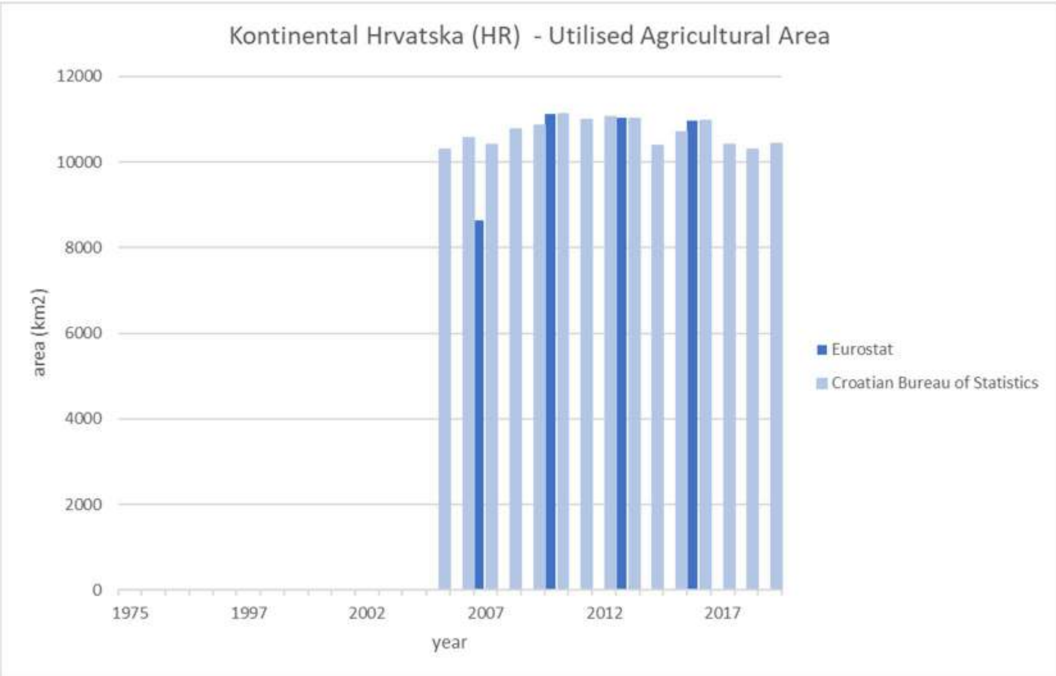
[1] http://www.jms-insee.fr/2018/S23_4_ACTE_BALLET_JMS2018.pdf

## Kontinentalna Hrvatska – Croatia

- Data on land use for the region Kontinentalna Hrvatska are available for the period 2005-2018;
- In 2007, the Utilised Agricultural Area registered in Eurostat was 20% smaller than in the database of the Croatian Bureau of Statistics. The difference decreased to 0-0.3% in the years 2010, 2013, 2016.
- For the years 2013 and 2016 differences in are between -3.7% and +0.7% of the areas registered in Eurostat for all land use types.
- Differences between Eurostat and the LPIS (ARKOD) are larger, notably for Utilised Agricultural Area (13-16%) and permanent grassland (55-58%). This may relate to differences in definitions and parcels not being registered in LPIS due to ownership issues.

**Sources:**
Case study report for Kontinentalna Hrvatska, Croatia
Eurostat

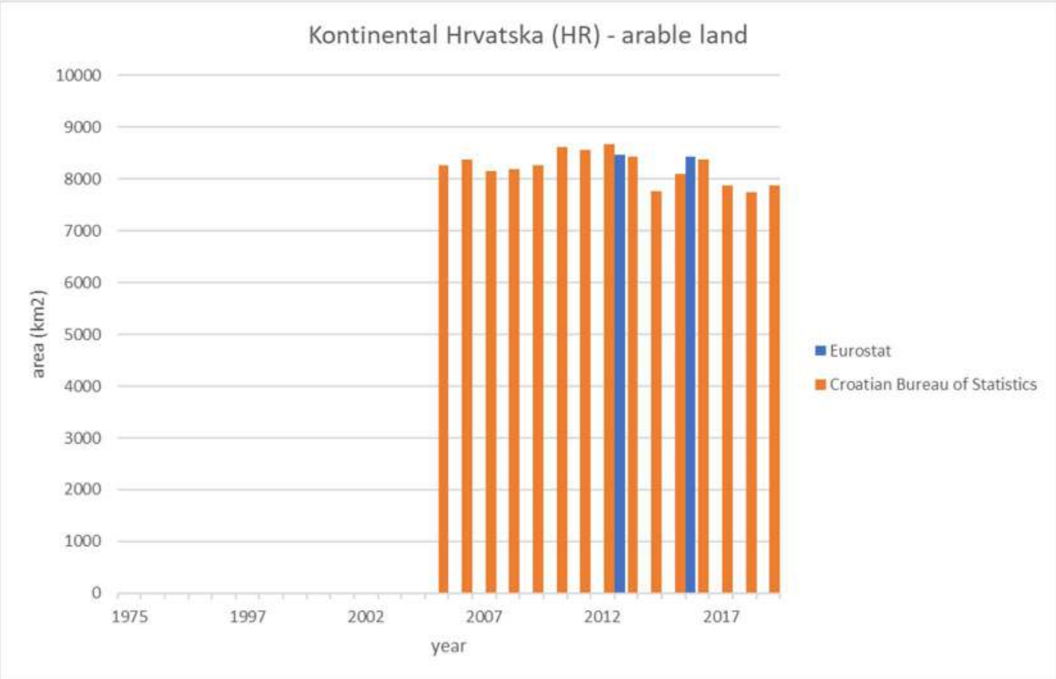
**Utilised Agricultural Area (UAA)**




| year | Eurostat | Croatian Bureau of Statistics | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2007** | 8640 | 10409 | -1769 | -20.5% |
| **2010** | 11113 | 11113 | 0 | 0.0% |
| **2013** | 11038 | 11010 | 28 | 0.3% |
| **2016** | 10954 | 10955 | -1 | 0.0% |

| year | Eurostat | LPIS (ARKOD) | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 11038 | 9181 | 1857 | 16.8% |
| **2016** | 10954 | 9513 | 1441 | 13.2% |

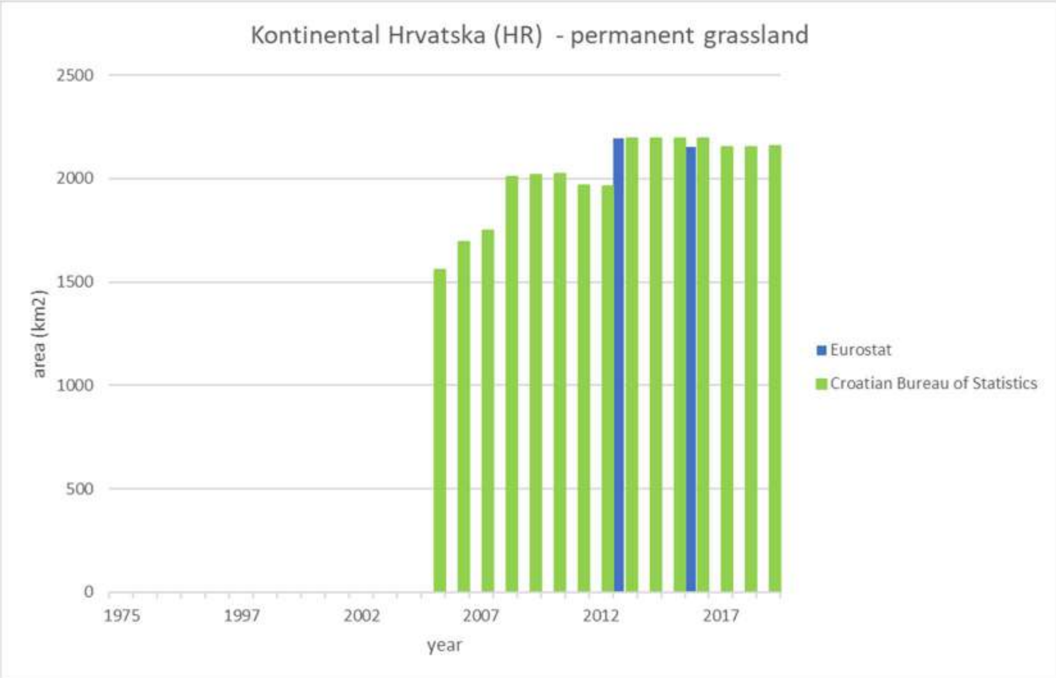
**Arable land**




| year | Eurostat | Croatian Bureau of Statistics | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 8460 | 8429 | 31 | 0.4% |
| **2016** | 8435 | 8378 | 57 | 0.7% |

| year | Eurostat | LPIS (ARKOD) | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 8460 | 7918 | 542 | 6.4% |
| **2016** | 8435 | 8160 | 275 | 3.3% |

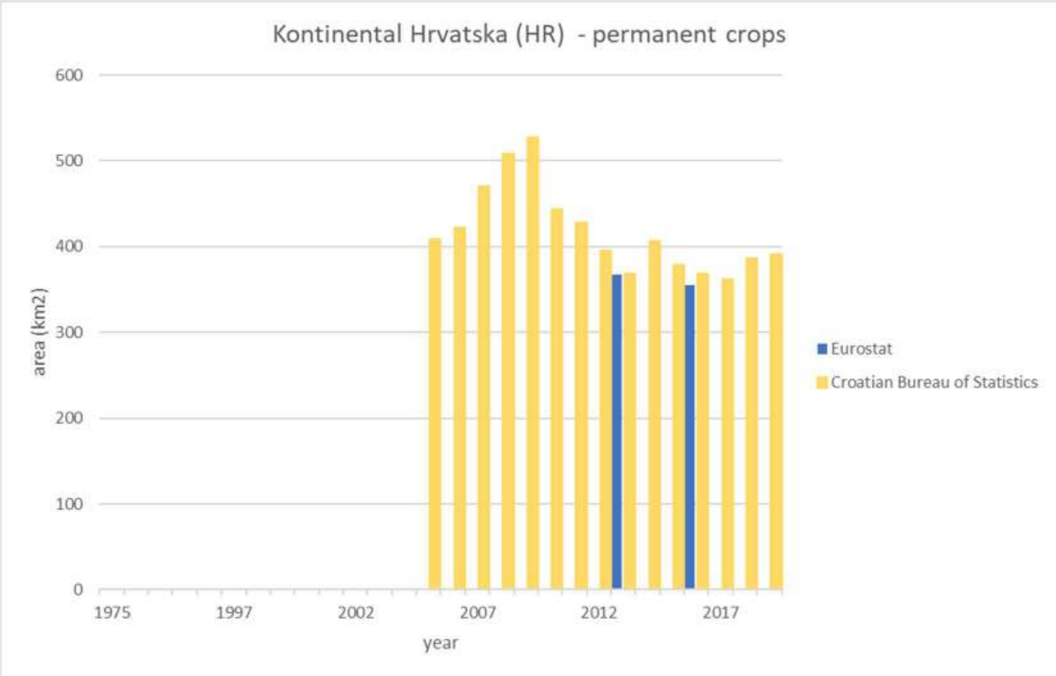
**Permanent grassland**




| year | Eurostat | Croatian Bureau of Statistics | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 2196 | 2196 | 0 | 0.0% |
| **2016** | 2152 | 2196 | -44 | -2.0% |

| year | Eurostat | LPIS (ARKOD) | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 2196 | 913 | 1283 | 58.4% |
| **2016** | 2152 | 974 | 1178 | 54.7% |

**Permanent crops**




| year | Eurostat | Croatian Bureau of Statistics | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 367 | 368 | -1 | -0.3% |
| **2016** | 355 | 368 | -13 | -3.7% |

| year | Eurostat | LPIS (ARKOD) | difference (km2) | difference (% of area in Eurostat) |
|---|---|---|---|---|
| **2013** | 367 | 337 | 30 | 8.2% |
| **2016** | 355 | 367 | -12 | -3.4% |

# 12 ANNEX V DATA SOURCES THAT REGISTER UNUSED OR ABANDONNED LAND

In Figure 12.1 and Figure 12.2 the total agricultural area and the land registered as 'fallow and abandoned lands' from LUCAS for different survey years are presented.

From Figure 12.1 it becomes clear that LUCAS data show that the largest absolute area size of 'abandoned and unused areas' is found in Spain, Sweden, Italy, France, UK, Finland, Greece, Poland and Croatia. Clear declines in UAA between 2009 and 2015 are particularly seen in Spain, UK, Italy, Poland and Ireland.

When looking at relative shares of abandoned and unused lands (Figure 12.2) the largest shares are in Cyprus, Croatia, Greece, Malta, UK, Italy, Ireland, Spain, Sweden. The largest relative declines in Agricultural area between 2009 and 2015 are found in Ireland, UK, Spain and Portugal. The latter does not necessarily imply a decline of agricultural land to an abandonment status. It could also be converted to urban, forestry or other land uses.

When looking at Table 12.1 with the top 25 of Nuts 3 regions with the largest area of unused and abandoned land we conclude that these are mainly regions from Spain, Finland, Sweden, UK (Scotland), Italy, Greece, France, Croatia and Latvia. In conclusion: Countries that score high on all 3 LUCAS indicators are: Spain, Italy, UK and Greece.

In the 9 regional case study regions data registering unused lands have also been identified. An overview of what came out of this inventory is presented in Table 12.2.

Figure 12.1 Unused and abandoned land area in relation to other land use (km2).

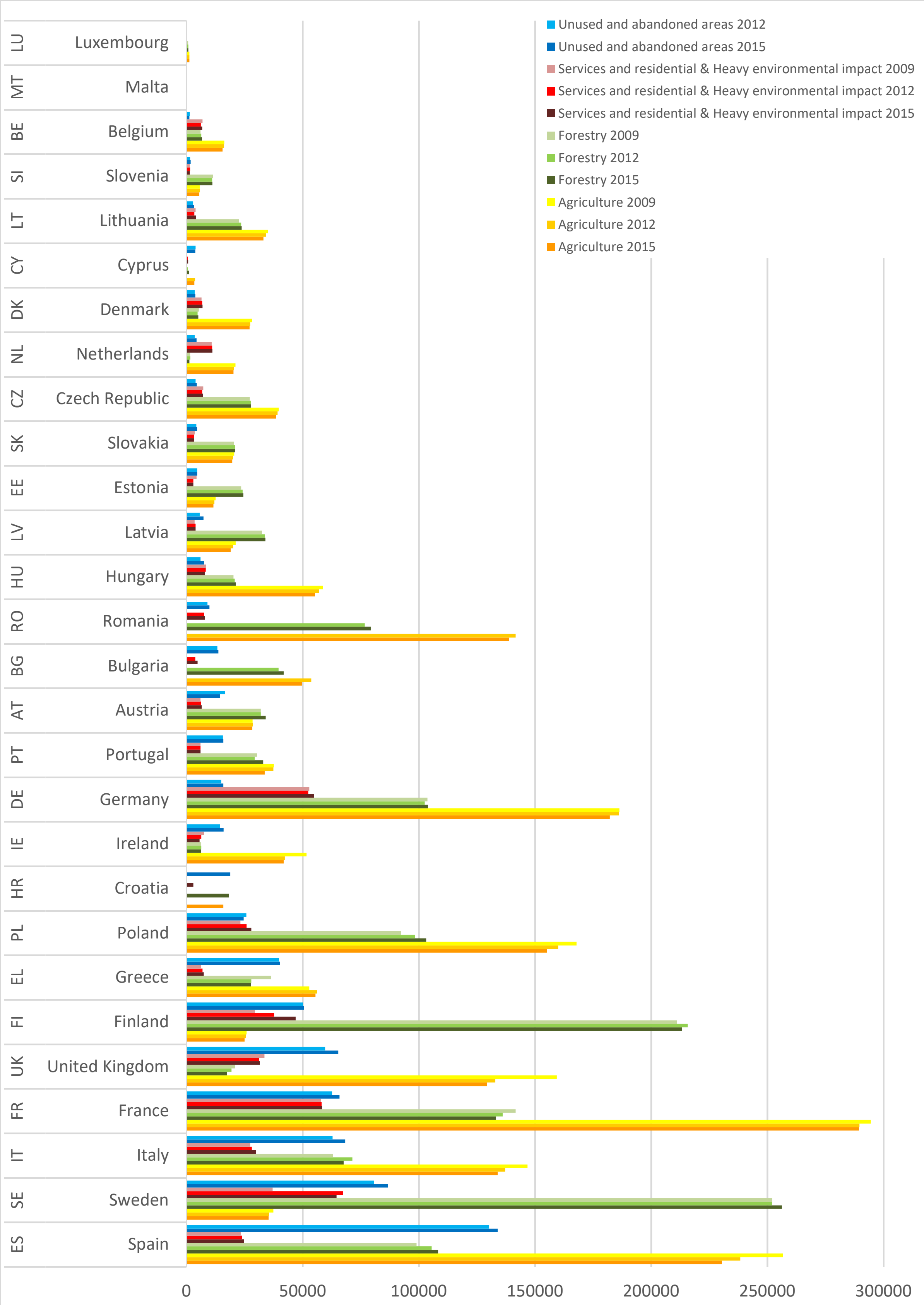


Figure 12.2 Relative share of unused and abandoned lands of the total land area (%).

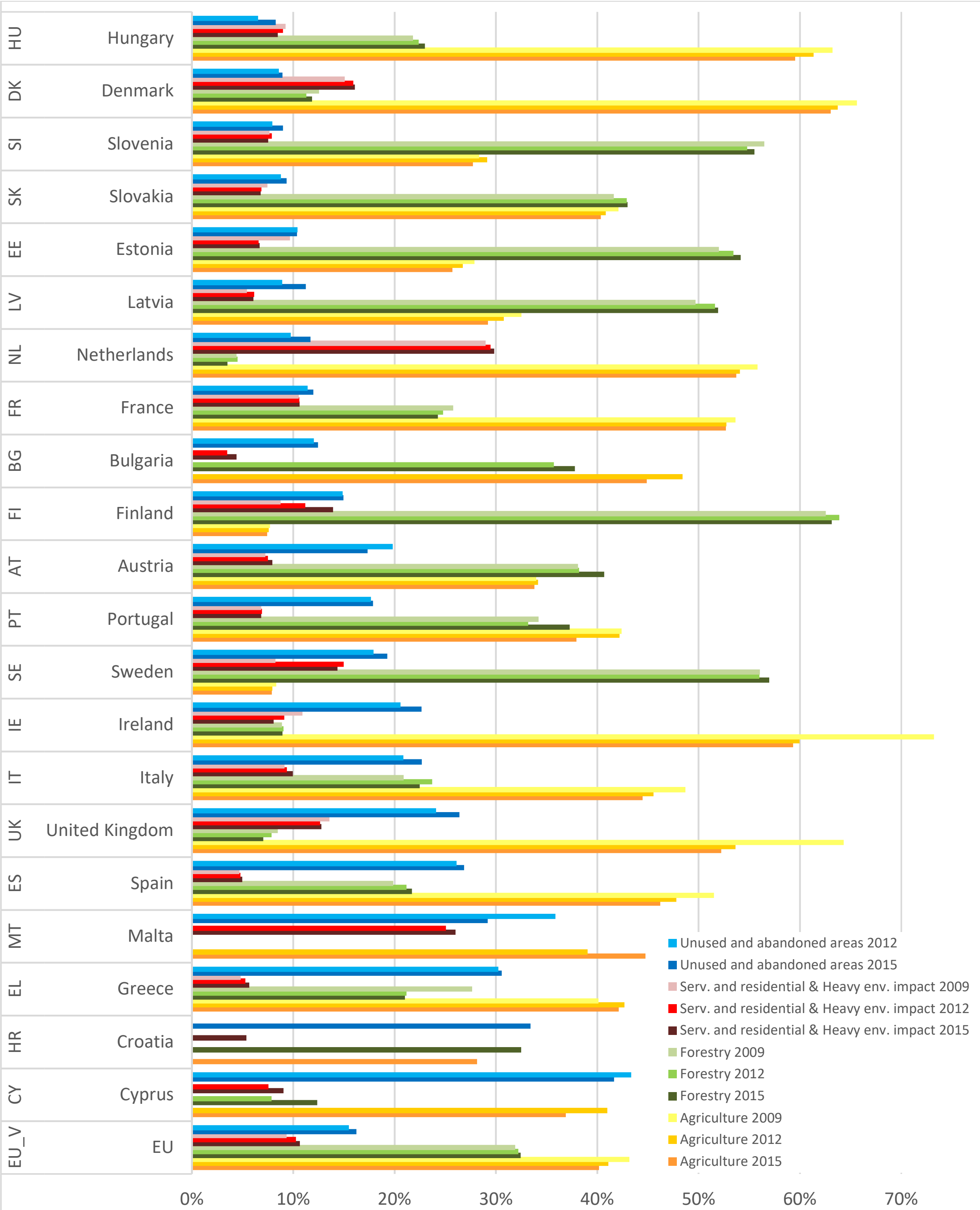


Table 12.1 Top 10 of regions with the largest unused and abandoned land resource (in km2) in the EU according to LUCAS 2012 and 2015

| GEO/TIME | Abandonend_2015 | Abandonend_2012 |
|---|---|---|
| **SE33 - Övre Norrland** | 56832 | 51530 |
| **FI1D - Pohjois- ja Itä-Suomi** | 43992 | 45238 |
| **UKM6 - Highlands and Islands** | 30638 | 25528 |
| **ES41 - Castilla y León** | 21435 | 19802 |
| **EL6 - Kentriki Ellada** | 20198 | 19802 |
| **ES24 - Aragón** | 19758 | 18905 |
| **ES42 - Castilla-la Mancha** | 18713 | 19078 |
| **ES61 - Andalucía** | 17795 | 17790 |
| **FR82 - Provence-Alpes-Côte d'Azur (NUTS 2013)** | 15014 | 14126 |
| **HR03 - Jadranska Hrvatska** | 14892 | |
| **SE32 - Mellersta Norrland** | 14720 | 14735 |
| **ES51 - Cataluña** | 12445 | 13069 |
| **EL5 - Voreia Ellada** | 11786 | 11732 |
| **ES52 - Comunidad Valenciana** | 11613 | 11191 |
| **IE01 - Border, Midland and Western (NUTS 2013)** | 10003 | 9241 |
| **FR71 - Rhône-Alpes (NUTS 2013)** | 9900 | 10466 |
| **FR81 - Languedoc-Roussillon (NUTS 2013)** | 8921 | 8404 |
| **ITG2 - Sardegna** | 8653 | 8718 |
| **ES11 - Galicia** | 8298 | 8229 |
| **ITC1 - Piemonte** | 8218 | 8190 |
| **LV - Latvia** | 7359 | 5833 |
| **FR83 - Corse (NUTS 2013)** | 7348 | 6285 |
| **UKM2 - Eastern Scotland (NUTS 2013)** | 7197 | 6759 |
| **SE31 - Norra Mellansverige** | 7023 | 7164 |
| **EL4 - Nisia Aigaiou, Kriti** | 6857 | 7375 |

Table 12.2 Statistical data registering unused, abandoned and degraded lands in the nine case study regions.

| Country-case region | Type 1 | | | | Type 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Definition | Source | Area (Km2) | Part of UAA | Definition | Source | Area (Km2) | Part of UAA |
| **Bulgaria - Blagoevgrad** | **Fallow land**: Ploughed land which is not cultivated, and no fertilizers are applied | https://www.agrostat.bg/ISASPublic/Land Use - Annual reports | 81 Km2 (2019) for Blagoevgrad region | YES | **Unuses land**: Calculated as difference between total Agricultural land and UAA | https://www.agrostat.bg/ISASPublic/Land Use - Annual reports | 189 Km2 (2019) for Blagoevgrad region | NO |
| **Croatia - Kontinentalna Hrvatska** | **Fallow land** | Croatian Bureau of Statistic | 222 Km2 (2019) for Kontinentalna Hrvatska | YES | **Temporary unused parcel**s registered in ARKOD (HR-LPIS). Parcel in the ARKOD (LPIS) system which is currently not used for agricultural activities, nor maintained for grazing and cultivation | ARKOD | 16 Km2 (2019) for Kontinentalna Hrvatska | NO |
| **France - Basse Normandie** | **Fallow land**: rotational fallow land | Database Teruti-Lucas 2006-2015 | 56 km2 (2015) for Basse Normandie | YES | | | | |
| **Hungary - Eszak** | .. | | | | .. | | | |
| **Italy - Sicilia** | **Fallow land** | http://dati.istat.it | 670 km2 (2016) forSicilia | YES | Non utilised agricultural area | http://dati.istat.it | 317 km2 (2016) for Sicilia | NO |
| **Latvia** | **Total agricultural land and used agricultural land** are registered. By subtracting the last from the first unused land can be estimated. | Rural Support Service, Survey of agricultural land | 2562 km2 (2019) for Latvia | NO | | | | |

| Country-case region | Type 1 | | | | Type 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Definition | Source | Area (Km2) | Part of UAA | Definition | Source | Area (Km2) | Part of UAA |
| **Portugal - Guarda** | **Fallow land**: Land included in crop rotation, which may be worked, not providing crops at any time in the season in order to improve it. It may take the form of a) land with no crops, b) land with spontaneous vegetation sometimes used by animals or buried or c) land sowed for the exclusive production of green matter for burying to increase soil's fertility. Source: http://smi.ine.pt/Conceito/Detalhes?id=1310&lang=EN | Source: http://smi.ine.pt/Conceito/Detalhes?id=1310&lang=EN | 124 km2 (2009) for Beiras e Serra da Estrela | YES | | | | |
| **Spain - Soria** | **Fallow land** | | | | | | | |
| **Romania - Braşov** | **Degraded and unproductive land** defined as ' Land which has permanently lost the ability of agricultural production through erosion, pollution or some other destructive action of anthropogenic origin" and "Land which is naturally eroded or devoid of vegetation (rocky slopes, screes, quick sands, ravines, gullies, torrents, moors, swamps, quarries, dumps and other degraded lands)" | Romanian National Institute of Statistics (NIS) | 69 km2 (2014) for Brasov county | NO | **Fallow (arable) land**: "land at rest (fallow and not seeded) and generally characterised by not being used for all of the agricultural year" | Romanian National Institute of Statistics (NIS) | 191 km2 (2019) for Brasov county | YES |

# 13 ANNEX VI MAPPING DRIVERS OF ABANDONMENT AT REGIONAL LEVEL AND CASE STUDY SELECTION

## Drivers mapped

Land abandonment is a complex process which often happens gradually. In chapter 3 of this report a review is presented of the main drivers of land abandonment as detected in former work by the JRC (Terres et al., 2013) and other literature and as experienced in the nine case study regions of this study.

Several of these factors can be identified and further reviewed using EU wide statistical and spatial data, although the spatial detail at which these drivers can be identified is limited and usually not sufficient to directly link to abandonment processes as these are often very local in character. The several drivers on farm income and stability and also regional drivers have also been quantified at regional level for the EU in Terres et al. (2013) using statistical data. Also these are based on data sources that refer to larger administrative regions. The coarseness in data is a limitation. However, it is still relevant to map the drivers, particularly showing those regions where many drivers come together. The review in chapter 3 tells us that the more drivers apply the larger the risk is for agricultural land becoming unused, abandoned and/or degraded.

In this Annex the drivers of abandonment based on existing EU wide sources are mapped in combination for two reasons:

- To identify hot spot regions of drivers of abandonment in the EU
- From this hotspot mapping select the nine case study regions used in this study for the collection of in-depth information on the process of abandonment of agricultural lands and policy information to prevent abandonment or option to bring unused, abandoned and degraded lands back into production.

Given that land abandonment processes can be very local and may have different combinations of drivers it is logical to follow a three-step approach:

1. Formulation of approach for spatial/statistical analysis aimed at identifying to which extent the possible drivers of abandonment coincide (or not) with the hotspot regions of declining UAA as identified in task 2 and already presented in sections 2.4 and 2.5 of this report.
2. Combine this information further with the mapped drivers of abandonment.
3. Combine with the regions with the highest incidence of land use change flows going towards loss of UAA and based on this selection of nine case study regions.

***Step 1***

Abandonment mapping is complex because it usually involves a gradual process of transition from agricultural land to shrubs and eventually forest. In part of these areas natural regeneration of woodland on former farmland can be a deliberate choice rather than simply abandonment, which makes it difficult to distinguish from abandonment although we can assume that this process is much less common then the transition to full abandonment. Overall, it is therefore difficult to determine when land has become abandoned completely or when it is still managed. This makes detecting abandonment based on land cover data alone practically impossible. Usually a combination of statistical and different spatial data sources is needed from different time periods. We used a set of criteria to create a typology of regions with signs of land abandonment in the EU-28 (Figure 13.1). This typology builds very much on the drivers study by Terres et al. (2013) and is is used to identify regions with unused, abandoned and degraded land resources with high or low potential for biomass production for energy and other non-food uses. The typology serves as a basis for the selection of nine case study regions with a diverse combination of factors leading to farmland becoming unused. The typology also ensures an even representation of all environmental zones in the final selection of the regional case studies.

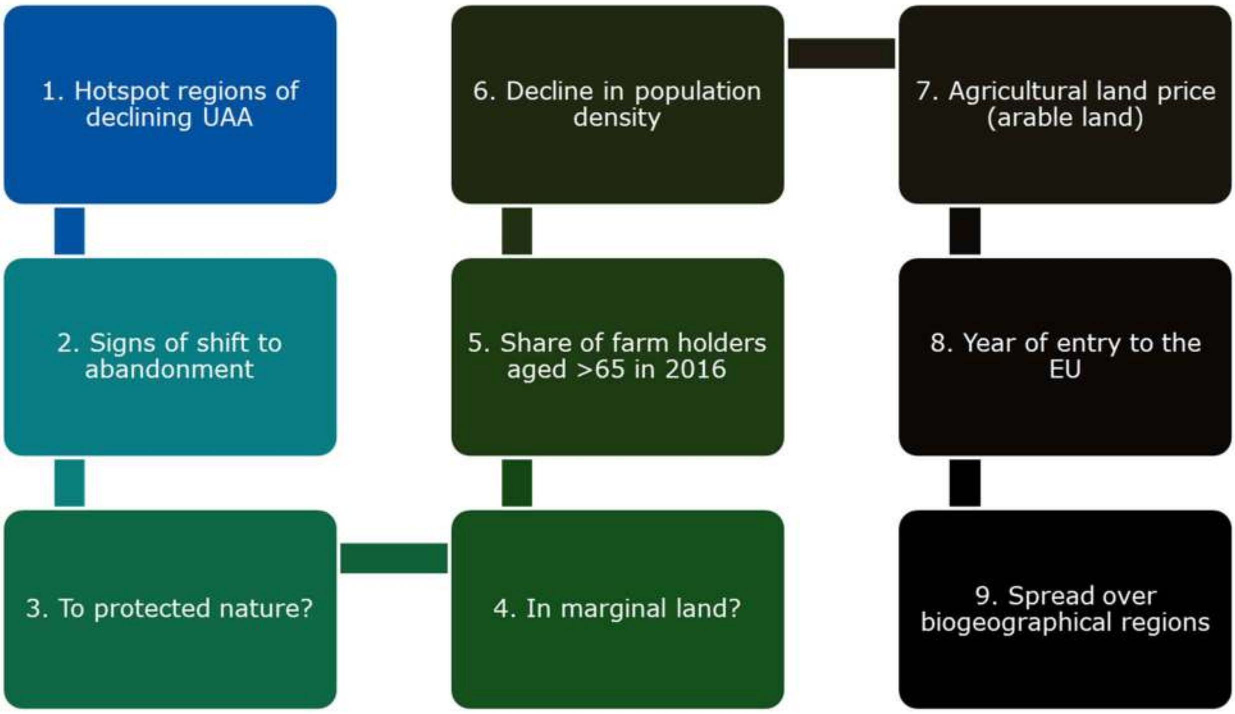



Figure 13.1 Criteria for the identification and classification of regions with regard to land abandonment (based on the review presented in chapter 3 of main report).

The proposed classification of regions in profiles of land abandonment is composed of (numbers refer to Figure 13.1):

- criteria that provide indications or evidence of land abandonment (1, 2, 5, 6);
- criteria that reflect barriers or opportunities for the production of crops for biomass (3, 4, 5, 6, 7)
- criteria that reflect diversity in environmental and socio-economic and historical conditions (3, 4, 8, 9)

The criteria are illustrated below together with the eventual selection of regions for the case studies.

***1. Hotspot regions of declining UAA***

We identified hotspots of potential land abandonment by analysing the change in utilized agricultural area (UAA) as registered in the Eurostat database, and conversions from agricultural land to other land cover types using the Corine Land Cover (CLC) data. The change in UAA was analysed over the long term (1975-2016) and short term (2005-2016) at the level of NUTS2- and NUTS3-regions (see Sections 2.4 and 2.5 of main report). The mapped results of this analysis are presented in Figure 2.8 in the main report.

For some countries, no data were available for 1975 in the Eurostat database. The following operations were applied to obtain values for the UAA in 1975 for these countries:

- No Eurostat data for 1975, FAOSTAT data available: FAOSTAT data from 1975 were used (for example, Austria, Portugal, Romania);
- Countries that were part of a larger country in the first part of the period 1975-2016: FAOSTAT data from 1975 for the larger country were disaggregated based on the proportional area of smaller countries in 1990 (Czechia, Croatia, Slovenia, Slovakia).
- These operations were not applied for Estonia, Latvia and Lithuania because of their small area compared to the larger previous country (USSR). For these countries the data on change in UAA were taken only for the period 1990-2016.

Regions with large declines in UAA (>25%) in the period 1975-2016 are in Spain, France, Italy, Austria, Slovenia, Croatia, Hungary, Slovakia, Bulgaria, Estonia and Sweden. Regions with large declines in UAA (>10% of the area present in 2006) in the period 2005-2016 are in Sweden, Portugal, Spain, Italy, Austria, Romania, Cyprus, Poland and The Netherlands.

**Step 2: Combine this information further with the mapped drivers of abandonment**

***2. and 3. Signs of shift to abandonment in and outside protected nature***

This mapping is based on the Land Use Change Analysis (LEAC) based on Corine Land Cover comparison between 2000 and 2018 at 250 m grid resolution. This change analysis is already extensively discussed in Annex III of this report. The resulting maps (see Figure 10.1 to Figure 10.4 in Annex III) were used as input in the hotspot mapping here but a further overlap of the map 'sign of shift to abandonment' has been made overlapping it with the location of Natura 2000 sites (see Table 10.2 in Annex III). Based on this overlap showing the share of land within a region with 'signs of shift to abandonment' outside and inside Natura 2000 areas (see Table 10.2 in Annex III). The reason this distinction is made is that a conversion to a nature protection area can go together with a (deliberate) intensification or full withdrawal of farming. So, the reason behind the land use flow in Natura 2000 areas could be different from the shifts to abandonment seen outside Natura 2000 areas. Furthermore, as discussed in Chapter 4 and 5, conversions of biodiversity-rich unused and abandoned lands towards cropping for energy another non-food uses is not recommended from a sustainability perspective. By making this distinction we enable the selection of case studies to be made for areas where unused and abandoned lands are mainly located outside of Natura 2000 areas.

From the Table 10.2 in Annex III we conclude that the signs of abandonment between 2000 and 2018 in agricultural land are spread all over the EU. A large concentration of signs of abandonment is seen in the southern part of the EU, particularly in northern and central regions of Spain and all regions in Portugal, with the exception of the Centro region, Northern Greece and Corsica. In central and eastern EU the regions with signs of abandonment outside Natura 2000 standing out are Centru region of Romania and Yugozopaden in Bulgaria. In the North of the EU the strongest sings of abandonment outside Natura 2000 were found in Scotland, all regions of Finland and Latvia.

When concentrating on signs of abandonment that can be linked to conversions to nature protection areas, so located within current Natura 2000 boundaries, there is a more diverse picture. Again, in southern EU strong signs are seen in all Spanish and Portuguese regions, in Italy most strongly in Sicilia, Apulia, Basilicata, Liguria and Aosta, in Slovenia and the Mediterranean region of Croatia and several Northern Greek regions. In the Central and Eastern part of the EU the regions with strongest signs within Natura 2000 are found in Austria in Tirol and Lower Austria, in most of Western part of Romania, Southwestern half of Bulgaria, Zachodniopomorskie and Podkarpackie regions in Poland and the eastern regions of Slovakia.

Still we can also conclude that the distribution of signs of abandonment is much larger outside Natura 2000 areas then within Natura 2000 areas, as was already concluded in Annex III.

**4. Marginal land**

Many studies mention biophysical or agro-ecological conditions that negatively influence the suitability of land for agricultural activity, or that directly limit yields or increase the costs of farming as reasons for agricultural land abandonment in Europe. These include a.o. factors that determine the productivity and economic viability of agricultural holdings or the ready access to land. Examples are inherent limitations with regard to climate, soil, and topography, for which an overview for Europe is available in the framework proposed for identifying 'areas of natural constraints' by the European Commission Joint Research Centre (JRC) (Van Oorschoven, et al., 2014 and Terres et al, 2014). These indicators are based on older land classification approaches from FAO-CGIAR and USDA-LCC, Mueller et al. (2010), Cai et al. (2010), Fischer, 2002 and 2008). The constraints developed in the JRC approach were taken as a key starting point for the mapping of marginal lands in the EU MAGIC project for the EU-28 (29/30). The MAGIC map has also been used in this study to detect where natural constraints are important in driving abandonment of farmlands (see Figure 13.2 where the mapped results in MAGIC have been presented at regional level).

The criteria proposed for biophysical constraints typical to marginal lands in MAGIC (Elbersen et al., 2018) have been identified for the classification of severe limitations; 18 single factors, grouped into 6 clustered factors:

1 Adverse climate (low temperature and/or dryness)
2 Excessive wetness (Limited soil drainage or excess soil moisture)
3 Low soil fertility (acidity, alkalinity or low soil organic matter)
4 Adverse chemical conditions (Salinity or contaminations)
5 Poor rooting conditions (low rootable soil volume or unfavourable soil texture)
6 Adverse terrain conditions (steep slopes, inundation risks)

The 6 clusters are discussed below and summarized in Table 1.

Table 1 Land area share (% of agricultural area)* of total and 6 clusters of biophysical constraints making up marginal lands for EU-28 (total) and per Environmental zone (Source: MAGIC – Elbersen et al., 2018)

| | **1. Adverse climate** | **2. Excessive soil moisture** | **3. Adverse chemical comp.** | **4. Low soil fertility** | **5. Adverse rooting cond.** | **6. Adverse terrain** | **Marginal** |
|---|---|---|---|---|---|---|---|
| Alpine | 40% | 21% | 0% | 2% | 45% | 47% | **61%** |
| Atlantic | 4% | 14% | 1% | 1% | 12% | 5% | **26%** |
| Continental | 1% | 5% | 2% | 1% | 5% | 2% | **14%** |
| Mediterranean | 13% | 1% | 1% | 6% | 18% | 9% | **34%** |
| North | 62% | 14% | 0% | 3% | 13% | 3% | **71%** |
| **Grand Total** | **11%** | **8%** | **1%** | **2%** | **12%** | **6%** | **29%** |

*Area share of the total marginal area in Europe that can be regarded 'agricultural' as it has been in continuous or discontinuous agricultural use (according to Corine Land Cover (CLC)) between 1990 and 2012

The European map of marginal lands from MAGIC showed that 29% of the agricultural area is marginal in the EU-28. Of the natural constraints considered in the classification, the most common are rooting limitations, with 12% of the agricultural area affected. The constraints of adverse climate and excessive soil moisture occur in respectively 11% and 8% of the agricultural land (Table 1).

### *Adverse climate (cluster 1)*

Farmland abandonment is often reported to be associated with adverse climatic conditions. Adverse climate conditions for agriculture in Europe can either constitute low temperature limiting crop growth, a short growing season (Fischer et al., 2007) (often measured as the length or the thermal sum for the growing period), or dry conditions and water stress affecting crop physiological processes (Hassan and Dregne, 1997; Le Houerou, 2004), also expressed in the ratio of the annual precipitation to annual potential evapotranspiration (P/PET) or the aridity index.

Low rainfall is reported to be important for land abandonment in mountain areas in the Mediterranean, as as in arid and semi-arid areas in Southern Europe, imposing water shortage during the growing period. Land abandonment due to the low productivity of drylands is reported to occur in semi-arid areas in south-eastern Spain (Romero-Díaz et al., 2007) and the centre-south of Portugal (Van Doorn and Bakker, 2007; Nunes et al., 2010).

Excessive wetness is also reported as an adverse climate condition for agriculture, expressed in excess soil moisture or limited soil drainage in areas which are water logged for periods in the year in wet and cool areas in Europe, for example in Latvia (Nikodemus et al., 2005).

In the framework of the indicator for risk of farmland abandonment by, low temperature, aridity and excess soil moisture are considered as unsuitable environmental climatic conditions in areas with natural handicaps. In the potential risk map of agricultural land abandonment in the EU (Elbersen et al., 2018 mapped in Figure 13.2 below), abandonment risk due to climate limitations is mostly found in the Mediterranean countries where soils suffer from drought (Greece, Italy, Spain) and in the United Kingdom and Scandinavia (due to acidic and waterlogged soils).

In the long-term, further abandonment may be driven by climate change, especially in southwest, southern-central and southeast Europe, where declines in yield are expected as a consequence of droughts and high temperatures.

*Soil properties (clusters 2, 3, 4, 5)*

Soil properties are usually divided in the categories of physical, chemical or biological soil properties. In the category of unfavourable physical conditions related to agricultural land abandonment, limitations in rooting are mentioned, caused by unfavourable texture and stoniness and shallow rooting depth. Physical soil properties determine the hydrologic behaviour of soils. Limited soil drainage (8) and excessive soil moisture or wetness are a separate cluster of natural constraints in the classification of marginal lands. These characteristics were found responsible for crop production reduction (Schulte et al., 2005) and for farming restrictions (Earl, 1997; Fitzgerald et al., 2008; Jones and Thomasson, 1993).

High moisture content is mentioned as a characteristic of abandoned fields in regions with peat or moraine soils in Baltic countries (IEEP and Veen, 2005).

Among the adverse chemical composition or conditions of soils, often mentioned are low fertility (1) (6), low soil organic matter, unfavourable soil pH, acidity, alkalinity, salinity and sodicity and contaminants (29/30). Low organic matter content is reported as the principal biophysical constraint for low grain yields (1.5 Mg/ha) in rainfed arable land in Spain. Salinisation and sodicification are mentioned among the major degradation processes endangering the use potential of European soils. The salinity of soils is influenced by natural and human-induced factors. Natural factors include characteristics of the area (e.g. temperature, rainfall, geology, relief, hydrology) and natural characteristics of the soil (e.g. structure, clay mineral composition, hydrophysical properies, salt content).

*Terrain (cluster 6)*

Characteristics of terrain (elevation, elevated and steep slopes) are also mentioned as factors rendering land unsuitable for agricultural use or as predictors of agricultural abandonment. Cases were mentioned in Slovakia, Spain, Italy, Portugal, Ukraine (Pazúr et al. 2014); (Corbelle-Rico et al. 2012); (Bakker & Van Doorn 2009); (Bakker et al. 2008); (Cocca et al. 2012); (Baumann et al. 2011). But also in flat areas, land abandonment is reported in coexistence with land use intensification in irrigated areas. In this case, the abandonment is closely linked to water scarcity problems, salinization, and low soil fertility. Fields positioned at the bottoms of valleys in areas with excessive water accumulation or subject to inundation risks were also reported to be subject to abandonment in mountain areas in Central Europe (IEEP and Veen, 2005).

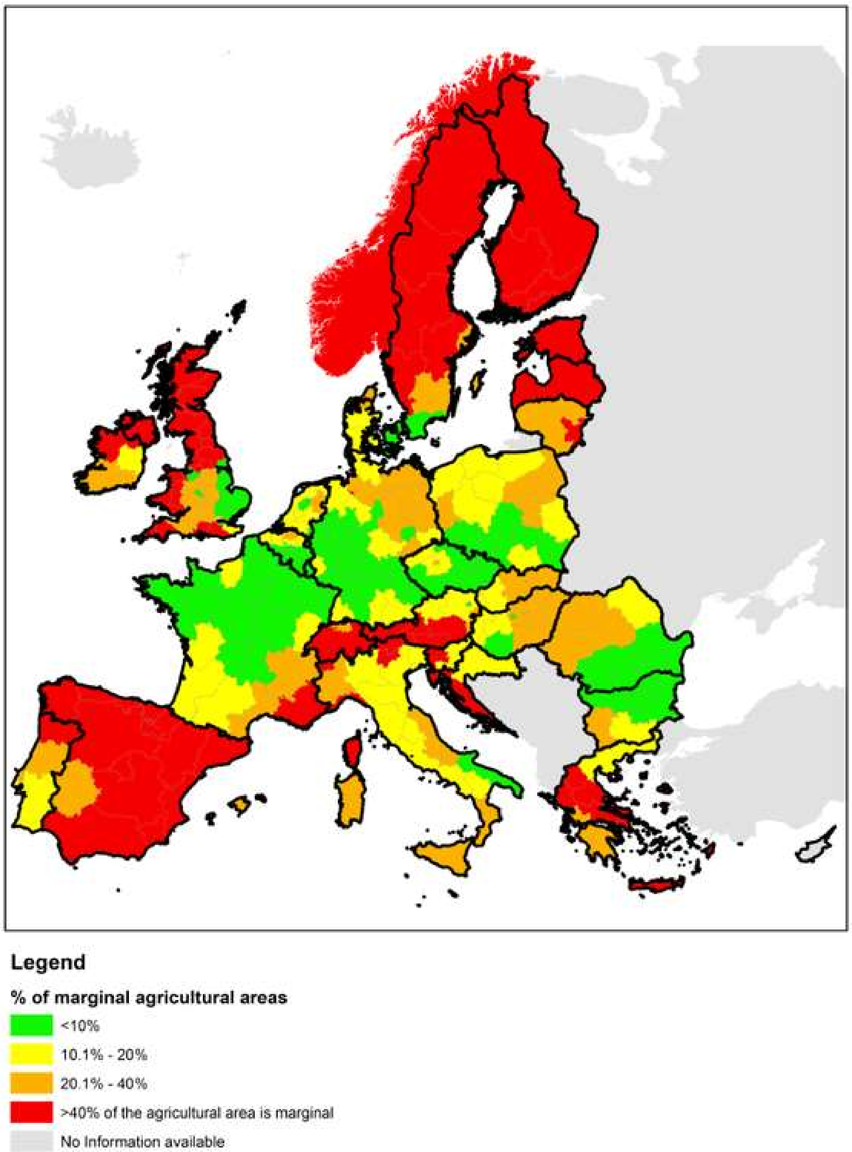



Figure 13.2 Marginal land in agricultural area. (Source data MAGIC-EU project: Elbersen et al., 2018)

**6. Decline in population density**

Drivers in the regional context of rural regions, or beyond the farm enterprise and the region include economic opportunities in other regions or sectors, demographic trends, accessibility and rural infrastructure, agricultural and land markets. Demographic trends and settlement patterns are mentioned in relation to agricultural land abandonment in several studies, manifesting in high emigration rate, a decline in rural population (Cramer et al., 2008; García-Ruiz & Lana-Renault, 2011; Svetlitchnyi, 2009) and a high average age of residents). In the EU, the rural population has declined from 38% in 1960 to 24% in 2018 by 17% between 1961 and 2010 (FAOSTAT, 2019). In Figure 13.3 the average change in population density is presented and in Figure 13.4 the change in rural households which are both indicators of population decline.

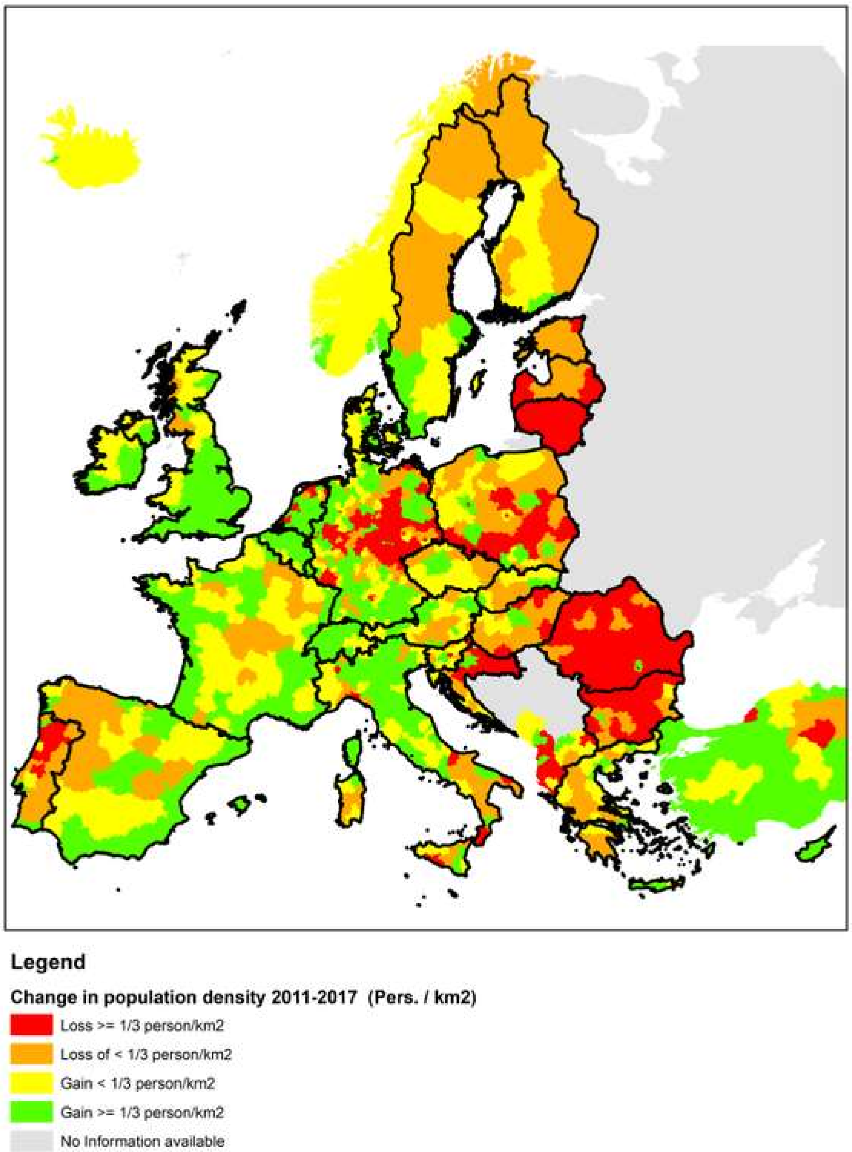



Figure 13.3 Average change in population density over the period 2011-2017 (persons per km2). Source data: Eurostat.

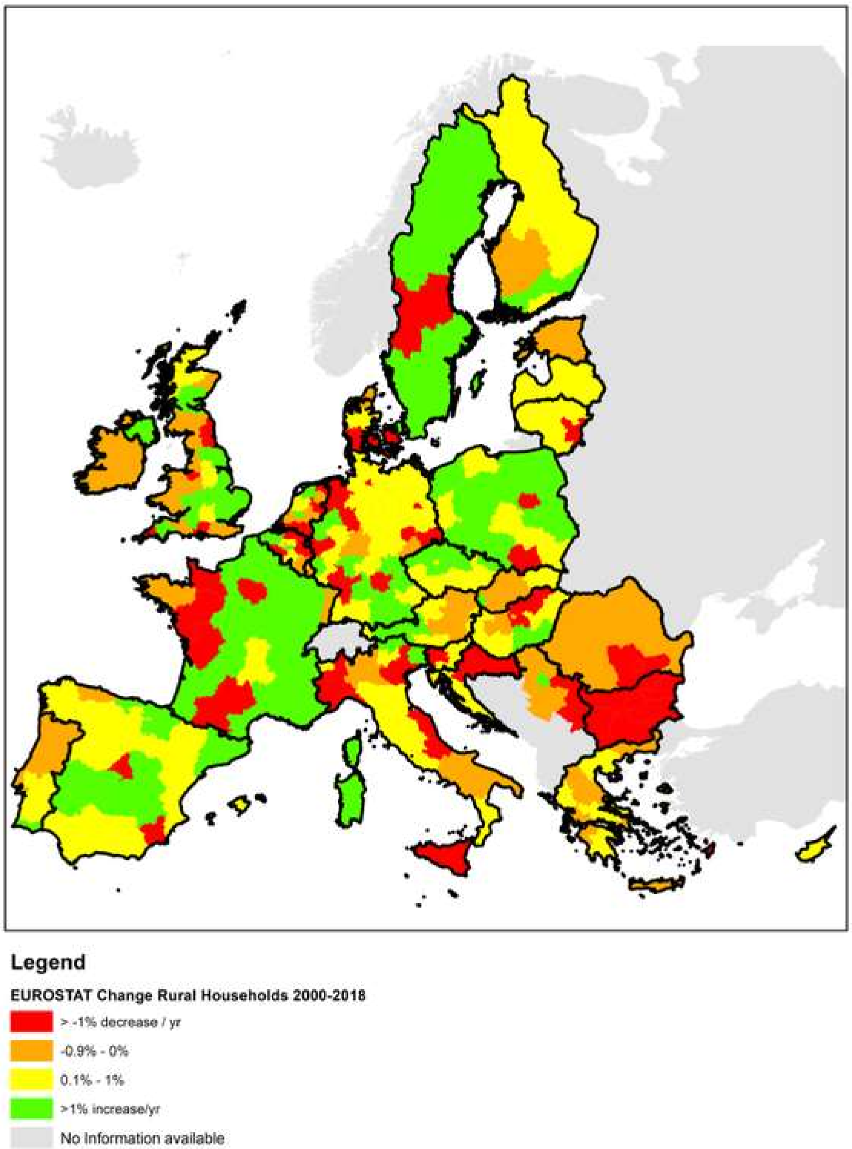



Figure 13.4 Change in the number of rural households in the period 2000-2018 (% of total households). Source data: Eurostat.

***7. Share of farm holders aged >65 in 2016***

The age of farm holders is generally acknowledged in the literature as an important driver for land abandonment (Kristensen et al., 2004; Mishra et al., 2010; Potter and Lobley, 1992; Baudry, 1991; Van Doorn and Bakker, 2007; Baldock et al., 1996; Van Doorn and Bakker, 2007; Kristensen et al., 2004; MacDonald et al., 2000). Farmland extensification and abandonment are reported to be more likely to occur when the farmer is old and close to retirement ((Kristensen et al., 2004; Van Doorn and Bakker (2007), in 56). According to (Baldock et al, 1996) the number of farmers near the retiring age may reflect the expected transition of the land and its structure in a period of 10 years. A high average age of farmers remaining after a rural exodus from mountain areas, and their lack of interest to increase the size of their farms was also mentioned in literature. In Figure 13.5 the proportion of farmers in the age of 65 years and older is mapped as an average per region. There are certainly many regions, particularly located in the more peripheral regions in the EU-28 with high concentration of old farmers.

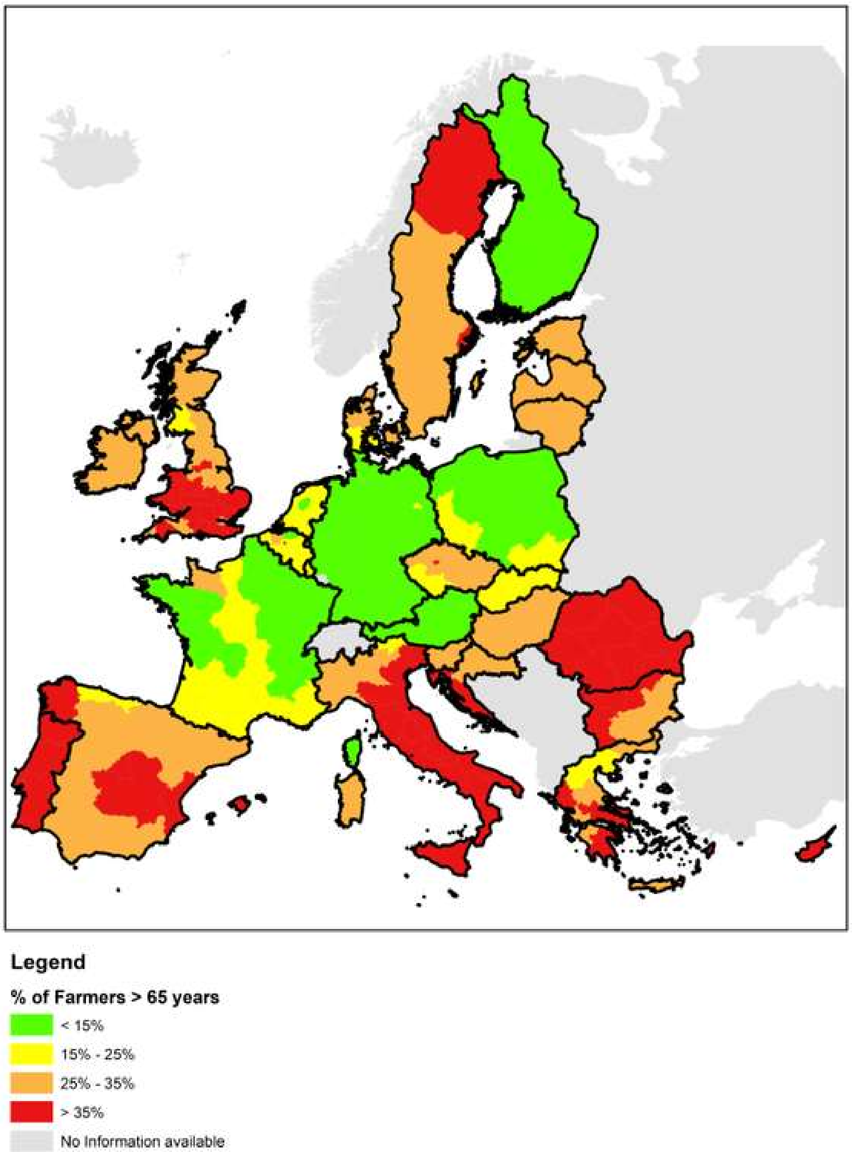



Figure 13.5 Share of farm holders aged >65 in 2016 (%). Source data: Eurostat.

**8. Agricultural land price**

The agricultural land price is the result of the demand and supply of land. In regions where agricultural is abandoned, the land demand goes down, while the supply goes up which results in lower land prices. This price is also determined by the quality of the land. If it overlaps strongly with marginal lands the yield and returns of these lands are low which also declines land rent levels. Finally, relative location of the agricultural land is influencing the price of land. In remote rural locations with low accessibility markets are difficult to reach for the production on the land. This also lower land rent prices, even of high quality soils. Given these three factors, land price is a good combined indicator for a combination of socio-economic driving forces of land abandonment discussed in Chapter 3.

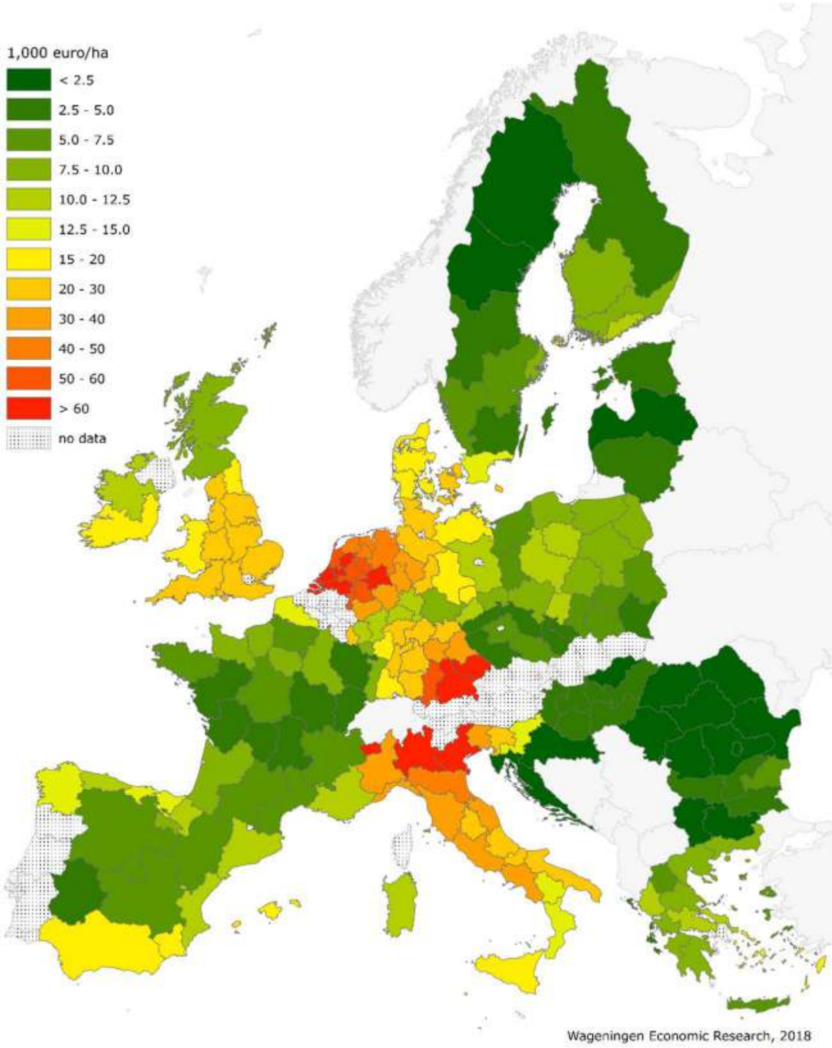



Figure 13.6 Regional (NUTS 2 level) a) agricultural land prices (euro/ha) in the EU, 2016 b) a) The United Kingdom at NUTS 1 level; b) Italy 2015. Source: Eurostat and German statistical offices, processed by Wageningen Economic Research (Silvis and Voskuilen, 2018).

**9. Differences in environmental and socio-political context**

The Environmental Stratification of Europe (EnS; Metzger et al. 2005; Jongman et al. 2006) forms the latest statistical classification of the European environment, distinguishing 84 strata at a 1 km2 resolution. The EnS consists of 84 strata, which have been aggregated into 13 environmental zones (EnZs) based on divisions of the mean first principal component score of the strata. The only exception is the Mediterranean mountain zone, which was separated based on altitude.

The EnS has been constructed using tried and tested statistical procedures so that the strata are unambiguously determined and, as far as possible, independent of personal bias. Twenty of the most relevant available environmental variables were selected for the construction of the stratification, based mainly on those identified by statistical screening (Bunce et al. 1996b). These were (1) climate variables from the Climatic Research Unit (CRU) TS1.2 dataset (Mitchell et al. 2004), (2) elevation and slope data from the United States Geological Survey HYDRO1k digital terrain model, and (3) indicators for oceanicity and northing. Data were analysed at 1 km$^2$ resolution. Principal component analysis

(PCA) was then used to compress 88% of the variation into three dimensions, which were subsequently clustered using an ISODATA clustering routine. The classification procedure is described in detail elsewhere (Metzger et al. 2005). The following 13 EnZs are distinguished and mapped in Figure 13.7 Here only 12 EnZs are important, as Anatolia (Turkey) is not covered in this project.

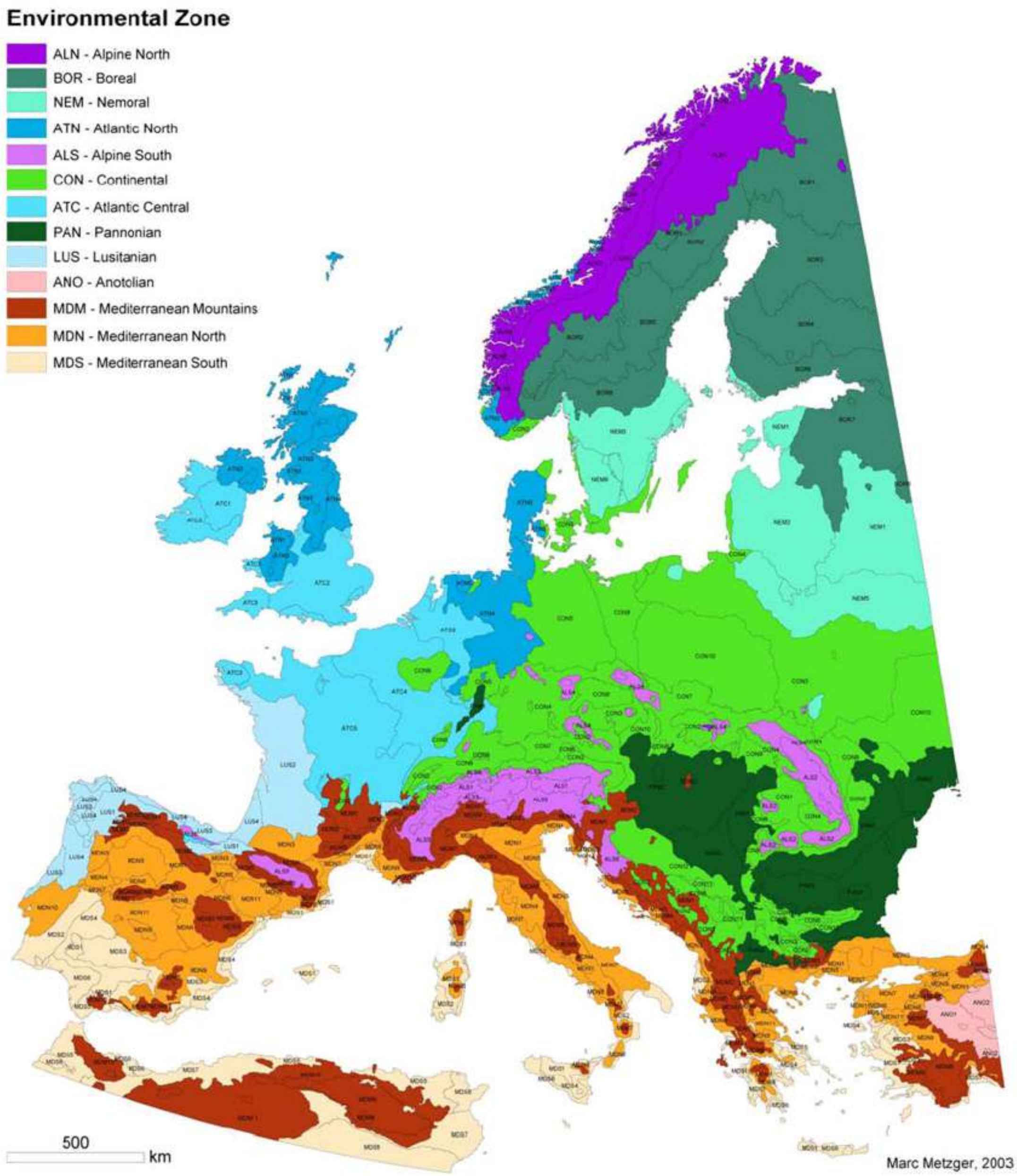



Figure 13.7 Environmental Stratification of Europe (EnS; Metzger et al. 2005; Jongman et al. 2006)

**Step 3 Combine with the regions with the highest incidence of land use change flows going towards loss of UAA and based on this selection of nine case study regions**

The above presented mapped drivers of land abandonment were combined with the long-term and short term decline of UAA data (Figure 2.8 in the main report). This resulted in a selection of 20 regions in the EU with highest integrated scores on all drivers. These 20 regions are presented in the map in Figure 13.8. All regions are characterized by a decline in UAA over the period 1975-2016, but show different combinations of values on the other criteria.

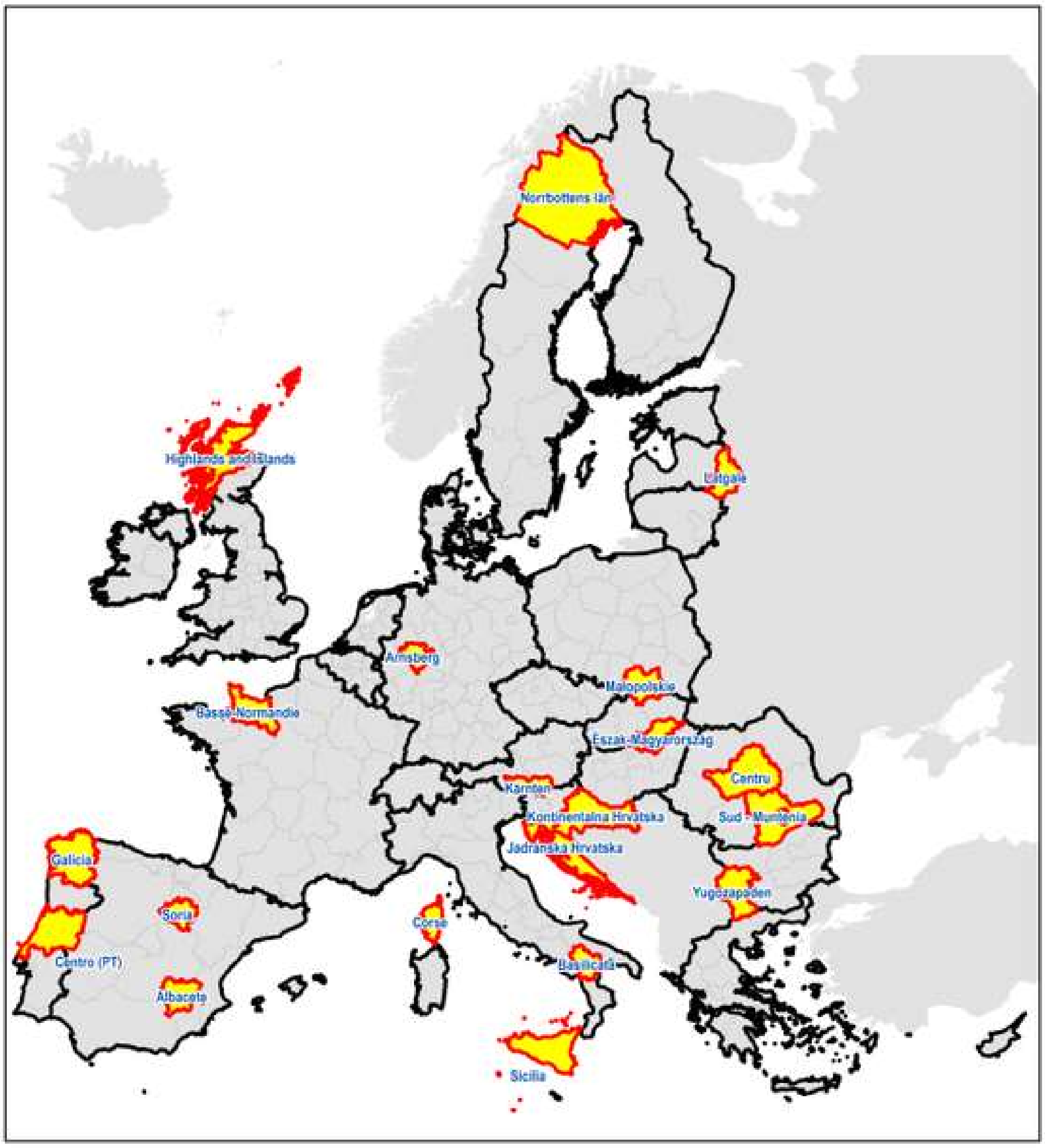



Figure 13.8 Preliminary selection of case study regions with farmland abandonment.

To limit the 20 regions to the nine case study regions for this study a further diversity in selection was ensured by ensuring representation of regions in different Environmental zones and also coverage of 'old' EU Member States and more recently accessed EU Member States (see Table 13.1).

| NUTS2 | NUTS3 | NUTS3Name | NAME_ASCI | NAME_ENGL | Change_UAA_long | Change_UAA_short | LCF_Signs_shift_abandonment | LCF_Abandonment_inclN2K | Change_popDensity | Change_ruralHousehold | Farmholders>65 | MarginalAreas | ArableLandPrice | YearOfEntry | EnvZone | EnvZone2 | Average score | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT21 | | | Karnten | Austria | 1 | 1 | 3 | 4 | 2 | 3 | 2 | 1 | n.a. | 1995 | ALP | | 2.1 | tourism gaining importance over agriculture? |
| BG41 | | | Yugozapaden | Bulgaria | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2007 | CON | ALP | 1.1 | |
| DEA5 | | | Arnsberg | Germany | 2 | 3 | 2 | 3 | 1 | 3 | 4 | 4 | 4 | 1958 | CON | ATL | 2.9 | inner-peripherical area between large cities in the core of Europe, outside main economic development |
| ES11 | | | Galicia | Spain | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 1 | 3 | 1986 | ATL | | 1.6 | |
| ES41 | ES417 | Soria | Castilla y Leon | Spain | 3 | 3 | 1 | 1 | 2 | 3 | 2 | 1 | 2 | 1986 | MED | | 2.0 | representative of the region, available field data |
| ES42 | ES421 | Albacete | Castilla-La Mancha | Spain | 2 | 2 | 1 | 1 | 3 | 4 | 1 | 1 | 2 | 1986 | MED | | 1.9 | representative of the region, available field data |
| FRD1 | | | Basse-Normandie | France | 2 | 3 | 4 | 4 | 3 | 1 | 2 | 3 | 2 | 1958 | ATL | | 2.7 | relatively high score for France; what is going on? |
| FRM0 | | | Corse | France | 1 | 4 | 1 | 2 | 4 | 4 | 4 | 1 | n.a. | 1958 | MED | | 2.6 | relatively high score for France; what is going on? Choice between Sicily |
| HR03 | | | Jadranska Hrvatska | Croatia | 1 | 4 | 2 | 1 | 2 | 3 | 1 | 1 | 1 | 2013 | MED | | 1.8 | available field data |
| HR04 | | | Kontinentalna Hrvatska | Croatia | 1 | 4 | 4 | 3 | 1 | 1 | 2 | 3 | 1 | 2013 | CON | | 2.2 | available field data |
| HU31 | | | Eszak-Magyarorszag | Hungary | 1 | 4 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 2004 | PAN | | 1.9 | unique biogeographical region in the sleection; salinization; mining region |
| ITF5 | | | Basilicata | Italy | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 3 | 3 | 1958 | MED | | 1.8 | |
| ITG1 | | | Sicilia | Italy | 1 | 4 | 3 | 1 | 3 | 1 | 1 | 2 | 3 | 1958 | MED | | 2.1 | |
| LV00 | LV005 | Latgale | Latvija | Latvia | 2 | 4 | 1 | 2 | 1 | 3 | 2 | 1 | 1 | 2004 | BOR | | 1.9 | Estland could also have been selected, relatively large change in population density; border region with Russia |
| PL21 | | | Malopolskie | Poland | 2 | 1 | 2 | 3 | 2 | 1 | 3 | 3 | 2 | 2004 | CON | ATL | 2.1 | mining region |
| PT16 | | | Centro (PT) | Portugal | 3 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | n.a. | 1986 | MED | | 1.6 | north-Portugal could also have been selected; here higher short term decline of UAA; mining area; forest fires |
| RO12 | | | Centru | Romania | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2007 | CON | ALP | 1.3 | |
| RO31 | | | Sud - Muntenia | Romania | 2 | 2 | 3 | 3 | 1 | 1 | 1 | 4 | 1 | 2007 | CON | ALP | 2.0 | |
| SE33 | SE332 | Norbotten | Ovre Norrland | Sweden | 1 | 1 | 2 | 1 | 2 | 4 | 1 | 1 | 1 | 1995 | ATL | | 1.6 | mining region |
| UKM6 | | | Highlands and Islands | United Kingdom | 2 | 3 | 1 | 1 | 3 | 3 | 2 | 1 | 3 | 1973 | ALP | BOR | 2.1 | grazing areas |
| | | | | | | | | | | | | | | | | | | |
| | | | | Average score | 1.6 | 2.4 | 2.0 | 1.9 | 1.9 | 2.3 | 1.8 | 2.0 | 1.9 | | | | | |

Table 13.1 Combined  scores for drivers of abandonment and other EU stratification  factors for the nine selected regional case study regions

# 14 ANNEX VII SUMMARY OF BARRIERS AND OPPORTUNITIES FOR BRINGING UNUSED, ABANDONED AND DEGRADED LANDS BACK INTO USE

Table 14.1 Summary of main barriers and opportunities for land conversions to biomass crops for energy and other non-food uses

| Land use conversions & type of biomass crops | Opportunities | Barriers |
|---|---|---|
| **Socio-economic aspects** | | |
| **Unused/abandoned degraded lands to annual non-food (oil & multipurpose) crops** | Avoids ILUC. May create additional employment, income, income diversification particularly for high quality oil, starch, fibre crops where market demand is developed and market prices are high enough to cover cost. | Limited financial attractiveness for farmers. Farmers are not familiar with these crops. Economic returns may be too low particularly in beginning but also if lands are very marginal. If perennials and agroforestry systems are established it may take several years before returns are delivered and investments can be earned back |
| **Unused/abandoned/severely degraded lands to perennial herbaceous or woody crops** | Avoids ILUC. May create additional employment, income, income diversification and may help to local energy resources | |
| **Unused/abandoned/severely degraded lands agroforestry systems** | Avoids ILUC. May create additional employment, income, income diversification and may help to local energy resources | |
| **Soil quality aspects** | | |
| **Unused/abandoned degraded lands to annual non-food (oil & multipurpose) crops** | On bare (black)unused, abandoned, degraded lands the establishment of any crop that will create a soil cover will help stabilising the soil. | Management in a rotational arable crop will imply more soil disturbance and therefore higher risk for loss of nutrients and carbon through wind and run-off erosion. Risks for soil quality loss in rotational arable systems are much larger as compared to leaving land unused that has already spontaneous vegetation growing on it on and soil loss. |
| **Unused/abandoned/severely degraded lands to perennial herbaceous or woody crops** | Perennial crops are effective in reducing soil erosion and building up soil carbon. The continuous ground coverage, the low soil disturbance, and the large rooting systems are reasons for this. | The effect on soil carbon by perennials very much dependents on the land use before. Clearing and tillage of grasslands long abandoned lands with dense shrub and/or forest vegetation coverage or wetlands, for the purpose of perennial biomass crops results in serious decline in carbon (both above and below soil). These carbon losses for which the restoration period is variable and depending on the yield may not be compensated within the plantation lifetime of the new perennial. |

| Land use conversions & type of biomass crops | Opportunities | Barriers |
|---|---|---|
| **Unused/abandoned/severely degraded lands agroforestry systems** | Agroforestry are better in erosion control and overall maintenance of the soil fertility then conventional single forestry, cropping or pasture systems. | The effect on soil carbon by agroforestry systems very much dependents on the land use before, the type of agroforestry system and the establishment. (See above) |
| **Water quality aspects** | | |
| **Unused/abandoned degraded lands to annual non-food (oil & multipurpose) crops** | **No opportunities** | In arable (row) crops there is very frequent multi-annual field activities. This involve strong disturbance of the soil or leave the soil bare for a shorter or longer time, which enhances turnover of nutrients, increase the potential risk of loss of nitrogenous and phosphorus compounds, through surface runoff and soil erosion into water resources.<br>Inputs in arable crops that may affect water quality are always higher then when lands are left unused, unless these crops are established on bare unused and degraded soils where any newly create a soil cover will help stabilising the soil. |
| **Unused/abandoned/severely degraded lands to perennial herbaceous or woody crops** | Perennials have low lower soil disturbance, year-round soil coverage and deep rooting which explains very low nutrient leaching to water. The deep and well branched roots in all of these perennials make that they hold large amounts of water and nutrients. Many perennial biomass crops have an increased nitrogen uptake from air and/or through fine root system and/or translocation of nutrients to the root system before the crop is harvested. In perennials water transpiration rates are high and this reduces water drainage and leaching. | Cropping activities, even in perennial crops always lead to some soil disturbance and losses of inputs (fertilisers & pesticides) through surface runoff and soil erosion into water resources and through air. So even in perennials the effect on water quality will mostly be higher than when lands are left unused, unless these crops are established on bare unused and degraded soils where any newly create a soil cover will help stabilising the soil. |
| **Unused/abandoned/severely degraded lands agroforestry systems** | Adverse water quality effects of agroforestry systems are very limited as in several studies it is indicated that the use of herbicides, pesticides and nutrient inputs is generally lower in agroforestry systems as compared to mono-cultural cropping systems and intensive grazing systems | Cropping activities, even in agroforestry, always lead to some soil disturbance and losses of inputs (fertilisers & pesticides) through surface runoff and soil erosion into water resources and through air. So in sylvoarable agroforestry the effect on water quality will mostly be higher than when lands are left unused, unless these crops are established on bare unused and degraded soils where any newly create a soil cover will help stabilising the soil. |
| **Water quantity** | | |

| Land use conversions & type of biomass crops | Opportunities | Barriers |
|---|---|---|
| **Unused/abandoned degraded lands to annual non-food (oil & multipurpose) crops** | There are several industrial oil crops (producing non-edible oils), that are drought tolerant. The yields may not be so high in these circumstances, but plants at least survive.<br>Non-food crops can be irrigated with waste water. | In drought prone areas additional establishment of crops may increase unsustainable water use through irrigation. |
| **Unused/abandoned/severely degraded lands to perennial herbaceous or woody crops** | The building up of below ground biomass (and facilitates access to water resources particularly in arid circumstances. Perennial biomass crops, particularly those of C4 photosynthetic group are more water efficient which implies that they transpire less water per unit biomass.<br>Non-food crops can be irrigated with waste water. | In drought prone areas additional establishment of crops may increase unsustainable water use. This may happen when irrigation is used, but also in rainfed situation where deep rooting perennials may deplete ground water. |
| **Unused/abandoned/severely degraded lands agroforestry systems** | Agroforestry entails integrating woody with crop and/or animal production systems to create shading which reduces the water loss through evaporation and enables higher efficiency in water use. The deep rooting system in trees and shrubs ensure that these systems cope well with long drought periods. | In drought prone areas additional establishment of trees, shrubs and/or crops may increase unsustainable water use. This may happen when irrigation is used, but also in rainfed situation where deep rooting trees may deplete ground water. |
| **Air and climate** | | |
| **Unused/abandoned degraded lands to annual non-food (oil & multipurpose) crops** | Some compensation for the GHG emissions in the crop phase can be reached when annuals are used as feedstock for energy or other non-food applications which are otherwise based on fossil feedstock. | Application of fertilizers, manure in arable crops leads to nitrification and denitrification in the field through $N_2O$ (and NOx) that is released to the air are always higher then when lands are left unused. Furthermore, annual row crops, particularly in temperate climates, have a long period of absence of plants and thus plant uptake of nitrogen which increases $N_2O$ emissions further. |
| **Unused/abandoned/severely degraded lands to perennial herbaceous or woody crops** | Perennials can compensate the emissions of GHG in the cropping phase through the strong capture of carbon below and above ground during the plantation phase and through use as alternative to fossil feedstock to avoid fossil based emissions. | Perennial biomass crops, even though they require low levels of fertilisation and mechanisation, certainly as compared to annual crops, still release nitrous oxide and CO2 to the atmosphere during cropping. |
| **Unused/abandoned/severely degraded lands agroforestry systems** | The perennial crops used in agroforestry systems can compensate the emissions of GHG in the cropping phase through the strong capture of carbon below and above ground and when it delivers biofeedstock for use as alternative to fossil feedstock to avoid fossil based emissions. | Perennial and annual crops in agro-forstry systems, even though they require low levels of fertilisation and mechanisation, still release nitrous oxide and CO2 to the atmosphere during cropping. |

| Land use conversions & type of biomass crops | Opportunities | Barriers |
|---|---|---|
| **Biodiversity** | | |
| **Unused/abandoned degraded lands to annual non-food (oil & multipurpose) crops** | New bioenergy plantations can be created in a more strategic way that considers landscape context and is sensitive as to how they affect biodiversity and ecosystem services. This involves planning the spatial arrangement of bioenergy plantations so that they interact positively with other landscape units. | If a shift takes place from no land use to a rotational arable crop this may lead to higher input use and tillage. This will have negative implications for overall habitat quality in terms of soil, water quality on soil and water quality and subsequently soil organisms. A shift from vegetated abandoned lands to rotational arable will diminish shelter and breeding opportunities for mammals and birds and will diminish the floristic diversity that was present in the abandoned land. Introduction of rotational crops on unused lands may lead to loss of fallow lands, which are an important habitat for species from a range of biota. If permanent grasslands are converted to arable this will have negative impacts on biodiversity and especially ground nesting birds. |
| **Unused/abandoned/severely degraded lands to perennial herbaceous or woody crops** | Some species (certain birds and small mammals) might profit from introduction of perennial crops in typical open monotonous permanent grassland or arable landscapes as they provide additional new landscape structural diversity and shelter and nesting opportunities. | Any shift from abandonment to perennial biomass cropping will generally lead to increases in input uses, more mechanisation and changes of landscape structure. This will have negative implications for habitat quality and landscape structure. If degraded lands are exchanged with perennials, the effects for biodiversity could be beneficial however. |
| **Unused/abandoned/severely degraded lands agroforestry systems** | As compared to unused, abandoned and degraded lands the introduction of agroforestry systems will provide a more diverse landscape structure creating wider diversity which may be beneficial for a wider range of species in different biodiversity strata. This applies both in relation to more open unused and abandoned lands, but also as compared to unused and abandoned lands with a full shrub and/or tree cover. | |

# 15 ANNEX VIII CASE STUDY DATA COLLECTION PROTOCOL

Information on the occurrence of unused, abandoned and degraded land in the case study regions and drivers was derived from interviews with 65 stakeholders. The numbers of respondents according to type of stakeholder and country and the number of responses are shown in Table 15.1**Error! Reference source not found.** and Table 15.2.

Table 15.1 Number (nr) of respondents in case studies according to stakeholder type.

| Stakeholder type | Nr of respondents |
|---|---|
| **cadastral office** | 3 |
| **environmental NGO** | 5 |
| **expert** | 1 |
| **farm advisor** | 5 |
| **farmer** | 7 |
| **farmer association** | 10 |
| **local government official (municipal level)** | 6 |
| **local government official (regional level)** | 9 |
| **local rural development organisation** | 8 |
| **national government official** | 3 |
| **Researcher** | 6 |
| **technician from national government institute** | 1 |
| **regional research office** | 1 |
| **Total** | 65 |

Table 15.2 Number (nr) of respondents in case studies per country and for questions on occurrence of land types, drivers of abandonment/non-use and degradation.

| Country | Region | Nr of respondents | Nr of respondents occurrence | Nr of respondents drivers | Nr of respondents degradation |
|---|---|---|---|---|---|
| **Bulgaria** | Blagoevgrad | 6 | 6 | 6 | 6 |
| **Croatia** | Kontinentalna Hrvatska | 10 | 5 | 6 | 1 |
| **France** | Normandie | 7 | 6 | 7 | 6 |
| **Hungary** | Észak-Magyarország | 11 | 6 | 4 | 5 |
| **Italy** | Sicily | 6 | 6 | 6 | 4 |
| **Latvia** | Latgale | 5 | 5 | 5 | 4 |
| **Portugal** | Beiras e Serra da Estrela | 8 | 6 | 7 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| **Spain** | Soria | 6 | 5 | 6 | 6 |
| **Romania** | Braşov | 6 | 6 | 7 | 1 |
| **Total** | | **65** | **51** | 54 | 38 |

# 16 ANNEX IX POLICY OVERVIEW

Table 16.1 EU policies with the potential to influence land transitions in and out of agricultural use

| Policy | | Potential way it influences land use transitions |
|---|---|---|
| | | **Policies providing financial assistance to rural areas and rural land** |
| Common Agricultural Policy<br>- Pillar 1 support<br>- Pillar 2 support | Regulation (EU) No 1305/2013<br>Regulation (EU) No 1306/2013<br>Regulation (EU) No 1307/2013<br><br>Proposals for the CAP for the 2022-27 period are currently under negotiation. | Pillar 1 support provides direct payments to farmers to support incomes, with an option to provide additional support to small farms, young farmers and areas facing natural constraints as well as coupled for certain crops and livestock in most Member States. 30% of direct payments are allocated to 'greening' measures currently.RCIn the future it is proposed these will be replaced by an 'eco-scheme'. These measures support the viability of farming activities and as such can help maintain land under agricultural use that might otherwise be abandoned, particularly in systems that are economically vulnerable.<br>Pillar 2 support provides a range of different types of support targeted at economic, social and environmental / climate objectives, including area payments (agri-environment-climate / organic farming), compensation payments to Areas facing Natural Constraints (ANC), as well as payments for investments on farm, support for business start-up, diversification, forest creation and management, support for the establishment costs and initial maintenance of agroforestry systems, cooperation, advice etc. Member States have the freedom to use and design these measures to meet their priorities, including to counter drivers of land abandonment, but also to increase the area of woodland on both agricultural and non-agricultural land. |
| Structural Funds<br>- Cohesion Fund<br>- European Regional Development Fund | Regulation (EU) No 1300/2013<br>Regulation (EU) No 1301/2013 | The European Regional Development Fund (ERDF) aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions. Action to promote low-carbon economies, the environment and strengthening research, technological development and innovation are amongst the 11 priority themes for the 2014-2020 period. Investments can be made that strengthen the bioeconomy, including finding way of increasing the production of sustainable biomass and the infrastructure that supports this.<br>The Cohesion Fund (CF) is aimed at Member States whose Gross National Income (GNI) per inhabitant is less than 90 % of the EU average. It aims to reduce economic and social disparities and to promote sustainable development. Environmental projects are a key category for investment, including projects related to energy, as long as they clearly benefit the environment in terms of *inter alia* the use of renewable energy. |
| LIFE Programme | Regulation (EU) No 1293/2013 | The LIFE programme can provide financial support to achieve environmental/climate goals under its sub programmes. These may directly or indirectly support bringing back land into active use or preventing it from becoming abandoned. Funding is of two types: grants of around 55-60% for traditional, integrated and preparatory projects; and financial instruments, for example the Natural Capital Financing Facility (NCFF), that provides tailored loans and investments, backed by an EU guarantee. |

| Policy | | Potential way it influences land use transitions |
|---|---|---|
| **Environmental policies** | | |
| Habitats Directive | Directive 92/43/EC | The Habitats Directive requires the establishment of the Natura 2000 network to maintain and restore Annex 1 habitats and Annex II species to favourable conservation status and to manage features in the wider landscape of major importance for flora and fauna. Since achieving favourable conservation status of many of the relevant habitats and species, as well as the landscape features on which they depend, relies on the continuation of agricultural practices, the designation of the Natura 2000 network and requirements for the management of these areas should help keep land under appropriate agricultural management and help constrain it from becoming abandoned. In other cases there may be a requirement to cease certain agricultural practices, if not to abandon farming. |
| Birds Directive | Directive 2009/147/EC | The conservation measures (Art 3, 4) require the preservation, maintenance or re-establishment of habitats necessary to protect the birds covered by the Directive and to avoid the pollution or deterioration of these habitats. Since a number of these habitats involve areas of farmland, the measures taken should help maintain land under appropriate agricultural management and help constrain it from becoming abandoned. (previous point re 92/43 applies here too) |
| Floods Directive | Directive 2007/60/EC | Member States are obliged to put in place Flood Risk Management Plans. The tools adopted by Member States should help manage flood risk, thereby reducing the resilience of land to flood events and helping avoid the degradation of these areas and their potential loss from agricultural production. The plans could also promote the development of woodland areas to mitigate flood risk, which would take land out of agricultural production. |
| Water Framework Directive | Directive 2000/60/EC | Member States are obliged to develop River Basin Management Plans under the Water Framework Directive. These set out the objectives and actions required to protect and improve the water environment to meet the WFD objectives (namely to enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands, promote the sustainable use of water and reduce water pollution and ultimately to achieve good ecological status of all water bodies. Since water and land resources are closely linked river basin management plans also inform decisions on land-use planning and work alongside other strategies, such as flood risk management plans |
| **Climate Policies** | | |
| RED (to end 2020)<br><br>Recast RED II | Directive 2009/28/EC (in force to end 2020)<br>Directive (EU) 2018/2001 and | The Recast RED II sets a binding target of 32% for renewable energy sources in the EU's energy mix by 2030. It includes sustainability criteria for biomass feedstocks if they are to be eligible to contribute to the EU target, GHG criteria for solid and gaseous biomass fuels and defines feedstocks with high risk of Indirect Land Use Change (ILUC). The Directive states that if energy crops grown on abandoned or degraded agricultural land (as defined) would be considered as meeting the sustainability criteria and therefore may indirectly influence abandoned or degraded land being brought back into production for this purpose. |

| Policy | | Potential way it influences land use transitions |
|---|---|---|
| | Delegated Regulation (EU) 2019/807 | |
| Land Use, Land Use Change and Forestry Regulation (LULUCF) | Regulation (EU) 2018/841<br><br>Decision No 529/2013/EU (in force to end 2020 only) | Covers emissions and removals from: managed forest land, afforested land, deforested land, managed cropland, managed grassland, managed wetlands, settlements and other land, harvested wood products. The Regulation establishes a 'no-debit' target for Member States, which means that any debit in the LULUCF sector must be compensated by credits. This may influence Member States in their decisions relating to land use, particularly to improve the sustainable management of agricultural (and forest) areas to minimize carbon emissions and to increase their forest area to meet the 'no-debit' target. This could be at the expense of agricultural land. |
| Effort Sharing Regulation | Regulation (EU) 2018/842 | The ESR establishes national binding emission reduction targets for each Member State. It also establishes limited flexibility for MS to use credits from the LULUCF sector to achieve the national targets. Although there are no sector specific targets set for agriculture, in some Member States where agriculture contributes to a significant proportion of GHG emissions, these targets may influence choices about land use, potentially influencing the sustainable management of soils (thereby preventing land degradation) or increasing the prevalence of woody features or tree planting, thereby taking land out of agricultural production, but potentially to produce another form of energy feedstock. |
| EU Adaptation Strategy | COM(2013) 216 final | Aims to make the EU more climate-resilient by encouraging Member States to prepare for and reduce their vulnerability to the impacts of climate change. |
| Regulation on the Governance of the Energy Union and climate action | Regulation (EU)2018/1999 | Requires Member States to prepare National Energy and Climate Plans (NECPs) for the period 2021-2030 – in these they must set out how agriculture and forests will contribute to the EU's 2030 climate targets. The actions identified in these will influence land use /management choices nationally, including decisions about increasing forest area and potential land use changes away from agriculture. |
| **Planning Policies** | | |
| EIA Directive | Directive 2011/92/EU | This requires Member States to act to minimise environmental damage from agricultural developments and other 'projects' in rural areas including the restructuring of agricultural land, the conversion of uncultivated or semi-natural habitats to intensive agricultural management, and initial afforestation and deforestation for the purposes of conversion to another type of land use. As such it should protect environmentally valuable sites from being cultivated or their management and land use intensified or substantially changed. In practice, the frameworks and criteria introduced by Member States for screening whether or not a full environmental assessment of projects for restructuring or intensifying or afforesting agricultural land have been found to be generally weak, effectively exempting most such projects (COWI, 2009; IEEP, 2010). |

| Policy | | Potential way it influences land use transitions |
|---|---|---|
| State Aid rules relating to certain categories of aid in the agriculture and forest sectors | Commission Regulation (EU) No 702/2014 | These State Aid rules allow for funding to be provided by the public sector to be provided to the agricultural and forest sector that are outside the scope of Article 42 of the Treaty insofar as such aid is granted in accordance with Regulation (EU) No 1305/2013 and is either co-financed by the European Agricultural Fund for Rural Development (EAFRD) or granted as additional national financing for such co-financed measures'<br><br>It specifically allows for the following types of aid relevant to land abandonment or the use of agricultural land for biomass production:<br>- Investments in tangible assets or intangible assets on agricultural holdings linked to primary agricultural production in certain circumstances as long as certain criteria are met. Investments for which aid is permitted include those for the production at farm-level of biofuels or of energy from renewable sources, provided that such production does not exceed the average annual consumption of fuels or energy of the given farm (Article 14). This allows for investments necessary to support bioenergy production at farm level<br>- Aid for agricultural land consolidation (Article 15) which can be used to reduce fragmentary abandonment.<br>- Aid for investments concerning the relocation of farm buildings (Article 16)<br>- Start-up aid for young farmers and the development of small farms (Article 18)<br>- Aid for agroforestry systems (Article 33) |

# 17 ANNEX X NON-AGRICULTURAL LAND

The shortlist selection criteria are: (1) size of available land, (2) expected practical feasibility, (3) level of interference with ongoing activities, (4) expected financial viability.

Table 17.1 Longlist of non-agricultural land categories and reasoning for inclusion or exclusion from shortlist.

| Category | Selected for short list? | Description | Reasoning for exclusion from short list |
|---|---|---|---|
| **Closed landfills** | YES | historic waste landfills that are currently closed | high order of magnitude of available land area |
| **City greening plans** | YES | city/municipal plans for green spaces in urban areas | high order of magnitude of available land area |
| **Military terrain** | YES | military owned land used for training, etc. only partially used | high order of magnitude of available land area |
| **PV farms** | YES | photovoltaic plants with solar panels | high order of magnitude of available land area and financial viability |
| **Former mining facilities** | YES | land formerly used for mining of materials such as metals or minerals | high order of magnitude of available land area and co-benefits of remediation |
| **Roadside** | YES | strips of land along roads and highways | area is already landscaped by government and has unused waste streams |
| **Desertified land** | YES | degraded land in drylands with bioproductivity loss | high order of magnitude of available land area |
| **Closed quarries** | YES | former aggregate mines | potential co-benefits of remediation |
| **Airports** | YES | unused land at airports, e.g. along runways | financial viability and high practical feasibility |
| **Railroads sides** | YES | strips of land along railway lines | area is already landscaped by government and has unused waste streams |
| **Brownfields general** | YES | previously developed land (typically industrial) that is often contaminated | co-benefits of remediation |
| **Closed coal mines** | YES | former surface coal mining facilities | potential co-benefits of remediation and public support |
| **Saline land** | YES | land with reduced soil fertility due to accumulation of salts | high order of magnitude of available land area |
| **Onshore wind farms** | NO | wind turbine farms that are on land | high perceived level of interference with ongoing activities- most is already agricultural and/or topography is not suitable for biomass growth |
| **Burned areas** | NO | land that has been burned due to wildfires or other causes | most is previously forested or agricultural and some MS have legislation to return back to natural land |
| **Golf courses** | NO | recreational areas for golf | low practical feasibility |
| **Green roofs** | NO | building partially or completely covered with vegetation | small order of magnitude of available land area and low practical feasibility- grouped with city greening plans |
| **Power plants** | NO | electricity generating plants | small order of magnitude of available land area |
| **Abandoned salt pans** | NO | land previously used for salt production | still suitable for algae, but likely not for crops |
| **Peatland** | NO | degraded or drained peatlands with potential for restoration | peat restoration focused on maintaining carbon stocks and no harvesting of grown biomass, negative public support |

| | | | |
|---|---|---|---|
| **Sound panels roadside** | NO | panels on highways used to block noise pollution | small order of magnitude of available land area and low practical feasibility |
| **Abandoned car parks** | NO | land previously used for parking for cars | most will be developed as they are primarily in urban areas |
| **Flood prone land** | NO | land prone to flooding | other crops more suitable for flood prevention and much of this land overlaps with agricultural land |
| **Acidic soils** | NO | degraded land with high soil acidity | large overlap with agricultural land |
| **Land with open permitting** | NO | temporarily unused land while permitting being processed | difficult to estimate available area and may overlap too much with other categories |
| **Land reclamation** | NO | new land created from filling oceans, seas, riverbeds or lakes | potentially infinite available area and low feasibility |
| **Unstable land** | NO | land prone to landslides | low practical feasibility and other crops are more suitable for landslide prevention |
| **Energy infrastructure** | NO | unused land in areas of energy generation or distribution | small order of magnitude of available land area and large overlap with other categories |

Table 17.2 Details of barriers and opportunities for shortlist non-agricultural land categories (green indicates opportunity and red indicates barrier).

| Land category group | Land category | Barrier/Opportunity category | Description |
|---|---|---|---|
| Brownfields | Closed landfills | Environmental | Potential to remediate contaminated soils. |
| | | Ongoing initiative | There are existing European to integrate and improve policy instruments for landfill management projects.[85] Also, bioenergy crop cultivation for landfill remediation has been demonstrated by waste management companies.[86] |
| | | Economic | Bioenergy crop cultivation could help to reduce costs of landfill remediation projects by generating additional income. |
| | | Policy and regulation | The Landfill Directive requires operators are responsible for the maintenance, monitoring, and control of the landfill and its potential hazards.[87] Also, the revised waste proposal includes "A binding landfill target to reduce landfill to maximum of 10% of municipal waste by 2030" so it is expected that the number of closed landfills will increase in the coming decades.[88] |
| | | Public perception | The public generally supports the closing of landfills and rehabilitation of these. |
| | | Environmental | Landfills have contaminated soils and could limit crop yields. |
| | | Ongoing initiative | There are EU circularity projects focused on the enhanced mining of landfills.[89] Cultivating bioenergy crops would only be possible after the landfills have been mined for their secondary raw materials which could delay bioenergy crop cultivation. |
| | Closed coal mines | Environmental | Bioenergy crop could aid in rehabilitating land, such as improving soil quality and biodiversity. |
| | | Ongoing initiative | There are EU initiatives focusing on transitioning coal region, that assists regions to prepare and implement transition activities, and bioenergy could be part of this transition package.[90] |
| | | Economic | Decommissioning coal mines has associated job losses and socio-economic decline which additional income and jobs for bioenergy growth could mitigate.[91] |
| | | Public perception | The public generally supports the closing of coal mines and rehabilitation of these. |
| | | Environmental | Closed coal mines have very contaminated soils which could limit crop yields. |
| | | Economic | Bioenergy cultivation could be more costly if yields are low. |
| | Closed quarries | Environmental | Bioenergy crop could aid in rehabilitating land, such as improving soil quality and biodiversity. |
| | | Ongoing initiative | Aggregate companies (like cement) are active in rehabilitation projects.[92] |
| | | Economic | Bioenergy crop cultivation could help to reduce costs of quarry remediation projects by providing additional income. |
| | | Ongoing initiative | Many quarry rehabilitation projects highly focus on increasing biodiversity and might be opposed to monoculture bioenergy crops.[93,94] |
| | | Environmental | Rocks and minerals are mined from quarries so soil might not be suitable for bioenergy crop growth. |
| | | Economic | Bioenergy cultivation could be more costly if yields are low due to low soil quality. |
| | Closed mining waste facilities | Environmental | Bioenergy crop could aid in rehabilitating land, such as improving soil quality and biodiversity. |
| | | Economic | Bioenergy crop cultivation could help to reduce costs of mining waste remediation projects by providing additional income. |
| | | Ongoing initiative | There is good documentation of closed waste facilities from extractive industries, as it is part of a directive (Article 20 of Directive 2006/21/EC). There is also funding from the European Development Fund and the Cohesion Fund for the decontamination of brownfield sites, including for abandoned mining waste facilities.[95] |
| | | Public perception | Could be well perceived by the public. |
| | | Policy and regulation | Plans for closure and site clean-up are part of the permitting of the site, so new bioenergy projects would mostly likely only be possible for new mines that eventually close. |
| | | Environmental | Mining waste typically consists of tailings and waste-rock which may not be conducive for biomass growth because of the rocky material, pH levels, and other contaminants. |

| | | | |
|---|---|---|---|
| | | Economic | Bioenergy cultivation could be more costly if yields are low due to low soil quality. |
| | Brownfields general | Environmental | Bioenergy crop could aid in rehabilitating land, such as improving soil quality and biodiversity. |
| | | Ongoing initiative | There are several European and various national initiatives for the rehabilitation of brownfields. DG ENV is actively working on this topic.[96] Successful pilots using biomass to remediate brownfields have also been demonstrated in the EU.[97] |
| | | Economic | Bioenergy crop cultivation could help to reduce costs of brownfield remediation projects by creating additional income. |
| | | Public perception | Could be well perceived by the public. |
| | | Environmental | Brownfields are typically contaminated or degraded. These conditions (pH, metal content) may limit crop yields. |
| Abandoned agricultural land | Desertified land | Ongoing initiative | Desertification is being recognised as a larger and larger problem and the countries that have declared desertification a problem are Bulgaria, Greece, Spain, Croatia, Italy, Cyprus, Latvia, Hungary, Malta, Portugal, Romania, Slovenia and Slovakia.[98] |
| | | Environmental | Bioenergy crop could aid in rehabilitating degraded land. |
| | | Ongoing initiative | Much of desertified land is previously agricultural land and will aim to be restored back to this. |
| | | Economic | Bioenergy cultivation could be more costly if yields are low due to low soil quality. |
| | | Environmental | By definition, desertified land is land that has been wrought with drought and is no longer able to sustain conventional agricultural crops. Only very drought resistant bioenergy crops could be used on this type of land. |
| | Saline land | Environmental | Salinated land may increase $N_20$ emissions and reduce carbon storage, so the cultivation of bioenergy crops on this type of land could mitigate these issues. |
| | | Ongoing initiative | The EU Halosys Project focuses on cultivation of selected halophytes species on salt-affected soils with the aim of developing new value chains from obtained biomass.[99] |

[85] Consortium for a Coherent European Landfill Management Strategy. https://www.interregeurope.eu/cocoon/
[86] Energy Crops Harvested from FCC Landfill Sites (2013). https://waste-management-world.com/a/energy-crops-harvested-from-fcc-landfill-sites
[87] European Commission, Review of Waste Policy and Legislation. https://ec.europa.eu/environment/waste/target_review.htm
[88] European Commission, Landfill Waste. https://ec.europa.eu/environment/waste/landfill_index.htm
[89] EU training Network for Resource Recovery Through Enhanced Landfill Mining. https://new-mine.eu/project/
[90] European Commission, Coal regions in transition. https://ec.europa.eu/energy/en/topics/oil-gas-and-coal/EU-coal-regions/coal-regions-transition
[91] JRC, EU coal regions: opportunities and challenges ahead. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112593/kjna29292enn.pdf
[92] CemBureae, Rehabilitating quarries. http://useofcement.cembureau.eu/2018/11/19/rehabilitating-quarries-restoring-biodiversity-portugal-national-parks/
[93] UEPG, Biodiversity. http://www.uepg.eu/key-uepg-topics/case-studies/biodiversity
[94] European Network for Sustainable Quarrying and Mining, Biodiversity. https://ensqm.weebly.com/biodiversity.html
[95] European Commission, Closed and abandoned waste facilities. https://ec.europa.eu/environment/waste/mining/implementation.htm
[96] JRC, Conference on brownfield redevelopment in the EU. https://esdac.jrc.ec.europa.eu/event/conference-brownfield-redevelopment-eu
[97] Megharaj, Mallavarapu, and Ravi Naidu. "Soil and brownfield bioremediation." Microbial biotechnology 10.5 (2017): 1244-1249.
[98] Courthouse News, EU warned to do more on desertification. https://www.courthousenews.com/eu-warned-to-do-more-on-desertification/
[99] HalSYS Project. http://www.halosys.eu/

| | | | |
|---|---|---|---|
| | | Economic | Bioenergy crop cultivation could help to reduce costs of salinisation remediation projects by providing additional income. |
| | | Economic | Bioenergy cultivation could be more costly if yields are low due to low soil quality. |
| | | Environmental | There is limited productivity due to the toxicity of dissolved salts or the destruction of soil structure which reduces water infiltration capacity.[100] |
| Infrastructure landscaping | Roadside | Ongoing initiative | Roadsides are already maintained by governments and have unused waste streams. |
| | | Ongoing initiative | Crops needs to be at a safe distance from drivers and keep visibility for the safety of drivers. |
| | | Economic | The costs of cultivation could be high as roadside areas are narrow and cover long distances. |
| | Railside | Ongoing initiative | Railsides are already maintained by governments and have unused waste streams. |
| | | Ongoing initiative | Railsides need to kept clear so that there is no obstruction of trains. |
| | | Economic | The costs of cultivation could be high as railside areas are narrow and cover long distances. |
| | Green city planning | Environmental | Bioenergy crops in urban areas could help improve air quality. |
| | | Ongoing initiative | Many cities have city greening plans ambitions in place in which bioenergy crops could be integrated. |
| | | Ongoing initiative | City greening plans may prioritize functional (for residents) and utilizable green space over cropland. |
| | | Policy and regulation | Agricultural operation in urban areas might not be allowed in all instances. |
| Combined business | PV farms | Economic | Bioenergy crops could create additional income for PV farm developers or operators. |
| | | Economic | Bioenergy crops require high upfront investment which may be undesirable for developers. Crops could potentially cause shading and reduce the electricity produced. |
| | | Other | There is a risk of crops damaging PV equipment. |
| | Airports | Economic | In hot climates where flights are sometimes cancelled, bioenergy crops can have cooling effect. Crops also provide additional income. |
| | | Environmental | Bioenergy crops could improve air quality around airports which experience high emissions from fuel combustion and increase biodiversity. |
| | | Policy and regulation | Strict regulations concerning airport access and clearing (among others) could be restrictive. |
| | | Ongoing initiative | Airport farming could increase local animal population leading to collision hazards. |
| | Military terrain | Other | Military terrain cannot be used for most other activities besides agriculture because of security restrictions. |
| | | Economic | Bioenergy crops provide additional income. |
| | | Policy and regulation | Access to military terrains could be restricted at times because of security reasons. |

[100] JRC, Soil salinization. https://wad.jrc.ec.europa.eu/soilsalinization

# 18 ANNEX XI EXPERT INTERVIEW LISTS FOR NON-AGRICULTURAL LAND CASE STUDY ANALYSIS

Expert interviews were held to gain more insights in the three case studies presented in this chapter. For transparency, the lists of experts including organisations and affiliations are presented here.

Cast study: Closed Landfills

| Name | Organisation | Affiliation |
|---|---|---|
| **Eddie Wille** | Public Waste Agency of Flanders (OVAM) | Negotiator Brownfieldconvenants<br>Projects: RAWFILL, COCOON |
| **Michaël Van Raemdonck** | Public Waste Agency of Flanders (OVAM) | Projects: RAWFILL, COCOON |
| **Jan Frank Mars** | Ministry of infrastructure and water management (The Netherlands) | Department: Accountteam Bodem+<br>Projects: COCOON |

Case study: Airport land

| Name | Organisation | Affiliation |
|---|---|---|
| **Rosanne Blijleven** | Royal Schiphol Group | Compliance Specialist EASA |
| **Howard Davis** | WisDOT Bureau of Aeronautics (USA) | Manager Airport Compliance |
| **Michael Menon** | WisDOT Bureau of Aeronautics (USA) | Airport Safety & Operations Manager |
| **Yanniek Huisman** | Rotterdam The Hague Innovation Airport (RHIA) | Program coordinator |

Case study: Utility scale PV farms

| Name | Organisation | Affiliation |
|---|---|---|
| **Wijnand van Hooff** | Holland Solar<br>TKI Urban Energy (The Netherlands) | Director<br>Program manager 'Solar' |
| **Maximilian Trommsdorff** | Fraunhofer ISE (Germany) | Project Manager Agrophotovoltaics<br>Project: APV-RESOLA, SHRIMPS, |
| **Stephan Schindele** | Fraunhofer ISE (Germany) | Project manager Agrophotovoltaics |

# 19 ANNEX XII AREA DETAILS ON AIRPORTS

Table 19.1 Overview of total land area of airports per EU country and average imperviousness*.

| | Total area of airports ($km^2$) | Total area non-impervious ($km^2$) | % imperviousness | Number of airports (excluding grass-only) |
|---|---|---|---|---|
| *Austria* | 62.9 | 46.6 | 26.0% | 84 |
| *Belgium* | 129.6 | 102.1 | 21.2% | 52 |
| *Bulgaria* | 69.5 | 59.6 | 14.3% | 64 |
| *Croatia* | 32.0 | 25.3 | 20.9% | 43 |
| *Cyprus* | 23.7 | 19.9 | 16.0% | 6 |
| *Czech Republic* | 137.6 | 111.8 | 18.8% | 374 |
| *Denmark* | 123.1 | 100.4 | 18.4% | 98 |
| *Estonia* | 36.5 | 30.3 | 17.0% | 12 |
| *Finland* | 217.0 | 170.1 | 21.6% | 61 |
| *France* | 933.3 | 742.4 | 20.5% | 1722 |
| *Germany* | 871.8 | 636.9 | 26.9% | 965 |
| *Greece* | 135.3 | 106.7 | 21.1% | 61 |
| *Hungary* | 70.4 | 61.4 | 12.8% | 65 |
| *Irish Republic* | 59.5 | 47.9 | 19.5% | 51 |
| *Italy* | 367.7 | 277.2 | 24.6% | 555 |
| *Latvia* | 37.0 | 34.6 | 6.7% | 76 |
| *Lithuania* | 18.7 | 15.0 | 20.1% | 67 |
| *Luxembourg* | 7.9 | 5.1 | 36.1% | 3 |
| *Malta* | 5.2 | 3.7 | 29.8% | 2 |
| *Netherlands* | 173.9 | 136.9 | 21.3% | 67 |
| *Poland* | 308.1 | 262.1 | 14.9% | 254 |
| *Portugal* | 82.0 | 59.9 | 26.9% | 90 |
| *Romania* | 88.4 | 74.3 | 15.9% | 58 |
| *Slovakia* | 50.5 | 44.0 | 12.9% | 67 |
| *Slovenia* | 17.2 | 14.0 | 18.3% | 27 |
| *Spain* | 327.4 | 237.7 | 27.4% | 262 |
| *Sweden* | 283.9 | 220.9 | 22.2% | 255 |
| *United Kingdom* | 836.2 | 658.5 | 21.3% | 478 |
| *Grand total* | **5506.4** | **4305.3** | 21.8% | **5919** |

*Source: Open street map:
"Aeroways=aerodrome" https://wiki.openstreetmap.org/wiki/Key:aeroway?uselang=en