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Data sources to support land suitability assessments for bioenergy feedstocks in the EU – A review

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Disclaimer: The arguments expressed in this report are solely those of the authors, and do not reflect the opinion of any other party.

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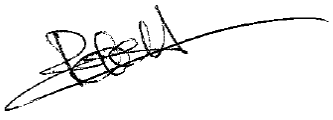
Preface by the European Climate Foundation

In December 2015, world leaders agreed a new deal for tackling the risks of climate change. Countries will now need to develop strategies for meeting their commitments under the Paris Agreement, largely via efforts to limit deforestation and to reduce the carbon intensity of their economies. In Europe, these climate protection strategies will be developed via the EU's 2030 climate and energy framework, with a view to ensuring an integrated single market for emissions reduction technologies.

Existing EU energy policy for 2020 foresees an important role for bioenergy as a means of reducing carbon emissions from heating, power and transport, and yet there are concerns that this has led to a number of negative consequences related to the intensification of resource-use. If bioenergy is to continue to play a role in EU energy strategies for 2030, it seems wise to learn from the past to ensure that this is done in a manner that is consistent with the EU's environmental goals, including the 2 degrees objective.

With this in mind, the European Climate Foundation has convened the *BioFrontiers* platform, bringing together stakeholders from industry and civil society to explore the conditions and boundaries under which supply-chains for advanced biofuels for transport might be developed in a sustainable manner. This builds on work developed in the ECF's *Wasted* platform in 2013-2014, which focused on waste- and residue-based feedstocks for advanced biofuels. This time around, there is an additional focus on considering land-using feedstocks and novel fuel technologies.

As the name *BioFrontiers* suggests, this discussion enters new territory and is faced with numerous gaps in knowledge. To facilitate a transparent and constructive debate between industry and civil society, the ECF has commissioned a number of studies to help fill such knowledge gaps. This is one such study. It does not represent the views of the members of the *BioFrontiers* platform, merely an input to their discussions. If this research also helps inform the wider debate on the sustainability of bioenergy, that is a bonus. I would like to thank the IEEP for using the resources provided by the ECF to improve our understanding of these important issues.



Pete Harrison
Programme Director, Transport
European Climate Foundation

1 Introduction to the study

This scoping study provides a brief review of the availability and utility of data that can be used to assess the potential areas of land that could be suitable for producing biomass for energy supply, in an agricultural context. The report begins with an introduction to land use and cover data and its interpretation before considering the principal sources of data available at the EU level and in three selected Member States. A discussion of the nature, availability and utility of data in this sphere of land use is provided. This report concludes with recommendations for future study that would be relevant to the sourcing of feedstocks.

Context: A range of existing strategic and sector specific policies are contributing to increased demand for bioresources for industrial purposes. In some cases this is explicit, such as the development of Member State bioeconomy strategies[1], or implicit through the development of sector specific policies that drive biomass demand, such as the EU Renewable Energy Directive (RED), and its implementation in EU Member States.

There is significant potential for the mobilisation of bioresources from non-land-using sources to meet these needs, as demonstrated in a number of existing studies[2]. However, it is clear that to meet a growing suite of demands, there will continue to be some primary production of biomass for this purpose. Understanding the scale of this resource, the potential to mobilise it, and the environmental and climate consequences of doing so, is important in addressing the ambition of the sectors that will rely ultimately on biomass. In assessments that have attempted to meet these aims, data availability has often been identified as a key limiting factor in coming to a confident assessment of the potentially available land in Europe, particularly that which could be used for increased biomass production (Estel *et* al, 2015; Allen *et* al, 2014; Khawaia and Janssen, 2014; Hart *et al*, 2013).

Aims: This scoping study is intended to inform decisions as to whether there are adequate data to undertake a more detailed future study to determine the area of specific land types that could be available for biomass production with limited impacts to both current agricultural production levels and the environment in the EU. The study provides an initial broad assessment of the potential for identifying the presence of land that might be suitable for dedicated biomass feedstock production, by using sources of land use or land type data that are available already. Such data has been collected for other purposes at various spatial scales but is not prepared or presented in a uniform way in the EU. The assessment exercise therefore involves the characterisation of these data sources, many of which are available in map form. It includes clarification of their primary purpose and the information they provide and then examination of how they contribute to the identification of land potentially suitable for biomass production. The study assesses the consistency, availability and content of data and information sources relating to relevant land uses at the pan-European level, and at Member State level for three selected countries: France, Italy and the Czech Republic[3].

[1] In line with the European Commission's bioeconomy strategy (EC, 2012)
[2] Such as Wasted (Harrison, P (ed.), 2014)
[3] The rationale for the selection of these three Member States is provided in Chapter 4.

The focus is on land in agricultural use or land that could be managed in an agricultural context[4], including "marginal" land rather than afforested and wooded land. Clearly wooded land is also a major source of biomass for industrial and energy purposes but is outside the scope of this study. The study also sets out the issues inherent in combining data and information from a variety of sources; the importance of understanding land use and land management terminology; and what land use and land cover information can tell us and what it cannot.

Scope: A number of studies have attempted to quantify how much land might be available for feedstock production. Some include environmental constraints on potential availability; others do not (Khawaia and Janssen, 2014). The most common approach to such assessments is to try to quantify the areas of potential land available for growing energy biomass that do not impact on current food and feed production. These assessments look primarily at land that is either not used for agricultural production currently (i.e. long term abandoned land, semi-natural land not managed through agriculture, contaminated or industrial land in other uses); or has only temporary or limited use for agricultural production (i.e. the marginally productive lands that may come in and out of production depending on commodity prices etc.). Other, less common approaches have taken a different view and have looked to assess the potential to increase production of crops on currently agricultural land, either through increasing yields, or changing crop production patterns (inter-cropping and catch crops)[5].

This study concerns itself primarily with the first (more common) approach, and has looked at whether the available data can be used to support the identification of currently unused land that could be considered sustainably available for biofuel production. This will help to understand the myriad claims made about land area potentials in relation to biofuels and bioenergy production in the EU. The study does not consider ways in which biomass production could be integrated to the existing agricultural production system. Whilst there may be merit in exploring such options, studies assessing potential for this type of bioenergy project are far less common, and would require a different approach to their review and understanding.

This study should not be considered as a comprehensive review of all available land use and cover datasets that relate to rural land in the EU. The review takes place within the specific context described above and therefore focuses on those data that can help us to understand land use patterns and availability in the EU. Two broad principles have been used to refine the scope of our assessment and help identify specific land use and cover datasets to review. These are:

- that the production of biomass should not compete with food or feed production; and
- that the production of biomass should not lead to significant adverse environmental impacts.

[4] i.e. land that requires, or could be brought under agricultural practices for its management

[5] This approach is gaining a lot of interest given the difficulties in identifying sustainable land areas.

2 Understanding land data and terminology

This chapter provides an introduction to understanding land use and land cover data used in the EU including what land use data are, what they can tell us about land as a resource, and importantly what they cannot. Key terms and definitions are described in order to provide a more consistent approach for studies that seek to compare or combine such data in future.

2.1 Making appropriate assessments

Land cover data provides a means of describing the vegetative or non-vegetative cover at the Earth's surface, for example forests, cropland, grassland or urban areas. Land use data describes how those land covers are being utilised by society, for example forestry, agriculture, recreation or habitation. Land use and cover data can be thought of as describing ***what*** the land is, how it is distributed and what it is being used for.

It is important to recognise that the majority of land use datasets describe the direct human utilisation of land for productive or economic purposes. Whilst this is helpful to describe the reasons why land is being used, this approach misses a whole range of other services that are provided by land, and that in turn benefit society, referred to commonly as ecosystem services. When making assessments of land availability these services should be taken into account, particularly where land appears 'unused' for human activities (see Allen *et al*, 2014). Studies such as '*land as an environmental resource'* (Hart *et al*, 2013) or the JRC led mapping and assessment of ecosystem services (MAES) study (Maes *et al*, 2011a; 2011b) provide an assessment of the EU's land resource and the current and future potential of different land types to support a range of different services.

When trying to understand and interpret land use and cover patterns, particularly when looking to identify land that is not in any apparent use, it is important also to recognise ***why*** these patterns of land use exist, in what conditions change might be feasible or could occur and at what cost[6]. Land use and cover distribution is influenced both by bio-physical characteristics, such as slope, climate and soil quality (Box 2); as well as socio-economic factors, such as ownership, regulation governance regimes and the motivations of individual landowners. Understanding why land is in a certain state often requires an understanding of agricultural practices, land use, climate conditions and culture for a given region or area. For example, an area of land that is in some form of agricultural abandonment in one area may appear visually similar to an area of land undergoing natural regeneration to forest and scrub for nature conservation purposes in another. They may both be considered in the same land cover class, or even in the same land use class, depending on the detail and type of survey that was undertaken.

Considering the **what** and the **why** are necessary when attempting to quantify the potential land availability for any type of production and where conclusions are to be drawn about the future potential of land resources. These require different types of data as well as a detailed understanding of the land uses systems and context in which they operate.

[6] Environmental, social and economic

2.2 Understanding land use and cover data

Data and information relating to land is collected, almost without exception, for a specific purpose or task. Applying those data to specific research questions[7] presents significant challenges depending on whether or not the land types of interest can be assessed or interpreted from the available data.

There is a wide variety of land use and cover datasets that are designed to help with EU, national and regional decision making, environment and land use monitoring and policy assessments. Three principal types of data are available:

- interpolated remote sensing data collected from satellite or aerial photographic survey, such as Corine Land Cover (CLC) data;
- survey data collected through field survey or census initiatives, such as the Farm Structural Survey (FSS) or Land Use and Cover Aerial Frame Survey (LUCAS); or
- modelled data using a combination of the first two data types applied to specific themes, such as soil erodibility as part of the Agri-Environmental Indicator (AEI) datasets.

All of these data involve some interpretation depending on the objective of the data collection exercise. Such analysis is a necessary stage in data compilation in order to make the information useful for its intended purpose. Whilst for some datasets, such as the LUCAS or CLC data, efforts are made to limit this interpretation in order to make the data useful to the widest possible application, whilst remaining accessible[8], the data is still modified or categorised to some extent. For example, the CLC data is based on satellite remote sensing[9] with ground truthing, providing a clear picture of the vegetative cover at the Earth's surface. The limitations in the data come when the categorisation framework is applied. In this case, the CLC system uses a 44-class hybrid approach in order to describe land cover and use across the EU. Whilst this is helpful in providing a system to assess change over successive survey years, or to be linked to other data to produce applied datasets, it does not allow for a more fine grained interpretation of specific aspects of land use that are not included within the initial classification system. i.e. each land cover is assigned to a particular class, or sub-class. Whilst much of the 'raw' satellite data can be accessed from a range of sources, reclassifying this imagery and undertaking ground truthing exercises requires specific expertise and understanding.

Even if the data is available to identify the specific land types sought, further considerations about what the data can tell us need to be made. For example, the distribution, size and characteristics of the individual land areas (Box 1), or how likely it is that this land will be utilised and therefore the realistic scale of the potential.

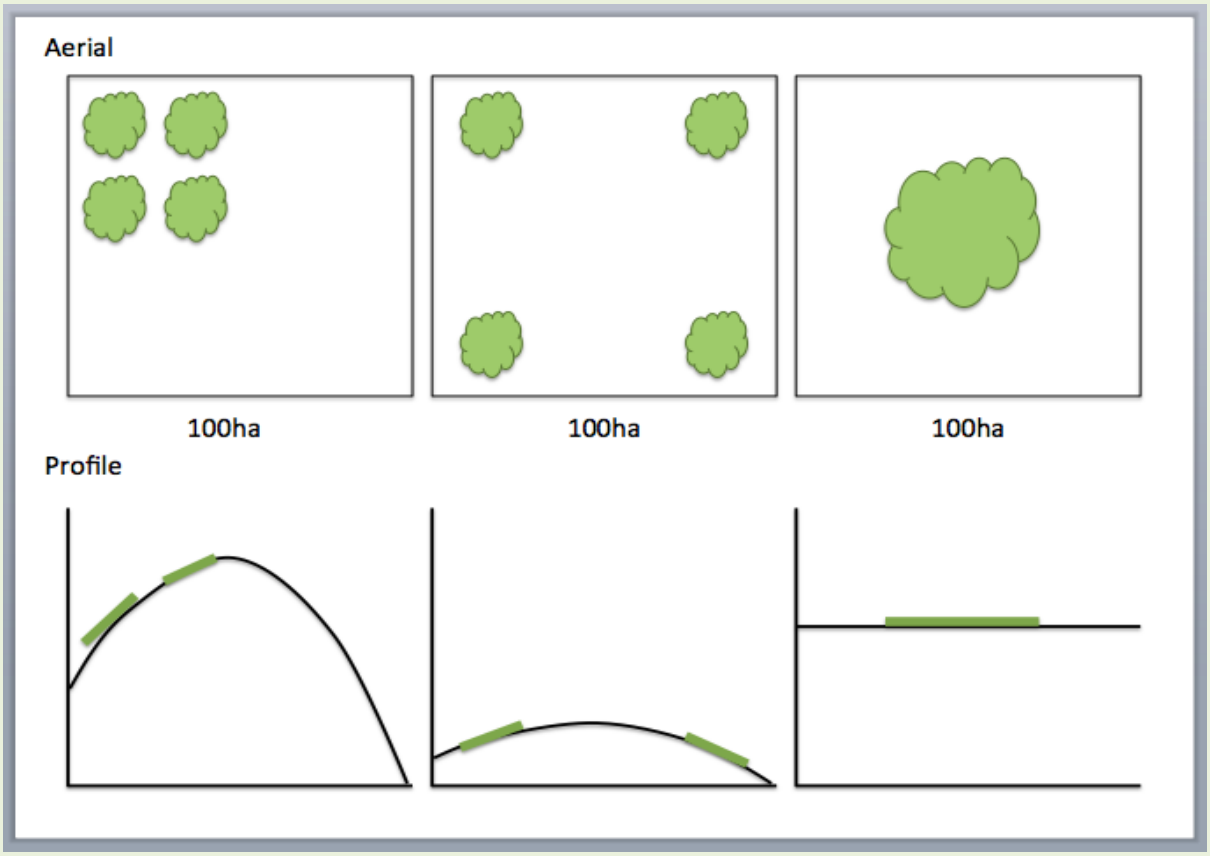
[7] Such as the availability of specific types of land that might be considered suitable on which to grow energy biomass.

[8] i.e. rather than presenting raw data to be interpreted by the user.

[9] With ground truthing (IRS, SPOT and RapidEye satellite images, dual coverage, orthophotos, topographic maps.

Box 1: Varying patterns of land

The diagram below shows a very simplistic view of how 100 ha of land can vary in composition and distribution, in relation to some key parameters regarding its availability for new uses e.g. whether it is in one patch, in separate patches, their relative proximity, on sloping land and so on. Understanding these dimensions of the land in question ideally require spatial data, or at the very least, data that can identify individual patches of land that have been categorised in a particular way.



For assessments that look at the potential of land to produce energy biomass the location and characteristics of the land are important to help understand whether land could be brought into production within reasonable economic costs relating to the challenge of cultivating on certain types of land, such as steep, rocky, or fragmented areas; or whether the land could produce sufficient yields of biomass through out the year.

The distribution of land types is also subject to temporal variations. Land use data is almost always a snapshot in time, the point at which the aerial photo was taken, when the map was drawn or survey was conducted. Relatively few land use datasets capture the dynamic nature of a particular land type within a given area, instead requiring repeat datasets over successive years. For example a coherent land use dataset may describe 100ha of land as being fallow. Of course this might be entirely accurate for that period of time, but it may not be fallow the next year, and may not have been fallow the year previous as it comes in and out of cultivation.

Source: Own compilation **Note:** Green shapes indicate different patched of the same land use. In the profile view, the gradient of the land is represented in order to show how these patches could vary in distribution further.

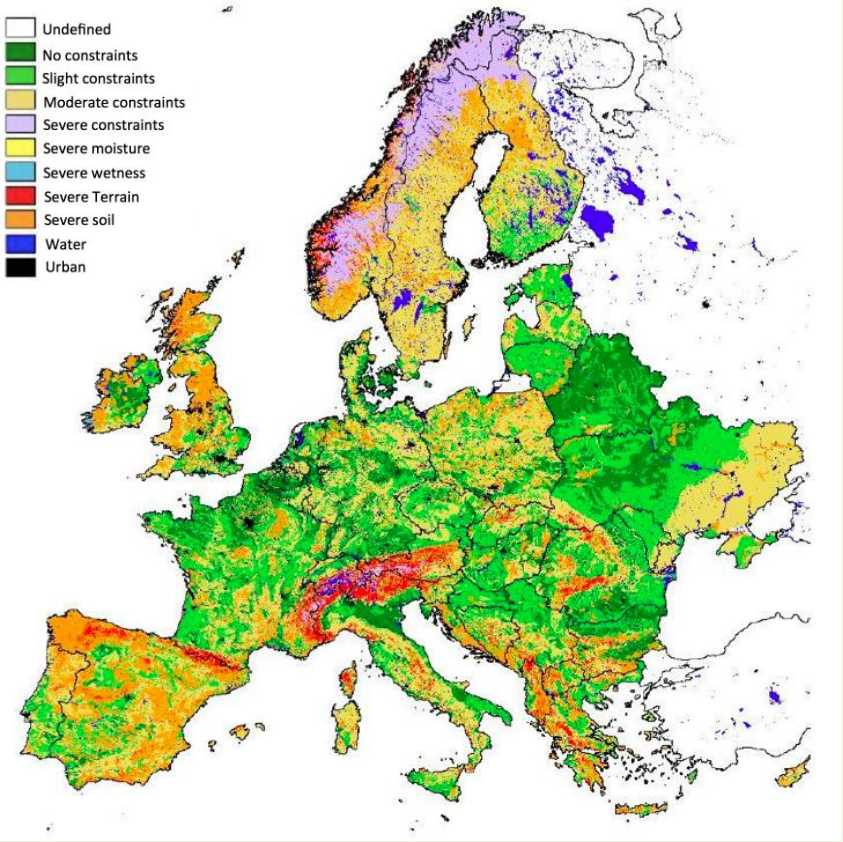
In addition to the varying distribution and size of land parcels between areas, the underlying bio-climatic and bio-physical factors, such as climate, soil and terrain constraints also influence the proportion of land suitable for different uses. There are many areas of the EU that are not used for productive purposes, or where production is limited. Bio-physical data

helps to describe the conditions of land that are necessary in order to assess whether or not that land would be suitable on which to produce energy biomass at a reasonable cost, such as whether it is flat and with sufficient natural water supply. Box 2 shows the distribution of bio-physical constraints on rain-fed agriculture in the EU in 2007 and provides a fairly accurate identification of the current pattern of agriculture and forestry that have resulted from it.

Box 2: Bio-physical constraints determining land use

The spatial distributions of bio-physical limitations on rain-fed agricultural land have been assessed using soil and terrain maps (e.g. the image below). These have been used to identify the areas of EU terrestrial rural land that experience various constraints on agricultural production in relation to temperature, slope, wetness and soils (FAO - IIASA, 2007 based on Fischer and van Velthuizen, 2002).

The distribution of severe terrain constraints correlate with high alpine areas, with the Pyrenees, Alps, Dolomites and the Carpathian mountain ranges. These areas, and the majority of northern Scandinavia all tend to be dominated by forests. Severe soil constrains are apparent in the Mediterranean Member States, particularly from thin mineral soils suffering from drought conditions in Spain, central Italy and Greece where bareland and shrubland are significant proportions of land cover and where irrigated cropland is common. Other soil constraints are seen in northern UK and Scandinavia, particularly upland areas, with acidic and often waterlogged soils dominated by semi-natural vegetation. In contrast the dominant arable production regions of the EU also stand out, generally those areas of no or only slight constraint.



Perhaps the most interesting parts of this map to consider are those areas in between these two extremes, those with moderate constraints. These tend to represent more extensive arable or mixed farming areas, particularly in western and some north-eastern Member States as well as the grassland and pasture areas in Scandinavian and more central and eastern Member States. Given the marginal economic nature of farming and the natural constraints faced, these areas may be more at risk from changes in land use, particularly from agricultural abandonment (Laurent, 1992; Keenleyside, 2004; Pointereau et al, 2008). Soil type, slope and exposure are important factors to explain farmland abandonment, but their relevance varies according to the type of agricultural system that characterises the production (Gellrich and Zimmerman, 2006)

Source: adapted from Hart *et al*, 2013 **Note:** The constraints are derived using the Global AEZ methodology applied to European datasets (FAO/IIASA, 2007, quoted by Eliasson *et al,* 2007).

Datasets relating to bio-physical aspects of EU land use are relatively well established and available for much of the territory and the data provided is often objective, allowing it to be used for a wide variety of applications (see section 3.1).

2.3 Terminology and definitions

One of the main challenges in interpreting land use and cover data is understanding the different terms and classifications used and how these relate to situations on the ground. Terminology and definitions often vary between datasets, countries and sectors, even at the broadest level and must be identified clearly in any assessments, particularly where data are combined.

In relation to the potential for growing energy biomass, three particular terms are used commonly in this literature. These are: “marginal”, “abandoned” and “fallow”.

Marginal land

Marginal land has no formal definition, or at least not a singular agreed definition that can be referred to here. It is important therefore, to be clear from what perspective the land is being assessed as ‘marginal’, whether or not it is marginal in other terms, and whether the relevant considerations are permanent or just temporary (Allen *et al,* 2013).

Marginal land is both a relative and subjective concept relating largely to the productivity of individual areas, and thus linked often to economic considerations. Such land may come in and out of production depending on commodity prices or the motivation of the individual land owner. However, land can be considered marginal for a variety of other reasons, including environmental or agronomic limitations, or a combination of all of these. The relativistic nature of the term ‘marginal’ can mean that what might be considered ‘marginal’ land in the Paris basin, could be relatively productive land in southern Spain, or even adjacent fields subject to different management histories may be considered marginal in relation to one another.

Most discussions of marginal agricultural land refer to the relatively low level of economic returns that are to be had from such land particularly from commercial agricultural production. These arise from the quality, scale and position of the land and its relative productivity or the ease at which crops can be grown (due to slope or accessibility issues, for example) There is no question that there are considerable areas of agricultural land in this category, particularly in upland or mountain areas and in some places where land will come in and out of production in response to market signals. However, despite the marginal nature from an agricultural productivity perspective, this land may have high environmental or social value, providing a range of useful services to society[10].

Given the absence of a clear and agreed definition, there is no single dataset that records the location and size of marginal land in the EU. There is however a range of different approaches that seek to map or identify those areas of the EU that face bio-physical

[10] These ecosystem services, such as carbon storage, water filtration or providing space for nature are often provided from economically marginal land precisely because these areas are not exploited for another purpose (Allen *et* al, 2014; Allen *et al*, 2013; Hart *et al,* 2013).

constraints that limit agricultural productivity. For example the FAO/IIASA (2007) rain fed agriculture constraints map (Box 2), or the JRC methodology to combine biophysical criteria to underpin the delineation of agricultural areas affected by specific constraints[11]. Similar efforts are seen at the local or regional scale in certain Member States such as Italy (see section 4.2.2).

Abandoned land

The term abandoned may at first seem relatively straightforward in its definition, but the abandonment of agricultural land describes a complex process of reduced farming activity over a continuum ranging from land that is temporarily unused (that may in some cases be considered fallow and part of a planned rotation for productive purposes) to land that is entirely abandoned for production, and where management is withdrawn completely. Three distinct categories of abandoned land can be observed in the EU, transitional abandonment, semi-abandonment, and actual abandonment (Box 3). There are various causes of actual farmland abandonment in Europe that differ between regions, including: geographic, ecological and agronomic factors; demographic and socio-economic drivers; the impact of policy; institutional factors; and historic circumstances, especially in new Member States. Farmland abandonment often results from a combination of these factors, with one predominating over the others (Terres and Nisini, 2013; Alcántara *et al,* 2012; Moravec and Zemeckis, 2007; Pointereau *et al,* 2007).

Box 3: Different categories of abandoned land observed in the EU

This box presents quoted text from Hart *et al*, 2013, based originally on Keenleyside and Tucker, 2010.

"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 set-aside, until this was abolished in 2008, or as a result of land use change. 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. They can appear also in an (peri)urban context with areas waiting for development as well as the result of other factors, such as following a family death, etc.

Semi-abandonment or hidden abandonment: Where the land is used by the farmer but with a very low level of management. The land is not formally abandoned and is subject to some form of management, which might be simply to keep it available for future use, for example for recreation and 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, not least on semi-subsistence farms and in dry and more mountainous areas, including those characterised as High Nature Value (HNV) farming. Such extensive farming is generally associated with very low or sometimes zero direct economic returns, but may be continued for personal or social reasons, to complement other income streams, for example from hunting and tourism, or for nature and landscape conservation (or simply to maintain a long term family investment). *It may also attract subsidy payments and probably does so over large areas.*

Actual abandonment: Where the farmland is not used at all for a sustained period of time. 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 southeast 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."

Source: Keenleyside and Tucker, 2010; Hart *et al*, 2013

[11] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC92686/lbna26940enn.pdf

The response to abandonment or potential abandonment of land has been different in different countries. A significant proportion of land that has been withdrawn from agricultural production in the EU lies in the central and eastern European Member States, partly as a result of changes from centralised government through to EU accession. However, the story of abandonment is different in different Member States and the resultant distribution of affected land also varies considerably (e.g. Box 11). These transitions and the current land use patterns now observed in these Member States are important to understand when making assessments of the potential scale on which to grow energy biomass.

The lack of an EU wide dataset of farmland abandonment is widely recognised in both the scientific and research community but there are attempts to bridge this gap with new approaches to land use assessments utilising more frequently updated satellite data (Box 4).

Box 4: Assessment of abandoned land using a new remote sensing approach

In work to identify a new approach to mapping abandoned land in the EU (Estel *et al,* 2015) the authors note that '*existing maps of abandonment or re-cultivation are either very local in extent (Baumann et al., 2011; Hostert et al., 2011; Kuemmerle et al., 2008; Müller et al., 2013; Prishchepov et al., 2012; Sieber et al., 2013), snapshots in time (Alcantara et al, 2012; Alcantara et al., 2013), or based on model outputs, instead of observations (Campbell et al, 2008; Renwick et al., 2013; Terres et al, 2013; Verburg and Overmars, 2009)'.* This is a fair characterisation of the information currently available on abandoned agricultural land. Some regional and national databases of abandoned land are available such as in the Czech Republic[12], but they are not comprehensively covered in all EU Member States.

The methodology proposed in the research by Estel et al (2015) combines Moderate Resolution Imaging Spectroradiometer (MODIS) satellite time series data with the LUCAS 2009 land cover dataset for validation purposes to assess active and fallow farmland over successive years in order to determine whether or not the land is temporarily unmanaged or in a longer term state of abandonment (see Box 3). The outcomes of the research appear highly promising in terms of identifying such land areas within Europe[13]. However, the authors note a series of limitations to their assessment, notably that climate variability has a significant affect on accurate detection using vegetation reflectance[14], and the need for significantly more ground truthing information to validate the remote sensing information.

Source: Own compilation following a review of Estel *et al*, 2015.

Fallow

Fallow is a term that is often used (sometimes incorrectly) to mean very different things, including land that is idle for part of the year; land that is in a state of abandonment; land that is in transition to another land use and so on. In an agricultural context, fallow describes agricultural land that has been deliberately left uncultivated as part of a crop rotation. The expectation is that it will be cropped in future on a regular basis. Some versions of fallow involve cultivation of a non-commercial crop designed purely for building soil fertility. This should not be confused with 'abandoned' agricultural land. The fallowing process can include leaving land uncultivated for one year as part of a short rotation or leaving land uncultivated for multiple years. Fallowing of land helps to rebuild soil fertility, prevent the accumulation of pests and diseases in crops and can provide certain

[12] Abandoned land - Czech structural land survey data https://www.czso.cz/csu/czso/270151-14-n_2014-01

[13] In this case the EU with the addition of European Russia, the Ukraine, Belarus and the Balkan regions.

[14] Such as the 2003 heat wave that resulted in a 30% reduction in gross primary productivity across Europe corresponding to the highest fallow year in their assessment.

environmental benefits, particularly where the land remains covered by some form of vegetation. Fallow land is not cropped but nor is it abandoned as it is still within the productive agricultural cycle. The formal EU Farm Structure Survey definition of fallow land is set out in Box 5. Other terms used sometimes to describe fallow land include 'idle' land.

Box 5: The definition of fallow land as set out in Commission Regulation (EU) 2015/1391

"All arable land either included in the crop rotation system or maintained in good agricultural and environmental condition (GAEC), whether worked or not, but with no intention to produce a harvest for the duration of a crop year.
The essential characteristic of fallow land is that it is left to recover, normally for the whole of a crop year. Fallow land may be:

- bare land bearing no crops at all;
- land with spontaneous natural growth, which may be used as feed or ploughed in;
- land sown exclusively for the production of green manure (green fallow)."

Source: Commission Regulation (EU) 2015/1391

There are relatively good statistical sources that record the state of fallow land in the EU, including the Farm Structural Survey (FSS) datasets held by Eurostat, or the LUCAS data. However, the reason for and the necessity of fallow land in the EU is a function of agro-ecological and historical conditions and trends. Understanding these trends and the reason for land being fallow is key to understanding whether or not such land has potential to support sustainable energy biomass production or not. In most cases the fallowing of agricultural land takes place out of agricultural necessity, to let the land rest, recover nutrients, remove pests, and reduce pressure on water resources in water scarce areas. To produce a crop on this land would likely prevent such processes from happening and instead require further intervention to maintain production over the long term.

Another aspect to consider beyond terminology relating to particular situational aspects of land use (as described above) is the way in which different definitions of land use and land cover are applied and therefore what the datasets using such definitions are showing. The change or difference in definitions of specific land cover or use types can have significant impacts on area assessments. The UNECE and FAO assessments of European forest areas make specific reference to this phenomenon, stating that the significant increase in forest area between 1990 and 2010 is partly caused '…by changes in the definition of forest' (Forest Europe *et al*, 2011). The same authors note the limitations in assessing the current situation and trend in forest patterns as a result of 'poor availability and lack of harmonisation according to a commonly agreed definition and assessment methodology'.

Definitional challenges are not limited to forest areas. The identification and sub-division of grasslands is a known issue when combining or assessing EU land cover data in this regard. Even coherent datasets, such as the Land Use and Cover Aerial Frame Survey (LUCAS), which provide sub-divisions of grassland, often lack the specificity to address policy related questions. For example, policies associated with grassland areas often require distinctions, such as, temporary or permanent, species rich or improved, etc. There remains a general paucity of information relating such subdivisions, or they are identified in different and incompatible datasets (Hart *et al*, 2013). *Future assessments of land areas or potentials would benefit from a clearer or more consistent definition and application of terminology, as well as improved data collection exercises to ensure such areas can be identified.*

3 EU level data availability

This chapter considers the data available at the EU level, provides an overview of the relevant and available datasets before making a summary assessment of the suitability and availability of the data for the purposes outlined in this study. A discussion on combining datasets for more comprehensive assessments is provided in chapter 5.

3.1 Overview of the relevant and available datasets

Two principle types of data can be used to make assessments of land suitable for bioenergy production in an agricultural context. These are:

- Existing land cover and use data that quantify different types of land cover and use based on a set of pre-defined categories (e.g. existing land cover datasets); and
- Raw or base data that can be manipulated or interrogated in order to both define land use and cover types and assess their extent and distribution.

Both types of data are available at the EU level with varying degrees of applicability in the context of this stud, most of which have, or are in the process of being updated.

3.1.1 Existing land cover and use data

At the EU level there are relatively few pre-defined land use and cover datasets that can be used to try and identify the land types that might be suitable for bioenergy production in an agricultural context[15]. What data exists tend to be subjective, focussing either on specific types of information collected for specific purposes, such as the Farm Structural Survey (FSS) data used to monitor changes in agricultural holding patterns; or data that is designed to be more general in nature and on which to broader assessments of land use and cover patterns across the EU can be made, such as the Corine Land Cover (CLC) map or the Land Use Cover Aerial Frame Survey (LUCAS) data.

The specific data identified in this review include datasets such as the High Resolution Layers (C-HRL) developed as part of the European Commission's Copernicus initiative[16], that aim to provide information on specific land characteristics[17]; or data such as the Riparian Zone Very High Resolution (VHR) land cover and use data used to support the Mapping and Assessment of Ecosystems and their Services (MAES) as part of the EU Biodiversity Strategy to 2020. More general land use and cover data is available in the form of the LUCAS and CLC datasets mentioned above, as well as other data, such as the OECD stat land cover dataset (relying on FAO data).

The ability of the different datasets to provide sufficient information on which to make an assessment of sustainable bioenergy production potential varies considerably. Datasets such as LUCAS and FSS provide an indication of land that might be considered as abandoned (to varying degrees). The LUCAS nomenclature includes a reference to *fallow or abandoned land within agricultural areas* that includes: agricultural land not used for the entire year for

[15] For suitability we refer to the description set out in the introduction to this study.
[16] http://www.copernicus.eu/main/copernicus-brief
[17] Such as the imperviousness of soils, tree cover density and forest type, permanent grasslands, peatlands (not yet developed) and water bodies

crop production or as part of a field rotation; land which has been set-aside from production for the long term; and bare land for agricultural use in other years (LUCAS 2009). This categorisation correlates with the term 'semi-abandonment' but not necessarily 'permanently abandoned' land. The overall area for '*fallow or abandoned land in agriculture*' from LUCAS correlates broadly also with that of the '*unutilised land and other areas'* provided by the Farm Structural Survey (FSS) dataset[18]. Despite this reference to abandoned land, these data do not paint a comprehensive picture for the EU, in particular given the point sampling approach undertaken for the LUCAS survey[19].

There are no *specific* datasets that identify comprehensively the areas of abandoned farmland in the EU with its varying definitions. Relatively good data on fallow land can be found through FSS data, as noted in section 2.3, but the reason for these areas being fallow (such as dryland areas in Spain), and the periods for which they may remain fallow, are not included within the data and need to be understood before assessments can be made.

The map based CLC data has been used widely to make assessments of land cover and use change as well as applied assessments of environmental changes in the EU[20]. The main advantage of the CLC data is that it provides a spatially explicit view of land cover and use across the EU that can be linked to a range of other datasets for more applied assessments. the CORINE program (**C**o-**or**dination of **In**formation on the **E**nvironment) aims to gather information relating to environment on certain priority topics for the European Community. CLC describes land cover (and partly land use) according to a nomenclature of 44 classes organised hierarchically into three levels.

CLC was developed to look at broad land use trend data rather than more specific fine-scaled assessments. Those who have sought to use CLC data for applied assessments[21] have noted accuracy issues, such as in identifying wetland or grassland areas (Maes *et al*, 2011b), which are unsurprising given the data was never intended for this purpose. Indeed the resolution of the CLC data released to the public presents particular challenges in this regard. Although the survey resolution of the data is at the 25m pixel level, the available data resolution of 25ha pixels[22] may not be high enough in order to make the sorts of assessments considered in this study. The nomenclature used in the CLC dataset also does not include any classes that could contain the type of land that this study is concerned with, e.g. abandoned land, marginal land, land 'not used'. In any case such land would likely represent a minor portion of any 25 ha land parcel and thus lack the necessary precision on which to make future assessments.

[18] Between individual Member States, there are some discrepancies within the data, particularly for Austria, Slovenia, Poland, the Netherlands and Portugal, which is to be expected given the different definitions, time series and sampling approach (Hart *et al*, 2013).

[19] The LUCAS data is based on a point sampling approach, using statistical up-scalling to provide a comprehensive picture of EU land areas. http://ec.europa.eu/eurostat/web/lucas/methodology

[20] Such as the EEA compiled State of Environment Reports that often combine CLC data with other reporting information from Member States.

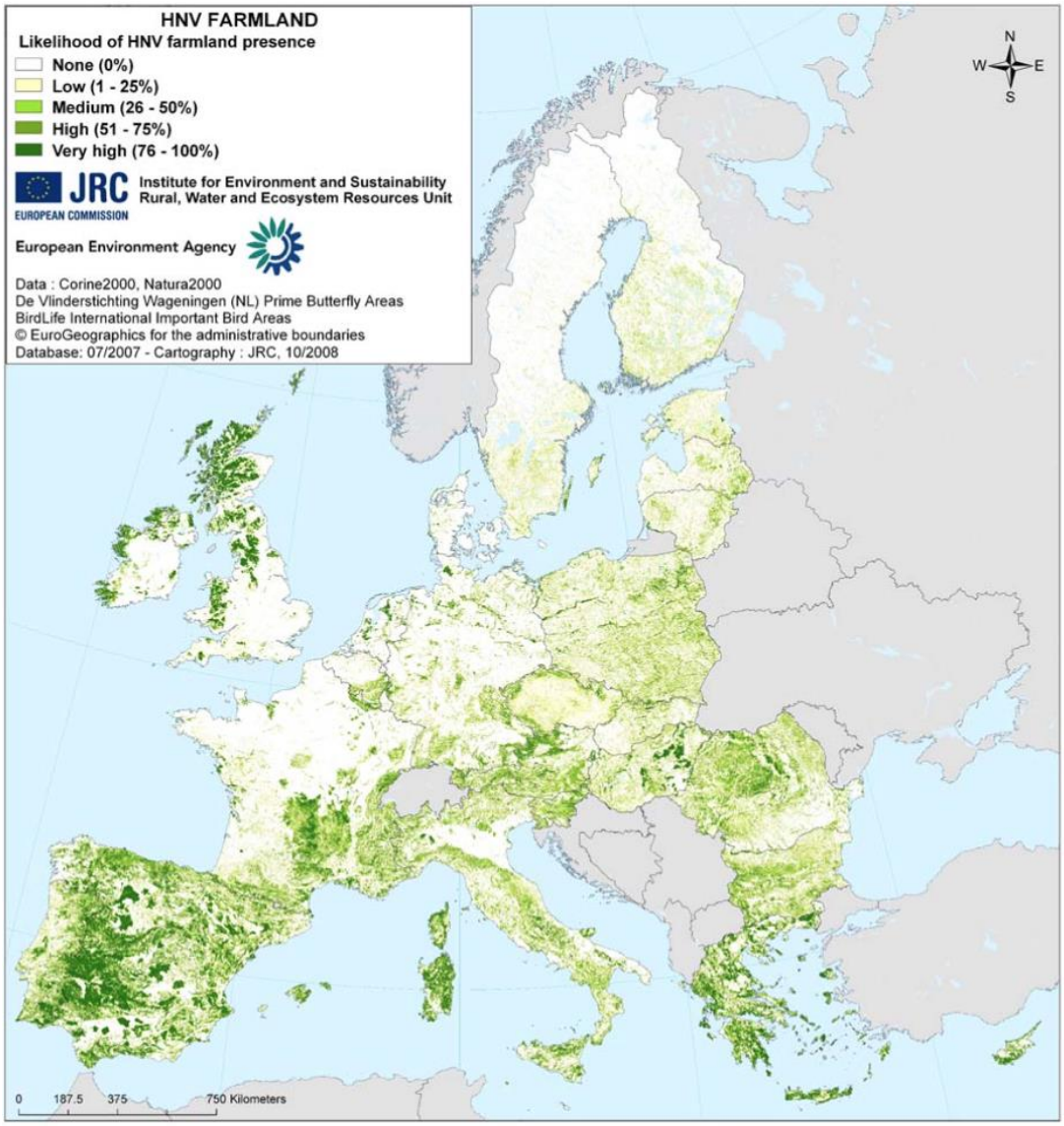
[21] Such as the mapping and assessment of ecosystem services undertaken by the European Commission.

[22] CLC uses a Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena and a minimum width of 100 m for linear phenomena.

There is no EU dataset that provides a comprehensive picture on 'marginal' land, mainly due to the lack of a consistent or agreed definition (see section 2.3).

In addition to the land use and cover data available at the EU level, there are a variety of contextual (i.e. broad descriptions of the landscape or area in question) and indicator based datasets (i.e. datasets that describe specific characteristics, such as soil organic matter content) that can be used to describe the pattern of land use, particularly agricultural land that has relevance to the context of this study. These include data such as the EEA - CAP context indicators developed to reflect relevant aspects of the general contextual trends in the economy, environment and society that are likely to have an influence on the implementation, achievements and performance of the CAP or the EEA - Climate indicators used for developing and assessing climate change mitigation and adaptation policies. Whilst these are again useful for describing certain aspects of land, their use in identifying areas on which energy biomass could be grown is limited as they do not always identify the specific areas or locations of such land. Those that do provide a spatial indication of these indicator datasets include, amongst others, data such as the Natura 2000 designated site inventory data held by the European Environment Agency (EEA), or the application of existing data to provide estimates of the proportion and distribution of High Nature Value (HNV) farmland across the EU by combining multiple data (Figure 1).

Figure 1: Use of multiple datasets to estimate HNV farmland distribution in the EU



Source: Parachini *et al,* 2008 **Notes:** Datasets used include - CLC 2006, Natura 2000 designated site data, Important Bird Areas and Prime Butterfly Areas

3.1.2 Raw data

Raw, or unclassified data, such as that obtained through satellite remote sensing and aerial photography, has the potential to provide a much more detailed picture of land that might be suitable for growing energy biomass, particularly when combined with existing land use and cover data (see Box 4, p9).

Unclassified satellite data, such as that obtained from MODIS, Landsat or Worldview-3[23], is widely available for the EU and can be used to provide a more detailed picture of land resources. The main limitation is that this data requires interpretation, classification and ground truthing in order to identify specific land cover and use types, much in the same way

[23] NASA's Moderate Resolution Imaging Spectroradiometer (MODIS); NASA's Land observation satellites (Landsat); and Digitalglobe's commercial Worldview-3 satellite.

that CLC data is produced[24]. Whilst the process of combining satellite data with existing land use and cover data could be sped up if the focus was on only identifying certain land types, this would still need considerable validation, either with existing datasets or through ground survey approaches.

More sophisticated approaches to identifying specific land types, such as marginal land would require a combination of a number of different datasets in addition to satellite data alone, such as slope, soil type, bio-climatic maps, as well as land use and cover data. The European Commission's Joint Research Centre (JRC) used a combination of data sources of this nature to delineate areas of natural constraint in order to inform specific aspects of European agricultural policy support (JRC, 2014) but noted specific limitations with the data that are relevant to note in the context of this study (Box 7).

Base data, such as soil maps, slope and bio-climatic zoning information is relatively widely available from centralised European data centres, such as the JRC soils data portal (Box 8) or the EEA's map and data centre[25]. Such data does have some limitations (as noted in Box 7), such as the frequency with which it is updated and the spatial resolution, but on the whole provides a useful set of data on which more detailed assessments could be made.

The European soils data and information provides a relatively comprehensive picture of EU soils, however, like the land cover and use data, they do not always provide some of the more detailed information necessary for specific categories of soils or agglomerated soil types, such as peatlands. In some cases, other initiatives aiming to bridge these data gaps can be found, such as attempts at producing a global peatlands database (Box 6), but in others there remain gaps.

[24] A process that takes a considerable time to compile by the European Environment Agency (EEA) (EEA, 1994)
[25] http://www.eea.europa.eu/themes/climate/dc

Box 6: The Global Peatland Database (GPD)

The Global Peatland Database (GPD) provides an overview on the extent and drainage status of peatlands/organic soils for 268 countries and regions of the World. Data is presented generally at the 1:25,000 scale based on various sources of point, vector or raster data.

The GPD was created in part as an attempt to harmonise data on peatlands and organic soils that is held amongst a wide range of institutions, such as authorities (geology, soil, forestry, agriculture, environment), universities and private persons, and involving a variety of different methods, definitions and survey strategies between European countries.

Source: Information taken from the GPD website and in conversation with Dr. Alexandra Barthelmes - Greifswald University

Box 7: Issues in using bio-physical data to delineate areas of natural constraint in the EU

In 2013 the JRC were tasked with identifying a common approach that could be used for assessing and defining natural constraints for agriculture in the EU28. The driver for this exercise was Article 50.3 of EC Regulation 1698/2005 calling for the revision of the existing system based on criteria related to low soil productivity and poor climate conditions for agriculture and the consequent Communication from the Commission: "*Towards a better targeting of the aid to farmers in areas with natural handicaps*" of 21 Apr. 2011.

In response to this challenge, the JRC adapted the FAO's agricultural problem land approach "*…because it is not crop-specific and for its simple assumptions regarding the mutual interaction of land characteristics on the overall suitability of the land, making it applicable for a territory as large and diverse as the EU28. Two climatic, and four soil criteria were retained and complemented by one integrated soil-climate criterion (Excess soil moisture – Field Capacity duration), with slope as the sole topographic criterion. For each criterion a critical limit was defined dividing the criterion range into two categories: not limiting and severely limiting for agriculture.*"

In assessing the challenge posed by the regulation the JRC identify three critical problems in utilising EU data for this purpose.

1. **Agriculture in Europe encompasses a wide range of crops that have different soil and climate requirements.** Therefore it would be very complex to present one single suitability map encompassing the huge variety of crops and their possible combination in a territory as large and diverse as EU28.
2. **Many soil and climate characteristics co-determine suitability and mutually interact**. In order to overcome the potentially complex problem of matching multiple and interacting land characteristics (LC) with crop requirements, FAO (FAO, 1976) introduced the concept of Land Quality (LQ). A LQ is defined as a combination of land characteristics, which acts upon the suitability of the land for a given use (an agronomic function). A typical example of a land quality is "Water supply capacity". This LQ is determined by soil characteristics such as depth, granulometry, bulk density, stoniness and by climatic characteristics such as amount and regime of precipitation and evaporative demand. The definition and quantification of all relevant LQs and their matching with the requirements of the multitude of crops is however beyond the scope of most land evaluation exercises covering large zones like EU28.
3. **Delimitation of zones is conditioned by available data.** Soil and climate characteristics are land attributes which typically show gradual change over space. In order to define land units and delimit zones, the point observations [the way in which most soil type data is collected in the EU] must be interpolated using specific techniques. These may be mathematical equations or based on expert-judgement.

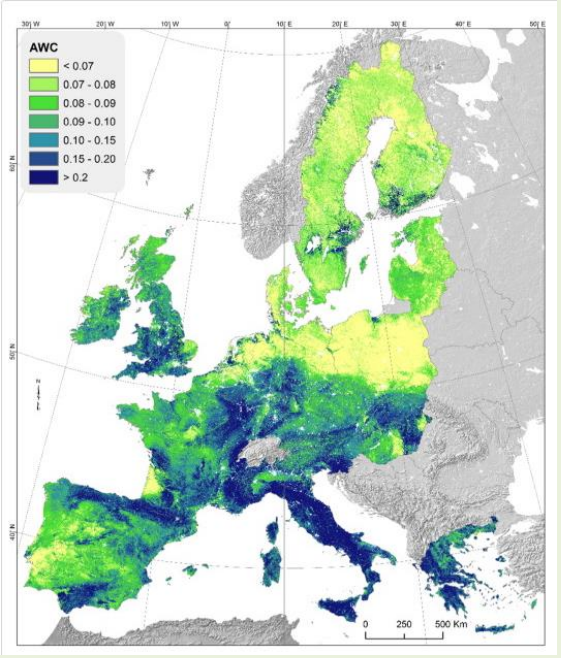
Source: Based on JRC, 2014. **Notes:** quoted text in italics

Box 8: The JRC Soils data portal

The European Commission's Joint Research Centre's (JRC) soils data portal is the online thematic centre for soil related data in Europe developed in response to the European Union's Soil Thematic Strategy. It contains a number of resources that are organised and presented in various ways: datasets, services/applications, maps, documents, events, projects and external links. The majority of the data and information are available freely to the public, although sometimes requiring registration to access specific datasets.

Datasets are grouped into broad categories: the European Soil Database (ESDB)*, datasets that have been derived with the help of the ESDB and general European datasets that contain soil properties; data that are related to soil threats (erosion, soil organic carbon, landslides, compaction, etc.); soil point data (LUCAS, SPADE, etc); and data that has been derived from specific projects.

The application of the LUCAS point soil survey data provides an interesting resource, particularly as it combines a survey record of land cover and use alongside the topsoil classification. This information has been used recently alongside other EU soils data to produce a map of available water capacity (AWC) in the EU (Ballabio *et al*, forthcoming 2016), which could be useful in identifying more precisely areas where water scarcity is an issue for crop production.



Source: Own compilation based on Ballabio *et al*, forthcoming 2016 **Notes:** * http://esdac.jrc.ec.europa.eu/ESDB_Archive/ESDBv2/fr_intro.htm

3.1.3 Summary assessment of data availability and suitability

The European Union is one of the most scientifically observed and mapped groups of countries in the world. There is a wealth of information and data that can be used to study the changes in land composition over time. These range from high resolution datasets that give a visual picture of vegetative cover through to thematic tabular data that aim to quantify certain types or qualities of land. The majority of this data and information is available freely through the EU institutions.

Despite this abundance of information there remain a number of limitations on the types and accuracy of data and information that can be applied to certain tasks[26]. For the majority of the existing datasets, land cover and use data is categorised into different groups or types concerning the use of, or impact of using, land. This has been necessary to make the datasets manageable but has prevented the data from being interrogated beyond a certain level. As a consequence, unused areas, such as those that might be of interest for growing energy biomass, are often omitted from the survey information or grouped within other categories of information. Unpicking these data is often impossible as the data often lacks

[26] For some areas there remains a lack of specific datasets or no European harmonised map able to identify certain, relatively conventional land cover types, such as different types of grassland areas (Maes *et al,* 2011).

the granularity[27] necessary to make distinctions within particular land cover or use categories, such as identifying where a particular crop or biomass type might be grown under specific criteria.

The type of data and information recorded in pan-European datasets, whether focussed on land use and cover, or more specific contextual information, has not been updated in recent years to meet the new challenges presented to such data, such as identifying 'marginal' or 'unused' areas, or making more wide ranging resource potential assessments. This is partly as a result of the challenges in defining the categories of interest, and partly as a function of the relatively slow process of updating existing datasets.

In assessing land area potentials, it is important to be able to understand the distribution of land parcels. Spatial data is therefore a particularly important source of information for such assessments. The availability of spatial information varies between datasets. CLC is spatially explicit, whereas LUCAS and FSS data are available only at the aggregated NUTS 2 administrative boundary level (without further spatial analysis).

Where existing land use and cover datasets provide relatively limited applicability to the challenges presented in this study, the interrogation of remote sensing data does provide some interesting opportunities, particularly where this can be combined with more local or regional data (or survey data such as LUCAS) to provide a quality cross comparison. This would enable a greater understanding of the spatial distribution of land types. Ground truthing assessments would remain a limiting factor in the ability to provide a comprehensive EU picture of any given assessment, but the approach could be used for specific site-based or regionally-based assessments using a consistent methodology and data in different locations across the EU.

[27] As it is not recorded as part of the original survey or has been lost in the processing of the data.

4 Member State data

This chapter considers the data availability in relation to different land use and land cover types in three selected Member Sates, France, Italy and the Czech Republic.

The review in **France** provides an insight into a Member State with a long history of land use mapping, agricultural policy and significant production potential. There are a number of dedicated statistical agencies working on land use data in France that provide a suitable frame for investigation. These include Agreste (the statistical department of the Ministry of Agriculture) and the regional Chambers of Agriculture amongst others.

Italy represents in part the Mediterranean region and is one of the forerunners of advanced biofuel deployment with commercial scale demonstration facilities in operation in a number of regions alongside national law promoting the use and production of advanced biofuels. It is a federalised country divided into 20 regioni[28] with some devolved responsibilities surrounding land use policy and data management. Italy therefore provides an insight into the potential opportunities and challenges that may arise in obtaining and assessing land use data in other federalised Member States.

The review in the **Czech Republic** provides an insight into the potential data availability, gaps and structural land use differences in some Central and Eastern European Member States. It is known to have particularly good data availability through its agricultural land use monitoring system (Land Parcel Information System (LPIS)). In particular this includes a digitised and differentiated set of information relating areas of land that are not subject to normal agricultural production, such as field margins, wet areas etc. The Czech Republic will be particularly useful in assessing the potential to identify and more importantly quantify areas of land that have been abandoned or are particularly under developed from a production perspective. With good data availability it should be possible to ascertain if a more detailed assessment of such lands could be possible in this and related countries.

For each country an overview of data availability is given alongside a summary assessment of the ability of that data to serve the objectives of a potential future study.

4.1 France

France has a long history of territorial and land use analysis at the national level with established institutions providing the general public with a diverse range of information. There are a number of databases/maps that are publicly available in France and that cover various characteristics of different land types. A web portal called 'Geoportail'[29] provides public access to interactive mapping of a range of various land and geographical information. Since France is a highly centralised country, all of the land use/cover data found was related to the whole (mainland) national territory. For agriculture-related datasets, data are typically collected and managed by regional agricultural authorities but the datasets are collated and held centrally by the Ministry of Agriculture. The

[28] The Italian regions.

[29] http://www.geoportail.gouv.fr/ - hosted by the French government

databases/maps of relevance to this study have been in place for medium to long periods of time therefore there is also relatively good time coverage of the data. However, data comparability between years is in some instances made difficult due to changes in methodology between years. For example, the Teruti land use survey, which began in 1981, has been used to provide input into the EU wide LUCAS survey and as such the methodology for data collection and classification has been adapted to suit the parameters of the EU survey. The dataset is now known as the Teruti-Lucas survey.

4.1.1 Overview of the relevant and available datasets

A number of maps are available through the web portal mentioned above. Among these, we have identified 16 that would be relevant to characterising land, of which 3 specifically cover land use: the Corine Land Cover (CLC) database is discussed at EU level[30], while the other 2 databases, RPG and Teruti-Lucas are discussed in more detail in the following sections.

The other (13) maps cover a range of physical/legal land characteristics. For example these include cadastral (i.e. land register) and other administrative maps, topographical maps, vegetative forest covers, various analyses of soils including rock types, national and regional natural parks and other protected zones, landscape types or the mapping of habitats. Data available on the portal comes from different national agencies, institutes (notably IGN, the national mapping institute) and Ministry services including the Ministry of Agriculture's statistical department.

While maps from the Geoportail web portal are publicly available, the public information is provided only in map form and not as a database. Unless SHP files of these databases were made available, this prevents the assessment of the national aggregated data - only a local, map-based analysis would be possible, i.e. parcel by parcel.

Registre Parcellaire Graphique (RPG), literally the *spatial land parcel register* is the French Land Parcel Identification System (LPIS) used to identify and map agricultural land cover for the purpose of distributing Common Agricultural Policy (CAP) (pillar 1) payments to farmers. As such, the data covers most of the agricultural land in France but excludes the majority of the agricultural land that is outside the remit of the CAP. The database, available as an interactive digital map to the public as well as a Shape file, is built on annual information provided by farmers for their CAP administrative dossiers which notably requires the identification of the parcels of land used for production (polygons drawn on aerial photographs) and the main crops grown. The most recent data available publically is from 2012 with the earliest being 2004.

The RPG database thus provides a detailed description of the use of agricultural land in receipt of CAP support at the national level. However, depending on the area, RPG would include more or less the total extent of agricultural land, depending on the proportion of

[30] The underlying database of CORINE Land Cover is available for France, but only through EU level data portals, with no further detailed breakdown available publically within the country.

agricultural land that is or is not in receipt of CAP support. The RPG nomenclature includes 28 agricultural land use classes (see Table 1) and 101 subclasses[31].

Table 1: The nomenclature of agricultural land used for CAP payments in France (2012)

#	Category	#	Category
0	No information	14	Rice
1	Soft wheat	15	Legumes
2	Maize	16	Forage
3	Barley	17	Moorland
4	Other cereals	18	Permanent pastures
5	Rapeseed	19	Temporary pastures
6	Sunflower	20	Orchards
7	Other oilseeds	21	Vines
8	Protein crops	22	Nuts
9	Fibre crops	23	Olive trees
10	Seed production	24	Other industrial crops
11	Fallow (without production)	25	Vegetables and ornamental plants
12	Industrial fallow	26	Sugar cane
13	Other types of fallow	27	Arboriculture
		28	Miscellaneous

Source: adapted from https://www.data.gouv.fr/

These land use categories are elaborated specifically for the purpose of the CAP payments, and lack detail in the description of land uses outside of the CAP's scope. As a consequence of the focus on land in some form of productive use, the dataset lacks the detail necessary to make assessments of 'other' land types that may be of interest to future studies on land availability, such as the various degrees of unmanaged/under-utilised land. It should however be noted that a miscellaneous category is included within the dataset that includes different types of land, e.g. other crops not covered by the current nomenclature, agricultural land used more or less permanently for other activities (e.g. manure storage, buildings). Within this category, one subclass covers '*non-cultivated land*' (excluding fallow) which is land that receives support under the Rural Development pillar of the CAP but is not cultivated as such. This category for instance covers non-standard sized hedges, groves, ponds, etc. This contrasts with other sub-categories within the miscellaneous class such as '*other uses*' or '*non-agricultural uses*' which correspond to different features such as buildings, manure storage, wood/silage storage, roads, etc. on which no rural development support can be claimed. The other miscellaneous categories have clear labels/definitions and include: '*aid for afforestation*' and '*other crops*'[32].

It should be noted that the RPG map and databases do not display the breakdown within the miscellaneous (or other) classes and this is because farmers are not required to indicate spatially and declare the detailed crop/use (i.e. at subclass level) of their land at parcel level. The polygon drawing exercise behind the mapping is only required at the level of continuous

[31] Description available in French in 'Description de la couche Registre parcellaire graphique 2012 (îlots PAC)' - 2012 is the latest available RPG data.

[32] Email exchange and personal conversation with the French CAP payment agency (Agence de Services et de Paiements - ASP), September 2015.

blocks of land that usually are formed of different crop parcels[33]. As a result, the database does not tell us how much land is assigned to the different subclasses and therefore the miscellaneous category could not be analysed further due to lack of sufficiently granular data. This being said, an overview of the map shows that little land falls in the miscellaneous category in general.

The **Teruti-Lucas** survey is the French implementation of the EU-level LUCAS survey. The dataset is based on an annual survey sample of 309,000 geographical points in France. Its objective is to monitor changes in land "use" across the territory. The main advantage of the Teruti-Lucas survey is that it covers all land types and is sufficiently detailed in its classification of land cover to identify specific land types that might be relevant for a future study on land potentials. There are however limits to the suitability of this data given its lack of spatially explicit delineation of areas, given that it is the only land use dataset identified that is not available as a map (in France). Reports of the data survey are published by the French Ministry of Agriculture every year. The Teruti-Lucas nomenclature uses two criteria: 'land occupation', which can be referred to as land cover and which describes what covers the land (according to various artificial, natural or agricultural land classes); and 'land utilisation', or land use or purpose, which describes the actual use made of the land. For example, a building (artificial land cover) could be used for agricultural purposes (e.g. grain storage), for sports and leisure (e.g. a sports centre) or for accommodation (e.g. a house).

In the Teruti-LUCAS land use nomenclature ('utilisation' or purpose), a **'other land uses'** category covers utilisations that are not agriculture, industrial use, housing, etc. It breaks down into three subcategories: wet areas, land not in use, and no information.

- **Humid zones** include any flooded land or land likely to be flooded most of the year by fresh, brackish or stagnant water. These areas are generally covered with trees, shrub or grass. The category excludes rice fields and salt meadows;
- **Land not in use**: any area not used (it could be land or humid zone/land covered with water), excluding fallow land. The land occupied by a building that is not used or very rarely used would for example fall in this category. According to Agreste[34], the statistical department of the Ministry of Agriculture, no information is available as to why a land parcel is not used. Understanding this would require a spatial representation combining the Teruti-Lucas survey points and other geographical information layers (topography, climatic data), as well as understanding the decisions of the land-owners.
- **No information**: any area on which data cannot be collected such as a military zone or non-accessible private land. In the publicly available database, these areas are aggregated with the 'land not in use' subcategory above for confidentiality reasons.

[33] Personal conversation with the French CAP payment agency (Agence de Services et de Paiements - ASP), September 2015.
[34] Email reply to information request, August 2015.

4.1.2 Summary assessment of data availability and suitability

Most data relating to land use and cover in France is publicly available in the form of maps, with the notable exception of the Teruti-Lucas survey data which is not geographically represented. The French web platform 'Geoportail'[35] described above, offers a wide variety of publicly available maps, including terrain, soil, land use and agriculture specific maps, with a high degree of interactivity. For example, it is possible to display different variables (e.g. habitats of protected species with agricultural land use data) on a background map to see areas of overlap or gaps. RPG is an exception in that it is publicly available both as a map from the Geoportail platform, as well as a Shape (SHP) file from another governmental platform[36]. Reports on the Teruti-Lucas survey are available in document form, but it is possible to access the Excel database upon request.

For the three land use databases identified (i.e. including CORINE discussed in Section 3.1.1), the underlying data are available under different formats (PDF - or Excel upon request[37] - for Teruti-Lucas, Shape files for RPG and CORINE). While this is useful, it is noted that the Teruti-Lucas survey is a geographical point–based survey and as such it is not represented with the same spatially explicit area information as the other two datasets. This makes comparison with other data somewhat limited (See section 5 for a description on combining data types) and further makes it difficult to assess the dispersion/fragmentation of the land under each category.

For most of the other data and information that may be relevant to land use/cover assessments (e.g. topography, soil, forest characteristics, nature conservation), the public information is provided only in map form and not as a database. Unless SHP files of these databases were made available, this prevents the assessment of the national aggregated data - only a local, map-based analysis would be possible, i.e. parcel by parcel. This is another potential limitation to be borne in mind as it may prevent the cross examination of RPG/CORINE data with other indicators. For example, it may be important to know that a particular agricultural parcel is located in a mountainous area or in a flooding risk zone in order to determine its suitability for future use.

Most of the available land use and cover datasets and maps in France do not directly identify unused, marginal or abandoned land. This can partly be explained by the fact that every database/map is interested in land use and not so much in 'unused' land. As a result, it becomes necessary to compare various land use indicators between them to be able to make a judgement on whether there exists such marginal or unused land that night be cultivated in future. There is however one database, Teruti-Lucas, which includes some potentially interesting land class information on which this type of information could be extracted. The three sub-categories of information available in the **'other land uses'** from Teruti-LUCAS described above (Humid zones, land not in use, and no information) are not further differentiated. Nonetheless from the data that is available, a quick analysis of the land 'cover' and land 'use' data shows that most of the 5.2 million ha of the French territory

[35] http://www.geoportail.gouv.fr/ - hosted by the French government
[36] – www.data.gouv.fr.
[37] Email exchange with the statistical service of the Ministry of Agriculture (Agreste), September 2015

classified under 'other land uses' (i.e. which potentially includes unused land) is covered by forest (1.8 million ha); moor, scrubland (*garigue* and *maquis*) and unmanaged land ('friche') (1.5 million ha); boulders and scree (800,000 ha) and to a lesser extent by natural grassland, lakes and other inland waters.

This demonstrates that wherever land is not engaged in a traditional activity (agriculture/industry/urban area), and potentially not used at all, most often there is a solid motive why it is not, e.g. presence of scree, forest, water. The only exception to this could be the land labelled as unmanaged land, however this is mixed in a subclass with other types of natural land such as scrubland and moor, and with land on which there is no information for confidentiality reasons, which undermines the suitability of this data for our study. This is especially true as moor and scrubland are widespread natural landscapes in some regions of France, such as Corsica and the South of France, likely to account for large areas and make it very difficult to isolate the comparatively small areas of unmanaged land within these. Assuming it was possible to isolate unmanaged land, this could indeed give us an idea of the potential land availability. However, it would still not provide us with an indication of the suitability of this land to grow biomass, especially as it cannot be displayed on a map and cross checked with other indicators, e.g. topology, type of soil, dispersion, etc.

It is questionable whether using data alone it is possible to assess if there are unused areas of land in France. The French CAP payment agency, which co-manages the RPG database, suggest that "*a simple territorial* [land use] *approach and analysis would not capture all reasons why a land is used/not used. For agricultural land, policies and public aid are important factors to take into account. These vary with the regional/local implementation of the CAP especially with the agri-environmental schemes in place locally, e.g. water protection, schemes in mountainous areas, to which farmers commit*"[38]. Other factors are likely to come into play in view of the increasing land pressure faced by French agricultural landowners[39] and it is likely that there would be good reasons explaining why a parcel of land is not used/not cultivated in a specific location. For example, there could be individual motivational or cultural factors in play or even other factors beyond the control of the land owner, e.g. administrative/neighbour litigation, lead time between ownership transition, land damage due to extreme climate events, etc. This additional socio-cultural information would be critical in making assessments of land use and cover both in France and elsewhere.

4.2 Italy

In Italy, a large amount of information on land use and cover is produced by a wide range of different public and private institutions, both at national and regional levels. Among these, a subset of datasets and maps is publicly available and provides a diverse range of information on different land types. At regional level, finer and more detailed information is provided by the regional administrations in the form of maps or datasets. In general,

[38] Agence de Services et de Paiement (ASP) – the French CAP payment agency. Personal conversation, September 2015

[39] For example, over the past 30 years, seven per cent of agricultural land has been lost to urbanisation, an average agricultural land loss rate in France of around 52,000 ha every year.
http://agreste.agriculture.gouv.fr/enquetes/territoire-prix-des-terres/teruti-lucas-utilisation-du/

however, information on land use and cover currently available in Italy is often highly heterogeneous and difficult to compare.

Recently efforts have been developed in Italy to provide a harmonised view of land use and cover information at the national level. At the regional level, work has been undertaken to map marginal land areas in Emilia-Romagna (see section 4.2.2).

4.2.1 Overview of the relevant and available datasets at the National level

A significant number of datasets and maps are available in Italy and provide, to varying extent and granularity, land use and cover data on the entire national territory. In addition, a number of maps providing contextual information and relevant to characterising land and land use are also available. These include, among others, cadastral maps, forest cover maps, landscape feature maps and Natura 2000 maps. Available data are produced by a range of institutions including Ministry services (both of Agriculture and the Environment) and national agencies and institutes. These datasets vary widely as to the features and purposes for which they were developed and only a subset of datasets could be used, despite information limitations, to assess land availability for energy biomass production that would not impact on other land uses. These include the land parcel information system database (SIP); the Inventory of Land Use (IUTI); and the Italian National map on Land Cover.

The **Sistema di Indenficazione delle parcelle (SIP)** is the Land Parcel Identification System (LPIS) database of Italy, used to map agricultural land with the purpose of CAP payments. SIP data are available in the form of viewable multi-layered digital maps. .This is the most up to date compound dataset available in Italy in relation to agricultural land cover and provides high-resolution data (1:10,000) at the national level. SIP data are produced based on digital orthophotos (updated yearly for 33 per cent of the national territory) and satellite images field surveys, cadastral maps, digital terrain models, and remote sensing.

Since 2008, the data on agricultural land has been complemented by additional land use and cover classes that provide information on land that is not subject to CAP payments, i.e. macro-categories such as forest land, water bodies, buildings and areas not suitable for cultivation. Although some of these non-agricultural land categories may have potential to grow energy biomass without impacting other land uses, the lack of information on any sub-categories within these areas limits the possibility to make judgements with the information available. The SIP data and related maps are not made public, however it is possible to gain access by submitting a formal request to the competent authority (Giuseppe Pulighe, INEA, *personal communication*).

The **Inventory of Land Use (IUTI)** is undertaken by the Ministry of Environment, Land and Sea to support the National Carbon Sink Accounting Register and monitor six land use and cover classes, according to the GPG-LULUCF[40] GHG accounting system[41]. IUTI is based on a tessellated stratified sampling scheme composed of 1.2 million geographic points and

[40] This is the system for accounting GHG emissions from Land use, land use change and forestry as set out in the IPCC's Good Practice Guidance. This includes the land use categories set out in the table in the text.
[41] IPCC Good Practice Guidance for LULUCF http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf

covers the entire national territory[42]. The inventory offers long-term land use data coverage, as updates have been carried out in 1990, 2000 and 2008. However, comparability of data over time may be a limitation. For example, in 2014, only one per cent of the sampling points were updated with 2012 data with the remaining data in the survey last updated in 2008. IUTI data are available to the public as an interactive map on the National Geoportal of the Ministry of the Environment and Protection of Land and Sea[43].

The IUTI nomenclature includes six land use / cover classes (see Table 2), amongst which is an 'other land' category. The latter category includes data on the extent of unproductive areas or areas with sparse vegetation that may be of interest in determining areas to grow energy biomass.

Table 2: The six-class land-use nomenclature of IUTI

GPG-LULUCF classification	IUTI classification		IUTI code
Forest land	Forest land		1
Cropland	Arable land and other herbaceous crops		2.1
	Orchards, vineyards and nurseries	Fruit trees	2.2.1
		Trees for the production of wood	2.2.2
Grassland	Natural grassland and pastures		3.1
	Other wooded land		3.2
Wetlands	Wetlands and water bodies		4
Settlements	Urban areas		5
Other land	Unproductive land or land with scare or no vegetation		6

Source: Own compilation based on IUTI data

The **Italian National Map on Land Cover** is produced by the Institute for Environmental Protection and Research (ISPRA)[44] and is available on the SINAnet portal[45]. The map provides information on land cover for the entire national territory at high resolution (20 m raster pixels). Underpinning data are based on Copernicus GSE Land – Urban Atlas and other available cartography. The National Map on Land Cover is based on an 8-class nomenclature, including built-areas; hardwood forest; softwood forest; grassland[46]; wetlands, and permanent water bodies. In addition, two categories are included describing land that does not fit in any of the other categories ('Other') and land for which data are not

[42] This system is based on plots that are distributed evenly to all parts of the target area according to a random sample. The set of sample points is extracted using a 0.5 km^2 grid, for a total 1.2 million points randomly located in each square cell and covering the entire Italian territory.

[43] National Geoportal http://www.pcn.minambiente.it/GN/en/

[44] ISPRA was established in 2008 for the merging of three former public agencies and institutes – the Environment Production Agency; the Institute for Scientific and Technological Research applied to the Sea, and the National Institute for Wildlife. ISPRA is a public institute that has the aim to coordinate the activities of the environmental agencies at regional and provincial levels.

[45] The SINAnet portal is coordinated by ISPRA and includes a wide cartography and a number o databases http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/copertura-del-suolo-ad-alta-risoluzione-20-m/carta-nazionale-di-copertura-del-suolo-ad-alta-risoluzione/view

[46] It has to be noted that this category includes permanent grassland under agricultural use. Information retrieved based on personal communication with Michele Munafò from Ispra.

available ('Non-classified'). However, it has to be noted that, given the absence of a specific category for arable / agricultural land, this land type mainly falls within the 'Other' category, along with bare land. The spatial nature of the data is helpful in identifying the location of different parcels of land. Nonetheless, the lack of information on any sub-categories within the 'Other' category, limits the possibility to make judgements on the potential for sustainable energy biomass production potential with the information available.

A wide cartography on other thematic indicators relevant to assessing land suitability for bioenergy production is available at the national level in Italy. These relate to nature conservation, forestry, bio-climatic and geomorphological conditions, sites of community importance (SCIs), special areas of conservation (SACs) and cadastral parcels.. Most information is publically available in map form on ISPRA's Geoportal[47] or on their dedicated websites.

4.2.2 Overview of the relevant and available datasets at the Regional level

An investigation into more detailed regional level information was carried out for three of the Italian regioni, Emilia-Romagna (E-R), Veneto, and Sardinia. A dataset and a map on land use and/or cover are publicly accessible via the regional Administration websites. For Sardinia, only a land use map is available[48]. These information sources provide finer grained information at regional level, compared to that available for Italy as whole, and the nomenclatures includes more detailed land use classes. However, as is the case with national-level data, identifying the particular types of land areas that are relevant to this study, such as marginal or unutilised land, remains challenging. There are however some promising initiatives, such as the development of a dataset to map marginal land areas in E-R as part of the Web GIS M2RES database (Box 9), that could potentially be used to assess the region's land availability for energy biomass production that would not impact on other land uses. The definition of marginal land used here is very specific and does not necessarily correlate to more commonly used definitions relating to marginal productivity of the land. This further highlights the importance of understanding the underlying data and what is meant by the category of land use or cover into which a particular areas falls.

The regional land use and cover datasets and maps available in E-R, Veneto and Sardinia provide information on the entire regions and at much higher resolution (1:10,000 for Veneto and Sardinia and 1:25,000 for E-R) compared to national-level datasets. The Veneto region has the most recent information relating to land cover dataset, based on the 2012 data provided by Copernicus GSE Land – Urban Atlas. Both E-R and Sardinia data were last updated in 2008. Each datasets relies on pan-European data (CLC or equivalent) that is further refined and classified using regional data[49]. The further sub-division of the CLC land

[47] Ispra's Geoportal http://www.geoportale.isprambiente.it/geoportale/catalog/main/home.page

[48] Data from both the E-R and Veneto datasets are available as digital maps, in the format of shape files (.shp) per province or municipality. The Land Use map of Sardinia is available on Geoportal website of the region (Geoportal of the Sardinia region: http://www.sardegnageoportale.it/webgis2/sardegnamappe/?map=mappetematiche).

[49] The Sardinia dataset includes: ortho AGEA 2003 Orthophoto 2004 2005-06 Ikonos images, Landsat images 2003 images Aster 2004, as well as auxiliary materials CTRN10k, DBPrior 10k and others, with inspections of 4,000 points distributed throughout the region.

classes into regionally specific classifications provides more specific information on which to assess specific and relevant land use and cover types. For each of the regioni, these data can be viewed through the geo-portal with the GIS shape files available for further interrogation, providing the opportunity to both calculate the area of specific land use and cover types and assess their spatial location.

These datasets use a different range and level of classifications, all of which are a further disaggregation of the 44 CLC land cover categories. For example, Emilia-Romagna region includes four levels and 83 classes[50]. To give an example of the further sub-division of specific categories of interest to this study, the E-R data includes a sub-division of the 'sparsely vegetated land' (Aree con vegetazione rada) category into two further sub-categories that are mapped. These are 'badlands' (Aree calanchive) and 'sparseley vegetated areas of other types' (Aree con vegetazione rada di altro tipo)[51]. However, a ground-based assessment would need to be undertaken to understand if these areas could be cultivated. Unused, marginal or abandoned land classes are not recorded in any of the regions but more detailed classes on land with sparse vegetation, ex-mining or landfill sites etc. do exist.

Box 9: Mapping of marginal land in the M2RES database for Emilia-Romagna

The **Web GIS M2RES database**[52], coordinated by National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), provides data on marginal land areas within the region suitable for the production of renewable energy sources, including photovoltaic, solar-thermal, wind, hydroelectric, biomass, biogas plants.

Marginal land areas are defined in this case as '*Areas that, for various reasons, are normally considered 'useless' and often remain 'unused', if not abandoned*.' Marginal land areas include: current and former landfill sites; abandoned quarries; areas unsuitable for agricultural use or unproductive (non suitable for buildings, no values or natural constraints); former military areas; abandoned industrial areas.

Data on marginal land for the E-R region has derived from the Corine Land Cover dataset that, although being comprehensive in terms of land types covered, do not provide a high level of accuracy at regional level. The data are available in form of a digital map; more detailed, site-related details are available upon request to ENEA.

One of the limitations of the Web GIS dataset is that it does not provide information on all marginal land within the region. It only provides data on those marginal land areas that are deemed to be suitable to host renewable energy sources, mostly in the form of facilities or solar photovoltaic systems. Some marginal areas have been excluded on the basis of their size (too limited). In addition, for some marginal land areas, i.e. former landfills or contaminated sites, accuracy is limited given the lack of / limitations in terms of data availability.

Source: Own compilation based on communication with Guido Tonini, ENEA (personal communication).

More information on other contextual and indicator based data, relevant to assessing land suitability for bioenergy production, is available in the three regions reviewed. These relate to nature conservation, forestry, slopes, soils, climatic conditions, etc. Most information is

[50] Veneto = 174 land classes on five levels; Sardinia = 70 classes on five levels.
[51] Vegetative cover between 10 and 55 per cent. (cui la copertura vegetale è compresa tra il 10% e il 50%).
[52] The dataset has been developed in the context of the European Marginal to Renewable Energy Sources (M2RES) project http://www.m2res.eu/pages/base.asp?grp=content&pge=13&currlang=1

available on the regional administration websites and could be utilised to provide a more detailed assessment combining land use and cover information with bioclimatic and geomorphological constraint maps where these can be combined and assessed.

4.2.3 Summary assessment of data available in Italy

There are sources on land use and cover in Italy that could provide useful data for making assessments on land availability for biomass production, particularly the fine scale information available at the regional level, in particular the regional disaggregation of the CLC data to a more granular level. However, combining such data remains a significant challenge. At a national level, these include the SIP; the Inventory of Land Use (IUTI); and the Italian National map on Land Cover. When looking at the regions covered by the study, regional land use and cover datasets and maps could be used as useful data sources, as well as the Web GIS M2RES database to map marginal land areas in Emilia-Romagna. Combining regional data, such as the regionally disaggregated CLC data would still face similar challenges to that of the national data, with regards to compatibility.

For the most part the national-level datasets available are the result of specific data collection exercises and were never intended to be applied to assessments of the specific land types that form the focus of this study. As such they are often, and for good reason, uncoordinated both in their intended aims and the classification and update frequencies adopted. These limitations apply also to regional-level datasets that are characterised by different methodologies for the collection of data. Nonetheless, they provide finer, more detailed data, compared to those datasets that cover the entire national territory.

Two common factors that limit compatibility are the different classification and nomenclature systems used for different datasets and the frequency with which data is updated. For some datasets the methodology for classification or data gathering changed over successive years. Not only does this make comparing the data to other datasets challenging, but also creates problems when comparing the same dataset over successive years. As to regional datasets, although the nomenclature systems are generally consistent with EU data they begin to diverge as the level of detail increases. In addition, the scale of the maps varies, as well as the frequency with which data is updated. For these reasons, the extrapolation of land use and cover data from regional datasets or maps may prove rather challenging.

Further limitations when trying to compare these data, both at national and regional levels, relate to accessibility, i.e. whether the information is available publically, and whether or not the data is sufficiently detailed or contains enough information on which to base an assessment. Several databases that may, in principle, provide useful information on specific land types, such as the GIS-LPIS Database, are not available to the general public because they contain certain confidential information. However, it is possible in some cases to submit a formal request to access the data from the managing authority. Where data can be accessed, there are many that include an ‘other land’ category that might warrant further investigation, such as the IUTI database. However, these ‘other’ categories are often vague in their description and contain a variety of different types of land or information that is not further disaggregated. The lack of comparability between different datasets is not a new

issue, with recent efforts in Italy to provide a harmonised view of land use and cover information at the national level (Box 10).

Box 10: Efforts to harmonise land use and cover information in Italy

In 2013, the Integration of Territorial and Land Information (ITALI) project, led by the National Statistical Institute (ISTAT) in collaboration with a number of partners, aimed to compare, integrate and enhance land use and cover data provided by key datasets at a national level[53]. The results of the study showed that at a relatively high level of aggregation (such as the LUCAS level 1 classification) information on land use and cover is relatively consistent. However, at more detailed classification levels, the data began to diverge quite substantially, making combining the datasets much more challenging. A second phase of this project – called ITALI 2 – has been financed and is due to start in 2015. On the basis of the results achieved during the first phase, this follow-up project has the aim to produce a national framework to harmonise future statistical information on land use and cover at national level in order to provide more detailed information in future[54].

Source: Own compilation

At a regional level, the Web GIS M2RES database provides useful information on marginal land areas, which could be used to assess the land potential for energy biomass production in E-R. However, it only provides data on those marginal land areas that are deemed to be suitable to host renewable energy sources, mostly in the form of facilities or solar photovoltaic systems. In addition, elements such as comprehensiveness and accuracy of data, need to be assessed carefully in a future study on land use potentials.

4.3 Czech Republic

The Czech Republic (CZ) has, like most of the central and eastern areas, a more turbulent history of land use and cover developments than other EU Member States, particularly following the collapse of centralised government in the late 80's and early 90's. However, the approach to monitoring agricultural land resources is one of the most detailed in Europe through the detailed grassland and agricultural feature mapping through the Land Parcel Information System (LPIS) database.

4.3.1 Overview of the relevant and available datasets

In relation to land use and cover data, there are two key datasets available in CZ that could provide more information on the potential to grow energy biomass without impacting significantly on other land uses. These are the LPIS data and information used to support CAP payments, and the land cover cadastral map.

The LPIS data for CZ provides an impressive level of detail surrounding agricultural holdings across the country based on satellite data in combination with cadastral maps and information gathered from each farmer in receipt of CAP support. These include detailed land use classifications of the main types of agricultural land uses[55], and include non-production land[56], which are of interest to this study. Additional information is recorded in

[53] As well as for some regional data also.

[54] Information compiled based on personal communication with Giuseppe Pulghe, INEA.

[55] Pond, hops, short coppice wood, grass on arable land, other land use, plantation of young wood, forestland, non-production land (e.g. farmyard), arable land, orchard, grassland, black fallow, vineyard, vegetable garden.

[56] The definition of which and the precise composition are unclear from the information available to the public.

relation to a range of different categories of information[57], such as administrative borders, water bodies, soil characteristics, suitability assessments (conversion of arable land to grassland), slope, flood potential, amongst other administrative information in relation to support schemes. These data are generally updated yearly, unless they rely on longer term survey information, such as soil mapping.

The key advantage of the LPIS dataset is that it provides a highly detailed parcel by parcel level assessment (1:10,000) of land cover and use with a near real time assessment (provided by yearly updates), combined with contextual data, such as slope, soil profile etc. The information is generally available publically[58], although there are restrictions with regards to confidential information.

The main disadvantage of the LPIS dataset is that it is concerned only with agricultural land and only that land that is in receipt of CAP support (~3.5 million ha). This means that around 700,000ha of agricultural land, mostly hobby farming and gardens, is not covered by the data. More limiting is that the LPIS data does not extend beyond agricultural land and therefore does not provide the ability to assess wider land use and cover to the same level of detail.

The other dataset available in the Czech Republic to help explore land use and cover information beyond that of agricultural land, is that provided through the national Cadastral map, again at 1:10,000 resolution. The Cadastral map is produced on the basis of parcel ownership (ZABAGED layer[59], and parcel maps) and data on land use[60]. Whilst this information allows an assessment beyond just agricultural land, the categories that can be assessed are more limited in detail[61] and lack specific categories that could help identify land with potential for energy biomass production.

Box 11: The abandonment of land in the Czech Republic

During the early to mid 1990's in the Czech Republic, there was a real threat of land abandonment due to the collapse of Eastern European market with several agricultural commodities and a cessation of nearly all agricultural support from the state.

Those areas most at risk of being abandoned were grassland areas, and some arable farms in certain areas of the country. Recognising this risk and the growing areas of abandoned grasslands in the region (estimated by the Ministry of Agriculture at ~ 7% of agricultural land in the country (2001)), the state started to support the

[57] Administrative borders, cities, water bodies, railways. Soil characteristics (Czech BPEJ), results of soil sampling-nutrients and contaminants, growing of GMO crops, soil erosion risk - GAEC, organic/convectional; LFA according to type/non-LFA, limits of land use according to Nitrate directive, suitability to conversion of arable land to grassland, Natura 2000 site, average slope, average altitude, size of wet meadows, uptake of AEM according to each scheme, protected areas - national system, distance to water bodies, water protection sites, landscape features according to type, dry polders, erosion, potentially flooded areas, farmyard manure deposits. Owner/land manager contact details.

[58] http://www.cuzk.cz/Katastr-nemovitosti.aspx

[59] A land use dataset used to support the production of other map based information.

[60] http://www.cuzk.cz/Katastr-nemovitosti.aspx

[61] They include land uses of water bodies, hops, other land use, forestland, arable land, orchards, grassland, vineyard, gardens.

cost of grassland management under multiple Government decrees[62] in the mid 90s and the land was brought back to production.

Following the accession of the Czech Republic to the EU in 2004, the combination of direct payments, less favoured area (LFA) and agri-environment support through the Common Agricultural Policy (CAP) provided motivation for farmers to utilise their lands to a greater extent for both environmental and productive reasons.

These developments led to a dramatic reduction of the areas of abandoned (or unutilised) land in the Czech Republic, now covering only 0.18 per cent of all agricultural land in the country, representing around 6,187 ha (2013) mostly in scattered plots*. There remain some methodological issues in the identification of abandoned land that still need to be resolved in the structural survey to improve the accuracy of assessments, but this is not likely to provide a significant change to the limited areas of abandoned land in the country.

Source: Prazan, J, *pers comm – report co-author* **Notes: *** According to Czech statistical office, structural survey 2013, available at https://www.czso.cz/csu/czso/270151-14-n_2014-01

4.3.2 Summary assessment of data availability

The information available in the Czech Republic on land use and cover resources is particularly detailed for agricultural land in receipt of, or eligible for, CAP support. This and the cadastral map information are available publically. Yet despite the detailed and frequently updated information, these datasets, like those for France and Italy, are purposive and do not record land types that might be considered suitable for energy biomass production, such as marginal or abandoned land (although there is some limited information available on the latter). New and more detailed data would be needed in order to make the type of assessment considered in this study for the Czech Republic, in particular data that extends beyond current agricultural land areas.

[62] For example Government decree 341/1997 Coll. on supporting programmes supporting non-production functions of agriculture, supporting of landscape management, and supporting LFA areas.

5 Data compatibility and discussion

This chapter provides a brief discussion on the ability to combine the different datasets identified in previous chapters and the challenges that face existing and future assessments.

The previous two chapters have shown that there is a wide variety of data and information sources on which to make assessments of land cover and use across the EU. However, they have also demonstrated that information relating to the types of land that might be considered suitable on which to grow energy biomass is generally lacking, both at the EU and Member State level. These land areas tend to fall outside of commonly collected statistics, or they represent areas and sub-divisions of existing land cover and use types that cannot often be disaggregated from the current statistics. Existing assessments of land potentials of the type considered in this study have all faced similar problems and have had to make certain assumptions as to the extent of suitability of different types of land in order to provide an overall figure. Most studies recognise this and caveat their conclusions accordingly.

Datasets available, on which to make pan-European assessments of land cover and use have seen iterative updates in recent years, both in geographic coverage and detail. However, they are relatively limited in number, confined to the LUCAS, Corine and Copernicus initiatives; to sector specific datasets such as FSS; or the varying degrees of information available at the Member State level. Taking a more bottom up approach by combining more detailed Member State or regional data may yield better results and allow access to a wider and in some cases more detailed suite of information, where there is suitable data availability.

When making more detailed assessment of the EU's land resources that could support energy biomass production, it would often be necessary to combine different sources of data, particularly where this allows a disaggregation of categories of information. Data combinations of this sort should not be approached lightly and present particular challenges as a result of different time series, survey methodology and definitions used. Previous studies have made attempts to combine such data and noted the challenges in doing so (Box 12). These highlight in particular that '*further work is needed in a range of areas in order to build a more comprehensive picture of rural land in the EU-27, particularly for the currently underrepresented categories of land cover, such as grasslands*' (Hart *et al*, 2013).

In developing land use and cover assessments focussed on specific and subjective attributes or classifications of land, such as marginal, more flexibility in the data can be found by looking at remote sensing information, particularly where this can be classified for a particular purpose. Assessments such as those described in Box 4 and Box 7 give an indication of such potential, but they are not without their drawbacks.

Box 12: Challenges associated with combining datasets

The EU is one of the most observed and data rich territories in the world, yet there remains a great diversity in the information available between and within Member States. Despite common assumptions, data collection is often a subjective process relying on culturally specific nomenclature and definitions as is recognised in the pan-European datasets that attempt to combine such data (Hart *et al*, 2013; Forest Europe *et al*, 2011).

The shortcomings of combined data sources are being addressed by some pan-European survey and remote sensing approaches, such as LUCAS and the CLC initiatives. However, even with a consistent approach, there is often a need for specific datasets representing individual sectors (e.g. agriculture or forestry), sub-sectors (e.g. organic farming), objectives (e.g. biodiversity or hydrology) or geography (e.g. municipalities and regions).

One of the most significant limiting factors for the integration of data is how the source data is classified into groups. For example, one category of land cover in one dataset may represent two or more categories of land cover in another dataset. Without knowing the relative proportions disaggregate the data is difficult. This overlap of land cover categories is common when trying to harmonise different data (Gallego and Bamps, 2008). Even where similar nomenclatures are used, harmonising data is not simply a case of removing one classification from one set and replacing with that from another. For example the grassland data from LUCAS cannot be used to replace the grassland data in the CLC dataset, and would result in a decrease in the overall grassland area recorded because the CLC mapping methodology tends to underestimate the actual grassland area (Maes et al, 2011b). Tucker *et al* (2013) note similar issues when trying to estimate peatland areas.

Source: Own compilation based on Hart *et al* (2013); Maes *et al*, 2011b; Tucker *et al*, 2013

What would be needed for a more detailed assessment?

Having reviewed the information available on land use and cover data in the EU and selected Member States, we have a fairly comprehensive understanding of the key issues that face assessments of identifying specific land areas that conform to specific criteria and definitions. Understanding the limitations of such data allows us to determine what would be needed for a more detailed assessment in the future, i.e. how the gaps in existing data and information could be bridged. Broadly two areas can be identified: retaining objectivity in the data; and improving the harmonisation of data sources.

One of the key limitations in our ability to interpret existing data for new and applied purposes is that the majority of information available on land use and cover has already been classified or collected in relation to specific categories. ***Retaining neutrality*** in the data can help to overcome such issues by either maintaining the original data that was subsequently classified so that another classification approach could be taken or by collecting the data in a more objective and detailed way in the first place, that could be combined or synthesised to produce the existing land cover and use categories, but also applied to other uses. The reclassification of existing satellite remote sensing data, and validating this alongside existing land use and cover datasets, would be possible with the existing satellite data available for the EU. However, this would be challenging and particularly time consuming, where additional data collection and validation exercises are required in order to improve the accuracy of the classification of specific categories of land use. In addition, some of the more subjective classifications, such as marginal, require more than a reprocessing of raw data.

Another approach to improving the way in which existing datasets could be applied is to better harmonise data and information sources collected at the EU and national level. There is a wealth of information available that, if combined, could help to provide a more comprehensive picture of Europe's land. However, data is often collected at different scales,

time periods and using different classification methods or even definitions (Box 12), which makes combinations difficult. ***Harmonising data sources***, by ensuring a common framework through which information can be classified and updated, would help to improve the compatibility of existing data in the future[63].

Are we asking the right questions?

When trying to identify the scale of the potential to produce energy biomass in the EU there remains the question whether quantifying this potential is meaningful. The information reviewed at the EU level suggests that this will depend greatly on the level of information that can be obtained on which to make an assessment of potential and at what scale. For the EU as a whole, the level of data and the detail of information needed would be prohibitive and largely impractical without significant resources, requiring a specific European-wide assessment, including ground surveys, for this particular purpose. Such limitations may be overcome in future years with new and emerging approaches to monitoring Europe's land surface, and in particular if the way in which the data is collected can be altered to allow a more adaptable dataset to serve different questions. Yet at the current time, it might be that the limitations of pan-European assessments of scale should be accepted, or at least it should be recognised that assessments of this sort lack meaning when it comes to understanding the true potential of land resources and whether these will be mobilised at a local or regional level.

The lack of granularity and specificity in the data, or the time needed to process the available data could be overcome through a broader assessment in order to identify 'zones' that would warrant further and more detailed assessments at the local or regional level, through a site survey type approach. Here the data available at the EU level could be utilised more effectively and the ground truthing or survey approaches to verify such data confined to specific locations where there is thought to be potential, and thereby limiting the resources needed in the initial exercise. Such approaches are not without precedence and have been used to target agri-environment payments under the 2007 – 13 Common Agricultural Policy (CAP) in England[64]; and have even been applied in the context of biofuel voluntary schemes and associated methodologies to assess the maps produced though such schemes (see Ecofys and IEEP, 2012). Whist this type of approach does not necessarily provide a view of the potential scale of energy biomass that could be produced, it would help to focus efforts in assessing suitable areas in which biomass could be grown with minimal impacts on other land uses or the environment. The added benefit with this approach would be that other contextual information could be taken into account that is wholly lacking from more benign assessments of the data, such as the socio-cultural motivations of the land owners and managers to utilise particular land areas, whether they are suitable or not.

In any future approaches, consideration should be given to the longevity of the work produced and seek where possible to ensure it is as compatible with existing and future initiatives and approaches.

[63] In some cases regional, national or thematic terminology is important to retain, but this does not prevent the possibility to provide read-across to a standard terminology so that the data can be understood in context.

[64] By identifying 'targeting zones' using national and regional data, that are then assessed on a case by case basis where an applicant is seeking entry into a scheme. http://www.magic.gov.uk

6 Conclusions and recommendations for further study

Based on the assessment carried out in this study, including a review of EU level datasets on land cover and use, and a review of the data available within three Member States (including regional data) the following conclusions are drawn.

- The land use and cover data available currently at the EU or Member State level is insufficiently detailed on which to undertake a more detailed future study to determine the area of specific land types that could be available for agricultural biomass production with limited impacts to both current production levels and the environment.

- Assessments of the current and future potential scale of suitable land in Europe to support production of biomass for energy supply have been limited by data availability in relation to the critical questions being asked, and compatibility. As yet there remains a lack of consensus around this aspect of the bioenergy debate. ***There is therefore justification to proceed with a more detailed assessment particularly in relation to the nature, suitability, availability and scale of "marginal" farmland and near farmland that might be available in order to make more informed decisions around both EU policy development as well as more practical decisions around industry deployment potential.***

- The information and data available on which to make assessments of the potential scale at which energy biomass could be grown sustainably in the EU outside woodland and forests is limited, both at the EU aggregate level as well as within Member States. The subjective nature of the data recorded in current statistics means that application to other, more novel applications is often challenging, although value can be extracted in different ways. To utilise and interpret the current datasets for the purposes outlined above would need a variety of techniques and approaches, such as geospatial analysis, field survey and ground truthing, database aggregation and likely consultation to validate the resulting data. ***The challenge is less one of collating and interpreting existing data, but rather one of finding or producing data that is fit for purpose.***

- The resources needed to support such an activity for the EU are comparable to that of other specific land and resource assessments such as the UNECE/FAO forest Europe assessments, the LUCAS or Copernicus initiatives. It would take considerable time, effort and resources to complete. Complete MS level assessments would also be challenging. However, ***site-specific assessments or regional assessments covering areas with relatively similar conditions might well prove more manageable within a modest research project.***

- There are a number of existing approaches that have been trialled or proposed for making specific assessments of certain categories of land, such as the JRC methodology to combine bio-physical data to delineate areas of natural constraint; or using satellite remote sensing data combined with existing ground survey data to assess land abandonment over specific time frames. ***Such approaches provide a useful potential future means of assessment relevant to sustainable biomass production and warrant further investigation.***

- Providing quantitative assessments on the scale of the potential is desirable, but not always practical. ***Other more qualitative approaches to assessing future potential may yield more fruitful results, and could include more synthetic reviews using expert judgements, particularly at the site or case-specific level involving those with good knowledge of the area.***

- ***Further work to develop capacity and understanding in this area may include:***
    - ***A guide for non-specialists explaining the key issues and the local nature of the issues involved.*** *This could include "a guide to the maize of agricultural terms" that would explore and define the terms commonly used in agricultural statistics and practice. This would aid in the understanding of what is possible from the data available, and in interpreting research undertaken in a context different to that of bioenergy.*
    - ***Specific regional/local case studies involving data gathering and stakeholder inputs.*** *Addressing the question of land availability and sustainability on a case-by-case basis provides much more potential for accuracy and understanding of the situation in a given context. One that doesn't rely on national or pan-European datasets that often lack the specificity and accuracy to draw conclusions at this scale. Assessments at the biofuel production plant catchment scale, such as those being explored in the BioFrontiers energy crop case study assessments, provide one such approach.*
    - ***A paper examining the issue in economic terms e.g. where would energy biomass most likely be established under real world conditions.*** *This would help to understand the motivations and likely deployment patterns of biomass cultivation. Particular focus could be made on the areas of land that farmers would choose for production purposes between different crop types and depending on the profitability of such crops in a given context, e.g. with or without bioenergy support schemes.*
    - ***Developing a concept for a larger EU study that might fit within Horizon 2020 such as research to develop a system of harmonising future data collection exercises relating to land use/cover.*** *This would look to identify areas for further study in addressing land area potentials including the design of data capture and management approaches building on existing approaches. It would explore the potential to harmonise existing pan-European and national datasets to allow their use across a greater range of thematic research areas.*

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