LAND AS AN ENVIRONMENTAL RESOURCE

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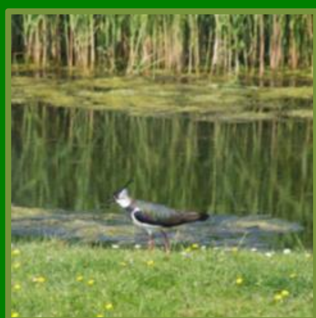

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GLOSSARY

CAP	Common Agricultural Policy
CICES	The Common International Classification of Ecosystem Goods and Services – an ecosystem services framework proposed by the EEA, UNEP and the FAO.
CSF	Common Strategic Framework
Cultural services	One of three ecosystem service types covered by this study. Cultural services describe the function of ecosystems in providing spiritual and recreational enjoyment of an area. These include: recreational activities and visits or a sense of place and landscape.
EAFRD	European Agricultural Fund for Rural Development
Ecosystem	An ecosystem is a dynamic complex of plant, animal, microorganism communities and the non-living environment interacting as a functional unit
Ecosystem service	Ecosystem services are the benefits people obtain from ecosystems
EEA	European Environment Agency
EFA	Ecological Focus Area
EFSOS	European Forest Sector Outlook Study
EIA	Environment Impact Assessment
EIP	European Innovation Partnership
EQO	Environmental Quality Objective (under the Swedish Environmental Code)
ESS	Ecosystem service
EU	European Union
EU-12	The 12 Member States that joined the EU after 30 April 2004
EU-15	The 15 Member States that joined the EU before 30 April 2004
EU-27	The 27 Member States of the European Union
GMO	Genetically Modified Organism
FSS	Farm Structure Survey
Ha	Hectare
HNV	High Nature Value – Usually used in reference to HNV farmland but can be applied to forestry also
ILUC	Indirect Land Use Change
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
JRC	Joint Research Council
Kt	kiloton
Land Cover	Describes the collective vegetative cover on the land surface, such as forests, cropland, grassland, water bodies etc.
Land Use	Describes the socio-cultural appropriation of land cover, such as forestry, agricultural production, recreation etc.
LIFE	EU Financial Instrument for the Environment
LU	Livestock Unit – A standardised measure of livestock equating approximately to

	one dairy cow
LUCAS	Land Use Cover Aerial Frame Survey – A dataset of land cover and land use in the EU based on site survey and statistical upscaling
LULUCF	Land Use Land Use Change and Forestry
Mha	Million Hectares
Mm	Millimetre
M^3	Cubic metres
MS	Member State
NAI	Net Annual Increment
Natura 2000	EU wide network of nature protection areas established under the 1992 Habitats Directive
PES	Payment for Environmental Services
PLU	Plan Local d'Urbanisme/d'Urbanisme Intercommunale
PLUI	Plan Local d'Urbanisme Intercommunale
Provisioning services	One of three ecosystem service types covered by this study. Provisioning services relate to materials and substances produced by natural ecosystems or through modification of natural ecosystems. These include: food, timber, fibres and biomass feedstock.
Ramsar	International designation of wetlands – following the Convention of Wetlands, signed in Ramsar, Iran.
RBMP	River Basin Management Plan
RED	Renewable Energy Directive
Regulating and maintenance services	One of three ecosystem service types covered by this study. Regulating and maintenance services relate to the functioning of ecosystems in regulating the biotic and abiotic environment. These include: maintaining water quality, regulating greenhouse gas emissions, and preventing soil erosion.
Rural land	For the purposes of this study, this term is taken to mean land under forestry and agricultural use as well as land that has the potential to be brought under either use.
SCoT	les Schémas Régionaux de Cohérence Territorial
SCP	Sustainable Consumption and Production
SEA	Strategic Environmental Assessment
SOER	State of the Natural Environment Report – A series of reports issues by the European Environment Agency detailing the status and trends of key environmental topics in the EU.
SRC	Short Rotation Coppice
SRCE	les Schémas Régionaux de Cohérence Ecologiques
TEEB	The Economics of Ecosystems and Biodiversity
TVB	Trame verte et bleue (green and blue infrastructure)
UAA	Utilisable Agricultural Area
WFD	Water Framework Directive

EXECUTIVE SUMMARY

Land is a multifunctional resource and the amount available to be used for different purposes is relatively fixed. This study focuses on the rural land resource and its essential role in delivering all ecosystem services, including food, timber, biomass for energy, clean water, healthy soils, carbon sequestration, cultural landscapes and recreational space, underpinned by biodiversity. Some of these ecosystem services, such as crops, livestock and timber do not have to be produced within the EU to be enjoyed by EU consumers as they can be traded. Others, notably environmental services such as clean water are location specific and have to be produced within the EU, for European citizens to benefit from them.

Consequently, while the main concern of this study is land use in the EU, it must be recognised that a larger area of the world, including land in many other countries, is deployed to meet the needs of European citizens. This 'footprint' overseas needs to take account of exports too, but includes land growing food, livestock feed, fibre, wood, bioenergy feedstocks and other commodities, as well as less quantifiable, but important, services provided by forests and other ecosystems. With large scale trade in commodities in and out of the EU, there is a dynamic interplay between land uses, which need to be taken into account. EU land use cannot be considered in isolation.

To meet the multiple demands being placed upon rural land in a way that is sustainable and promotes the efficient use of natural resources, policy decisions have to be made about the appropriate use of the available resource in any given location and situation. These can guide, influence and, in some cases, regulate the decision of land owners and managers. The need for a coherent approach to land use and its integration into key policy areas is therefore paramount.

The purpose of the study is to consider the range of demands facing different types of rural land use and related ecosystem services in the EU to 2050 and, in light of these, to examine the various ways in which these demands could be met. In so doing, it considers the extent to which there is potential to increase the production of food, bioenergy and timber for material use on rural land in Europe while also meeting the EU's environmental objectives. Alternative means of achieving these demands sustainably, including non land based alternatives, increasing imports and constraining demand are reviewed briefly.

The rural land resource and the provision of ecosystem services

Rural land accounts for 95 per cent of the EU land area (409 Mha). Of this total area, 38 per cent is under forest cover, 25 per cent is cropland (of which three per cent is currently used to produce crops dedicated for bioenergy use), 20 per cent is grassland, five per cent shrubland, three per cent water, two per cent wetland and two per cent bare land. Of the land under agricultural use, approximately seven per cent is currently not visibly being used for any specific activity, although in practice it may be used for a variety of purposes, including leisure uses which are difficult to identify from the statistics. Approximately 22 per cent of forests and 10 per cent of agricultural land is designated as habitats of nature conservation importance (Natura 2000 sites). **Over the past two decades (1990–2010) the population of the EU has grown by four per cent – equivalent to 28 million people (UN-DESA, 2011), with corresponding increases in food demand. Nonetheless, agricultural land**

in the EU-27 has declined by approximately 15.7 Mha (approximately 984,000 ha per year), while the forest area has grown by 9.8 Mha (approximately 611,800 ha per year). Urban areas have continued to expand over this time, with estimates suggesting that 100,000 hectares of rural land are built on every year, an area just over the size of Berlin.

The diversity, quality and the quantity of the different types of products and environmental services provided by a particular area of land depends on the land use and in addition its management, including the intensity of production as well as where it is situated geographically.

Within a given agricultural area, the **more extensive forms of land management generally support the highest levels of biodiversity and provide the greatest diversity and quality of ecosystem services**. This is because they tend to be managed using lower levels of nutrients and agro-chemicals, with lower livestock densities and they maintain a high proportion of semi-natural vegetation and landscape features. The farmed area is often intermixed with a diversity of different types of land cover such as scrub or woodland. The production of the provisioning services, food, timber and biomass for energy and biomaterials, relies on the modification of natural systems and the more modified the system, the fewer synergies there are likely to be with other ecosystem services. **However with the appropriate management, more intensive farming systems can also reduce current pressures on the environment,** for example through the use of new technologies to improve soil and water management and to reduce greenhouse gas emissions.

Overall there is a serious under provision of environmental goods and services from rural land in the EU when measured by the goals set in public policy for water, biodiversity, climate change and other parameters. In other words, farming and forestry land uses do not produce enough in terms of biodiversity, clean water or soil protection, or are using too much of finite resources leading to their depletion over time (for example the over use of water by the agriculture sector). This has occurred because of a lack of incentives. Land as an environmental resource has some distinctive characteristics. Firstly, most decision making over land use and land management is in highly decentralised and fragmented private hands – foresters, farmers and other land managers. Most of these millions of independent decision makers are primarily motivated by the fact that they are trying to make a living from the sale of food, forest and other products. Secondly, there are pervasive market failures in the delivery of environmental goods and services from land. Society generally does not pay for the biodiversity or water cleaning services provided by land, hence these types of services generally are undersupplied. Achieving the appropriate management of rural land to deliver these environmental goods and services alongside food, feed, timber is a major societal challenge.

Over time, market forces have driven an intensification of land use in agriculture and forestry, leading to significant productivity gains on land in the more fertile areas and marginalisation or abandonment of farmland in many other areas. These twin processes have led to significant declines in biodiversity and natural resources, such as water and soils. **Such changes mean that there is now very little more fertile land that is managed extensively. It is in these areas, where the potential for production of food, feed and timber is the greatest, where the competition and tensions between maintaining and**

improving the provision of environmental services and commodity production are most keenly felt. The continued poor quality of many environmental services relative to public expectations also imposes a cost on society, for example in clean-up costs to decontaminate drinking water. Environmental policies, including regulation, incentives and planning processes have been introduced to combat such declines but only limited progress has been made, mainly in reducing greenhouse gas emissions, improving water quality through reducing the level of nitrogen inputs and pesticides used in some parts of the EU and slowing the decline of some habitats and species through the establishment of the Natura 2000 network.

Future demands from rural land

Assessing future demand for all the ecosystem services that are required from the EU's rural land to 2050 is an inherently imprecise task, particularly since producers and consumers operate in an open international trading system.

World population growth is a prime driver of demand for food, forest products and energy, followed by economic growth. Against the UN's projections for global population to grow to nine billion by 2050, population levels in the EU-27 are expected to peak around 2030 before declining, accompanied by higher life expectancy. Economic growth will continue, but is unlikely to be as fast in the next four decades as in the last four, with a potential slow down in the numbers of those in developing countries most likely to adopt current western consumption patterns. However, **there is uncertainty over almost all the key variables affecting demand**. For example, even in the fast growing transition countries, such as China and Brazil, economic growth projections have been curtailed recently and it is uncertain that the rapid rates of recent decades will resume, affecting spending and consumption patterns. In the EU there is already some evidence of shifting dietary preferences, away from the consumption of red meat for example. Consumption of some processed foods may also decline and amongst a proportion of the population the demand for niche and environmentally added value products, such as organic, may rise. Nevertheless, at a global level, the overall message from the FAO and UNEP is still one of continued pressure on resources such as land and water for food production.

Future demand can be considered under some broad headings.

Environmental Services: As there are practically no markets for environmental services, societal demands are expressed through international, EU, national and regional targets and objectives for specific services. These show high levels of unmet demand for environmental services such as biodiversity, clean water and reductions in greenhouse gas emissions for example, compared with the current situation. This is signified by the non-achievement of environmental targets, such as the 2010 biodiversity targets and there is a long way to go before reaching targets under the Water Framework Directive. This unsatisfied demand and concern about the need to protect and enhance our natural resource base is also evidenced at the local level through economic studies on the willingness to pay for environmental goods and services as well as membership of environmental organisations.

It is anticipated that these demands will increase to 2050, both to reduce the current deficit and to respond to new demands. In particular there will be a need for the agriculture and forestry sectors to contribute to the EU's 2020 Biodiversity targets, the requirements of the Water Framework and Pesticides directives, as well as climate change mitigation and adaptation requirements, which can be expected to increase, particularly in relation to agriculture. Addressing issues related to soil degradation will be another key area of focus.

Agriculture**:** Demand for commodities from agriculture are driven by changes in demand for food, fibre and energy products at a European and global scale as well as technological, economic and institutional developments. Even with stable demand levels within Europe, significant changes in trade could take place and so there are large numbers of variables in play. **At a global level, demand for agricultural products will rise significantly by 2050.**

Within the EU, most projections of food consumption run only to 2020. These suggest that the consumption of cereals, including maize, will increase slightly, with the increase largely due to the increased demand for cereal feedstocks for bioenergy. For livestock, there is likely to be a decline in demand for red meat from beef and sheep and a slight increase in demand for white meat from pigs and poultry. Demand for dairy produce, however, is predicted to continue to grow. There may also be an increased demand for biomass grown on agricultural land, including more novel crops such as short rotation coppice as a feedstock for energy and other emerging uses such as biomaterials. These projections and those for 2050 are subject to considerable uncertainties. For example, unless there is a large increase in food aid, the relative cost of EU production will be critical. In the longer term it could be wise to plan for an expanded output. The demand for bioenergy is largely policy driven and changes to the way targets under the Renewable Energy Directive (RED) can be met to take account of indirect land use change (ILUC) currently under discussion could alter the demand for cereals and other crops for this purpose (although the direction of change is still likely to be upwards).

Forestry: For forest products, wood for material uses currently constitutes 57 per cent of production, and some leading models suggest that demand for such products will increase by eight per cent to 2030 (EUWood project and the European Forestry Sector Outlook Study (EFSOS)). A critical issue is the extent of increased demand for biomass for energy purposes in the EU and the proportion of this that is sourced from European forests. Up to 2010, almost half the EU's supply of renewable energy was based on woody biomass. The share of other types of renewable energy has been increasing (especially wind and solar) but no policy targets exist to specify the size of the contribution of agricultural crops or woody biomass in 2020, still less 2030. To reach the 20 per cent target for renewable energy in 2020 the demand for woody biomass is widely expected to increase, even if its share in the renewable energy mix continues to decline. In an extreme scenario it was assumed that the woody biomass share in the renewable energy mix would decline only as far as 40 per cent in 2020 and 2030, resulting in a strong overall increase in demand. In such circumstances the share of forest biomass used for energy was predicted to increase from 43 per cent currently to 61 per cent in 2030.

Looking ahead to 2050, this evidence suggests that the most significant demands on rural land will be for a sizeable increase in the provision of environmental services particularly from land under agriculture and forestry management, alongside increased demand for cereals and woody biomass, primarily for bioenergy. There will also be continued demand for land for built development. Conversely, assuming no major changes in trade, demand for conventional supplies of food and fibre from European land could grow little in the coming decades. The implications of these predicted future demands on rural land are complex. They suggest: continued overall decline in the EU's agricultural land area (although the rate of decline may be stemmed by increased demand for land to grown bioenergy feedstocks); expansion of the forest area, although the rate of increase may decline; expansion of built development; and increases in the aggregate intensity of production of both forest and agricultural areas. Of note is the reduced demand for beef and sheep products, which probably will affect the demand for grazing pasture. This is likely to have significant negative implications for achieving several environmental objectives, not only for biodiversity where semi-natural grassland is lost, but also for water, soil and greenhouse gas emissions, where grassland is converted to cropland.

There are three major caveats to these demand predictions. First, supplies may need to increase in future if Europe's contribution to global output needs to grow, for example because of constraints on production elsewhere. Substantially higher global prices would stimulate EU output. Second, climate change could damage productive resources and disrupt anticipated supply patterns and reduce anticipated yields. Third, renewable energy policy within and beyond the EU could increase greatly the demand for certain crops, residues and forest products. Two conclusions follow. First, the **EU may find it has an historic opportunity to correct the imbalances in material and environmental service provision from land,** as is being attempted currently through proposals to green support payments to farmers under the Common Agricultural Policy. Second, **the uncertainty ahead means that it is prudent to plan to ensure the EU's rural land is resilient to worst case scenarios and that, if greater production is needed, land is available, whilst tackling the manifest environmental deficit in many rural areas in the EU.**

Meeting future demands – EU potential for sustainable production of ecosystem services

Both marketable and public goods and services need to be supplied in a balanced way within the EU. This requires addressing the existing environmental deficit as well as the increased environmental pressures of the future (eg water scarcity) alongside meeting demands for marketed commodities. Essentially there are three ways in which land can be used to respond to such demands:

- through changes in land use, such as reduced rates of transfer to urbanisation, forest expansion or the allocation of land to priority environmental services, such as flood risk management;
- through increases in productivity per unit of land and per unit of output (needing less productive area for the same output); and
- by changing the way land is managed while maintaining the same output.

To be sustainable, whichever responses are chosen must meet environmental needs while balancing these with the production of other ecosystem services. Any increases in the production of food, feed or timber, therefore must be accompanied by improved resource efficiency (to avoid reducing natural capital) and improved flow of environmental services from healthier ecosystems.

The nature of this future balance of land use and service provision will depend on individual decisions taken by the millions of farmers and foresters across the EU. They will be heavily influenced by the future trajectories of supply side drivers, such as market prices and production costs for crops and livestock products and timber as well as by public policies.

Action in three core areas needs to be complementary.

Environmental services

Given the absence of powerful market drivers, the supply of enhanced services to meet current and emerging objectives will rely heavily on public policy. **Significant improvements in the effective implementation of existing environmental Directives and regulations and the incorporation within the Common Agricultural Policy of more comprehensive environmental objectives would be a logical starting point. The European Commission has made proposals along these lines.** Further measures may be needed in addition, including some already under discussion, such as sustainability standards for solid biomass. Much improved provision of environmental public goods from Europe's agricultural and forest areas is needed. Three aspects will need particular attention. First it will be important to ensure that forms of current land management which are depleting essential natural resources are modified to ensure that production methods are sustainable. Second, any growth in agricultural and forest productivity must be achieved within natural limits – sustainable productivity, with an element of intensification. Third, land that has a high environmental value currently (for example HNV farming and forestry systems, organic farmland, wetlands, extensive areas and organic soils) should be maintained and valued for the benefits already provided and measures taken to prevent abandonment, urbanisation or intensification of agricultural or forest management.

Agriculture

Models of future land use change are inherently uncertain and do not tend to take sufficient account of the imperative to reverse the significant environmental deficit that currently exists. Largely focusing on economic potential, they tend to suggest that over the coming decades less land in the EU will be used to meet future demands for food and feed, following the trends of the past 50 years, although this is likely to be accompanied by an increase in the volume of most commodities produced (with the exception of beef and sheep meat) as a result of increases in productivity. However, this is not to say that competition between production and the environmental functions of land will be relieved necessarily. These results are highly dependent on assumed rates of growth in yields, which may be hard to achieve given climate change and environmental limitations, especially the greater frequency of extreme weather events, growing water scarcity and potential reduction in soil fertility as a result of loss of soil organic matter.

Crop yields have stagnated and even decreased in Western Europe over the past decade. However, there is significant theoretical potential to increase crop yields in the EU-12, particularly in areas with fewest natural constraints (soil, water, temperature). **The degree to which the gap between realised and potential yields can be closed in a sustainable way remains the subject of much debate**. The outcome will depend on a range of factors including:

- enhanced investment in research and the accelerated development and take up of technologies aimed at enabling sustainable production;
- adoption of sustainable management practices to mitigate the impact of climate change and of yield losses due to environmental damage (pollination failure, soil erosion, water scarcity); and
- improved yields from organic agriculture.

There is also a need to overcome other limiting factors at farm level, including socio-economic and structural issues such as farm fragmentation, access to markets and extension services. Efforts are required to improve technology transfer to facilitate the adoption of new technologies by the majority of farmers, not just the most efficient. However, care is needed to ensure that these productivity investments do not also lead to further environmental damage (for example reparcelling). Changes in farm pressure and productivity also will be influenced by public policy, including agricultural support, investment aid, commitment to research and development, training and so on. The question of the EU's stance on several strands of technological development also will be significant. For example, whether or not the EU will maintain its relatively precautionary approach to technology in agriculture, compared with several other major production regions. Climate variability, natural disasters and the depletion or destruction of natural resources will also have impact on farmers' decision making and will limit the yields they can attain in practice.

The extent to which fertile land can be kept within agriculture, not directed to meet housing and infrastructure needs will also play a part. **If land currently abandoned or subject to minimum cultivation was brought into crop production, as some studies suggest, for example for bioenergy production, environmental safeguards would be needed.** For example, many of the soils concerned are relatively fragile or on steep slopes, water supplies may need to be augmented and infrastructure expanded to secure reasonable yields. Clearance of natural vegetation often will have negative biodiversity impacts. As a result, **the environmentally sustainable potential of such land is in fact much less than the area of apparently available land.**

Therefore, unless sustained higher international market prices for commodities or ethical pressures to help with international humanitarian issues lead to increased EU net exports or import displacement or dedicated bioenergy crop production expands significantly, the evidence suggests that there will be little pressure to increase in absolute terms the EU's agricultural area in the next two decades. Indeed, it is likely that, without policy intervention, considerable areas of agricultural land will be released from agriculture in the future, for example for built development, for afforestation or through the abandonment of extensively managed areas. Of course, this assessment is sensitive to broad assumptions on net trade and yield increases and it does not address possibly significant changes in the intensity of management of agricultural land to take account of environmental requirements. If demands for environmental services are to be addressed alongside those for agricultural commodities, then historic declines of agricultural land are likely to need to be reduced significantly. This will have implications for those land uses that are predicted to expand at the expense of agricultural land (urban and forest areas). Larger areas under extensive management could arise more as a result of policy than markets.

Forestry

The key findings in relation to forestry are based on scenarios modelled under the EUWood project and EFSOS. These conclude that although there may continue to be some expansion of the EU forest area, **most additional demand for timber bioenergy will be met through increased extraction rates from existing forests, alongside a small potential increase in short rotation coppice on agricultural land.** The models suggest that there is considerable economic potential to increase extraction rates from forests, although this is not necessarily environmentally sustainable. Because the forest growth cycle is measured in decades, any changes should be driven by wider long-term considerations not just short-term market demands. They should be phased in gradually, taking account of the impact of climate change on EU forests.

Maximum realisable potential was calculated under a range of scenarios, including a 'biodiversity' scenario, which gave priority to the protection of biological diversity, for instance by setting aside more land for biodiversity conservation, as well as applying stricter environmental constraints to favour other environmental services alongside long-term productivity. **The scenario results demonstrate clear trade-offs between the production of roundwood and residues and the environmental services provided by forests.** For example, when roundwood and residue removals are increased, biomass carbon storage, dead wood and recreation scores decrease and vice versa. The short-term realisable potential is therefore much less under the 'biodiversity' scenario than under other scenarios due to the limited removal of stumps, residues and deadwood – although in the longer term the removal of these elements could undermine growth potential given the important role that stumps and deadwood play in contributing to soil and nutrient balances.

The models show that the projected supply of stemwood from EU forests is enough to meet projected demand for wood for material use until 2030 except under the biodiversity scenario where there is a five per cent shortfall. In contrast, even with major efforts to mobilise more forest biomass within the EU for energy purposes it would not be possible to meet some of the higher projected demand levels (biomass meeting 40 per cent of the renewable energy mix in 2020) without recourse to other sources, such as imported biomass and dedicated SRC on agricultural land. Both alternatives could have questionable environmental and/or economic impacts even if they were acceptable in terms of reducing net emissions of GHGs. Therefore to avoid unsustainable rates of extraction, other solutions would need to be found, such as reducing overall energy demand and increasing the contribution made by other renewable energy sources to the energy mix.

In summary, the evidence suggests that there is still considerable potential to increase commodity outputs from existing land, particularly timber as well as crops in the EU-12. However to achieve this in a sustainable way will require far more attention to be paid to the environmental management of agricultural and forest areas. In some cases this will impact upon yields, at least in the short term, but in other areas there is still significant capacity to adjust environmental management to reduce environmental pressures without having a significant impact on yields. Consequently, alongside significant increases in output from existing agricultural and forest areas, there are also likely to be tensions between different land uses in the future. Greater restrictions may need to be put in place, therefore, to limit the area of land that is built upon and more attention paid to guiding the extent and location of shifts between agricultural and forestry land uses.

Local land use dynamics in different parts of the EU

The options for increasing production potential vary geographically, depending on a range of bio-geographic, climatic, economic, social and political factors. In some situations improvements to environmental services can be made simply by changing aspects of land management, while in others substantial changes in use may be needed. These are demonstrated in four case studies in North Karelia in Finland, Catalonia in Spain, the Great Plains of Hungary and Wales in the United Kingdom The case studies also showed that increases in the provision of crops or timber invariably require some sort of trade-off with environmental services, unless the increases in yields can be brought about through neutral changes in management, crop variety or livestock breed or improved technology (such as precision farming). Some win-wins are possible. **Identifying a balanced approach that allows all ecosystem services to flourish is not straightforward, although in the longer term increases in productivity will be constrained if the health of environmental services, such as pollination, fertile soil and adequate water resources are not maintained. Unwelcome trade-offs can be minimised through more sophisticated decision-making and well informed local assessments.**

This highlights why it is important to look beyond generalised prescriptions for Europe as a whole or groups of countries within the EU when making judgements about how to achieve sustainable land use in the future. **When nested within a coherent EU strategy, regionally differentiated approaches are likely to be more effective than a blanket approach**. The case studies show that the land use, cover and cultural history of a region can play a significant role in determining the key demands from rural land and the outcomes that are likely to be acceptable. Forest expansion is appropriate in some locations but not in others, for example.

The case studies also highlight the importance of scale in making decisions about balancing the provision of ecosystem services from rural land – whether field, farm holding or forest unit, water catchment, region or country. **Approaches that might be untenable at a European scale could be appropriate in a specific locality and *vice versa***. For example, commodity production or the use of straw for bioenergy could be increased sustainably in one area whilst other areas are dedicated to conservation management, while elsewhere commodity and environmental service production could be combined on the same unit of land. However, the case studies show that, at least on agricultural land, the complete withdrawal of management often leads to lower species diversity and richness in the longer term. **They also demonstrate the need to consider the impacts of local land management at the wider territorial scale.** An irrigation project, for example, can lead to reductions in water availability elsewhere in the catchment, causing negative impacts on habitats and other areas of crop production.

Alternative means of meeting future demands

In principle, there are several alternative ways of sourcing the services associated with land in Europe other than by altering the overall area, land cover or management. Those of particular interest are:

- changes in trade patterns, particularly increased imports;
- adopting production technologies that require very little land; and
- changing demand, including consumer preferences for food.

Each of these has impacts, although they are of quite different kinds. The feasibility of developing such options is clearly important, but was outside the scope of the study.

Increased imports: Certain commodities are important on a large scale or could be in future. The scale and nature of the impacts will depend on a range of factors, including: the country and specific locality from which additional imports are sourced; the impact on land use that increased production might have (for example whether it requires a change in land use or in intensity of land management); and the associated environmental impacts that would ensue, such as habitat destruction, increased water use or greenhouse gas emissions. **In general, concentrated production of a relatively narrow range of commodities is most likely to be linked to considerable environmental damage, especially where semi-natural vegetation is displaced**. This is already being played out around commodities such as soy, beef or palm oil.

Increased imports from outside the EU beyond current levels are mostly likely to arise in relation to biomass for bioenergy, particularly wood pellets (eg from Canada, the USA, Asia and perhaps Russia), biofuels and biofuel feedstocks, such as rapeseed and palmfruit, for processing in the EU (from Argentina, Malaysia, Indonesia and Brazil) as well as commodities imported to replace domestic crops diverted to biofuel production. This is in addition to the already significant levels of food and feed imports.

It is difficult to predict how much imports related to bioenergy will actually increase in practice, given that these demands are largely policy driven and projections are based on the current targets under the RED, which do not take account of the proposals for changes to the directive to take account of Indirect Land Use Change (ILUC). Increases in imports may also occur in relation to protein-rich animal feed, in response to the growth in the EU pig, poultry and dairy sectors, although this may be offset to a small degree by declines in demand from the beef sector. This could exacerbate the environmental pressures in countries from which these crops are sourced. There are no detailed commodity by commodity projections made beyond 2020.

At the broad level, the presumption generally is that Europe is a relatively high-cost producer of agricultural commodities. It has high land and labour costs, it imposes relatively strong, and sometimes costly or sophisticated human health, animal welfare and environmental conditions on its producers in many areas. For decades many sectors have been heavily subsidised or protected by tariffs. **For EU competitiveness to be transformed in a series of key markets, quite sizable changes in present conditions would be required.** This could happen, for example as a result of greater resource scarcity due to climate change, or political instability, but it is deemed unlikely in the short to medium term at the scale required to witness such a substantive change. In terms of wood products, however, the situation for Europe is less clear. The EU both imports and exports a wide range of forest derived products and there are many dynamics in play, both in world markets, in technical development and in policy, notably for bioenergy. Exports could increase as well as imports. Data from 2010 for example suggest that the EU has turned from a net importer to a net exporter recently, largely due to the introduction of Russian roundwood export taxes and the economic downturn.

Alternatives with lower land requirements: Another alternative is to consider whether there are other means of producing the outputs required without using very much land. **The main opportunity is in finding alternatives that could replace bioenergy as the source of renewable energy for heating and cooling, electricity generation and transport**. In the short term, to 2020, it is thought that land based sources of energy will continue to be needed to at least some degree if the EU is to meet its renewable energy targets. However, beyond 2020 other alternatives start to become more viable, such as advanced biofuels sourced from cellulosic materials, wastes and residues, although high costs and specific technical, regulatory and infrastructure related barriers have still to be overcome, including potential impacts on biodiversity. Some of these options still entail substantial areas of land. In the foreseeable future, bioenergy is likely to remain the only viable alternative to oil in certain contexts, ie liquid fuels for aviation and long distance road transport. **There are fewer land based alternatives for wood products as timber tends to be a much more sustainable material than many of the alternatives**, for example the use of steel, concrete or bricks for construction. Paper recycling rates are already reasonably high, although a large proportion of the recycled material is exported rather than used within the EU. **Improving the use of recycled paper within the EU and the increased prevalence of electronic media may reduce the need for fresh pulp wood.**

Within the timescale considered by this study it is unlikely that there will be a major shift to alternative systems of food production that do not use land. Nonetheless, a range of alternative production methods are being piloted in response to concerns about future land capabilities and water scarcity and could signal a new direction of travel in the future. Some, such as hydroponics, are already being used to a fairly wide extent for the production of fruit and vegetables. Others, such as vertical hydroponic production systems, *in vitro* meat production and nanotechnologies are less well developed. The success and potential uptake of these technologies will depend on whether they can be made to be commercially and environmentally viable, with their energy balance a major concern. These are unlikely to be contributors to food production on any noticeable scale this half century.

Changing consumer behaviour: Finding alternatives on the supply side is only one part of the equation. Although not the main focus of this study, **just as important is finding ways of changing behaviour to encourage more sustainable consumption patterns. This includes changing diets as well as reducing waste, particularly of food and energy.** Reducing waste is not just the responsibility of consumers however, with significant improvements also needed in post harvest waste (while taking care to avoid depletion of soil organic matter), along all parts of the supply chain. These should accompany greater efficiencies in the use of resources to produce food and bioenergy, such as water. Although most of the policy measures available to influence consumption behaviour are relatively soft (eg labelling, information, public campaigns), if they are sustained over long periods they can have significant impacts.

Approaches for ensuring sustainable land use

Increasing the supply of ecosystem services from land generally relies on a set of policy interventions, since market forces play only a limited role in this regard. Whilst there are constraints on policy initiatives in this sphere at a time of economic downturn, some conditions for a new strategic emphasis on public goods are more favourable. These include the fact that stabilisation of the human population is now in sight in Europe, the greater understanding of the extent of the damage to natural capital and the threat to the sustainability of our food and timber production systems – particularly through climate change – as well as changing, more environmentally focused objectives for the CAP. **It is now imperative to rebalance the provisioning and non-provisioning services from land in the EU and there is an opportunity to do so.**

A range of policy tools and mechanisms is available currently or might be developed to guide the rebalancing of rural land use and management in Europe at different geographical scales. Examples from four Member States illustrate some of the advantages and barriers to developing such approaches.

Policy tools for influencing land use range from the more systemic to the rather small scale, incremental and site specific. These can be divided into three groups: spatial allocation tools that seek to determine how and where certain land use activities are most appropriate; implementing/influencing tools, including the use of environmental regulations and incentives to influence land management decision making; and monitoring and evaluation tools. Many of the principal regulatory, incentivising and monitoring tools are deployed at both the EU and national levels, with a major EU role in certain spheres, such as agricultural and water pollution policy. To date, spatial planning and zoning is left entirely to Member States and regions. There is also a global level, which is emerging more strongly, for example in relation to climate change and biodiversity where action in one country can have important impacts on others and trade effects need to be taken into account.

The **policy approaches to integrated rural land use decision making vary significantly between Member States**. There are many interesting initiatives to extend the scope of more established approaches but generally the integration of ecosystem service considerations into spatial planning is still relatively undeveloped. The cumulative effect of different policies in a particular location tends to receive very limited attention until after decisions have been made and rural land use changes brought about.

Four recent examples of where Member States have sought to develop strategic and integrated approaches to rural land use provide practical illustrations of different approaches at various stages of development and with mixed degrees of success (France, Netherlands, Sweden and Scotland, UK). They highlight some common issues and barriers affecting the implementation of more strategic approaches to rural land use. These include:

- political sensitivities about the role of planning and encroachment on private property rights in rural areas;
- the limited awareness amongst the general public and land managers about the effects of land management on the environment and the need to address them in a more pronounced and coordinated way;
- determining the most appropriate scale at which a coherent territorial approach should be applied, reconciling environmental and governance considerations; and
- issues with the quality and availability of data to support the development, implementation and subsequent monitoring and evaluation of more sophisticated approaches.

Achieving sustainable rural land use - the role of the EU

There is a need to think more strategically about how rural land is used in Europe, more so still in the longer term. Appropriate analysis and policy tools at an EU level are needed alongside national measures to assist policy makers and land managers to make more optimal use of rural land and address location specific conflicts more effectively. This will require a combination of approaches, including: strategic target setting; traditional land use planning; more creative means of planning and allocating rural land use to achieve greater synergies; appropriate environmental regulation; and steering agricultural and forestry land use and management by means of appropriately designed incentives provided within sectoral policies (such as the CAP and energy policy). New policy tools may be needed as well, for example in relation to soil.

The danger of inaction is that sub-optimal land uses may become more prevalent. Examples include persistent poor management of certain soils, failure to take account of carbon sequestration and emissions in land management, as in the case of peat soils, and inappropriate bioenergy developments detached from the best long term use of the land resource. Resilience to crises and extreme events, whether internal or external, may be lost.

All approaches should work as part of a coherent framework, informed by a more strategic vision of how far it is possible or desirable to meet long-term requirements for food, fibre, energy, biodiversity and ecosystem services from the limited land resource within Europe and a sustainable share of the planet's overall stock of land. Five different types of measure where the EU could make a worthwhile contribution by virtue of its policy competences, existing web of influences on land use and management and its scale have been identified and include:

i) support for a coherent transnational EU territorial framework for the provision of all ecosystem services (private and public goods) from rural land to prioritise building resilience into the rural land resource;

ii) Setting targets and measures to strengthen the provision of environmental services, such as extending targets to measurable aspects of land use, such as semi-natural habitats, soils, carbon etc; improved implementation of existing environmental regulations, developing new incentives for environmental issues or components not currently covered by EU legislation – soil management and carbon sequestration; and amending existing legislation to encourage better provision of integrated ecosystem service delivery;

iii) raising awareness amongst civil society and land managers who are responsible for the key decisions on the way rural land is managed on the environmental, economic and social benefits of promoting more sustainable approaches to land use, as well as supporting research into the most effective methods of improving awareness.

iv) improving the quality, coherence and availability of rural land information, with the EU institutions playing a leading role collating, standardising and monitoring spatially explicit data on rural land use at EU level and at other geographic and temporal scales and making these available in a format that can be used to inform decision making at more local scales. Member States will also have to play a role here to ensure their data are accessible and in the required format. The development of concepts such as ecosystem capital accounting, such as that development by the European Environment Agency, would also be helpful; and

v) encouraging and supporting information exchange and innovation in sustainable land use planning by institutions and communities at all levels of governance will help in the adoption of best practice techniques and tools of land use planning and management.

In summary, land use is addressed, often indirectly, in a spectrum of European policies extending well beyond the environment into agriculture and energy. At present there is a danger that conflicting signals are being generated unintentionally and opportunities to optimise the use of land, increasingly recognised as a scarce resource are not being seized. **Hence there is a challenge to strengthen coherence in the EU policy framework, to improve the capacity to address land use issues, investing in research and data acquisition in the process and to adopt a more proactive approach.** Whilst there are sensitivities about EU engagement in the sphere of land use planning, the Union is an appropriate level at which to take certain measures which would be less effective if advanced solely at the national and local levels.

1 INTRODUCTION

1.1 Rationale and Context

Land is both a relatively fixed and a multifunctional resource. The EU's rural land provides a wide range of functions and services on which society depends. Alongside the resources needed for the production of food, fibre, timber and fuel, rural land is also critical for the provision of biodiversity and ecosystem services, such as climate regulation, water quality, soil functionality, flood management, cultural landscape and recreation. Some of these ecosystem services, such as crops, livestock and timber do not have to be produced within the EU to be enjoyed by EU consumers as they can be traded. Others, that is many of the environmental services are location specific and have to be produced within the EU, for EU citizens to benefit from them.

The use of rural land to produce timber, food, feed, energy alongside important environmental goods and services involves a dynamic and complex relationship that is dependent on both land cover and intensity of land use. The demands on EU rural land change over time, driven by a range of factors such as population dynamics, the macro-economic situation and changing dietary preference. The degree to which land responds to these demands is also subject to change, influenced not just by biophysical characteristics, but economic, social and environmental drivers such as changes in global markets affecting price signals for tradable goods, technological development, climate change, social and structural change as well as public policy.

Over the last few decades, the drive to increase the production of food and other marketed outputs has led to significant degradation of many ecosystems, with serious impacts on their capacity to provide environmental benefits. In addition to the market drivers of agricultural and forestry production, in the last five years the targets set by the EU Renewable Energy Directive (RED) on the promotion of the use of energy from renewable sources have become a significant additional driver affecting land use in the EU (and globally). Responses to these drivers have significant long term implications for the sustainability of the natural resource base and hence the security of supply of all the land-based goods and services on which society relies. Although recognition of this fact has led to significant efforts to promote sustainable agricultural and forestry management through the introduction of legislation, incentives and advice, the environmental pressures from different types of land uses continue to be considerable (EEA, 2010a).

How to match natural resource use with human demands is complex spatially, with many interdependencies and environmental feedbacks. This is complicated further when land as an environmental resource is considered, given that it has a number of unique distinguishing characteristics. Firstly, property rights in land are, by and large, privately allocated so the primary decision making over land use and land management is in highly decentralised and fragmented private hands. Secondly, these millions of independent decision makers are primarily motivated by trying to make a living from the sale of provisioning services, food, forest products and fuel. Thirdly, the very nature of land management is that it is characterised by pervasive market failures in relation to environmental services, hence these are chronically undersupplied. This constitutes the societal challenge of the appropriate management of its rural land. The need to improve the sustainability of rural land use in the EU will be even more pertinent in the decades to come to ensure the resilience of rural land to the increased impacts of climate change.

Given the relatively fixed nature of land as a resource, decisions have to be made about the appropriate use of the available resource in any given location and situation in order to meet the multiple demands being placed upon it in a sustainable or resource efficient manner.

This ambition is reflected in the EU's goal to move towards becoming a low carbon and resource efficient economy[1]. To achieve this in relation to rural land, some of the key challenges include how to maintain or increase the production of food, fibre and other raw materials while ensuring that the capacity of the land to sustain the production of these outputs over time is improved by moving towards a more efficient use of natural resources, such as soils, water, energy and carbon as well as the role and contribution of the agricultural and forestry sectors to the supply of renewable energy and industrial raw materials. The need for a coherent approach to land use and its integration into key policy areas has become increasingly evident. This implies a more strategic view of the land resource within policies that address the environment, agriculture, forestry and bioenergy, with a more incisive analysis of what constitutes an optimal use of land on a European and global scale within a sustainability perspective, balancing social, economic and environmental needs, and how this might be achieved in practice.

1.2 Objectives

Although there is a general acceptance of the need for the use of rural land in the EU to become more sustainable in the long term, there is little consensus about what this means in practice.

The purpose of the study is to consider the range of demands facing different types of rural land use and related ecosystem services in the EU to 2050 and, in light of these, to examine the various ways in which these demands could be met. In so doing, it considers the extent to which there is potential to increase the production of food, bioenergy and timber for material use on EU rural land while also meeting the EU's environmental targets. Different approaches to achieve these demands sustainably, including non land based alternatives, increasing imports and constraining demand are reviewed briefly. To inform the development of policies on sustainable land use so that the full range of ecosystem services from rural land are delivered more efficiently and coherently in the future, the study considers the future role of different types of policy instruments, including land use planning to improve the consistency and coherence of decisions on the use of the land resource in rural areas.

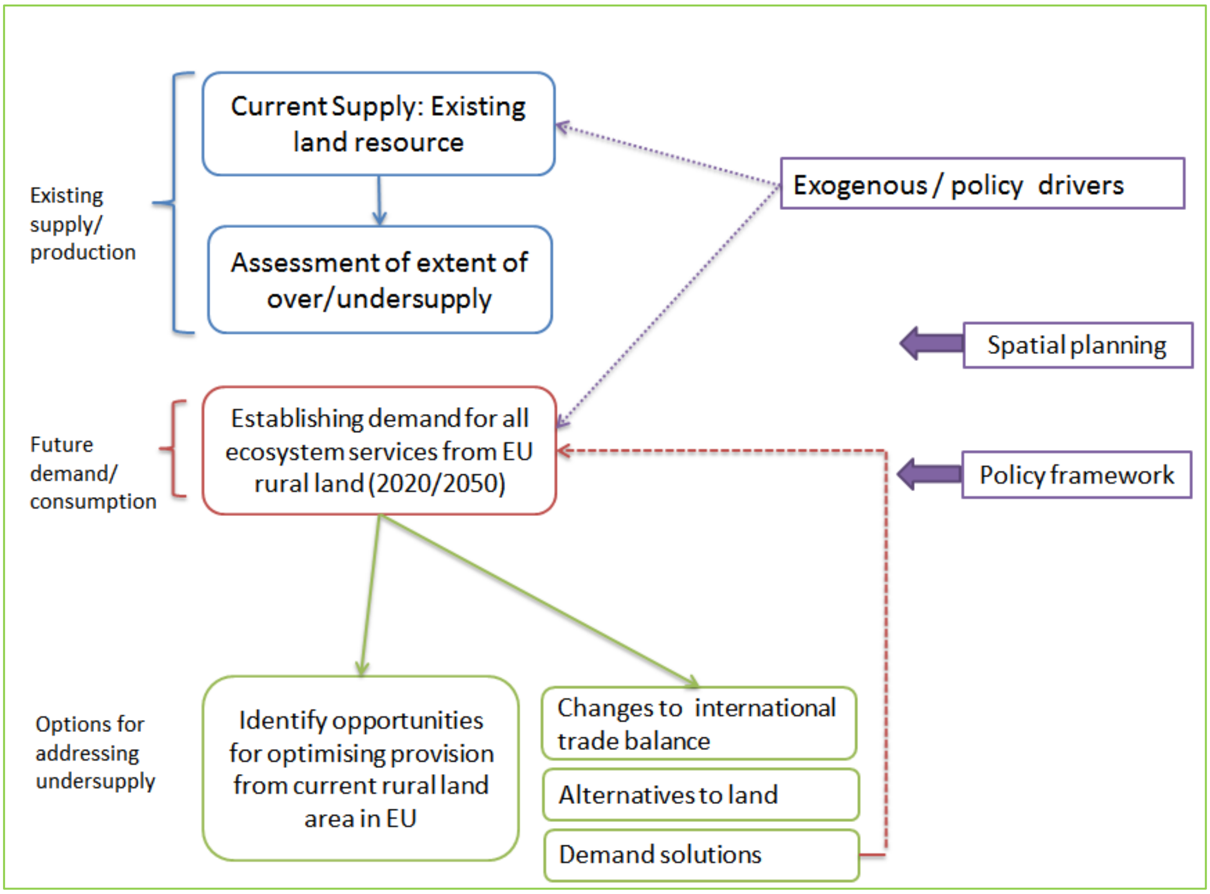
The underlying premise of the study is that solutions need to be found to meet future demand for all ecosystem services, environmental services as well as food feed and timber. This means finding ways of addressing the current environmental deficit as well as

[1] As set out in the Europe 2020 strategy (COM(2010)2020; the Roadmap to a Resource Efficient Europe (COM(2011) 571 final) and the Roadmap for moving to a low-carbon economy in 2050 (COM(2011)112)

increasing food and timber production. The study focuses solely on rural land use. Urban areas are only considered in relation to the potential demand for land for urban expansion.

The study's objectives are set out diagrammatically in Figure 1.

Figure 1: Schematic overview of study objectives



The contents of the report are structured as follows:

- First the current rural land resource in the EU is set out in relation to both current land cover and land use (**Chapter 2**).
- This is followed by a description of the potential of these land covers and land uses to deliver a range of ecosystem services (**Chapter 3**).
- An assessment of the growing demands on land for different purposes to 2050 is then carried out (**Chapter 4**).
- **Chapter 5** explores the potential for increasing the production of different ecosystem services from agricultural and forestry land in the EU in a sustainable way in the future, based on existing projections, considering the opportunities offered by technological advancements as well as some of the limiting economic, social and climatic factors. The analysis is caveated by the fact that any such assessments are inherently imprecise, given the uncertainty associated with many of the drivers of demand and supply over the next four decades, particularly in relation to global market prices and climate change.

- In order to investigate these issues in a more detailed manner, four case studies (Finland, Hungary, Spain and the UK) are used to illustrate, in a quantitative way, the various demands facing land use in different parts of the EU and the different choices, opportunities and risks that exist to meet these (**Chapter 6**).
- **Chapter 7** considers alternative approaches for reconciling future consumption and production of land based services by examining the environmental implications of importing more tradable commodities from outside the EU on the EU's ecological footprint, as well as the feasibility and viability of alternative means of production that have a much lower land footprint. It also considers briefly the opportunities for changing consumer behaviour through promoting more sustainable consumption patterns.
- Finally, the study reviews the mix of policy instruments (regulation, advice, incentives) that exist to influence the use of land in a resource efficient way, looking at the current and potential role for land use planning in this regard. It looks at a number of examples where spatial approaches to rural land use planning have been explored (**Chapter 8**).
- It concludes by highlighting some of the critical issues that a future policy framework will need to address and the role that the EU can play to ensure a coherent approach to land use, facilitating the appropriate use of the available resource in any given location and situation so that the multiple demands being placed upon rural land are met in a way that is sustainable and promotes the efficient use of natural resources (**Chapter 9**).

2 RURAL LAND IN THE EUROPEAN UNION

Key findings:

- 95% of the EU is covered by a mosaic of rural land. This land is used in a wide variety of different ways and under varying degrees of management intensity - from high yielding arable areas to more extensive high nature value systems. Agriculture and forestry account for 74% of all land use.
- The recent LUCAS data show that around seven per cent of agricultural land lies fallow or temporarily abandoned from production. The Baltic, Scandinavian and Mediterranean Member States have the greatest proportion of such areas, with the largest areas found in Spain and Italy (correlating with drought constrained areas).
- Approximately ten per cent of agricultural land and 22 per cent of forests are designated as Natura 2000 sites. Agricultural Natura 2000 sites are roughly evenly distributed within the Union, whereas forest Natura 2000 sites are considerably more prevalent in the EU-12 (33 per cent of total forest area) than the EU-15 (19 per cent).
- Over the past two decades (1993–2009) the agricultural land area in the EU-27 has declined by approximately 15.7 Mha (approximately 984,000 ha per year), while the forest area has grown by 9.8 Mha (approximately 611,800 ha per year). Urban areas have continued to expand over this time, with estimates suggesting that 100,000 hectares of rural land are built on every year, an area just greater than the size of Berlin.

This chapter provides a broad overview of the current EU rural land resource and its functions, including the extent, cover and use of rural land in the 27 Member States.

2.1 Determining land cover and land use

The main dataset used to inform the inventory of rural land development as part of this study is the 2009 Land Use Cover Aerial Frame Survey (LUCAS). Based on survey information and statistical upscaling, LUCAS provides a consistent approach to determining land cover and land use in the EU. Unlike any other dataset LUCAS not only provides a comprehensive assessment of EU land cover[2] but also allows each land cover category to be divided further into its primary land use[3]. At the time of this study the LUCAS 2009 survey is complete for 23 Member States[4]. Supplementary datasets have been used to build a comprehensive picture for all 27 Member States as well as providing information on sector specific land related descriptions that are not covered by the LUCAS survey. A description of the data used can be found in Annex 1.

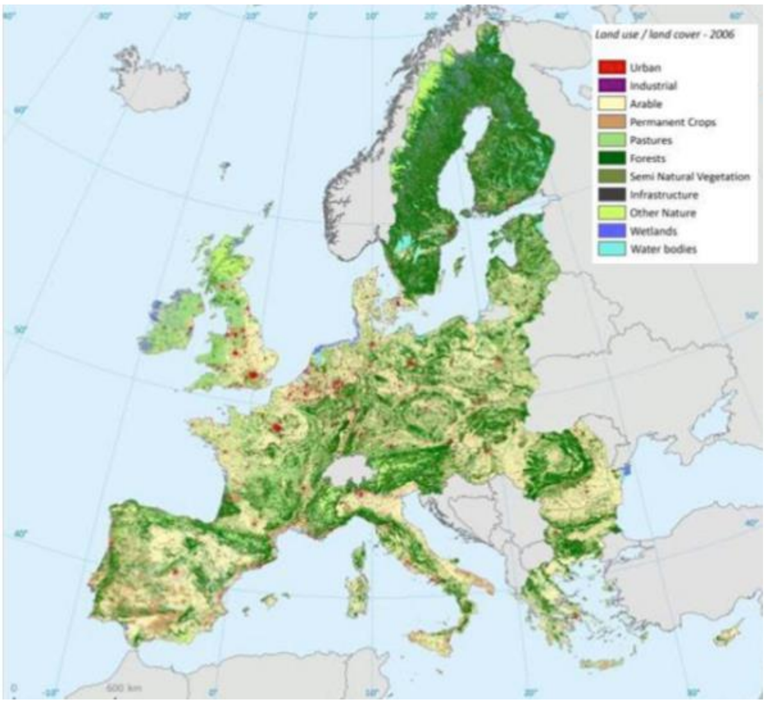
[2] Including cropland, forest, grassland, shrubland, wetland, bareland, water bodies and artificial land

[3] Including agriculture, forestry, hunting and fishing, heavy environmental impact (mining and quarrying; abiotic energy production; industry and manufacturing; water and waste treatment; construction; and transport, communication networks, storage, protective works, services and residential; and no visible use (For definitions see Table 6 in Annex 1).

[4] Excludes four Member States: Bulgaria, Romania, Malta and Cyprus.

2.2 Rural land cover in the EU

Figure 2: Distribution of broad land cover types across the EU-27



Rural land accounts for just over 95 per cent (409 Mha) of the EU land surface (see Figure 2[5]). Forests cover the largest proportion of the EU (38 per cent; 165 Mha), with cropland and grassland covering the next largest proportion (25 and 20 per cent (107 Mha and 84 Mha) respectively). These areas vary significantly between and within Member States. For example, forests cover between one (3,921 ha in Malta) and 68 per cent (22.8 Mha) of land in different Member States[6]. They are dominant in northern Europe, particularly in Finland and Sweden accounting for 68 per cent (22.8 Mha) and 66 per cent (29.6 Mha) of land cover respectively. However, there are also significant areas of forest in southern Europe for example Spain (32 per cent; 15.7 Mha) and Italy (33 per cent; 10 Mha). Of the southern and Mediterranean Member States, Slovenia has the greatest area of forest as a proportion of land cover at 63 per cent (1.3 Mha). For further details see Table 3 Annex 1[7].

Cropland, both arable[8] and permanent crops, is widely distributed throughout the EU. Distribution is limited in the very northern Member States and mountainous areas where environmental conditions are more suited to forests and grasslands. Cropland areas vary from 48 per cent of land in Denmark (2.1 Mha) through to as little as four per cent of land cover in Ireland (350,000 ha). The distribution within Member States can be equally striking, varying for example between 15 per cent (Saarland; 38,800 ha) and 48 per cent (Sachsen-Anhalt; 980,100 ha) in Germany. The type of cropland also varies significantly. Arable crops dominate in most Member States (90 per cent of total cropland in the EU; 104 Mha), however permanent crops represent a significant proportion of cropland areas in

[5] Source: JRC. Note: Visual distribution of different land cover types across the EU using the Corine Land Cover data categories. The LUCAS data is not available in a spatial format other than at an aggregate NUTS 2 level.

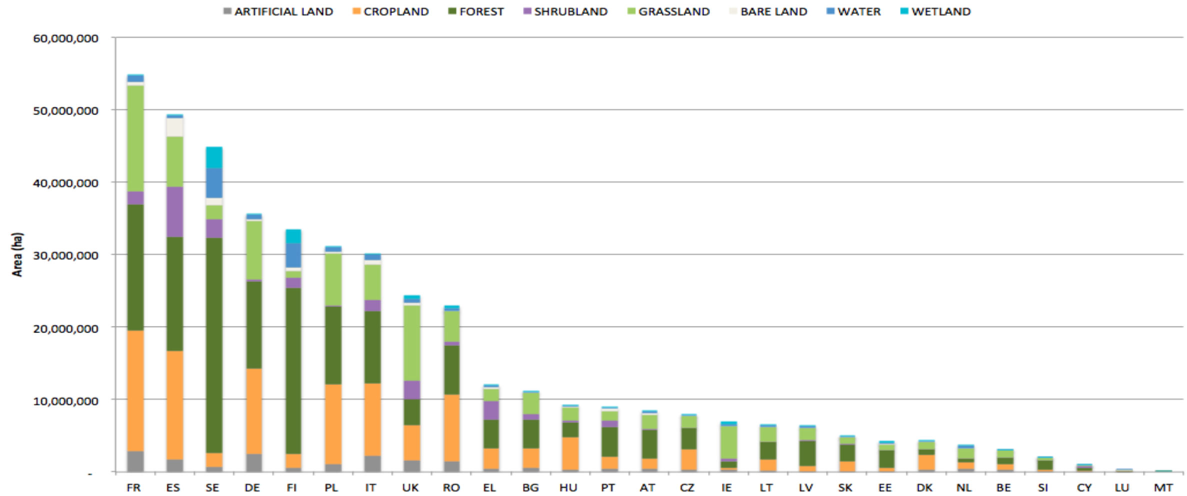
[6] Forests cover between 20 and 47 per cent of land in 17 Member States, only five Member States have a proportion of forest greater than this (Latvia (52 per cent; 3.4Mha), Estonia (55 per cent; 2.4Mha), Slovenia (63 per cent; 1.3Mha), Sweden (66 per cent; 29.6Mha), Finland (68 per cent; 22.8Mha).

[7] It is worth noting that the figures for forest, using the LUCAS2009 data, may differ slightly from those that are used in forest sector models. However, the distributions represented by these data are commensurate.

[8] The term 'arable' here refers to the subcategory of cropland land cover as determined by LUCAS and calculated based using FSS data. This includes all field crop types, including temporary grass, but importantly excludes permanent crops.

Mediterranean Member States, Greece and Portugal (35 per cent; 979,700 ha and 580,400 ha respectively), Spain (27 per cent; 4 Mha) and Italy and Cyprus (25 per cent; 2.5 Mha and 36,300 ha respectively)[9].

Figure 3: Rural land cover composition by Member State



Source: *Own compilation based primarily on LUCAS2009 with supplementary data for BG, RO, CY and MT. For further details see Annex 1.*

The third largest land cover, grassland, is one of the most difficult land cover types to quantify at the EU level, particularly when trying to subdivide grasslands into distinct types. According to the LUCAS definition, grassland[10] covers 20 per cent of the EU land area (84 Mha) with the largest areas in France (14.6 Mha, 17 per cent of the EU total) and the United Kingdom (UK) (10.3 Mha, 12 per cent of the EU total). As a proportion of total Member State land area the largest share of grassland is found in Ireland (64 per cent, 4.5Mha) and the UK (42 per cent, 10.4 Mha) with the smallest areas founds in Finland and Sweden (three and four per cent; 981,900 ha and 1.9 Mha respectively).

The LUCAS definition further subdivides grasslands into those with no/sparse tree cover and those without. Although this definition is helpful from a land cover perspective many of the policies associated with grassland areas require a more nuanced distinction. Common terminology to describe grassland includes: temporary or permanent, pasture or rough grazing, species rich or agriculturally improved. There remains a paucity of information relating to these subdivisions. However, in order to get an overall picture of grassland with relevance to agricultural policy (the main use of grasslands) it is possible to infer relative proportions from the Farm Structure Survey (FSS). As a proportion of the total grassland coverage (including temporary grass in arable rotation), the majority of Member States[11] have the greatest areas of their grassland as permanent pasture and meadow, five Member States[12] have predominantly rough grazing and three have predominantly grassland as part of an arable rotation (57 per cent or 262,430 ha in Denmark, 69 per cent or 1.1 Mha in

[9] Figures based on Farm Structural Survey (FSS) 2007 data. ef_lu_ovcropaa Accessed: October 2012
[10] That is not part of an arable rotation
[11] 18 Member States: Lithuania, Czech Republic, Germany, Belgium, Luxembourg, Poland, Netherlands, Romania, Slovenia, Slovakia, Ireland, France, Italy, United Kingdom, Austria, Cyprus, Bulgaria and Estonia
[12] Hungary, Portugal, Greece, Spain and Latvia

Sweden and 94 per cent or 652,150 ha in Finland). A further description can be found in Annex 1. With the data available to the study it is still not possible to determine further the level of grassland that is permanent (ie never ploughed or reseeded), that which is semi-permanent (ie that which is ploughed or reseeded very infrequently) and that which is temporary grassland but part of a continuous grassland area (ie intensive dairy production where grassland is ploughed and reseeded).

The remaining types of rural land cover represent a much smaller proportion of EU land. These tend to be more geographically fragmented: shrublands account for five per cent; water, three per cent; and bare land and wetlands two per cent. These land covers, with the exception of shrublands, show relatively little variability between Member States in percentage terms[13]. Shrublands do vary significantly with large areas in Mediterranean Member States including Greece and Cyprus (21 per cent; 2.5 Mha and 195,092 ha respectively), and Malta (12 per cent; 3,927 ha). Spain has the largest overall area of shrubland at 6.9 Mha (14 per cent) however there is significant regional variation with up to 34 per cent in La Rioja (equivalent to 170,200 ha) and as little as nine per cent (equivalent to 870,600 ha) in Castilla y León. Further details of the distribution of land cover within Member States can be found in the Member State land cover and land use fiches in Annex 5.

2.3 The use of rural land in the EU

Rural land is an inherently multi-functional resource supporting a wide range of uses simultaneously. In many areas however, the predominant use of land is for a single primary purpose, usually related to the production of some form of tradable commodity, with other uses being secondary to this.

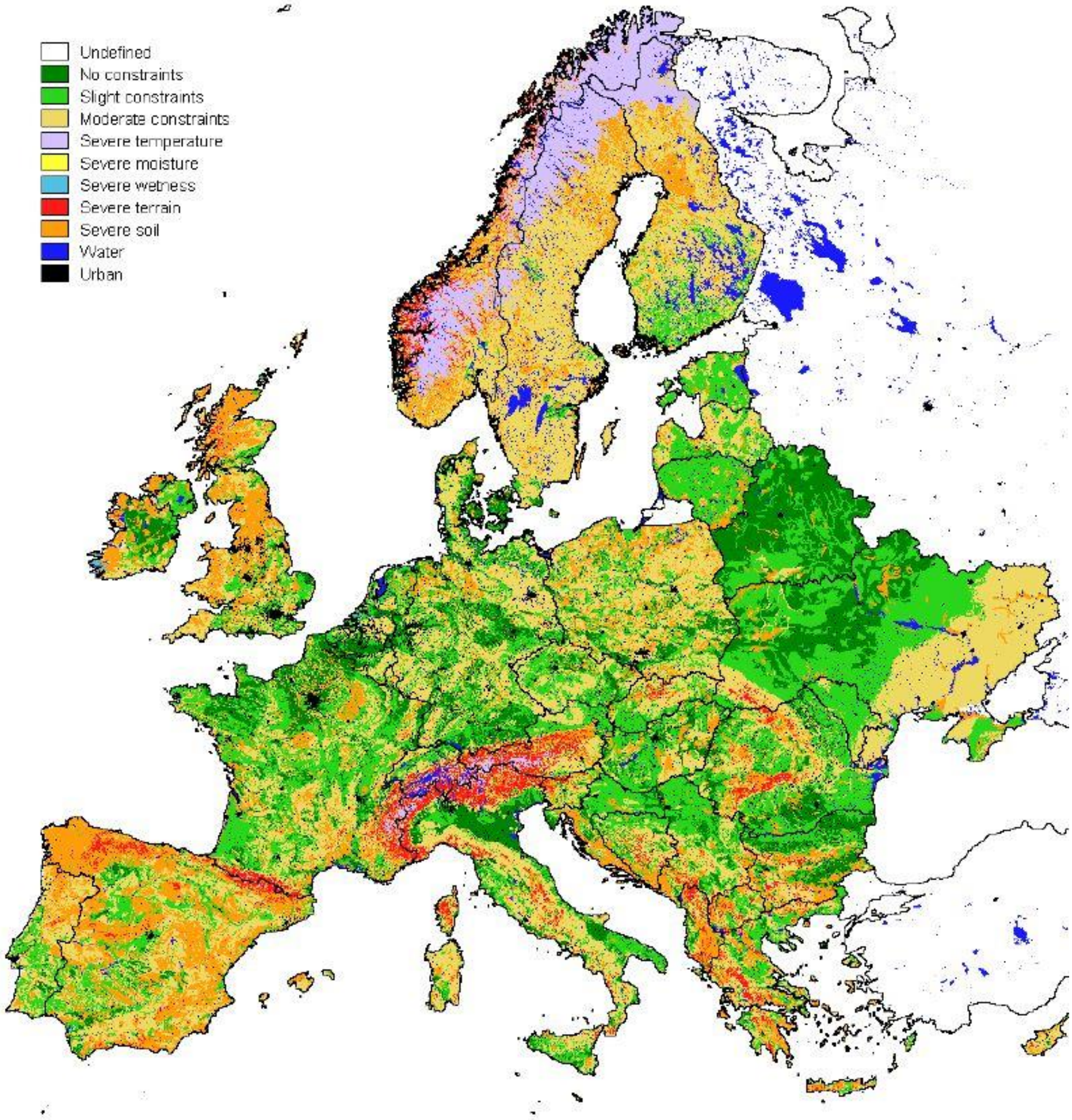
2.3.1 Bio-climatic constraints on rural land use in the EU

Bio-climatic factors, such as climate, soil and terrain constraints influence the proportion of land suitable for different uses. The spatial distributions of such limitations have been assessed using soil and terrain maps. These have been used to identify the areas of EU terrestrial rural land that experiences various constraints on agricultural production in relation to temperature, slope, wetness and soils (FAO - IIASA, 2007)[14]. These are expressed spatially in Figure 4.

[13] Although there are some small exceptions, see Table 5 Annex 2

[14] ***Severe temperature*** – less than 120 days length of growing period (2.9% of land); ***severe wetness*** – less than 60 days length of growing period due to drought (<0.1% of land); ***severe terrain*** – greater than 30 per cent slope (3% of land); ***severe soil*** - soil depth less than 50 cm, poorly drained, low natural fertility, coarse texture and stones, or severe salinity or alkalinity (18.7% of land); ***moderate*** – with a growing season of fewer than 190 days (due to temperature and drought) or fewer than 180 days (due to temperature), a slope of 16-30%, a soil depth of 50-100 cm, a medium rather than a high level of natural fertility, or the soil comprised a heavy cracking clay (37% of land); ***slight*** – 8-16% slope (23% of land); and ***no constraints*** – less than 8% slope (9.1% of land). Source: FAO/IIASA, 2007

Figure 4: Map of climate, soil and terrain constraints for rain-fed agriculture in the EU



Note: The constraints are derived using the Global AEZ methodology[15] applied to European datasets (FAO/IIASA, 2007, quoted by Eliasson *et al,* 2007).

For agricultural production, the map shows that only around nine per cent of land was subject to no constraints on production, with a further 23 per cent subject only to slight constraints. Conversely, almost a quarter of all EU-land was considered to be subject to severe constraints, with the largest proportion of this area constrained by limited soil quality. The distribution of these constraints is not even. Thirteen Member States have over 40 per cent of their land area facing no or only slight constraints[16] whilst six were shown to

[15] Global Agricultural Ecological Zone Methodology (Fischer *et al,* 2002)

[16] SK (42%), DE (45%), FR (49%), BE (48%), the CZ (48%), DK (49%), NL (50%), BG (52%), RO (52%), HU (54%), EE (65%), MT (67%), and LT (76%)

have more than one fifth of their land area subject to poor soil quality, including a number of Mediterranean regions, but also the UK and Ireland[17].

The spatial distribution of these land use constraints can also be applied beyond agricultural production to other types of land use. 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. These areas tend to be dominated by semi-natural vegetation such as upland blanket bog on peat soils. In contrast the dominant arable production regions of the EU also stand out, generally those areas of no or only slight constraint[18].

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).

2.3.2 The distribution of land use in the EU

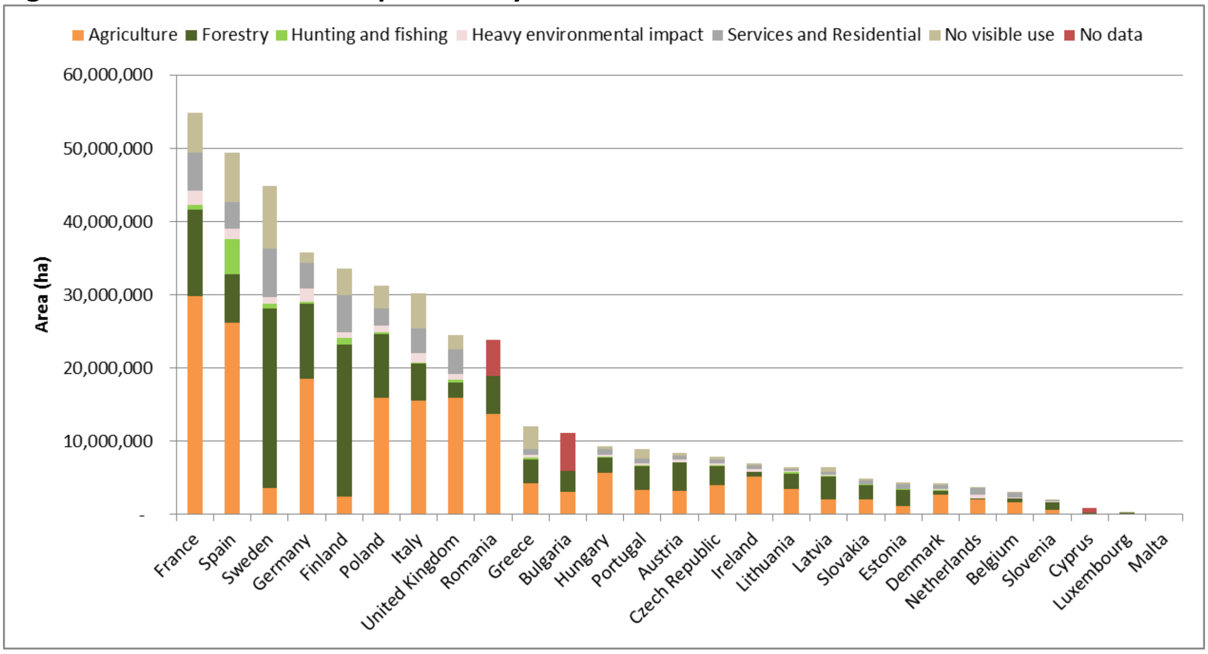
Two primary land uses stand out across the EU, agriculture and forestry, which together make up 74 per cent (311.5 Mha) of the land area (44 and 30 per cent or 186 Mha and 125 Mha respectively) and are the main land uses in all Member States (see Figure 5). Other land uses, including nature reserves19, hunting and fishing and where the use of land cannot be determined, account for much smaller proportions of rural land, again with significant variation between Member States.

[17] GR (21%), CY (22%) PT (25%), IE (38%), the UK (39%), and ES(43%)

[18] For example, the lowland and plain areas such as the Carpathian basin, the East Anglian fenlands and the Paris basin; or the areas of southern Romania and northern Bulgaria surrounding the Danube.

[19] Part of the LUCAS services and residential category

Figure 5: Rural land use composition by Member State



Source: *Own compilation based primarily on LUCAS2009. For further details see Annex 1 and Annex 5.* ***Note:*** *RO, BG, CY and MT use UAA figures from FSS and the area of forest available for wood supply to indicate the area of forestry from the State of Europe's Forest. The latter will be an overestimate of the total area of forestry in these Member States.*

With the exception of croplands, which are used primarily for agricultural purposes, all rural land cover types support a range of different primary uses. Forests are primarily used for forestry operations (74 per cent; 114 Mha) with smaller proportions covered by the services and residential category of LUCAS (eight per cent; 12 Mha)[20], and hunting and fishing (two per cent; 3.5 Mha). The land use for eleven per cent of forests (17 Mha) cannot be determined, which correlates broadly with the areas of EU forests under management restriction for biodiversity conservation[21]. Grasslands are predominantly used for agriculture (76 per cent; 58 Mha) with a small proportion as services and residential (10 per cent; 8 Mha) and nine per cent (6.7 Mha) where the land use cannot be determined. Shrublands are primarily where the land use cannot be determined (43 per cent; 9.4 Mha) with equal proportions devoted to services and residential (20 per cent; 4.5 Mha) and agriculture (20 per cent; 4.4 Mha). Small areas of shrubland are used for forestry operations (seven per cent; 1.6 Mha) and hunting and fishing (eight per cent; 1.8 Mha). A third of wetlands (2.3 Mha) are categorised under the services and residential category and the use of the majority (58 per cent; 4.2 Mha) cannot be determined. Land with less than 50 per cent vegetative cover (bare land) is primarily used for agricultural grazing (30 per cent; 2.2 Mha) or has no visible use (28 per cent; 2.1 Mha). The remainder of bare land is either under some form of service and residential use (19 per cent; 1.4 Mha) or land uses with heavy environmental impacts such as quarrying (16 per cent; 1.2 Mha). A small proportion is used for forestry (six per cent; 476,900 ha).

[20] Based on the LUCAS Residential and services
[21] MCPFE classification 1.1 – 1.3 data for the EU from Forest Europe *et al,* 2011

These distributions again differ between Member States. For example, as a result of the more traditional multi-functional agro-forestry systems found in Spain, 29 per cent (3.6 Mha) of Spanish forests are under agricultural use with only 39 per cent (6.1 Mha) used primarily for forestry.

Agriculture in the EU

Agriculture in the EU can be characterised by its diversity, covering a wide range of different types of crop and livestock systems, farmed with varying degrees of intensity. We necessarily rely on certain generalisations in order to describe what is, in essence, a continuum of production systems.

Agriculture as a primary land use[22] accounts for around 44 per cent of the EU land area (186 Mha). Approximately two thirds of this area is cultivated23, with the remaining third being permanent grassland. France, Spain, Germany Poland, Italy and the UK have the largest areas of agricultural land. Ireland, the UK and Denmark have the greatest proportion of land under agricultural use (73, 65 and 64 per cent or 5.1 Mha, 15.1 Mha and 2.8 Mha respectively) compared to Finland and Sweden with only seven and eight per cent (2.5 and 3.6 Mha respectively).

Different levels of land use intensity can influence the impact farming has on both the environment and its potential to support ecosystem services (see for example Cooper *et al,* 2009; Poláková *et al,* 2011). The specialisation and intensity[24] of agricultural land use varies considerably across the EU from dedicated cereal or bioenergy cropping with high levels of mechanisation and artificial inputs, to extensive mixed and organic farming systems[25].

The trend towards intensification of agriculture results from the aim of increasing the crop production functions of ecosystems. Agricultural land use intensity and specialisation can be defined and measured in many ways. For example, different types of land can sustain naturally different crop yields. These areas may also support different levels of input use or grazing densities, and require differing levels of financial resources to ensure a continuation of production. For the purposes of the description provided here, we necessarily rely on existing measures of intensity as described by the agricultural statistics[26].

Recent decades have witnessed a trend towards increased farm specialisation, with a separation of those farms that produce crops and those that produce livestock (Cooper *et al*, 2009; Poláková *et al*, 2011). Specialisation in production ranges from 97 per cent of UAA

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[22] This includes annual and permanent crops and the grazing of livestock for meat and milk production.

[23] This includes annual and permanent crops and temporary grassland.

[24] Intensity of agricultural land use can be described in relation to the modifications needed to an area of land in order to produce a crop of livestock product

[25] Poláková *et al* (2011) provide a typology of agricultural land in relation to the pressures on biodiversity.

[26] Specialisation refers to the number of types of crop or farming approach undertaken. For example, highly specialised farming may involve continuous farming of arable crops in rotation. Low specialisation may involve more mixed farms (livestock and arable production) or where a variety of crops are produced). For intensity, farms are classified into three intensity categories, low, high and medium, according to the level of input expenditure (in Euro) per hectare of Utilised Agricultural Area (UAA) reflecting the level of expenditure on fertilisers, pesticides and feedstuffs. Farms spending less than €125/ha are classified as low intensity, those spending more than €295/ha as high intensity, and those with intermediate spending are considered to be medium-intensity farms (Eurostat 2012c)

in Ireland[27], which is dominated by specialist livestock production (92 per cent of UAA) to as little as 34 per cent in Romania. Dedicated bioenergy cropping, driven by renewable energy policy is estimated to take place currently on three per cent of the cultivated land area (~5.5 Mha), the majority of which is used to grow oil crops (82 per cent)[28] (Elbersen *et al*, 2012a). Bioenergy cropping covers the largest areas in France and Germany, with significant areas of oil crops for biodiesel also found in the UK, Poland and Romania. EU-15 Member States tend to have more specialised production (83 per cent average area) compared to the EU-12 (55 per cent average) [29] (Elbersen *et al*, 2012).

There is also significant variation between Member States in the intensity of agricultural land use. The overall distribution across the EU is reflective of the level of mechanisation and investment in agricultural systems with EU-15 Member States having a proportionally greater area under high input use (31 per cent) than the EU-27 average (26 per cent) and EU-12 Member States having a lower area (16 per cent) (Eurostat, 2012a)[30]. However, some variation is to be expected, as different levels of inputs will be needed on different soil types and under different environmental conditions. The use of irrigation can also be an indicator of intensive land use, either as a means of maximising output (for example Denmark and the Netherlands) or for combatting desertification, such as in Mediterranean areas (Beaufoy, 2001). The irrigable area[31] ranges from zero per cent of agricultural land in some Member States, such as Ireland and Latvia, up to 38 per cent in Greece. Only ten Member States are have irrigable areas above the EU average of nine per cent, with the remaining significantly below. Italy, Spain, France and Greece have the largest number of irrigable hectares reflecting the environmental limitations on productivity in these areas.

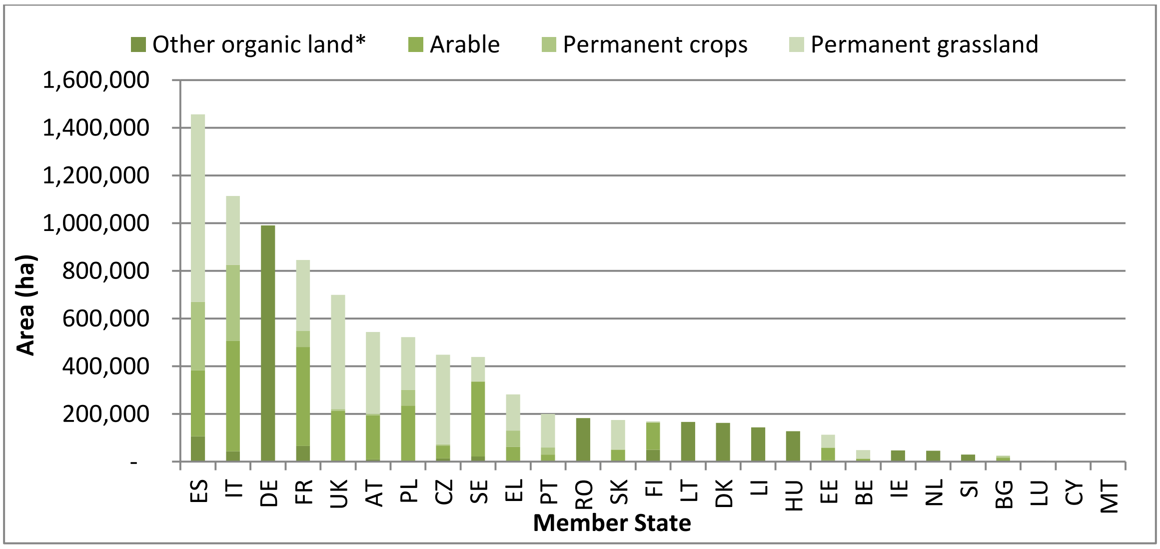
As the counterpoint to intensive agricultural land use it is important to recognise the significant areas of low intensity agriculture throughout the EU. Many of these areas correlate with moderate constraints on agricultural production (Figure 5). These areas do not typically respond to intensification, such as increased inputs, at least not within the margins of normal economic constraints. As a consequence of limited production potential, substantial tracts of Europe's agricultural area continue to be managed at a low intensity. Extensive farming systems, low input and typically low output, have been mapped (European Commission, 2011a)[32]. Extensive arable farming systems are more common in

[27] The remaining three per cent are under mixed farming.
[28] The remaining areas are used for the production of ethanol crops (11 per cent), biogas (seven per cent) and perennial crops (one per cent).
[29] Although significant specialisation is seen in Cyprus (88 per cent, mainly permanent crops) and the Czech Republic (72 per cent, field crops and grazing livestock)
[30] Over 70 per cent of farms in the Netherlands, Malta and Belgium are classified as high input farms compared to Member States such as Bulgaria, Estonia, Latvia and Slovakia where less than 10 per cent of farms use high levels of inputs.
[31] It should be noted that irrigable areas only refers to land with the potential to be irrigated and does not reflect the actual irrigated land area. For an in-depth look at the potential impacts of irrigation on crop production and other ecosystem services, see the Catalonia case study in Chapter 6.
[32] The European Commission JRC mapped extensive land management, referring to cereal production levels for arable crops and livestock density for grazing systems. Extensive arable crops are defined as systems producing less than 60 per cent of the EU27 average. Extensive grazing areas are defined as areas with a livestock density of less than 1 LU/ha of forage area.

the Baltic, Scandinavian, some south-eastern and some Mediterranean Member States[33]. A similar pattern is seen for extensive grazing, but covering also mountainous areas, for example in Austria, where crop production is limited, as well as Mediterranean areas where there are limitations caused by water availability[34].

Organic systems represent a specific category of low intensity farming systems and result from a positive decision to follow certain agricultural practices (Poláková *et al*, 2011). Just over five per cent of UAA in the EU-27 is under organic production (Eurostat, 2012a; FiBL, 2012) but varies from as low as 0.2 per cent (182,706 ha) in Romania to 18.5 per cent (543,605 ha) in Austria[35] (FiBL, 2012) (Figure 6). The distribution of organic farming follows a similar pattern to that of other extensive farming systems with a relatively high proportion in southern Member States[36]. Other Member States with large areas of land managed organically include the Czech Republic, Latvia, Slovakia, Finland and Sweden (Eurostat, 2012a).

Figure 6: Area of organic agriculture by agricultural land use for selected Member States



Source: FiBL, 2012 **Note:** *no data is available for organic land by agricultural by land use in 10 Member States (DK, DE, HU, LT, LV, NL, RO, SI, SK, IE, CY). For these Member States the total organic area is shown under the 'Other organic land' category.

[33] Examples for Baltic and Scandinavian Member States include Estonia, Latvia, Lithuania and parts of Finland and Sweden; south-eastern Member States include Bulgaria and Romania; and Mediterranean Member States include regions in Spain, Italy and Portugal.

[34] These distributions represent patterns at the aggregated NUTS 2 level and do not reflect the significant variation in extensive and intensive agricultural production at the local and regional scale.

[35] Although Romania has the lowest per cent of organic crop area, it has a high level of HNV farmland. Therefore it should be noted that organic farming systems only represent EU certified organic production and do not necessarily indicate all areas of low intensity land use.

[36] Namely Greece, Spain and Italy – averaging eight per cent organic crop area.

Transitions out of agricultural land use

Despite the different types of agricultural land use and the policies that support them across the EU, the area of agricultural land is decreasing (see section 2.3.4). Some of this decrease is as a result of the active or passive withdrawal of agricultural management from land.

Abandonment can be a complex and gradual process, starting with a progressive withdrawal of management that leads initially to a reduction in farming or forestry intensity. Thus it can be difficult to define and recognise abandonment of various degrees from pan-European datasets, especially since it can also be temporary, transitional or permanent (IEEP and Veenecology, 2005; Pointereau *et al*, 2008) (see Box 1). There are various causes of farmland abandonment in Europe including: geographic, ecological and agronomic factors; demographic and socio-economic factors; policy impact factors; and historic factors in new Member States. These differ in every European region. Farmland abandonment often results from a combination of these factors, with one predominating over the others (Terres and Nisini, 2013; Moravec and Zemeckis, 2007; Pointereau *et al,* 2007). Determining the area and distribution of abandoned land across the EU is problematic (Keenleyside and Tucker, 2010). The LUCAS nomenclature used for this study includes a reference to fallow or abandoned land within agricultural areas that includes: agricultural land not used for the entire year for 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 terminology, 'semi-abandonment'. 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[37]. Although there are differences in some Member States, these data can be used in very broad terms as a proxy for abandoned farmland.

Box 1: Definitions of abandoned agricultural land

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

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 tourism. Such land may also be subject to the minimum management necessary to meet cross-compliance requirements by all 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. Such extensive farming is generally associated with very low or zero direct economic returns, but may be continued for social reasons, to support other farm income streams, for example from hunting and tourism, or for nature and landscape conservation.

Transitional abandonment has been observed particularly in EU-12 as a result of restructuring and land reforms, and in EU-15 as a result of compulsory set-aside, until this was abolished in 2008, or as a result of land use change. 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.

Source: Adapted from Keenleyside and Tucker, 2010

[37] 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.

Both the FSS and LUCAS show that around seven per cent of land in the EU-27, within agricultural areas, is not being used currently (at the time of the survey) for agricultural production[38] (between 11 and 12 Mha). Those Member States with proportions greater than the EU-27 average are predominantly found in Mediterranean regions[39] and Baltic and Scandinavia[40]. In area terms, Spain and Italy have the greatest areas currently not being actively managed, around 3.4 Mha in Spain and between 1.2 and 1.8 Mha in Italy. The areas in France are also significant (500,000 – 800,000 ha)[41]. The smallest areas are found in the north-western[42] and eastern Member States[43].

From the data available it is not possible to determine the type of agricultural production that used to exist in these areas or if the land could be brought back into production. However, the broad geographical locations of some of these areas can provide some insight. Depending on which figures are used, between 40 and 49 per cent of the total area of agricultural land that is not currently under active management, is found in Spain and Italy. Evidence of land based constraints on production (see Figure 4) suggest that significant proportions of these Member States are already under severe soil and terrain constraints, neither of which are expected to improve in the coming years.

Where land is abandoned or left out of agricultural production for a significant period of time the natural successional processes for European latitudes lead to the development of scrub and then forest vegetation[44] (see Poláková *et al*, 2011 after Goriup, 1988). This process has been responsible partly for the gradual increase in forest areas across the EU.

Forestry in the EU

Forestry as a primary land use accounts for around 30 per cent (125 Mha) of the EU land area and dominates the use of forest areas (74 per cent; 114 Mha). The distribution of forestry matches that of forest land cover ranging from significant areas devoted to forestry in Finland and Sweden (62 and 54 per cent or 21 Mha and 24.4 Mha respectively) compared to as little as three per cent (114,800 ha) in the Netherlands. Although there is some variation, most Member States (25)[45] have more than 70 per cent of their forest accessible as a wood supply[46]. The EU average is 85 per cent.

Management practices in the forest sector, like those in agriculture, vary strongly and range from production oriented plantation systems to more nature-oriented silviculture, with its focus mainly on the provision of a range of ecosystem services such as recreation, water and

[38] The same proportions are seen in the EU-12 and EU-15 Member States from both data sets

[39] CY 22% - n/a, IT 10 – 12%, GR 7 – 10%, PT 6 – 39%, MT 13% - n/a and ES 14 – 13% (FSS – LUCAS)

[40] FI 38 – 10%, SE 7 – 10%, LV 21 – 10% and EE 9 – 8% (FSS – LUCAS)

[41] Poland, Portugal and Finland may have a considerable area of unutilised agricultural land, however there are significant discrepancies between the two datasets.

[42] DK 4 – 2%, IE 4 – 2%, DE 2 – 2%, FR 2 – 3%, UK 2 – 2%, BE 2 – 1% and LU 1 – 0%. (FSS – LUCAS)

[43] LT 4 – 6%, SK 3 – 5%, RO 3% - n/a, BG 3% - n/a and the CZ 1 – 5%. (FSS – LUCAS)

[44] Except in cases of extreme water logged soils, such as upland peat blanket bog, or in areas of extreme altitude.

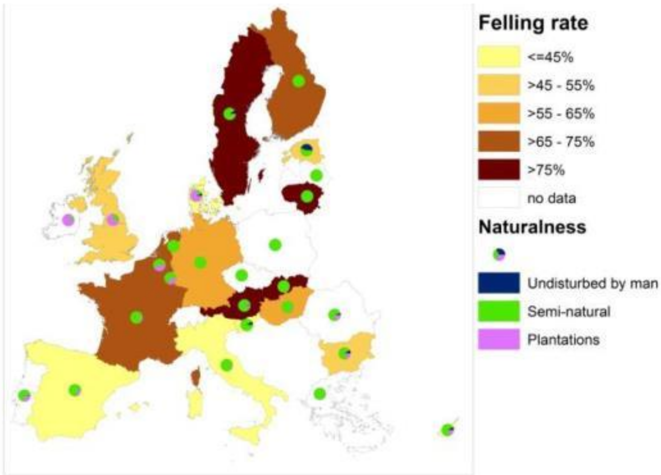
[45] Excluding Cyprus (24 per cent) and Portugal (53 per cent)

[46] 'Available for wood supply' defined by the UNECE FAO as forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood (UNECE and FAO, 2010)

air purification, or protection of biodiversity. Significant areas of forests, especially in the Mediterranean region, are undermanaged or abandoned. Most of the EU forest area (88 per cent; 139 Mha) is considered semi-natural[47] however a large proportion of these areas is used for the production of forest products[48]. A smaller proportion of the EU forest area (eight per cent; 13 Mha) is considered as plantation forests. These plantations are important for wood production in many countries and dominate forest areas in Ireland (89 per cent of forest area; 655,000 ha), Denmark (78 per cent of forest area; 455,000 ha) and the United Kingdom (77 per cent of forest area; 2.2 Mha). Around ten per cent (~17 Mha) of EU forests are under strict protection from forestry activities with another nine per cent (13 Mha) of forests protected for landscape and nature where some forestry activities are permitted in order to meet the management objectives (Forest Europe *et al,* 2011)[49]. Forests which are undisturbed by man (often called forest reserves)[50] cover only four per cent (4.9 Mha) of the EU forest area, mostly in remote areas, and are found mainly in Sweden, Estonia, Finland, Bulgaria, Romania and Slovenia.

Modern high intensity forest management can involve the heavy use of machinery, introduced tree species or genetically improved plant material, site preparation, including soil tillage, artificial drainage and fertilisation as well as the use of pesticides (Raulund-Rasmussen *et al,* 2011). One common measure of forest management intensity relates to the balance between annual fellings and net annual increment[51]. In 2010 the EU-27 average felling rate was 64 per cent, with large spatial variation – ranging from 25 per cent in Cyprus and 94 per cent in Austria

Figure 7: Felling ratio and naturalness in EU forests in 2010 (Forest Europe *et al* (2011)



[47] Semi-natural forests are less intensively managed than plantation forests, but there is a wide range, from hardly any management at all to quite intensive management.

[48] Approximately 85 per cent of the EU forest area is available for wood supply. This area comprises plantations and the majority of semi-natural forests. Forests not available for wood supply (15 per cent) are either strongly protected (eg forest reserves) or not usable economically (for example because they are unproductive, too remote, or too steep).

[49] Forests protected for biodiversity (MCPFEE class 1.1 – 1.3) do not permit forestry activities that may impact conservation objectives. Forests protected for landscape and nature (MCPFEE class 2) allow more intervention but only in line with objectives to maintain landscape and nature values (Forest Europe *et al,* 2010).

[50] Forests undisturbed by man according to the Forest Europe definition (Forest Europe *et al,* 2011) are under no form of management. Such forests have a high conservation value and serve as reference areas which can be studied or observed to help increase the understanding ecological processes.

[51] Felling rate is equal to the number of fellings per year as a percentage of the annual increment. It should be noted that felling rate is usually a measure for sustainability in forestry. Fellings should be below net annual increment, so that there is a balance (except in exceptional cases, for example over-mature forests).

(Figure 7)[52]. In southern Europe, management intensity is generally low (with the exception of some areas of plantation forests) with overall intensity increasing towards the northern Member States.

The number of different forest management operations in use in European forestry is high and the operations are diverse both within and between different forest types. Duncker *et al* (2007) proposed a set of five typical management operations from forest reserves through to intensive plantations. These are described in relation to their potential to support different types of ecosystem services in Chapter 3.

Agro-forestry in the EU
Agro-forestry as a hybrid land use represents a separate and important category that merits attention. Agroforestry covers a wide range of systems in which arable or livestock production is combined with low-density forestry on the same parcels of land. Traditional systems were highly adapted to local bioclimatic conditions and formerly widespread throughout Europe. During the 20th century the intensification of agriculture has led to a decline in agro-forestry systems and area. Traditional systems still account for the largest areas of agro-forestry in the EU[53]. These systems are economically fragile but of high importance for their biodiversity and cultural services, for example the wooded pastures of Fenno-Scandinavia and the *dehesas* and *montadas* of the Iberian Peninsula. Increasingly, and especially in more northern Member States, a more modern approach to agro-forestry is being developed. Rather than developing through the more traditional opening of native Mediterranean forests for grazing (see Willaarts *et al,* 2012), these systems follow a more rigid structure of alternating rows or alleys of arable crops and strips of woodland or trees.

The only EU-wide dataset that explicitly distinguishes agro-forestry is the Corine Land Cover data. This shows that the most significant areas of agro-forestry remain in their traditional heartland of the Mediterranean Member States. The largest areas are found in Spain with five per cent of total land use (2.5 Mha), Portugal seven per cent (620,621 ha) and Italy one per cent (175,066 ha).

Areas where the land use cannot be determined
Amongst the most difficult uses of rural land to capture at a European scale are those outside the primary production sectors of agriculture, forestry, the extraction of minerals, and the clearly differentiated nature reserves and spaces for formal recreation, such as golf courses, ski slopes, adventure parks. These can be sizeable areas where other uses, such as different forms of recreation, hunting and less visible forms of private activity are exercised (see Box 2). These uses may not be very visible either in the relevant statistics or in rapidly conducted ground surveys. They include land where horses and other non-agricultural stock are kept, small holdings not covered within the agricultural area, land surrounding retirement and holiday homes, forest managed for shooting, recreation and conservation.

[52] The highest felling rates are reported for Austria (94 per cent), Lithuania (86 per cent) and Sweden (83 per cent). These high rates are, however, partly due to catastrophic storms in the past decade, which resulted in high natural losses and consequent removal of downed timber as well as reductions in net annual increment (Forest Europe *et al,* 2011).

[53] Approximately 2.4 Mha of traditional 'dehesas' exist across Spain (MARM, 2011)

Informal and recreational uses can arise on any farmland and may be more prevalent more outside the most productive areas. If production is concentrated on a limited area of better quality and more accessible land a patchwork of agricultural and other uses often develops over time elsewhere. Similarly, in wooded areas there may be a variety of uses outside the exploitation of timber, some with a commercial dimension, others not. This set of less visible uses, often recreational in a broad sense, some of which occur on land formally classified as agriculture or forestry, others on land falling into other categories, including abandonment, seems to be expanding because of rising disposable incomes and the greater availability of land not dedicated exclusively to production by the present owners. Although it is difficult to quantify, it should not be overlooked. The categorisation of land as having 'no visible use' in the statistics (Box 2) may under-estimate the extent of activities taking place on rural land, with or without economic transactions occurring.

Box 2: LUCAS estimates of land with no visible use

The LUCAS data gives an indication as to those areas of different land cover that are not considered as being under any visible use. This accounts for 12 per cent (43 Mha) of the EU land area and typically occurs in wetland areas (58 per cent; 4.1 Mha), shrubland areas (43 per cent; 9.4 Mha) and bare land (28 per cent; 2.1 Mha). These areas differ significantly between Member States with the greatest areas in Sweden (8.6 Mha) and Spain (6.6 Mha) with the greatest proportion in Greece (25 per cent) and Sweden (19 per cent).

Source: Own compilation

2.3.3 Environmentally designated areas

Designated areas are another important category of land use relevant to the support of ecosystem services. There is a range of environmental designations ranging from local wildlife sites through to pan-European or international designations. The designation of land under a particular category of protection can influence the types or intensity of land use that takes place on such land. For example the International Union for the Conservation of Nature (IUCN) category I designations[54] severely limit, or restrict entirely, the use of land for anything other than conservation. However, low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of IUCN category VI areas. The majority of designations in the EU are classified under IUCN category V, protected landscape/seascape and permit some use of the land (EEA, 2010b).

Relating the area of land under specific designations to the broad land cover and land use statistics is problematic. The LUCAS data for nature reserves, part of the services and residential land use category, are only described in broad terms, covering 19.5Mha or approximately five per cent of rural land[55]. There are however many different designations for the protection of the natural environment across the EU. Multiple designations of the same site under national, European (mainly Natura 2000) and/or international processes (eg Ramsar wetlands[56]) are common in many countries (EEA, 2010c) (see Figure 8).

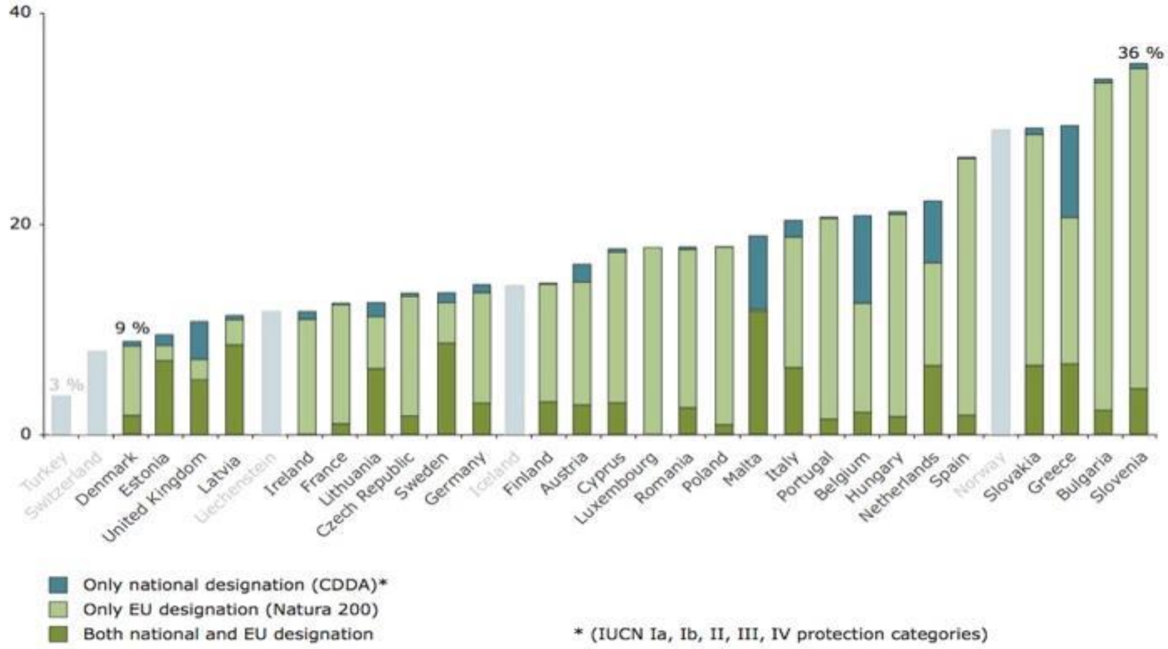
[54] Strict nature reserve or wilderness area (IUCN, 1994)

[55] The proportion of land cover varies from 12 per cent in Sweden to one per cent in the Czech Republic.

[56] The Convention on Wetlands (Ramsar, Iran, 1971), called the 'Ramsar Convention', is an intergovernmental treaty that embodies the commitments of its member countries to maintain the ecological character of their

Established under the Birds and Habitats directive, one of the most significant of all designations in relation to the protection of the natural environment is the Natura 2000 network, covering all types of European ecosystems (EEA, 2010b) [57]. In 2011 the total area of terrestrial EU Natura 2000 sites was 75.1 Mha, or 17.5 per cent of the EU area[58]. Across the EU, 10.4 per cent of the Utilised Agricultural Area (UAA) is covered by Natura 2000 designations with a much high proportion of the forest area at 22.2 per cent[59]. For agriculture, the distribution of designations between the EU-12 and EU-15 Member States is similar (11.6 and 10 per cent respectively), however there is a significant variation in forest areas with 32.8 per cent under Natura designations in the EU-12 and only 18.5 per cent in the EU-15 (European Commission, 2011a).

Figure 8: Proportion of terrestrial protected areas in EU-27 Member States



Source: Adapted from EEA, 2010c.

2.3.4 Land cover and land use change in the EU

The picture of rural land in the EU described above is part of an ever changing dynamic of land cover and land use interactions. The patterns of land cover and land use are influenced by a wide range of sometimes disparate but often interrelated factors, such as population dynamics, topographic and climatic factors, and global market economics.

Wetlands of International Importance and to plan for the "wise use", or sustainable use, of all of the wetlands in their territories. www.ramsar.org

[57] Approximately 38 per cent of Natura 2000 sites are covered by agro-ecosystems including 11 per cent that are grasslands, 34 per cent covered by forests, 16 per cent by heath and scrub, and 11 per cent by wetlands.

[58] This proportion varies among Member States, from 7.2 per cent in the UK to 35.5 per cent in Slovenia.

[59] These areas correlated with the area of 'protective' forests as described by Forest Europe *et al* (2011), covering a slightly larger area than the MCFEE protected forest categories. Forest ecosystems cover ~46 per cent of the area of Natura 2000 sites and agro-ecosystems 38 per cent (17.5 per cent are regularly cultivated; 14 per cent need extensive management; and 6.5 per cent are complex agro ecosystems), (EEA, 2010c)

The influence of some of these factors is apparent from long term land cover and land use trends seen within the EU. Table 1 shows that between 1961 and 2009 the agricultural area has declined from over 210 Mha to just under 190 Mha, a decrease of 14 per cent. In contrast the forest area has increased by 13 per cent from just under 136 million ha to over 156 million ha over the 16 years from 1993 to 2009. These trends are comparable to those seen in other studies, but over shorter time periods (for example EEA, 2010a).

One of the few datasets available to look at changes between land cover and land uses (rather than simply area changes) are the Corine Land Cover datasets for 1990, 2000 and 2006. Table 1 shows the changes in land cover and land use categories between 1990 and 2006. The major changes in area between 1990 and 2006 involve the shift from agricultural land to urban (1.1 Mha) and forest and terrestrial semi-natural areas[60] (209,198 ha). In total transfers to urban land over this period are in the region of 1.33 Mha from all types of rural land. The majority (in area terms) of other changes are represented by a shift towards forests and semi-natural areas, particularly transitional woodland scrub (three Mha). Of course these changes will have taken place in different regions and at different times in the 16 years covered by the data. For example 82 per cent (54,173 ha) of the shift from natural grasslands (as defined by Corine) into arable land occurred in the period from 1990 to 2000 with the remaining 18 per cent (9,563 ha) changing between 2000 and 2006. These changes have occurred in response to different market and policy environments.

Table 1: Changes in land cover and land use between 1990 and 2006 (EU-27)

Changes in Corine Land Cover/Use categories from 1990 (categories on the right) to 2006 (categories below). Areas are in hectares	11 Urban fabric	12 Industrial, commercial and transport units	13 Mine, dump and construction sites	14 Artificial, non-agricultural vegetated areas	21 Arable land	22 Permanent crops	23 Pastures	24 Heterogeneous agricultural areas	31 Forests	32 Scrub and/or herbaceous vegetation associations	33 Open spaces with little or no vegetation	41 Inland wetlands
11 Urban fabric		1,347	43,789	4,217	233,774	28,943	84,449	171,919	20,651	30,518	1,695	296
12 Industrial, commercial and transport units	7,097		38,357	2,024	191,598	14,976	40,155	67,310	24,495	22,008	1,188	762
13 Mine, dump and construction sites	708	827		536	123,868	11,504	25,573	37,401	35,421	45,377	4,203	758
14 Artificial, non-agricultural vegetated areas	421	807	8,822		43,952	2,712	20,562	17,973	9,698	10,651	1,040	437
21 Arable land	231	380	16,270	161		138,956	691,462	172,442	35,950	117,101	14,596	3,189
22 Permanent crops	47	1	1,130		285,651		3,387	109,894	10,367	37,959	3,515	42
23 Pastures	149	428	16,771	99	679,650	7,924		83,398	17,118	20,819	1,616	5,636
24 Heterogeneous agricultural areas	113	157	8,601	22	302,442	63,012	109,444		58,149	186,364	5,159	3,242
31 Forests	286	188	7,455	47	77,461	3,941	34,619	52,890		1,751,902	26,420	36,449
32 Scrub and/or herbaceous vegetation associations	107	996	41,977	8	160,616	10,985	52,758	147,559	2,356,783		180,475	89,519
33 Open spaces with little or no vegetation	3	13	5,177		1,760	225	47	2,335	62,721	69,036		63
41 Inland wetlands	7	20	1,024		4,737	72	7,996	1,837	3,138	4,040	26	

Source: Corine Land Cover data as displayed for the Land accounts data viewer of the EEA. Available at: http://www.eea.europa.eu/data-and-maps/data/data-viewers/land-accounts Accessed March 2013. **Note:** Green cells show small changes in area between the two years whereas purple cells show large changes, the darker the colour the most significant the change. The CLC dataset does not cover all Member States for the years 1990 and 2000 and thus the changes shown reflect only the Member States for which there is full coverage.

As highlighted earlier, one of the most significant land use changes having an impact on the natural environment is urban expansion and soil sealing. The growing spread of impervious surfaces is harmful to the environment and reduces the capacity of the area to provide

[60] Including forests, natural grasslands, inland wetlands and other non-urban Corine categories.

ecosystem services such as food production, the supply of clean water, climate and energy regulation and the provision of a variety of habitats for biodiversity to thrive (JRC and EEA, 2012). Furthermore the concentration of populations in urban areas leads to the increased diversion of natural resources, such as water, from natural systems into urban centres. In the Mediterranean region, soil sealing is a particular problem along the coasts where rapid urbanisation is associated with the expansion of tourism[61].

Urbanisation tends to take place in the peri-urban environment at the edges of towns and cities, where the majority of the public has access to rural land. Between 1990 and 2000 an estimated 970,000 ha of agricultural land across 20 Member States was urbanised (JRC and EEA, 2012). Between 2000 and 2006 urban land accounted for the greatest increase in all land covers (over 100,000 ha per year), again mostly onto agricultural land. Despite the environmental impact of soil sealing, it is worth noting that urban areas, including transport infrastructure, represent only 4.5 per cent (19.2 Mha) of the EU[62] land area. Therefore, although urban expansion appears significant in absolute terms, it only equates to a small fraction of total EU rural land area (approximately 0.25 per cent per year).

Of course there are greater subtleties to be seen in the data underpinning Table 1, which result in different environmental pressures. For example transport infrastructure, consisting of long linear urban strips can contribute significantly to fragmentation and pollution of ecosystems. In the 16 year period from 1990 to 2006 we see that the increased area taken by transport infrastructure[63] comes from agricultural land (74 per cent of the changed area; 39,167 ha)[64], followed by forests (16 per cent; 8,594 ha). Another more diffuse type of shift in land cover can be seen through the expansion of renewable energy infrastructure, such as solar arrays and wind turbines (see Box 3).

Box 3: Land used for renewable energy installations

Driven in part by renewable energy policies, increasing areas of rural land across the EU are being used for renewable energy infrastructure. However, quantifying the extent of these developments is problematic as they are either included within broader descriptions of land use, such as urban infrastructure, or represent such small areas so as not to be represented in some statistics. Despite this difficulty, the land take from these types of infrastructure should not be underestimated. The largest solar panel array in Europe, covering 85 ha, is found in Italy, with the second largest in Spain and third in Germany. Smaller arrays have started to appear across much of the EU-15, including 17 ha and 21 ha arrays in England.

Wind turbines, are also an increasingly common sight across much of the EU. Wind farms have a relatively small footprint and in most cases over 95 per cent of the area on which they are built can continue being used for farming or other purposes. The land take required for a typical 10-turbine wind farm is around 1.3 ha (excluding access tracks) plus a further one hectare during the construction phase (Coriolis Energy, 2012; EWEA, undated). However, despite their relatively small footprint, their location can lead to impacts on rural land. For example, in the UK wind turbines are most often placed in upland areas to maximise wind capture. These areas can be important cultural landscapes, represent more extensive and HNV type farming systems or cover areas of fragile soils, such as peat.

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61 JRC Soils portal, http://eusoils.jrc.ec.europa.eu/library/themes/Sealing/ Accessed: November 2012

62 These areas vary significantly from as high as 29 per cent in Malta and 13 per cent in the Netherlands, to as little as 1.5 per cent in Sweden (LUCAS, 2009).

63 Road and rail networks and associated land

64 The main contributing land types are non-irrigated agricultural areas (42 per cent; 22,323 ha) followed by pastures (12 per cent; 6,435 ha) and complex cultivation patterns (eight per cent; 4,405 ha).

Changes as a result of forest expansion are also significant. Based on the changes in Corine land cover between 1990 and 2006 forest area has increased mainly onto areas of existing transitional woodland scrub (86 per cent of all land becoming forest; 1.6 Mha). Of the remaining land becoming forest, almost equal areas comes from peatbogs, agricultural mosaics with natural vegetation, and pasture (10 per cent each); natural grasslands (16 per cent; 55,251 ha); sclerophyllous vegetation (12 per cent; 43,182 ha), and arable land (21 per cent; 77,461 ha). The most noticeable trend in relation to forests is the degree of flux in and out of traditional woodland scrub. Over the 16-year period observed 2.3 Mha have moved from woodland scrub to forest and 1.6 Mha moved from forest to woodland scrub. This may represent natural regeneration cycles or forestry harvesting operations.

The regeneration of forest areas through natural succession has been examined over the 1990 to 2006 time period. Results indicate that expansion in a given region does not necessarily improve the forest connectivity and that fragmentation remains a significant issue in many regions (Forest Europe et al, 2011).

For considering the land use change within agricultural areas, a fifty-year time series of data is available (Table 2). This shows that the trend in declining agricultural area across both the EU-12 and EU15 Member States has been taking place since the early 1960s. The only area showing any increase is permanent grassland in the EU-12, an increase of seven per cent over the period65, although this is an artefact of the increases witnessed between 1989 and 1999 and the area of permanent grass has since declined to pre-1989 levels.

Although not necessarily in agricultural use, natural grasslands[66] warrant particular attention, as they represent some of the most species rich and ecologically vulnerable habitats on farmland in the EU. Approximately one quarter of the natural grassland area that has been converted over the 16 year period has been agriculturally improved in some way either to pasture land (one per cent; 2,743 ha) or other forms of agriculture such as permanent crops (three per cent; 8,488 ha). The greatest conversion (19 per cent; 63,736) has been to some form of arable land. Despite the changes seen here, the overall figures on flows between land covers mask more complex patterns of change at the local level. For example, although cropland is decreasing overall, it will be increasing in some areas.

[65] It should however be noted that despite being covered under the agricultural resource statistics it is unclear if this entire area is under agricultural use.

[66] Low productivity grassland, often situated in areas of rough, uneven ground. Frequently includes rocky areas, briars and heathland. Often found in areas where there is extensive agricultural activity.

Table 2: Historic land cover/use trend for agricultural land in the EU-27

Land Use	1961	1969	1979	1989*	1999	2009	Change
EU-12 Total Agriculture	54,974	54,552	53,810	52,979	58,429	52,554	↓4%
Arable	40,590	39,471	38,495	37,760	41,570	37,614	↓7%
Permanent Crops	1,658	1,921	1,810	1,606	1,570	1,297	↓22%
Permanent Grass	12,726	13,160	13,505	13,613	15,289	13,642	↑7%
Forest	-	-	-	25,092	34,105	35,469	↑29%
EU-15 Total Agriculture	164,399	160,678	153,284	149,054	141,809	135,726	↓17%
Arable	87,718	83,651	79,102	78,140	74,061	71,131	↓19%
Permanent Crops	11,244	11,488	11,898	11,490	11,129	10,692	↓5%
Permanent Grass	65,437	65,539	62,284	59,424	56,619	53,903	↓18%
Forest	-	-	-	110,888	116,858	120,891	↑8%
EU-27 Total Agriculture	219,373	215,230	207,094	202,033	200,238	188,280	↓14%
Arable	128,308	123,122	117,597	115,900	115,631	108,745	↓15%
Permanent Crops	12,902	13,409	13,708	13,096	12,699	11,989	↓7%
Permanent Grass	78,163	78,699	75,789	73,037	71,908	67,545	↓14%
Forest	-	-	-	135,980	150,963	156,360	↑13%

Source: Own compilation based on FAOStat – Land resource data. http://faostat3.fao.org/ Accessed: October 2012 **Note:** Areas are quoted as 1000ha. * Forest areas for this period are from 1993.

2.4 Dataset consistency

This chapter has used a range of datasets to present a picture of rural land cover and land use across the EU. However this was not a simple task and the lack of consistent pan-European datasets is striking. Although the EU is one of the most observed and data rich territories, there remains a great diversity in the information available between and within Member States. This makes comparisons of the scale attempted in this study, problematic. 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 (see 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 2009 and the Corine Land Cover survey. However, even with a consistent approach, there is often a need for specific datasets representing individual sectors (eg agriculture or forestry), sub-sectors (eg organic farming), objectives (eg biodiversity or hydrology) or geography (eg Member States and regions). 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. Further information on how the data sources used for this study have been combined is set out in Annex 1.

3 ECOSYSTEM SERVICES SUPPORTED BY RURAL LAND IN THE EU

Key findings:

- Rural land plays an essential role in delivering a wide range of ecosystem services. These include food, timber and energy feedstocks, clean water, healthy soils, carbon sequestration, biodiversity and recreational space.
- There is a serious deficit in the provision of environmental goods and services from EU rural land, as measured against the goals set by public policy. This threatens the future sustainability (economic, social and environmental) of agricultural and forestry systems, their resilience to climate change and the natural environment on which they depend.
- Whereas provisioning services such as food and timber need not be sourced from within the EU as they can be traded, environmental services have to be provided within the EU for EU citizens to derive benefit from them.
- More extensive forms of agricultural and forestry management generally support the highest levels of biodiversity and the greatest diversity and quality of ecosystem services. However, with appropriate management more intensive systems can also reduce current pressures on the environment.
- There remains very little fertile land that is managed extensively as most areas have either been taken up by urban sprawl or by intensive agriculture. It is these areas, where the potential for the production of food, feed and timber is the greatest, where the competition and tensions between maintaining and improving the provision of environmental services and commodity production are most keenly felt.

This chapter sets out in broad terms the range of ecosystem services supported by rural land in the EU. It considers both the potential for rural land to support ecosystem services as well as their current supply.

It should be stressed that the interactions and trade-offs summarised in this chapter only represent a broad analysis of the potential for different land covers and uses to support different ecosystem services. They provide a general picture for the EU-27, but do not reflect the local and field scale variability in management and land cover interactions present in the EU. These local variations can be critical in determining the types and range of ecosystem services delivered in practice, as discussed in more detail in Chapter 6.

3.1 Ecosystems and ecosystem services

An ecosystem is a dynamic complex of plant, animal, microorganism communities and the non-living environment interacting as a functional unit. Ecosystem services are the benefits people obtain from these ecosystems (MEA, 2005). They include: provisioning services, such as food and fibre; regulating services, such as water quality and nutrient cycling; and cultural services including recreation and spiritual benefits. Biodiversity is not technically an ecosystem service in its own right, yet it is critical to underpin all ecosystem services and forms an integral component of essential core ecological processes[67]. However, this chapter considers biodiversity, for its own intrinsic value, as a key supporting service[68].

[67] Including, genetic diversification, soil formation, pollination and biological control, which in turn support a range of provisioning and cultural services.
[68] This follows a similar logic to that employed in TEEB where biodiversity is included under the Habitat services function (TEEB, 2010).

Rural land plays an essential role in delivering a wide range of ecosystem services, such as the production of food, fibre and forest products and increasingly energy, as well as a range of regulating and cultural services demanded by society. Considering the full range of services together can help to illustrate the challenges involved in achieving the sustainable use of rural land, creating favourable conditions for producing crops, livestock, timber and energy whilst also providing a healthy, functioning environment and resource base. For the purposes of this study, the ecosystem service framework is used to classify the range of different services provided by rural land, including both goods and services that are provided predominantly through the market as well as those for which functioning markets do not exist. The Common International Classification of Ecosystem Goods and Services (CICES) for integrated environmental and economic accounting, as developed by the EEA, UNEP and the FAO is used (see Table 3).

All these services can be produced in the EU, but this need not be the case. Some services are more location specific than others. For example, many of the regulation and cultural services need to be produced in the EU if their benefits are to be enjoyed by EU citizens. To a large extent, these services are non-tradable. Conversely, provisioning services can be produced elsewhere in the world and then traded in response to demand from citizens. In this sense, EU rural land can be used to provide provisioning services for both EU and global consumption, but EU demand for such services also can be met using land elsewhere.

3.2 Ecosystem services and rural land use

Through the appropriate use of land it is possible to support many ecosystem services simultaneously. The degree to which this is achievable varies depending on a range of factors, including: the proximity to those who benefit from the service (Vermeulen and Koziell, 2002; Hein *et al,* 2006); and temporal and physical scale (Turner *et al,* 2000; Limburg *et al,* 2002; Raulund-Ramussen *et al,* 2011). However, the most significant factor affecting the range of ecosystem services supported by rural land is its use and how it is managed (Cooper *et al,* 2009; Hart *et al,* 2011a; Raulund-Ramussen *et al,* 2011). Whether land is dedicated to producing food and timber or protected for nature, different land uses and the juxtaposition between them will have a fundamental impact on the type of ecosystem services that can be provided in a particular location. Furthermore, the nature and degree of management intervention very often will influence the level at which the service is provided (Maes *et al,* 2011a; Stoate *et al,* 2009; EEA, 2010d; Balmford, 2008; MEA 2005; Poláková *et al,* 2011).

Table 3: Ecosystem Services framework used for this study

Service	Service Class	Description
Provisioning	Nutrition	The provision of food from crops and animals grown domestically or harvested from the wild. This category includes the provision of fodder for animal consumption as well as the provision of fresh water for both human and animal consumption.
	Materials	The provision of biotic materials including non-food plant and animal fibres, as well as genetic, ornamental and medicinal resources.
	Energy	The provision of biomass for the use in energy production including dedicated crops and organic residues and fibres.
Regulation and Maintenance	Regulation of wastes	The dilution, filtration and sequestration of wastes from both anthropogenic and non-anthropogenic sources. This service also includes the remediation of waste using plants and micro-organisms.
	Flow regulation	Services that regulate the flow of liquid (flood protection), solid (erosion) and gaseous (windbreaks) substances. Natural fire regulation has also been included within this section.
	Regulation of physical environment	Services that include water purification, maintenance of soil fertility and structure. This group of services also includes local and global climate regulation covering the sequestration of carbon and the control of GHG emissions.
	Regulation of biotic environment	This group of services includes pollination, seed dispersal, pest and disease control and gene pool protection through nursery populations. Biodiversity for its own intrinsic value has been included within this category.
Cultural	Symbolic	Services that provide aesthetic, heritage and spiritual benefits including cultural landscapes, wilderness and sacred places.
	Intellectual and Experiential	These services include services that provide recreation and knowledge including iconic wildlife or habitats, hunting, scientific or educational services.

Source: *Own elaboration of the CICES categories* ***Note:*** *the services included in the table are restricted to land based biotic services in keeping with the focus of the study. A more detailed description of the framework can be found in Annex 2.*

3.2.1 Ecosystem services from agricultural land

The extent to which agricultural land will provide different ecosystem services depends both on its primary use – understood here as arable, permanent pasture, permanent crops and fallow – and on the way it is managed. Key parameters of management include scale, structure, level of specialisation, the use of inputs and the livestock systems employed. The interaction between the management techniques and the environment in which they are applied is critical and varies between locations. Given the variety of management choices exhibited on European farms, some generalisation and simplification of management regimes is necessary to characterise the broader trends and relationships. In the discussion below we distinguish between the relatively high yielding and generally specialised farming systems that predominate in lowland agriculture and parts of the uplands and the more extensive systems found on less productive soils, at higher altitudes and in some dryer regions.

Intensive and specialist agricultural production

It is widely accepted that the specialisation and increased intensity of agricultural production can lead to increased yields, which is the main purpose of increasing input use (Woods *et al*, 2010; Rey-Benayas and Bullock, 2012). The more efficient use of resources, in particular land, in food production, can lead also to environmental benefits, such as GHG emission reductions, reduced consumption of resources, such as water, fossil fuels and the 'sparing' of land for other activities including urbanisation and nature protection (Burney *et al,* 2009; Garnett, 2010; Phalan *et al,* 2011). Fewer livestock require less food and produce less waste with attendant pollution hazards. Specialised systems can be efficient in production terms. However, despite these potential benefits more intensive systems are not necessarily more efficient, and when negative environmental impacts are taken into account, their greater efficiency becomes even more questionable. High input systems generally create more environmental hazards although the specific techniques used are critical in assessing impacts.

Improving agricultural yields generally have been associated with higher input[69] and machinery use; greater crop and livestock densities; and more specialised production and crop systems. Intensifying production in this way can place significant pressures on the natural environment and resources upon which production depends. For example intensive and repetitive cultivation and tillage can result in increased soil erosion, particularly on sloping land and next to water bodies (Pimentel and Kounang, 1998; Louwagie *et al*, 2009) and lead to increased GHG emissions (for example Cooper *et al,* 2009; Woods *et al,* 2010; Rey Benayas and Bullock, 2012). High density and intensive livestock production[70] can reduce species diversity on grassland and lead to increased water pollution (Thomas and Settele, 2004; Asl *et al*, 2004; Vandewalle *et al*, 2008). This can in turn lead to a reduction in pollinators and other agriculturally important species and cause negative impacts on landscapes (Vandewalle *et al*, 2008; Cooper *et al,* 2009).

Water use in agriculture illustrates many of the issues. Agriculture in the EU consumes a third of all water use by sector, but this differs significantly across the territory. Lower irrigation rates are found in wetter northern and Scandinavian Member States and higher levels of irrigation in dryer southern and Mediterranean areas[71]. The use of irrigation has significant benefits to crop production, particularly in more arid and drought prone regions and Member States such as Spain, Portugal and Italy. Yield differences can be significant, with up to 20 times greater yields in vegetable production (see Catalonia case study, Chapter 6). Irrigation can also help to enhance the quality of crop products, for example preventing damage by temperature extremes, desiccation or related crop disease (IEEP, 2000). However, diverting water from natural systems can have a fundamental impact on the environment, both on cropland and on the wider water catchment. Despite benefits to yields and overall agricultural output, irrigation can lead to a large increase in input use, with subsequent water pollution issues and impacts on related ecosystems. Monocultures

[69] Fertilisers, plant protection products and, in some cases, energy or water.

[70] Over and above the ability of the land to support such densities.

[71] Irrigation accounts for over 80 per cent of total water abstractions in Greece (Caraveli, 1999), 72 per cent in Spain (Sumpsi and Varela-Ortega, 1999), 60 per cent in Italy (Hamdy and Lacirignola, 1999) and 59 per cent in Portugal (Caldas, 1999).

can become more economically attractive, with maize an example in some regions. Extensive farming systems, including, in some areas, High Nature Value farming systems can be displaced, particularly in Mediterranean areas (IEEP, 2000). Where agriculture becomes excessively reliant on irrigation, typically in very dry areas, this could have long term impacts on the sustainability of production in such regions, particularly with climate change predicted to lead to greater water shortages in future years.

The seasonality of irrigation demands, usually highest in the summer months, often coincides with the period when water levels are lowest and there is a greater demand from other sectors[72]. Diverting water resources from natural systems can have significant impacts on the environment. Where water abstraction exceeds natural recharge rates this can lead to a lowering of groundwater levels and increased salinisation[73] of aquifers (IEEP, 2000). Surface water abstraction from rivers or springs can reduce the volume and increase the variability of flow rates resulting in flood risks or disrupting aquatic and wetland ecosystems through drought, water temperature rises and increasing concentrations of harmful contaminants (EEA, 2009a). This can lead to the subsequent desertification of some arid areas with light and erosion-prone soils, particularly on steep slopes (IEEP, 2000). Excessive irrigation can also be damaging to agricultural land, through water logging of soils, which further leads to surface run-off and a deterioration in water quality (IEEP, 2000; EEA, 2009a).

In short, irrigation, particularly when on a large scale in regions with water scarcity, increases the risk of negative impacts on the provision of other ecosystem services. Good management can reduce these risks. Parallel issues arise in other forms of high input production, including intensive livestock farms.

Looking ahead to the future, there may be significant changes in the choice of crop and management systems employed in Europe, entailing new trade-offs between ecosystem services. For example short rotation coppice (SRC) has been seen as one potential option of meeting increased demands for woody biomass from agricultural land (Styles and Jones, 2007; IEA Bioenergy, 2011). However, the wider environmental impacts of SRC are not clear-cut and may not necessarily be positive (see Box 4).

[72] Such as water for human consumption and domestic use and for natural ecosystems.
[73] This can be due either to saltwater intrusion, where irrigated land is near to the coast, or it can be caused from over saturation and concentration of salts in the topsoils of irrigated land due to the increased circulation of water through them.

Box 4: Short rotation coppice and ecosystem services in the EU

SRC has been shown to have a range of potential environmental benefits, however these can be highly variable and differ throughout the full lifecycle of an SRC stand. For example, low nitrogen fertiliser requirements can result in much lower GHG emissions and improvements in water quality (Schildbach *et al,* 2009; Dimitriou *et al,* 2009; IEA Bioenergy, 2011; Lamersdorf, 2012). However, despite the reduced fertiliser use on SRC headlands, fertilisation can still be important to maintain yields and is required in significant quantities during the establishment phase, which can lead to soil and water issues (Venendaal *et al,* 1997; Goodlass *et al,* 2007; Mola-Yudego, 2010). A similar picture is true for water requirements.

The impacts on biodiversity are also variable. The permanent ground cover between SRC rows can be an important habitat for invertebrates (Gustafsson, 1987; Weih, 2008), plant diversity (Augustson *et al,* 2006; DTI, 2004; DTI, 2006; Gustafsson, 1987; Weih *et al,* 2003). The tree canopy also provides an important habitat for invertebrates, including important pollinator species such as bumblebees (Sage and Tucker, 1997[74]. However benefits are not seen for all species types. Lower species diversity has been found for ground beetles (*Carabidae*) (Liesebach and Mecke, 2003; Britt *et al,* 2007; Lamersdorf *et al,* 2008; Brauner and Schulz, 2010)[75] and the most abundant bird species and small mammals tend to be habitat generalists with rare and threatened species less well suited to SRC (Christian *et al,* 1998; Gruß and Schulz, 2008; Jedicke, 1995).

One potential benefit of SRC over other forms of agricultural production is that the typical tree species used (poplars (*Populus sp.*) and willows (*Salix sp.*) can be used for phytoremediation[76] (Glass, 1999; IEA Bioenergy, 2011). Therefore SRC may be able to be grown on more contaminated land which is less suitable for conventional agricultural production. However, in general SRC does not appear to provide significant environmental gains over conventional agricultural production of a similar intensity.

It is generally assumed that SRC will be grown on arable agricultural land and thus benefit from relatively favourable growing and access conditions. However this need not be the case as SRC could be grown on grass or forestland. Therefore when assessing the potential environmental benefits provided by growing SRC it is important to consider the land use that it is replacing as well as the previous management approaches.

Extensive crop and livestock production

Lower intensity agricultural land management provides a different balance between the production of food, fuel and fibre and environmental management. Particularly where inputs are low in relation to local environmental conditions, pressures on soil, water and biodiversity will be correspondingly more limited (Cooper *et al,* 2001; Altieri, 2004; Prasad *et al*, 2004; Pujol *et al*, 2005; He *et al*, 2007; JRC, 2009; Rey-Benayas and Bullock, 2012). The provision of environmental goods and services is higher in low intensity systems in Europe than in the generality of farming systems. However, extensive production generally results in lower yields (see for example UNEP-WCMC, 2011; Rey-Benayas and Bullock, 2012) and may be less efficient in the use of natural resources per unit of output. Some products from these systems command higher prices because of their origins or quality, but market returns to farmers can be below average.

Beyond simply limiting the immediate environmental pressures from agriculture, extensive farming practices can work within the natural and environmental limits of a region, such as through low density grazing management of high alpine pastures. This can lead to a more sustainable approach to production in the long term as well as improving the resilience of farmed and associated semi-natural systems to environmental change (Huitric *et al,* 2009;

[74] Compared to conventionally grown barley and wheat
[75] Compared to conventional crops
[76] to improve and clean soil from hazardous compounds such as heavy metals or organics

EEA, 2010b). For example extensive agricultural systems tend to result in more heterogeneous land use patterns with a greater proportion of natural or uncultivated land. This in turn can support a mosaic of well-connected habitats and reduce crop vulnerability to climate changes (Bianchi *et al*, 2006; Reidsma and Ewert, 2008; Rey-Benayas and Bullock, 2012). Extensive management can also help to improve nutrient cycling and carbon sequestration (van Noordwijk, 2002; Rey-Benayas and Bullock, 2012) as well as supporting a wider range of biodiversity than intensive systems (Tscharntke *et al,* 2005; Batary *et al,* 2012; Navarro and Pereira, 2012)[77]; particularly pollinators and pest control species (Tscharntke *et al*, 2005; Balmford *et al,* 2008)[78].

Box 5: High Nature Value farmland in the EU

Significant areas of Europe's agriculture continue to be managed in ways that provide benefits for the environment, particularly biodiversity. These farming systems also make a significant contribution to sustaining rural communities and shaping rural culture and traditions. Increased recognition of this fact led to the development of the concept of HNV farming and its embodiment in the Community Strategic Framework (CSF)[79]. The average area of potential HNV farmland in the EU-27 is around 30 per cent of UAA but ranges from 10 per cent in some northern Member States to 50 per cent in some southern Member States[80].

HNV farmland is typically found in regions with less fertile soils and are characterised by a combination of low intensity land use, the presence of semi-natural vegetation and unfarmed features, and a diversity of land cover and land uses (Beaufoy and Cooper, 2008; Keenleyside and Tucker, 2010; Hart *et al,* 2011a; Beaufoy *et al,* 2012). By definition, HNV farmland plays an important role in helping to conserve biodiversity within functioning agricultural landscapes and provides a wide range of other environmental benefits (Beaufoy *et al*, 2012). For an estimate of the potential area of HNV farmland across the EU see Table 5 Annex 1.

Source: Own compilation

Although environmental benefits are more often associated with extensive agricultural management, it is important to recognise that these are not always produced synergistically and the sensitivity of management to local conditions is critical in all systems. For example, there can be conflicts between practices that are desirable for carbon and water management and those preferred for biodiversity objectives (Ridder, 2008; Cao *et al*, 2009; Putz and Redford, 2009; Rey-Benayas and Bullock, 2012). It is important therefore to ensure that management approaches are tailored to ensure environmental synergies whilst reducing any potential conflicts.

[77] Some argue that extensive farming systems can support greater biodiversity when compared to non-managed ecosystems and natural forests (Blondel, 2006; Navarro and Pereira, 2012).

[78] Of the 231 habitat types in the Habitats Directive, 41 are linked to extensive production (Halada *et al,* 2011; Navarro and Pereira, 2012).

[79] The 'preservation and development of high nature value farming systems' was formally recognised in 2005 as one of three core priorities to be addressed under Pillar 2 of the CAP, as set out in the Community Strategic Guidelines for Rural Development (Council Decision 2006/144/EC).

[80] There continue to be issues with the accuracy of the data used to map HNV farmland. In addition, due to the fact that there is no data at the pan European scale that allow the identification of low intensity grassland, estimates of the spatial extent of the HNV resource are likely to be an overestimate and provide at best a proxy distribution (Paracchini *et al,* 2008). For further details and commentary on the different methods used to calculate the area of HNV farmland see EEA, forthcoming.

3.2.2 Ecosystem services from abandoned agricultural land

The balance of provision of ecosystem services changes as land moves out of agriculture, generally either to forest, urbanisation or to a form of minimal management, or outright abandonment. Permanent abandonment of agricultural production is an interesting case. Abandonment of agricultural land can occur in relatively extreme conditions, either through intensive management leading to the over-exploitation of natural resources or, far more frequently, through the economic marginalisation of low intensity management systems (Keenleyside and Tucker, 2010). Either route can reduce production, but also may reduce any associated environmental pressures.

Marginalisation, land abandonment and the natural successional transition at European latitudes generally leads to a decline in grassland and arable habitats and an increase in scrub and forest in the landscape (see Box 7). This re-vegetation, particularly of cultivated land, can be important for improving soil organic matter content[81], carbon sequestration and regulating water flow to prevent flooding (Arbelo *et al,* 2006; Navarro and Pereira, 2012; Kuemmerle *et al*, 2008*;* Pointereau *et al*, 2008; Stoate *et al,* 2009)*,* particularly in mountain areas (Körner *et al*, 2005; Navarro and Pereira, 2012).

However, with a change in vegetation communities, the biodiversity impacts of land abandonment vary depending on the species being considered. In some cases, land abandonment can help to improve species numbers and diversity and contribute to habitat restoration (Baudry, 1991; Myers and Harms, 2009; Rey-Benayas and Bullock, 2012; Navarro and Pereira, 2012)[82]. Furthermore there can also be knock on benefits from the re-establishment of species populations and the development of new habitat mosaics, such as those associated with appropriate ecotourism and hunting (Gortázar *et al,* 2000; Navarro and Pereira, 2012)[83]. However, in the EU context, agricultural land abandonment can often lead to declines in habitat heterogeneity and species diversity across the landscape, as is well documented (Hölzel *et al,* 2002; Kull *et al,* 2004; Navarro and Pereira, 2012; Hart *et al,* 2011a; Keenleyside and Tucker, 2010). The species that may benefit from abandonment are often generalist species of low biodiversity value (IEEP and Alterra, 2010).

Although there are environmental benefits that can result from abandoning agricultural land in certain circumstances, as well as risks for biodiversity there are other trade-offs. All land abandonment impacts upon the character of the agricultural landscape and whether or not this change is viewed as positive or negative will depend on the geographic location, cultural heritage of the area and social preferences (Hart *et al,* 2011a)[84]. The development of woody and scrub vegetation can lead to increased fire risk, particularly in Mediterranean

[81] With higher biomass levels supporting greater populations of earthworms for example (Russo, 2006)

[82] However, as a passive form of habitat restoration, there is little control over what becomes of the land and which species colonise – as opposed to active habitat restoration targeting for example species-rich grasslands and heathland (Rey Benayas and Bullock, 2012)

[83] For example, the Abruzzi region in Italy has seen rises in tourism due to growing presence of bears and wolves (Enserink and Vogel, 2006)

[84] For example, the French Causses and Cevennes Mediterranean agro-pastoral cultural landscapes or the Mont Perdu in the Pyrenees have been negatively affected as a result of agricultural abandonment (Baudry, 1991; Navarro and Pereira, 2012).

regions and where there is a lack of management (Dunjo *et al,* 2003; Conti and Fagarazzi, 2005; Proenca and Pereira, 2010; Navarro and Pereira, 2012). In addition the increased absorption and interception of water can reduce overall availability lower in the catchment (Brauman *et al*, 2007; Navarro and Pereira, 2012). In some situations the abandonment of agricultural land can lead to a loss of vegetation cover (such as in semi-arid areas) or lack of management of agricultural structures (such as terraces) this in turn can lead to higher rates of soil erosion and land degradation (Cerda, 1997; Pointereau *et al,* 2008; Pimentel and Kounang, 1998; Dunjo *et al,* 2003).

The loss of production that occurs will vary in magnitude and may be small in more marginal areas. Increases in hunting, wood harvesting and recreational activities may occur over time as agricultural production activities and associated incomes and products are lost (Rey-Benayas and Bullock, 2012). Land abandonment may lead also to an increase in production intensities elsewhere, with consequent pressures on the environment.

3.2.3 Ecosystem services from forests and forestry

Forests and other wooded land deliver a wide range of social, economic and environmental benefits to society (FAO, 2004; CEC, 2006; EEA, 2006; De Jong *et al*, 2011). Forests sequester carbon, provide habitat for numerous species, regulate water cycles, improve air quality and provide timber for various uses. In addition to these general benefits forest ecosystems can provide more benefits to society such as local gathering of fuel-wood, game, berries, mushrooms and flowers, provide recreational space, nature tourism and have important aesthetic values depending on their character, location and management (Maes *et al,* 2012).

As with agricultural systems, forest management practices vary significantly and range from intensive production oriented plantation systems to more extensive close-to-nature silviculture. However, the distinction between intensive and extensive forestry covers a wide spectrum of conditions and is less pronounced than in agricultural systems. For example, semi-natural forests can be managed at a high intensity with frequent interventions and plantation forests can be managed with low intensity, without thinning or fertilisation (which is far less widespread than in agriculture). For the purposes of this section we refer to two broad types of management intensity, using the categories set out by Duncker *et al* (2007; 2012). These include: intensive forestry (intensive even aged forestry and short rotation forestry for energy) and extensive forestry (unmanaged forest nature reserves, close-to-nature forestry and combined objective forestry) (see Table 4).

Table 4: Definition of forest management types from an ecosystem services perspective

Management alternatives			Description and management objective	Tree species Rules	Site management and cultivation rules	Harvest and stand management rules
<------------- Increasing degree of manipulation and management intensity <-------------	Extensive forestry	Unmanaged forest nature reserve	No management. Natural disturbances and succession drives development. Reference for authenticity and biodiversity refuge.	Natural	Not applicable	Not applicable
		Close-to-nature forestry	Stand management that mirrors natural processes as a guiding principle. Economic outturn is important but must occur within the frame of this principle.	Natural or adapted	Mostly natural regeneration without soil tillage. None or only exceptional chemical or physical site manipulations.	Thinnings are extensive and selective. Final harvesting often according to target diameter
		Combined objective forestry	An alternative defined by man characterised by inclusion of several considerations and goals, eg social, environmental and economic.	Often natural or adapted.	Cultivation might be artificial after site and soil preparations. Fertilisation and use of pesticides and other physical manipulation are limited.	Thinnings and stand regulation are often performed. Rotation lengths often increased for environment and social reasons.
	Intensive forestry	Intensive even-aged forestry	The main objective of intensive even-aged forestry is to produce timber. If ecological aims can be achieved without much loss of revenue, they are normally incorporated.	Optimal according to production purpose.	No restrictions besides general national legislation or guidelines. Site preparation used to improve establishment success and fertilisation to increase growth rates. Planting/seed material can be genetically improved, but not modified.	No restrictions besides general national legislation or guidelines. Rotation length depends mainly on the economic return and is normally similar to or shorter than the age of Maximum Mean Annual Increment.
		Short-rotation forestry	Focus is only on production of fibres typically for energy or pulp. Often short rotation coppice. Could be called lignoculture.	No restric-tions. Tree species selection depends mainly on economic returns.	Planting material can be genetically improved and/or modified. Sites are cultivated and can be drained or irrigated. Fertiliser/lime applied to enhance growth. Chemicals used to control pests, weeds and diseases.	Rotation length depends only on economic returns (≤(20 yrs). Final clearcut harvesting combined with removal of all woody residues if suitable markets exist.

Source: Adapted from Duncker *et al*, 2007 and Duncker *et al,* 2012.

Intensive forest management

Most forms of forest management[85] result in some form of biomass harvesting with greater volumes of timber and biomass harvested in more intensive forest management systems. The range and type of ecosystem services supported by different forest management tend to decrease as management moves away from near natural forests and towards intensive

[85] With the exception of forest nature reserves that involve no management or harvesting.

short rotation biomass production systems (Raulund-Ramussen *et al,* 2011). However, there are exceptions to this generic observation. For example, recreational and cultural enjoyment of forest areas can improve with active forest management as a result of improved access and landscape management.

As demonstrated in the literature forestry practices such as harvesting, soil preparation, and choice of tree species in intensive regimes can have negative effects on soil functionality (Hansen *et al*, 2011), biodiversity (De Jong *et al*, 2011) water quality (Gundersen *et al,* 2011), carbon cycles (Loustau *et al,* 2011) and water availability (Katzensteiner *et al,* 2011). Local factors often are critical.

Soil and site preparation prior to afforestation and reforestation is the first step where impacts will arise. Ploughing and scarification can have a mixed impact on biodiversity, with benefits to some types of vascular plants (Pykälä, 2004; Haeussler *et al,* 2002), but with negative impacts on others and on arthropods (Bellocq *et al*, 2001). Where ploughing and scarification occurs there will be impacts on soils beyond increment levels (Matthesen and Kudahl, 2001), water quality (Gundersen *et al,* 2011) and carbon stocks (Loustau *et al,* 2011)). Drainage, particularly of peat soils, can negatively impact biodiversity composition (Lavers and Haines-Young, 1997; Rune, 1997), soil functionality (Worrel and Hampson, 1997) and water quality (Callesen *et al,* 1999: Gundersen *et al,* 2006; Prevost *et al,* 1999; Westman and Laiho, 2003). A more complex and uncertain picture is presented for greenhouse gas emissions depending on factors such as soil type, but most recent studies suggest an overall net cooling effect of forestry drainage (Ojanen *et al,* 2013).

Site preparation using chemical treatment is relatively rare in EU forestry, but can occur, for example in nurseries or Christmas tree plantations (Raulund-Rasmussen *et al,* 2011). Where pesticides are used it often has a negative impact on biodiversity and although the use of fertilisers can lead to improvements in soil nutrient levels, there are potential impacts on water quality and nutrient balances (Gundersen *et al*, 2006; Smith *et al*., 2000; Simcock *et al,* 2006; Johnson and Curtis, 2001). Burning, another means of site clearance and preparation, can have important benefits for biodiversity (Wikars, 1992; Dale, 1997; Vrålstad *et al,* 1998) but may also benefit forest pest species[86] (Petersen, 1971; Raulund-Rasmussen *et al,* 2011).

The selection and specialisation of forest tree species to fewer types, including some outside their natural vegetation range, can improve wood production, but can also lead to detrimental impacts on forest biodiversity (Southwood, 1961; Raulund-Rasmussen *et al,* 2011) and reduce the overall resilience of forest stands to disease and natural environmental changes.

Harvesting patterns have environmental as well as production impacts. For example, significant amounts of nutrients are exported from forests during harvesting. It can lead to a decrease in soil and water quality (Glatzel, 1990; Augusto *et al,* 2002; Raulund-Ramussen *et*

[86] For example the longhorn beetle *Monochamus sutor,* the wood wasp *Urocerus gigas, and* fungal pathogen *Rhizina undulate.*

al, 2007), have an impact on natural regeneration of understory vegetation, and in some cases limit the future production potential of a forest stand (Smith *et al,* 2000; Raulund-Ramussen *et al,* 2007; Helmisaari *et al*. 2011). Negative impacts are generally more severe in intensive forest harvesting and clear cutting compared to continuous cover forestry[87] (Duncker *et al,* 2012; O'Hara, 2001). Increased harvesting intensity can reduce the level of carbon sequestered in particular forest stands. Forests of all management types play an important role in global carbon cycles (IPCC, 2007; Brown *et al,* 1996; Cannell, 2003), however where extraction exceeds the net annual increment or the accumulation of woody biomass, forests change from being a carbon sink to a carbon source (Loustau and Klimo, 2011).

The increasing use of branches, tops (including needles)[88] for wood fuel is leading to depletion in soil nutrient levels and organic matter composition in some areas (Helmisaari *et al,* 2011). However, good practice guidelines for harvest residue extraction recommend to apply this only twice during a forest rotation and advocate application of wood ash to compensate for the nutrient losses (Aronsson and Ekelund, 2004; Skogsstyrelsen, 2008).

Extensive forest management

Extensive forest management practices (those in the upper half of Table 4) generally result in a more naturally functioning forest system, particularly in 'close-to-nature forestry' and forest reserves. These types of management tend to result in improvements in the environmental benefits provided by forests such as increasing the retention of organic matter in soils, reduced soil susceptibility to erosion, improved capacity for infiltration, carbon sequestration, biodiversity composition and cultural enjoyment (JRC, 2009; Cooper *et al,* 2009; Raulund-Rasmussen *et al,* 2011). These environmental benefits are accompanied often by lower wood production especially in case of forest reserves. However, continuous cover and close-to-nature forest management systems can also be highly productive as tree regeneration takes place under a shelter of mature, but still vigorously growing trees. This avoids the unproductive regeneration phase that is typical for clear cut systems.

Forest reserves provide an important service by protecting genetic diversity, both in the forest understory[89] and the tree species. This is under increasing pressure. Despite the area of forest that consists of a single tree species having declined annually by around 0.6 per cent during the last 15-year period, 30 per cent of forests continue to be dominated by one tree species alone[90] (Forest Europe *et al,* 2011). These forests are typically homogenous single-age coniferous forests. Broadleaf forests show a greater mixture of tree species

[87] Intensive forest management is associated with single species even aged stand structure. Continuous cover forestry has a more mixed age structure, often with mixed species composition.

[88] Although these fractions only amount to a small proportion of the total weight of the tree, they have a much higher nutrient concentration per unit weight than stems. Thus, the increase in nutrient export might be significant. Another undesired effect of the nutrient export is enhanced soil acidity.

[89] Forest genetic resources may be invaluable for the human population for example for their potential in areas such as medical research (Vandewalle *et al,* 2008).

[90] Single tree species forests, representing more than 40 per cent of the forest area, are found in large areas in Finland, Bulgaria, Ireland, Austria, Belgium, Iceland, the United Kingdom, Portugal, Albania and Cyprus

(Forest Europe *et al,* 2011). Diversifying tree species composition, particularly by pursuing natural regeneration of native species, can be particularly beneficial to biodiversity and help improve forest stand resilience in the long term (Peterken, 1993; Patterson, 1993; Humphrey *et al,* 1998; Humphrey *et al,* 2000).

3.2.4 Ecosystem services from agro-forestry

Agro-forestry, as a hybrid land use system, can have a different impact on a range of ecosystem services to more conventional agriculture or forestry practices. Agro-forestry ranges from the more traditional areas of montado and dehesa in Spain and Portugal, to the more intensive strip-agro-forestry found on a small scale in the UK and other northern Member States. As with agriculture and forestry systems, the relative environmental benefits provided by agro-forestry are highly dependent on the way in which these systems are managed.

The traditional and extensive agro-forestry systems remaining in Europe, such as Spanish dehesas, developed in response to specific bio-climatic limitations, supporting livestock production, cork harvesting and cereal cultivation in combination with associated biodiversity and recreational benefits (Bugalho *et al*, 2011; Navarro and Pereira, 2012). These systems typically have a low level of productivity when compared to more specialist production. However, when taken in combination, the total agriculture and forestry output per unit area of land can be significant (for example Dupraz and Talbot, 2012), of higher quality than conventional approaches to production (Mosquera-Losada *et al,* 2012) and result in some environmental benefits and increased environmental sustainability (see Box 6).

Despite the many ecosystem services that can be supported through agro-forestry systems, farmers have been reluctant to invest in new systems, mainly because of lower crop yields (as a result of shade), and difficulties with machinery access (Van Gils *et al,* 2012). This has led to the development of more modern forms of agro-forestry, such as strip and alley cropping[91] where the forest component is isolated from that of agricultural areas. These systems differ significantly from traditional agro-pastoral landscapes and, although they can be more productive, they generally provide fewer environmental benefits.

[91] Growing crops and trees in alternating strips or alleys

Box 6: Agro-forestry and ecosystem services in the EU

There can be wide environmental benefits from growing crops and livestock in conjunction with trees. Extensive agro-forestry can have a positive impact on biodiversity, particularly improving pollinating species[92] (Varah *et al,* 2012) and pest predators (Burgess, 1999). Agro-forestry systems can help also to improve habitat connectivity (Vandermeer and Perfecto, 2007; Rigueiro-Rodriguez *et al,* 2009; Lombard *et al*, 2010; Rey Benayas and Bullock, 2012). However, for certain species these corridors need to be of sufficient width and habitat type to facilitation such movement (Mazza *et al,* 2011).

The presence of trees can also benefit soils and water by helping to reduce wind erosion, stabilising slopes and acting as buffers to intercept surface run-off into watercourses (Blondel, 2006; Freese and Bohm, 2012; Navarro and Pereira, 2012; Jacobson, 2012; Santamarta-Cerezal *et al,* 2012). Some have argued that trees reduce the water available for crops, however recent studies suggest this is not the case, with trees being better at retaining water during both dry and wet periods and thus have lower competition for scarce resources (Talbot, 2011; SAFE, 2012; Béduneau and Gabory, 2012). The presence of grazed or cropped land between woody vegetation can also help to reduce fire risk (Mosquera-Losada *et al,* 2012).

Modern and more intensive agro-forestry systems, can lead to production benefits over more traditional and extensive systems. Some have argued that agro-forestry systems have the potential to act as a near carbon-neutral source of energy (Palma *et al*, 2007; Wise and Cacho, 2005; Dupraz and Talbot, 2012). However, the full carbon balance of such systems is not fully understood and where agro-forestry systems are introduced onto existing arable land, Indirect Land Use Change (ILUC) effects may result. Furthermore, fast growing trees, particularly non-native species, have fewer environmental benefits than traditional ones (Vandewalle *et al,* 2008) and intensive crop production can have similar environmental impacts to those seen in conventional intensive agriculture.

Source: Own compilation

3.2.5 Ecosystem services from land with no visible use and areas protected for the environment

Beyond agriculture and forestry systems, approximately 12 per cent of EU rural land is recorded in surveys as being under no visible use and thus without cultivation activities, although in reality this may not necessarily be the case (see Chapter 2). A proportion of this area is more likely to be managed under more natural processes or left alone with fewer pressures on the environment. Some of this is managed specifically for environmental reasons such as nature reserves and may involve no active interventions, or may require some form of management to maintain habitat structure, such as extensively grazing of grassland, the thinning and cutting of vegetation or regular inundation of floodplains[93]. Both types of land have the potential to provide a wide range of environmental services.

There are relatively few natural areas left in the EU and even those areas that do exist, such as extensively grazed tundra, blanket bogs and montane grasslands[94] are likely to have been influenced at some stage by direct or indirect human intervention[95] (Vera, 2000; Poláková *et al,* 2011). Many areas of semi-natural vegetation and habitats do remain and have developed over centuries as a result of agricultural silvicultural practices (see Box 7). These areas are important both for biodiversity (see for example Poláková *et al,* 2011) as well as

[92] When surveying both hoverflies and bumblebees in comparison to arable or grasslands
[93] Such as in semi-natural water meadows and floodplains
[94] Which can be considered analogous to former natural habitats
[95] Such as fire, increased fertility or drainage

the provision of a wide range of other ecosystem services, such as carbon sequestration (see for example Duncker *et al,* 2007), water filtration (Scoones, 1991; Vandewalle *et al*, 2008) and recreational enjoyment (Vandewalle *et al,* 2008).

One of the environmental benefits of (semi) natural areas is they provide refuges for wildlife and act as reference areas which can be studied or observed to help increase the understanding of ecological processes and preserve genetic diversity. These areas, where accessible, can also provide significant cultural and spiritual benefit to society through their enjoyment for recreational purposes.

Box 7: Development of semi-natural vegetation in the EU

Most natural grassland and virtually all natural forests have been lost in Europe as a result of management modifications or indirect impacts. Nevertheless, the legacy of low-intensity and diverse traditional agricultural practices and their interactions with the varying climates, topography and soils of Europe has created a rich diversity of landscapes and habitats (Poláková *et al,* 2011). Despite these changes, new and diverse semi-natural habitats have been created with novel species communities, which initially probably increased species richness across much of Europe (Baumann, 2006; Ellenberg, 1988; Kornas, 1983; Stoate, 2011). Furthermore, some of the semi-natural habitats that arose from human intervention, such as wood pastures, hay meadows and heathlands that are dependent on livestock grazing for their maintenance are likely to be analogous to some former natural habitats that were dependent on grazing by wild herbivores (Goriup, 1988; Vera, 2000).

Source: Poláková *et al*, 2011

The mix and extent of protected areas and land outside commercial production can play a big factor in the types of services provided. For example, large and extensive upland blanket bog communities may support carbon sequestration. Maintaining semi-natural areas, such as wetlands, as part of a wider landscape mosaic can help to deliver regulating and cultural ecosystem services alongside other land uses which focus on food production (Soerjani, 1992; Omari, 1993)[96]. In addition, small strips of land adjacent to cultivated fields can be important for providing pollinating services or acting as buffers, reducing surface water run-off and spray drift (Cooper *et al*, 2009; Natural England, 2009).

Despite these land areas not being used specifically for agricultural or forestry production they can contribute to a range of provisioning services, such as natural wild food resources (berries, mushrooms etc) as well as hunting activities for game (EEA, 2010a). Equally, where the land is under some form of conservation management, vegetation thinnings and management residues can also provide sources of renewable energy (Kretschmer *et al,* 2011).

3.3 Ecosystem services and the EU rural land mosaic

In broad terms, a greater number of synergies between ecosystem services, particularly regulating and cultural services, can be expected on areas under more extensive forms of land use. Provisioning services, such as food and timber production generally rely on the

[96] For example maintaining natural water courses and wetland areas can help to reduce flood risk (Cooper *et al*, 2009); seasonal wetlands can provide a valuable resource for livestock grazing as a result of the high biomass associated with these areas; and riparian areas can provide natural habitat to pollinators and pest predators (Vandewalle *et al,* 2008).

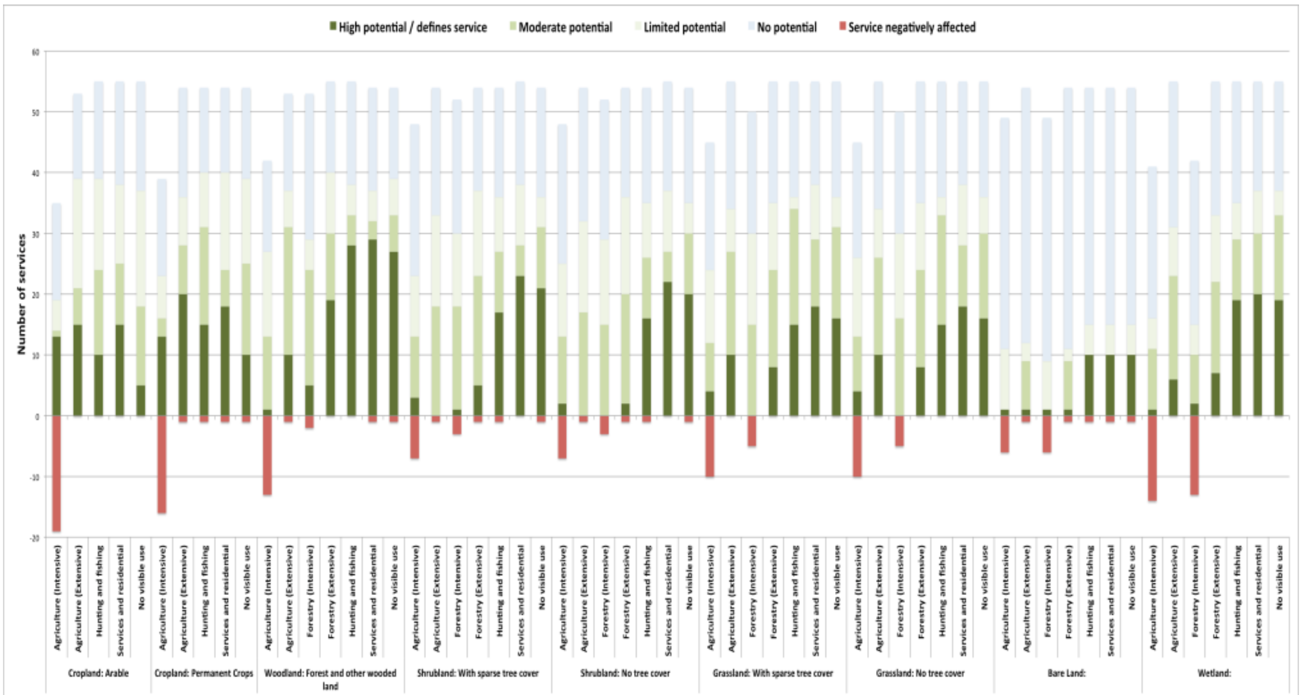
modification of natural systems and economic returns tend to improve with specialisation and land use intensity. Where land uses are specialised and focussed on production there are fewer synergies with other service types and often greater trade-offs experienced. In many circumstances intensive forestry, due to relatively long rotation cycles can still deliver synergies with regulating and cultural service, such as carbon sequestration or recreational activities, but to a lower degree than more extensive management practices[97]. These trade-offs are not a new concept and are well described in the literature (MEA, 2005; UNEP-WCMC, 2011; Maes *et al*, 2011a and b).

Understanding the relationship between land cover, use, management and ecosystem services is an important element of meeting the EU's environmental targets such as those set out under the EU biodiversity strategy (COM(2011)244). Work is already underway in this regard with the establishment of the DG Environment working group on Mapping and Assessment of Ecosystems and their Services (WG-MAES). Their role, as set out under Action 5 of Target 2 of the biodiversity strategy, is to assist Member States in mapping and assessing the status of ecosystems and their services in their national territory by 2014. They will also help to assessing the economic value of such services, and in promoting the integration of these values into accounting and reporting systems at EU and national level by 2020.

The resources available to WG-MAES are beyond that of this study and spatial mapping of ecosystem services would only seek to duplicate effort. Instead, and building on the information set out in Chapter 2 and the review of available literature, a matrix-based assessment was used to identify the potential level of ecosystem services supported by a range of land cover and land use categories in the EU-27. This assessment98 follows recent work (Kienast, 2009; Burkhard *et al*, 2009; Maes *et al*, 2011b) and provides a visual illustration to the descriptions set out earlier in this chapter (see Figure 9).

[97] Further details of the synergies and trade-offs are explored in Chapter 6 in the North Karelian case study.
[98] An account of the methodology can be found in Annex 3 and the output matrix of land cover and land use can be found in Annex 4 along with some graphical outcomes of the assessment.

Figure 9: Number of different services supported by rural land in the EU



Source: Own compilation based on the land cover and land use descriptions provided in Chapter 2 and the assessment of ecosystem services provided in this chapter[99]. **Note:** In some cases the combinations of land cover (horizontal text) and land use (vertical text) may seem counter-intuitive, such as the presence of forestry on shrubland without tree cover. However, they represent the types of land use found in the EU as described using the LUCAS2009 data. In the case of forestry on shrubland areas this land could form part of a wider mosaic of forestry practices including woodland stands, cleared areas or areas in preparation for planting. It is worth noting that the 'services and residential category' of land use includes sub categories such as nature reserves or sport and leisure use. The combination of land cover and land uses are relevant to the overall assessment of the potential of land to deliver a balanced suite of ecosystem services in the future and are discussed further in Chapter 6. A larger version of this figure can be found in Annex 4

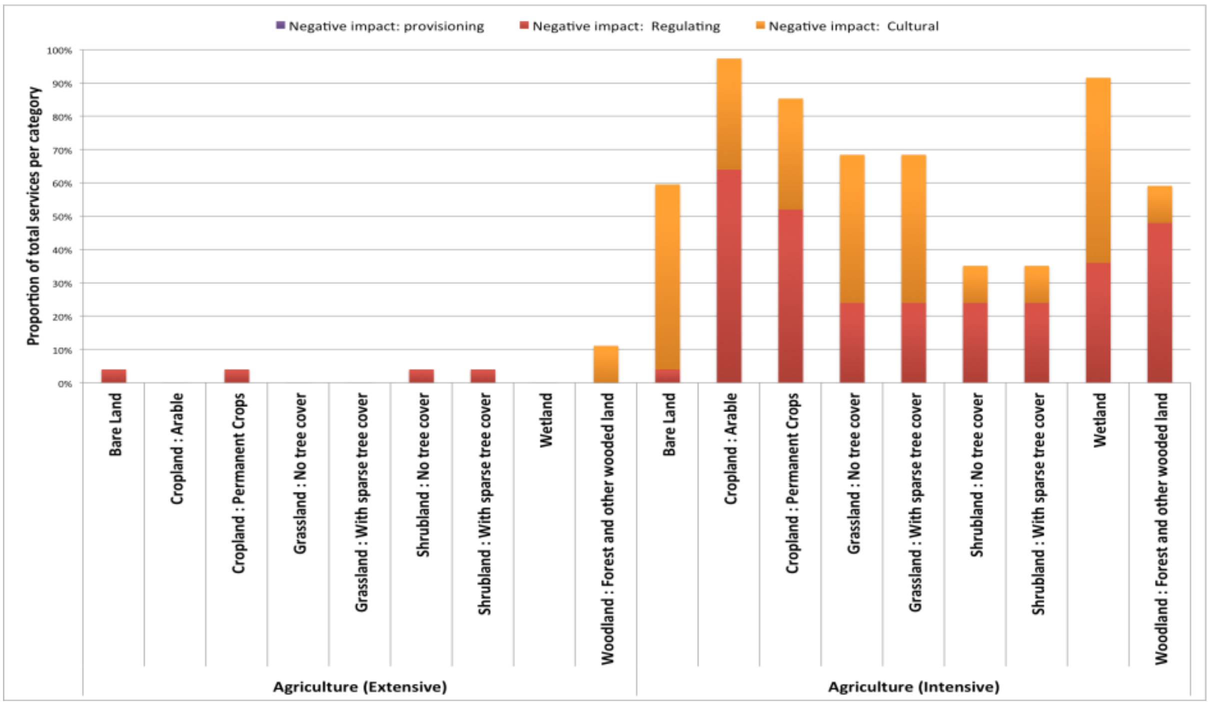
Figure 10 highlights the potential negative impacts from intensive and extensive agricultural land use, based on the literature. The impacts on regulating and cultural services, particularly under intensive use, are clear. However, the trends represented here are based on a general overview of the link between rural land cover and land use. In practice, the local and field scale variations in natural features and management will determine the types and range of ecosystem services supported[100]. This has implications for decisions and

[99] Each bar shows the number of different services supported and the colours indicate the level of potential. These range from: **'high potential'** (dark green) or where a land cover and land use combination defines a service, for example the provision of food through cropland in agricultural use; through to combinations of land cover and land use that have the potential to negatively impact on a particular service, **'service negatively affected'** (dark red), for example the negative impacts on water quality as a result of intensive agricultural practices. A more detailed description of these different potentials is provided in Table 11 of Annex 4.

[100] Even cropland, which is under intensive agricultural use, can be managed more effectively to help achieve greater synergies between ecosystem services. For example riparian buffers to water courses, the presence of traditional landscape features such as hedges or terraces and even changes in crop management times, can mean the difference between providing environmental benefits and causing environmental pressures (see for example Hart *et al*, 2011a; Poláková *et al*, 2011).

choices that are made about future land use and the degree to which the provision of some services may need to be curtailed in order to increase others.

Figure 10: Potential negative impacts on a suite of ecosystem services under different agricultural land use



Source: Own compilation based on the data supporting Figure 9. **Note**: In this figure the different land covers (vertical text) are grouped together under a particular land use (horizontal text). In this instance the type of agricultural land use may differ depending on the land cover. For example grazing will predominate on grassland, shrubland and in most woodland areas, whereas the growing of crops will predominate on arable and permanent crop areas. Some combinations of land cover and land use descriptions may seem unusual. However, these represent the descriptions of land as set out in the LUCAS2009 nomenclature. For further information see Figure 10. The vertical axis shows the proportion of total services per category, ie the number of ecosystem services that are negatively affected by each land cover and land use combination, expressed as a proportion of the total number of ecosystem services present in each category. The three categories are Provisioning, Regulating and Cultural services.

3.4 The current state of environmental services provided by rural land in the EU

This section considers the current state of the range of environmental services associated with rural land in the EU and identifies some of the continuing pressures that may need to be addressed within rural land in the future. Provisioning services, such as food and timber production, are not considered here.

Over the past decades considerable effort has been made to reduce the environmental pressures associated with a range of rural land uses, in particular agriculture and forestry[101]. Over time, fertile land has been exploited to an ever greater degree, either through its transformation into urban areas or by increasing its productive capacity, often through the

[101] For example through the introduction of legislation, the development of incentive payments for agri-environment management and the provision of advice.

use of chemical fertilisers, pesticides and high levels of water use. This has put significant pressure on natural resources, including biodiversity and means that such areas are where the competition between the production of food, feed and timber and environmental services is most keenly felt.

Despite progress in many areas, many ecosystems have continued to suffer damage and as a result there is still a long way to go to meet European objectives for biodiversity, climate change and water quality. There remains an undersupply for many of the regulating and cultural services supported by rural land, such as in relation to water scarcity and achieving good soil management (JRC and EEA, 2012; EEA, 2010e). Many of these issues can be appraised by reference to the different environmental targets set out in EU policy and strategy (see Chapter 4).

Biodiversity, as the underlying component on which all ecosystem services rely ultimately, is an important indicator of the quality of ecosystems and their provisioning, regulating and cultural functions. The current state of biodiversity supported by rural land can be quantified to some extent by looking at the data relating to key environmental legislation, such as Natura 2000 designations, and progress made towards the EU's strategic targets. Although some progress has been made, it was not sufficient to meet the EU's 2010 target to halt biodiversity loss by 2010.

In 2011 the European Commission reported that only 17 per cent of habitats and species and 11 per cent of key ecosystems protected under EU legislation were in a favourable state, despite action taken to combat biodiversity loss (EEA, 2010b). Many species associated with agricultural land are continuing to decline, and many habitats remain in unfavourable conservation status, with figures varying across bioclimatic regions (ETC/BD, 2006). For example, less than 10 per cent of grassland habitats of Community Interest had a favourable conservation status in 2008 (EEA, 2009b).

A similar picture is seen in forest areas. The overall area of forest is increasing and forests are growing older and thus more valuable for conservation. A high percentage of forest area in some countries has now received independent certification indicating that sustainable management is in place, and 25 per cent of the forest area is protected to retain biodiversity and landscape values (Raulund-Ramussen *et al,* 2011). However, there is still a need to address issues such as the impact of habitat fragmentation, commercial harvesting of old-growth forest, climate change and pressure for the intensification of forest utilisation leading to simplification of forest biotopes in some countries (EEA, 2006). More than half of the species and almost two thirds of the habitat types of Community interest (protected under the EU Natura 2000 framework) in forest ecosystems continue to have unfavourable conservation status. Only 21 per cent of the conservation status assessments of forest habitats are favourable and 15 per cent of the assessments of forest species (EEA, 2010a).

The genetic diversity of forests is also under pressure, trees species variety has been declining by about 0.6 per cent per year in the last 15 years, with roughly 30 per cent of forests in EU dominated by single species, mainly coniferous (Forest Europe *et al*, 2011).

These declines in biodiversity are not simply the result of inaction. EU environmental policies have resulted in less intensive agricultural practices in many areas and an increase in forest and woodland conservation areas for the purpose of preserving biodiversity and landscapes (EEA, 2010d). Despite such efforts it is clear that much more and widespread action is needed to help stop the decline in biodiversity across the EU, to meet the EU 2020 biodiversity targets and helping to provide a solid resource base for the provision of a wider suite of ecosystem services from rural land.

Water is another fundamental supporting service on which many other services rely. **Water quality** is measured in a variety of ways, with overall trends being more difficult to establish from the many diffuse and context specific patterns seen across the EU. Despite improvements in some regions, diffuse pollution from agriculture remains a major cause of poor water quality and is the single largest source of freshwater pollution from rural land (EEA, 2010f). Although most frequently presented in the statistics, nitrogen[102] is not the only threat to water quality, with phosphorous, pesticides, and sedimentation also having a significant impact (Dworak *et al,* 2010; EEA, 2010f). Inputs of nutrients (mostly nitrogen, phosphorus and potassium) to agricultural land across Europe are generally in excess of what is required by crops and grassland, resulting in nutrient surpluses (Grizzetti *et al,* 2007). The level of diffuse pollution varies across the EU, tending to be higher in EU-15 Member States, particularly those in the north and west. The extent, speed and pathways by which pollutants are transported from agricultural land to freshwater bodies also vary and depend on a range of factors, including rainfall, slope, soils and vegetation. It should be noted that forestry operations can have a significant impact on water quality. However, these impacts are often more localised in nature, and less widespread than those from agriculture.

Water availability also continues to suffer from over exploitation and under management leading to droughts and floods. In general, water is relatively abundant, with only 13 per cent of the available resource abstracted each year (EEA, 2009a). However, water availability, populations and land uses are unevenly distributed. Seasonal and geographical variations in supply and demand of water are one of the main drivers of water scarcity and droughts, which have affected 17 per cent of the EU territory in the past 30 years. In recent years this has included 33 major river basins[103] home to 16.5 per cent of the EU population. Worryingly, under a 'business-as-usual' scenario, water withdrawals could increase by more than 40 per cent, exacerbated by climate change as a result of the more frequent and severe droughts projected for many parts of Europe. It is also expected that by 2030 the number of river basins currently under stress all year round will almost double from 26 basins to 47 basins. In addition, those river basins under water stress during the summer period (43) will increase by approximately one third to 63 basins under stress (Anon, 2012). Over a longer time period, the proportion of European river basins suffering from severe water stress is likely to increase from 19 per cent today to 34-36 per cent by the 2070s (EC, 2012).

[102] The average nitrogen surplus varies significantly across the EU from as little as minus ten kilogrammes of Nitrogen per hectare (kg/N/ha) in Hungary (a net loss) to over 210 kg/N/ha in the Netherlands. The EU-27 average is around 65 kg/N/ha with a higher surplus in the EU-15 than in the EU-12.

[103] Representing a total area of 46 Mha (about 10 per cent of the total EU area) and host a total population of 82 million.

Agriculture is the major user of water in the EU (64 per cent), followed by energy (20 per cent), public water supply (12 per cent) and industry (four per cent) (EC, 2012). However, unlike many other users of water, such as cooling and energy production, only around 30 per cent of water used for agriculture is returned to the natural water system. As a consequence, water resources are under severe pressure, with an increasing gap between demand and availability. Overexploitation has resulted in aquifer water levels falling by several tens of meters, salt-water intrusion, and the drying up of wetlands (EEA, 2010f).

In contrast to water shortages, the over the past ten years Europe has suffered more than 175 major floods (EEA, 2010g). These events are increasing both in severity and frequency although attributing their cause can be problematic. The majority of observed flood events in Europe can be attributed to urbanisation in flood-prone areas and to land-use changes, such as deforestation and loss of wetlands and natural floodplain storage (EEA, 2010f), resulting, for example, from the drainage of agricultural fields.

As with biodiversity and water, the pressures on **soil** continue to be significant. An estimated 115 Mha or 12 per cent of Europe's total land area are subject to water erosion, and 42 Mha are affected by wind erosion (EEA, 2010e). Approximately one third (57.7 million hectares) of agricultural land is at risk of erosion of more than one tonne of soil per hectare per year (t/ha/yr) and 47.2 Mha are at risk of soil erosion of more than 2t/ha/yr (Hart *et al*, 2011). Recent EU wide studies (Jones *et al*, 2012) calculate the mean rate of soil erosion on all rural land types by water in the EU-27 as 2.76t/ha/yr, with a higher mean rate in the EU-15 (3.1t/ha/yr) compared with the EU-12 (1.7t/ha/yr). This is thought to be due to the effect of high erosion rates in Mediterranean countries.

Almost half of Europe's land area has very low levels of organic matter[104]. This can be as much as 75 per cent of soils in southern Member States and some regions witness nearly complete organic matter depletion. Around 60 million hectares of soils with less than 3.4 per cent soil organic matter are under intensively cropped agricultural land and approximately half of these soils are under arable or permanent crop management (Nowicki *et al*, 2009). Without changes to management, soil organic matter is at risk on the majority of arable soils across Europe (Hart *et al*, 2011a). Peat soils deserve special mention. Around 16 per cent of peatland is currently used for agricultural purposes, both cropland and grassland areas, much of which has been drained[105], and this can be as high as 70 per cent in some Member States. In 2007, emissions from cropland on peat soils were 37.5 million tonnes CO_2 equivalent, corresponding to 88 per cent of total emissions from cropland. Compaction of soils from regular cultivation, and the use of heavy equipment, is also widespread (Poláková *et al*, forthcoming).

Global agriculture contributes about 14 per cent of **greenhouse gas emissions** in the form of nitrous oxide from soils and methane from enteric fermentation and manures. In the EU27 the corresponding figure is 10.5 per cent of total net emissions. However, EU agricultural emissions have fallen by 22 per cent since 1990. This is mostly as a result of falling agricultural output in some Member States and by efficiency gains in the livestock sector

[104] Low levels are defined as below 3.4 per cent soil organic matter or two per cent soil organic carbon.
[105] Including the vast majority of peat soils in northern and western Europe

through rises in yields of milk and meat (and thereby fewer animals) rather than purposive actions to reduce emissions. Agriculture will continue therefore to have an important role to play in achieving further reductions to 2020[106] (EEA, 2010g).

Land use change, especially through conversion of pasture lands and deforestation contributes 17 per cent of global total emissions. However, ecosystems also remove considerable CO_2 from the atmosphere. Based on current methodologies for accounting, emissions and removals of CO_2 in the EU-27 from Land Use, Land Use Change and Forestry (LULUCF) are calculated to provide a net removal of carbon, offsetting seven per cent of total EU emissions. LULUCF removals have risen but with no particular trend since 1990 (EEA, 2012a). The key driver for the increase in net removals is a significant build-up of carbon stocks in forests, as harvesting only represents 60 per cent of the net annual wood increment. This trend is expected to continue.

Significant changes in management practices and the way natural resources are addressed in land mangers' planning and decision making will be needed to address such a deficit. The implications of addressing the undersupply of environmental services alongside future demands from land more generally are addressed in Chapter 4.

[106] Particularly through minimising emissions of CO_2 and N_2O from soils, CH_4 emissions from enteric fermentation and rice cultivation; and N_2O and CH_4 emissions from manure management

4 THE CHANGING DEMANDS FOR SERVICES FROM RURAL LAND IN THE EU TO 2050

Key findings:

- Assessing future demand for all the ecosystem services that are required from the EU's rural land to 2050 reveals a complex picture, not least because producers and consumers operate in an open international trading system. The implications for rural land are difficult to predict with any degree of precision.
- Population and economic growth are prime drivers of demand for food, forest products and energy. There are reasons to expect that their rates of increase in the EU are diminishing in the period ahead – contrasting with stronger growth in several other regions.
- The evidence suggests that, looking ahead to 2050, the most significant additional demands on rural land in the EU will be for:
    - a sizeable increase in the provision of environmental services from land under agriculture and forestry management,
    - increased demand for cereals and woody biomass, primarily for bioenergy
    - continued demand for land for built development
- Despite the need for increased production of food and feed globally, it is predicted that the majority of this will be sourced close to the growth in consumption, ie outside the EU.
- The implications of the demands for rural land are complex. If only market led changes are considered (assuming no major changes in trade patterns), the overall impact is most likely to be:
    - continued overall decline in the EU's agricultural land area (although the rate of decline may be stemmed by increased demand for land to grow bioenergy feedstocks);
    - expansion of the forest area, although the rate of increase may decline;
    - expansion of built development; and
    - increases in the aggregate intensity of production of both forest and agricultural areas.
- Meeting the environmental challenges of the future at the same time will require significant changes in the management of both agricultural and forestry land. This has implications for the speed at which yields can increase and the area of agricultural or forestry land that continues to be needed for production. However, without such action long term productive capacity would be at risk.
- These demand predictions are affected by three major uncertainties: 1) supplies may increase in the future if global prices rise and stimulate output; 2) climate change could damage productive resources and disrupt anticipated supply patterns more than already assumed; and 3) renewable energy policies could increase the demand for certain crops, residues and forest products.
- The uncertainty ahead means that it is prudent to plan to ensure the EU's rural land is resilient to worst case scenarios and that, if greater production is needed in future, land is available, whilst also tackling the manifest environmental deficit in many rural areas in the EU.

This chapter sets out the range and scale of goods and services that the EU's rural land is expected to provide over a time horizon to 2050. It assesses demand for both market driven goods such as food, timber and bioenergy, as well as for the non-market services such as biodiversity, clean and adequate supplies of water, functioning soils, reduced greenhouse gas emissions and distinctive, accessible cultural landscapes all of which must be resilient to the impacts of predicted future changes in climate. The chapter considers the factors driving predicted changes in demands on land and sets these within the context of past trends. The evidence is used to examine whether or not the pressures on rural land in the EU are intensifying, creating challenges for finding ways to reconcile the competing demands.

4.1 Drivers of demand for land-based goods and services

4.1.1 Market demands, market failures and under provision

The fact that food, forest products and energy are classic, market based commodities means that their demand is driven by the normal forces of population and income growth, subject to changing tastes and preferences. These forces act internationally and locally. The twentieth century saw unprecedented increases in population and economic growth globally as well as in Europe. This imperative drove additional resources, investment and induced new technology that greatly expanded the production of these provisioning goods. Because these commodities are quintessentially land based, the effects of the large expansion in demand and associated structural, technical and scale changes, especially in agricultural production, impaired the capacity of land also to provide the other environmental and cultural services, with very significant and mostly negative impacts on the environment.

The environmental services provided from land are all examples of market failures. To varying degrees their very nature is such that there are poorly developed or no markets at all for many environmental goods and services and therefore no incentive (without some form of public intervention) for them to be produced spontaneously by private individuals or businesses (see for example Cooper *et al*, 2009; RISE, 2009). Therefore, although society's demand or desire to have these services exists, there is no market mechanism for them to be satisfied, hence no prices to indicate this demand. Instead, proxies have to be used.

Just as a growing population and incomes drive expanding demand for provisioning services, there is every reason to expect that a larger, higher paid, better fed and better informed population also has a growing demand for nature and the non-provisioning ecosystem services land can provide. The greater their scarcity, the higher their implicit value too. Indeed there is a wide variety of evidence indicating the growing demands for the non-market services of nature (TEEB, 2011). There is also a large number of studies demonstrating the willingness to pay for environmental services at the local level (for example Drake, 1992; Bonnieux and Goffe, 1997; Birol and Koundouri, 2000; Hanley *et al*, 2007), although the accuracy of the values attributed to the environment using such methods is questioned (Cummings *et al*, 1986; Hausman, 1993; Jacobs, 1997). The growing demand for environment shows up in the growth in membership of organisations devoted to environmental issues (Cooper *et al*, 2009). It is also illustrated by the growing attention of these matters in the print and broadcast media, and in a more direct way, in growing demands for organic food as well as environmentally certified forest products. The ultimate expression of these demands is that through the democratic process they become expressed in the growing body of national, supranational (EU) and international legislation on the environment, and in growing collective efforts to incentivise their provision. These are the proxies which indicate the EU demand for environmental services.

The prospective development of the EU's demand for all these services for the next few decades is set out below.

4.1.2 Market drivers of demand

The prime driver of the past expansion in demand for food, forest products and energy has been population growth. The population of the EU-27 has grown from 373 million in 1950 to just over 500 million in 2010, a 34 per cent growth. This was, of course, dwarfed by the much faster growth in global population from 2.5 to 6.9 billion, a 172 per cent increase, over the same period. The accelerating population growth of the 1950s-1970s has now slowed. However there is still a large expansion in global population forecast. The United Nation's medium projections show global population reaching 9 billion by mid-century and levelling off at around 10 billion towards the end of this century, with the greatest growth rate in Africa (UN-DESA, 2011).

Europe's population is already falling in seven of the new Member States and in Germany. Based on UN 'medium' projections the EU population is expected to peak in 2033 at 516 million before declining slowly to 495 million by the end of the century. The picture varies between Member States. Population in all the new Member States is projected to peak before mid-century, and the total EU-12 population may fall 10 per cent (10 million) by 2050, and at faster rates in several countries (eg Bulgaria and Romania). Whilst nine of the EU-15 are expected to have populations growing slowly throughout this century, the other six (Germany, Italy, Portugal, Austria, Spain and Greece) are projected to see their population fall by mid-century, in total by over 11 million (five per cent). These projections are based on assumptions around factors such as fertility, mortality and migration rates, all of which can change. However the figures suggest that, purely from the point of view of pressure exerted from population in the EU, the growth in demands on EU rural land from EU citizens may peak by the middle of this century and then decline. In some countries with severely declining population (eg Bulgaria) this effect could be quite marked. Of course, because goods from EU land are also exported, pressures may also be driven by population growth outside the EU.

The demand for services as a result of demographic change depends on more than just population numbers. The aging profile of the population also has important implications for the relative demands for food, heating, transport and different types of housing with further consequential effects on GHG emissions, climate change and ecosystem services. In addition, population movements within the EU, in some countries migration from peripheral rural areas to urban areas, and in others in the opposite direction from cities to rural communities, as well as changes in life expectancy and household size, have important impacts on land use. Policy on immigration from outside the EU, and its implementation, is also a critical variable.

The second major driver of demand for land-based provisioning services is economic growth. As people enjoy higher incomes their spending patterns change. Consumption of food, alcohol, energy, clothing and leisure all rise with income. Some of the most profound changes are that richer societies tend to consume more processed foods of all types, more livestock products (dairy produce and meat) and to be more wasteful with food. However, once societies become more affluent there is less evidence to suggest that these shifts continue in the long term, and therefore long term demands may look rather different. Further, as animals are inefficient converters of energy, dietary transitions towards livestock products significantly increases the demand for crops for animal feed, both carbohydrates and protein. Because the EU Member States (both West and East) have experienced considerable income growth for many decades now, these dietary transitions are very well progressed. Outside the developed world, transition economies such as China, some other parts of Asia and Brazil are fast moving along these dietary change paths. In some of the poorest countries these processes have yet to start.

Looking ahead, the short-run prospects for economic growth are poor. The protracted recession in Europe and many other high-income countries since the 2007/08 credit and then sovereign debt crises has consistently led to growth forecasts being revised downwards. EU-27 real economic growth averaged 2.3 per cent per annum from 1992-2007 and has dropped to 0.2 per cent per annum in the six years since. Even in the fast growing transition countries outside Europe, eg the BRICs, growth has been curtailed[107]. Whilst, it is policy everywhere to take steps to encourage resumption of economic growth, the next decade could be relatively stagnant in many EU countries in particular, and growth will be lower everywhere than was being projected as recently as 2009.

4.1.3 Policy drivers of demand

Because of market failures, the predominant drivers of demand for non-provisioning ecosystem services will be objectives and targets set through policies, both within and outside the EU. Three main categories of policy drivers influencing demand for services from EU rural land use are environmental and sectoral regulations, Directives and strategies, such as regulations and Directives for biodiversity, water, climate change mitigation, and energy, alongside less-binding strategies for resource efficiency and forestry. The most important sectoral policies are the Common Agricultural Policy and the Renewable Energy Directive.

Nineteen such sets of policy drivers influencing rural land use in the EU are set out in Table 5. Some of these drivers are much more powerful than others, particularly those that are legally binding and oblige Member States to take action. Other policy drivers, such as strategies and roadmaps are important in the sense that they send a signal about the intended political direction of travel, but unless their objectives or aspirations are translated into the legal framework, no sanctions can be brought should the objectives not be met. It is the stipulation of minimum standards or objectives for action expressed in these policies that represent the quantity of environmental services desired from rural land.

[107] See for example USDA figures: http:///www.ers.usda.gov/Data/macroeconomics/

Table 5: Key policy drivers stipulating demand for rural land-based services

Policy driver	Reference	Services influenced	Specifics
Renewable Energy Directive	Directive 2009/28/EC	Energy	MS to use 10% of renewable energy in transport, and 20% renewables by 2020.
UN Kyoto Protocol	Framework Convention on Climate Change	Climate	20% reduction in greenhouse gas emissions by 2020 - forest management C balance to be accounted under LULUCF.
LULUCF	COM (2012) 93	Climate	EU accounting rules for GHG emissions & removals in forestry and agriculture towards the EU commitment
Convention on Biological Diversity	UN, 1992	Biodiversity	Global commitments on biodiversity
Ramsar Convention on Wetlands	Ramsar, Iran, 1971	Biodiversity	Maintain ecological character of Wetlands of International Importance.
EU Biodiversity Strategy	COM (2011) 244	Biodiversity	Maintain, enhance and restore biodiversity and ecosystem services
Habitats Directive	Directive 92/43/EEC	Biodiversity	MSs to put certain measures in place to protect habitats, including the designation of Natura 2000 sites
Birds Directive	Directive 2007/417/EC	Biodiversity	MSs to put certain measures in place to protect birds
Water Framework Directive	Directive 2000/60/EC	Water quality and quantity	MSs to achieve good ecological status of water bodies by 2027
Nitrates Directive	Directive 91/976/EEC	Water quality	Requires MSs to take action to minimise nitrate levels in water
Sustainable Use of Pesticides Directive	Directive 2009/128/EC	Water quality, soil quality	Action by MSs to reduce pesticide use
(IED) Directive on Industrial Emissions	Directive 2010/75/EU	Air quality	Replaces IPCC by 2013
Thematic Strategy for Soil Protection	COM(2006)231 final	Soil quality	Non-binding aims: reduce soil sealing & erosion, & improve soil organic matter,
National Emissions Ceiling Directive	2001/81/EC	Air Quality	Upper limits for total emissions of specific pollutants
Floods Directive	2007/60/EC	Flood risk mitigation	MS flood management plans to reduce the potential of flooding and its impacts
Common Agricultural Policy	EC Treaty Article 33 (39) states the CAP objectives	Rural land use generally	Viable food production, sustainable management of natural resources & climate action, balanced territorial dev.
EU Forestry Strategy	Forestry strategy for the EU (1999/C 56/01)	Forestry	Sustainable forest management, by co-ordination of Member States policies
Resource Efficiency Roadmap	COM(2011)571	All	Changes needed to achieve a resource efficient economy by 2050.

Source: own compilation

4.2 Demand for land-based ecosystem services from Europe's rural land

This section summarises current projections of the 'quantity' of the range of ecosystem services demanded from EU rural land, in light of the different drivers set out above. Because of their crucial importance for global food security, regular analyses and projections of food consumption, production and trade are conducted by national and international bodies. The most authoritative analyses are provided jointly by the Food and

Agricultural Organisation (FAO) of the UN and the OECD. Most such projections are made for a decade ahead. Occasional studies look further ahead, however, as such studies rely on large number of assumptions this become progressively more difficult.

4.2.1 Provisioning Services

Agricultural commodities for feed and food

The FAO has estimated that demand for food will rise by approximately 70 per cent over the next 40 years to feed a rising world population with changing dietary trends. Overall growth rates of per capita consumption of primary products are predicted to be relatively low in high income countries and relatively high in lower income countries (Central and South America, Asia and Africa) (Nowicki *et al*, 2009). World meat consumption has increased by six per cent over the past five years as a result of demand from emerging countries, such as India and China, however in the EU, per capita consumption has stayed rather stable. The growing consumption of meat relative to cereals is predicted to continue to 2020 as a result of continued urbanisation of the population and rising per capita incomes (OECD-FAO, 2010). Indeed, EU annual per capita meat consumption is projected to increase slightly to 83 kg/head in 2020, with poultry meat consumption projected to increase the most, followed by pigmeat, in contrast to declines in the consumption of beef and sheep meat (European Commission, 2012a). Demand for dairy products is predicted to stay buoyant and increase over time. There is little consensus on projections of global cereal consumption in 2050, with estimates ranging from 2,739 million tonnes (IFPRI) to 3,338 million tonnes (IIASA), both including biofuels, while the FAO estimate (which excludes biofuels) is between these two at 3,000 million tonnes (FAO, 2011). In the EU, estimates of future demand for production are only available to 2020, but these suggest increased demand of 10 per cent in cereals over the next decade to 305 million tonnes in 2020, including bioenergy, seven per cent of which would be likely to be met from land in the EU-15 and 18 per cent from the EU-12 (European Commission, 2012a).

Biomass for bioenergy and biomaterials

Demand for biomass, especially wood, for energy purposes is not new. Roughly half of all wood harvested is not suitable for industrial use and has traditionally been used for energy, mostly as a cheap form of fuel for heating, sold in local or regional markets. More recently, an increased use of biomass for energy production has been driven by policy, specifically the targets set by the Renewable Energy Directive (RED) and the Emissions Trading Directive (ETS). The RED currently mandates 10 per cent renewable energy in the transport sector by 2020, and it drives bioenergy uptake in the heat and electricity sectors as well. Under the ETS, CO_2 emissions from the combustion of biomass are considered to be zero, which makes biomass burning an interesting proposition for installations covered by the scheme. How these policies and their associated targets and incentives will evolve in the future is uncertain. The Commission has put forward proposals to limit first generation crop-based biofuels to five per cent of transport fuel consumption (which is approximately the current level of usage) and the remaining five per cent to achieve the 10 per cent 2020 target is to be met by using wastes and agricultural and forest residues rather than agricultural crops[108]. In the longer term, it is conceivable that fossil fuel prices could eventually rise sufficiently to make dedicated bioenergy production competitive without strong policies which mandate percentages of bioenergy use, but how far in the future is unknown. Such a situation would place unprecedented demands on land.

Member States' National Renewable Energy Action Plans (NREAPs) show how they intend to meet the current RED targets. These show that by 2020 biomass is planned to constitute 19 per cent of total renewable electricity, 78 per cent of total renewable heating and cooling and 89 per cent of total renewable energy in transport. Altogether, bioenergy is expected to make up over 50 per cent of total renewable energy use (Beurskens *et al*, 2011).

Biomass for biofuels: The feedstocks for biofuels come from the agricultural sector and the outlook to 2050 is difficult to assess. The European Commission's Energy Roadmap 2050 provides estimates on the demand for biofuels under a number of different scenarios[109]. According to PRIMES[110] modelling, EU biofuel use may reach a maximum of 300 Mtoe (plus 20 Mtoe for bunkers, ie aviation fuels), with other scenarios projecting demand for approximately 270 Mtoe, including bunkers. These figures are roughly ten times the projected NREAP use in 2020.

Biomass for heat and power: Data on current wood energy consumption are scattered and comprehensive statistics are not available for all EU countries. In particular, small-scale household consumption of fuelwood is often not registered so consumption of fuelwood might be underestimated in the statistics. Currently 43 per cent of total demand of forest feedstock is used for energy purposes. To reach the 20 per cent target for renewable energy in 2020, the demand for woody biomass is expected to increase even if its share in the renewable energy mix declines. The Joint Wood Energy Enquiry data on wood energy showed the use of wood for energy generation is increasing in Europe (UNECE/FAO, 2011a). Data for 15 EU countries showed a total of 250 million m^3 of woody biomass used in 2009, 95 per cent of which was locally sourced. Estimates of future usage based on the NREAPs suggest the use of woody biomass for electricity production may double within the EU between 2010 and 2020 and the use of woody biomass for cooling and heating may increase by about 50 per cent (Hewitt, 2011; UNECE/FAO, 2011b). These projected increases in demand for woody biomass are substantial and even allowing for the known under-management and under-utilisation of the annual increment in forest biomass, the area of the productive woodland within Member States is likely to be insufficient to meet it at competitive prices and without using wood that would be suitable for industrial applications. This is investigated further in Chapter 5.

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[108] European Commission (2012), Proposal for a Directive of the European Parliament and of the Council amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources, 17/10/2012

[109] Communication COM(2011e) 885/2 from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions of 15 December 2011, `Energy Roadmap 2050'

[110] PRIMES EU-wide Energy Model - a partial equilibrium model for the European Union energy markets, PRIMES is used for forecasting, scenario construction and policy impact analysis up to the year 2030.

There is increasing political awareness of GHG accounting issues for bioenergy in relation to 'carbon debt' (Haberl *et al*., 2012). This arises when forest materials are burned to produce energy. The burning of wood releases more CO_2 (per unit of useful energy) than the fossil alternatives. Growing forests recapture the released CO_2, but it takes several decades for this to happen and thus compensate for the emissions. The carbon debt is particularly large when land with high carbon stocks is converted to bioenergy plantations of low carbon stock (Zanchi *et al*., 2011). These considerations might have an impact on demand for woody biomass in the future, although these are impossible to quantify currently.

Biomass for bio-based products: Demand for biobased products, such as bioplastics, industrial chemicals, pharmaceuticals and textiles, is set to grow considerably over the coming decades to replace existing fossil fuel based products. The European Commission's Strategy for the Bioeconomy (European Commission, 2012 b) promotes a shift towards replacing non-renewable products with more sustainable bio-based ones, in order to encourage new markets. Considerable investment in science and technological development is envisaged to help develop such products, which are already enjoying considerable growth globally (Natural Resources Canada, 2013). EU companies involved in the biobased industry have come together to promote this area, with a set of objectives for 2030 intended to encourage new markets (Biobased for Growth, 2012).

Forest Biomass for material use

In the EU, 57 per cent of total demand of forest feedstock is currently for material uses (sawn timber; wood-based panels and pulp and paper), while the rest is used to produce energy. The EU is a net exporter of wood products, with exports of primary wood and paper products[111] exceeding imports by three per cent (Forest Europe *et al*., 2011). The development of wood demand to 2030 was forecast in the EFSOS II study (UNECE/FAO, 2011b). Under the reference scenario where current policies remain unchanged, current trends continue and external trends follow the lines described by the IPCC B2-scenario[112], wood demand for material uses is forecast to increase by eight per cent from 2010 until 2030 in the EU. If, however, demand for woody biomass increases considerably in response to the EU 2020 renewable energy targets (as modelled under the wood energy scenario), competition between material and energy use of woody resources are predicted to lead to higher wood prices and a smaller increase in the demand for material use. Under this scenario, demand for material use is forecast to increase by only four per cent from 2010 to 2030.

4.2.2 Environmental (non-provisioning) services

Overall, there is significant under-delivery of biodiversity and other environmental services, that is, a significant unfulfilled excess demand. Analytically there is not yet a well-developed

[111] Energy wood in the form of chips and pellets is not included in the statistics

[112] The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the A1 and B1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels - http://www.ipcc.ch/ipccreports/tar/wg1/029.htm

way of expressing the scale of this unsatisfied demand although there are now a number of efforts underway to fill this gap. One such approach is through the construction of natural and ecosystem capital accounts, comprising natural resource accounts for biodiversity, water, and land. These seek to measure the shortfall in natural capital compared to the levels estimated as necessary to achieve the targets defined by EU and international environmental commitments. The European Environment Agency (EEA) has research projects underway to develop these accounts (EEA, in progress). In the meantime therefore the demand and associated scale of current under-delivery of environmental services and indications of how this gap might change in the next decades can only be indicated in a more *ad hoc* way using indicators of the state of the environment in comparison to the targets as set out in legislation.

Biodiversity

The demand for the protection and enhancement of can be illustrated by the objectives set for biodiversity policy internationally through the Convention on Biodiversity and at EU level, through the Biodiversity Strategy[113] and legislation, including the Birds Directive and Habitats Directives[114] which includes requirements to protect and manage particular biotopes and habitats and to conserve listed species. The EU level objectives for biodiversity, as a proxy for demand are set out in Table 6.

Significant changes will be needed if these objectives are to be realised by 2020, given that actions under the previous Biodiversity Strategy to meet the 2010 target were insufficient (Poláková *et al*, 2011).

Table 6: EU biodiversity objectives

EU Biodiversity Strategy	
2050 Vision	Protecting, valuing and restoring EU biodiversity and ecosystem services
2020 overarching target	To halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, restore them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss’
Target 1	To halt the deterioration in the status of all species and habitats covered by EU nature legislation and achieve a significant and measurable improvement in their status so that, by 2020, compared to current assessments: (i) 100% more habitat assessments and 50% more species assessments under the Habitats Directive show an improved conservation status; and (ii) (ii) 50% more species assessments under the Birds Directive show a secure or improved status.
Target 2	By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems.
Target 3*	A) Agriculture: By 2020, maximise areas under agriculture across grasslands, arable land and permanent crops that are covered by biodiversity-related measures under the CAP so as to ensure the conservation of biodiversity and to bring about a measurable improvement (*) in the conservation status of species and habitats that depend on or are affected by agriculture and in the provision of ecosystem services as compared to the EU2010 Baseline, thus contributing to enhance sustainable management.

[113] COM(2011) 244

[114] Birds Directive (2009/147/EC) and Habitats Directive (92/43/EEC)

	B) <u>Forests</u>: By 2020, Forest Management Plans or equivalent instruments, in line with Sustainable Forest Management (SFM), are in place for all forests that are publicly owned and for forest holdings above a certain size** (to be defined by the Member States or regions and communicated in their Rural Development Programmes) that receive funding under the EU Rural Development Policy so as to bring about a measurable improvement (*) in the conservation status of species and habitats that depend on or are affected by forestry and in the provision of related ecosystem services as compared to the EU 2010 Baseline.
Target 4	Fisheries – not relevant to rural land use
Target 5	By 2020, Invasive Alien Species and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS.
Target 6	By 2020, the EU has stepped up its contribution to averting global biodiversity loss.
Birds Directive	• To maintain population of a specified list of rare or threatened birds and migratory birds at certain levels through measures including the creation of protected areas; • To maintain the appropriate management of habitats within protected areas; • To re-establish destroyed habitats and to create habitats • To protect all wild birds, including in general a prohibition on their killing and the destruction of their nests
Habitats Directive	• To prohibit the killing, disturbance and destruction of nests of certain animal species and of the picking of certain plants • To set up a coherent European ecological network of special areas of conservation under the title Natura 2000. This network, composed of sites hosting the natural habitat types listed in Annex I and habitats of the species listed in Annex II, shall enable the natural habitat types and the species' habitats concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range • To encourage the management of features of the landscape which are of major importance for wild fauna and flora with a view to improving the ecological coherence of the Natura 2000 network.

Regulation and Maintenance Services

These are the services that help regulate the physical environment (water, soils and atmosphere), flows of water, air and soil, wastes (particularly in terms of their dilution or absorption/sequestration) and the biotic environment (through habitat protection, pest and disease control and protection of gene pools).

Climate protection

The level of climate protection required from the land based sectors is part of the overall goal proposed for the EU[115] of an 80 per cent reduction in greenhouse gas emissions by 2050 compared to 1990 levels, as set out in the Commission's *Roadmap for moving to a competitive low carbon economy in 2050* (European Commission, 2011b). Under the Kyoto Protocol, only management efforts linked to nitrous oxide (N_2O) and methane (CH_4) emissions from soils and livestock production currently count toward emission reduction targets. There are no agriculture-specific targets at EU level, although agricultural emissions (except for CO_2 from soils) are part of Member State targets specified under the Effort

[115] This goal is not binding, although it has the tacit agreement of all Member States apart from Poland

Sharing Decision. The low carbon roadmap provides an overview of the potential pathways for key sectors, including agriculture and forestry. It indicates that by 2030 the agriculture sector could reduce non-CO_2 emissions[116] by between 36 and 37 per cent and by 2050 by 42 and 49 per cent, compared to 1990 levels. These are stated as potential reductions and not targets.

These emission reductions do not refer to CO_2 emissions or sequestration from land use, land use change and forestry (LULUCF) activities. National accounting for emissions and removals from LULUCF activities was only partially mandatory under the first commitment period of the Kyoto Protocol - with respect to afforestation, reforestation and deforestation. A proposal has been presented by the Commission for integrating LULUCF into EU climate policy[117] which *inter alia* would require emissions and removals from forest management, grazing land and cropland management on agricultural soils to be accounted for mandatorily as well. Accounting would be optional for activities such as re-vegetation and wetland drainage and re-wetting.

Water Quality
Longstanding policies at EU level to protect surface and ground waters from pollution by agricultural and forestry reflect the demand from society for water that is of high quality. Policies include the Nitrates Directive[118], the Framework Directive on Sustainable Use of Pesticides[119], the Water Framework Directive (WFD)[120] and aspects of the EIA Directive[121].

The WFD requires Member States to 'enhance the status and prevent further deterioration of aquatic ecosystems and associated wetlands, promote the sustainable use of water, reduce water pollution and achieve good ecological status of all water bodies by 2015'.

The Nitrates Directive, aims to 'reduce the pollution of water caused or induced by the application and storage of inorganic fertiliser and manure on farmland and prevent further such pollution to safeguard drinking water supplies and to prevent wider ecological damage through the eutrophication of freshwater and marine waters'. It imposes limits to inputs of nitrogen on agricultural land and requires Member States to set up action programmes for reducing the pollution of water bodies and designation of Nitrate Vulnerable Zones (NVZ) within which the action programmes apply.

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116 primarily N_2O and CH_4 emissions (from ruminant livestock production and soils

117 European Commission (2012e) Proposal for a Decision of the European Parliament and of the Council on accounting rules and action plans for greenhouse gas emissions and removals resulting from activities related to land use, land use change and forestry, 12 March 2012, COM(2012) 93 final

118 Directive 91/976/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, Official Journal L 375, 31.12.1991.

119 Directive 2009/128/EC of the European Parliament and the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides, OJ L309/71, 24.11.2009

120 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community Action in the field of water policy, Official Journal L 327/1, 22.12.2000.

121 Directive 97/11/EC of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment, Official Journal L 073, 14.03.1997.

Despite the trends in total consumption of nitrogen fertilizers in the EU15 showing a decline in the past decade, consumption has increased gradually and slowly in EU12[122] and it is predicted that fertiliser use is set to increase by four per cent to 2020 (EFMA, 2009). The proportion of sites that exceed the limits for nitrate levels in groundwater also appear to be increasing, suggesting a direction of travel opposite to that which is demanded through EU targets (EEA, 2012b). Full compliance by Member States with the WFD is not required until 2027 and so far most Members States are behind schedule with putting the relevant actions in place, so these impacts would most likely become evident from 2030 onwards.

The objective of the Sustainable Use of Pesticides Directive is 'to reduce risks and impacts of pesticide use on human health and the environment and encourage the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides'. It does not set out any quantified targets set at the EU level, but it does require Member States to introduce National Action Plans which should set quantitative objectives and targets together with appropriate measures that can be taken, the timetable for their adoption and associated indicators to measure the degree to which risk and impacts of pesticide use on both human health and the environment can be assessed. The Directive also encourages Member States to introduce integrated pest management (IPM) or other approaches and techniques that reduce dependency on pesticides. Progress by Member States in developing such National Action Plans is slow, but the overall objectives demonstrate, at least qualitatively the demand for reduced pesticide use and the development of alternatives.

Water Availability and Use

There are no EU level policies that set legally binding targets for the efficient use of water to ensure water availability and avoid over abstraction, although the Water Framework Directive does require Member States to take account of these issues in their River Basin Management Plans. In addition, national policies exist in some Member States to protect water resources from over-abstraction at times of drought. The Resource Efficiency Roadmap sets an objective that 'by 2020, Europe's water should be of good quality, efficiently used and available in sufficient quantity but with water abstraction, as a rule, below 20 per cent of available renewable water resources'.

Soil Quality

EU soil policy is much less well developed, despite evidence of the damage caused by soil sealing, erosion, contamination and degradation especially the low level of soil organic matter, particularly in arable soils and the continued deterioration of carbon rich soils (JRC and EEA, 2012). Soil carbon content of EU forestry is currently around 90 tC/ha, while for cropland and grassland it is around 65 and 90 tC/ha respectively, with considerable variations between and within Member States.

Five years after the adoption of the Soil Thematic Strategy and a proposal for a Soil Framework Directive, a minority of Member States continue to argue that an EU directive is unnecessary. However, even without agreed overarching policy targets, the Soil Thematic Strategy aims 'to protect and ensure the sustainable use of soil by preventing further soil

[122] figures from FAOSTAT

degradation and restoring degraded soils'. Some of the objectives of this strategy have been integrated into other policy mechanisms, for example within the Resource Efficiency Roadmap, under sectoral policies, such as the CAP and, particularly in relation to carbon rich soils, as part of international agreements for biodiversity and for climate. These are summarised in Table 7.

Table 7: Objectives for soil protection in EU policy documents

Objective/Priority	Policy Document
• to protect and ensure the sustainable use of soil by preventing further soil degradation and restoring degraded soils	Soil Thematic Strategy
• To achieve no net land take by 2050 • To reduce soil erosion • To increase soil organic matter • Prevent soil damage by SO2 and NOx emissions; • Avoid pollution from fertilizers and pesticides	Resource Efficiency Roadmap
• Minimum soil cover (GAEC 4) • Minimum land management reflecting site specific conditions to limit erosion (GAEC 5) • Maintenance of soil organic matter level including ban on burning arable stubble (GAEC 6) • Protection of wetland and carbon rich soils including a ban of first ploughing (GAEC 7)	CAP – cross compliance (as proposed for 2014-2020)
• To secure soil functionality at a satisfactory level by 2020, including: Reversing the trend of losing soil organic matter; appropriate farming practices on agricultural land susceptible to erosion. Soil functionality encompasses the productive capacity of soils and its key roles in climate change mitigation and adaptation and eco-system stability	EIP on agriculture productivity and sustainability

Fire Risk Mitigation

There are no quantified targets for reducing fire risk at the EU level. However, it can be assumed that even in the absence of such targets, it is in long-term interest of society to eliminate as far as possible forest fires, which lead to a loss not only of forest productive capacity but also of soil services, water and air quality, carbon sequestration potential and lead to increased GHG emissions. The demand to reduce fire risk will be increasingly important in those regions, such as the Mediterranean, where increased drought is likely to be a more common occurrence as a result of climate change.

Flood Risk Mitigation

The Floods Directive[123] aims to 'reduce the probability of flooding and its potential consequences'. All Member states are required to introduce measures to reduce flood risk through the development of flood risk management plans, to be implemented in coordination with the river basic management plans put in place under the WFD.

[123] Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, OJ L 288/27, 06.11.2007

The scale and location of likely changes in magnitude of flooding occurrences in the EU has been modelled and mapped, and it can be assumed that where significant increases in flooding are anticipated, such as in parts of northern, central and eastern Europe[124], demand will be high to avoid such incidents.

4.2.3 Cultural Services

Despite an absence of EU objectives and targets relating to maintaining cultural landscapes or promoting recreation, or EU surveys assessing attitudes to rural landscapes, the importance of cultural heritage, regional identify and a sense of place is firmly embedded in the European psyche. The European Landscape Convention[125] encourages 'the integration of landscape into all relevant policies – cultural, social and economic' and the maintenance of specific landscape features, or farming systems that are important from a landscape (as well as ecological) perspective, such as High Nature Value farming, are highlighted within sectoral policies such as the CAP. In some Member States, national legislation also requires the protection of particular landscape elements[126] and many Member States also have laws protecting ancient monuments in the countryside.

Recent work by the JRC to develop an indicator for the rural-agrarian landscape includes 'societal appreciation' as one element (Paracchini and Capitani, 2011)[127]. This shows high levels of appreciation for landscape in many Mediterranean, alpine and central Member States, reflecting the areas with a higher density of protected landscapes and greater preponderance of place based products. In relation to forest areas, there is a growing demand for recreational experiences in forests, and there is greatest demand for those that are within a short walking distance from their home (Bell *et al*, 2007). Visitor survey confirm this, with the large majority of forest visits across Europe being made to urban and peri-urban woodland areas rather than those that are more rural (Konijnendijk *et al*, 2005)

4.2.4 Land for development and infrastructure (soil sealing)

The use of urban land is not within the scope of this study, however, the demand for rural land for built development is relevant because of the impact that this has on the delivery of ecosystem services on a diminishing rural land area.

Productive rural land in Europe continues to be transferred to urban development and infrastructure. More than 100,000 ha were converted every year for housing, industry, roads or recreational purposes between 2000-2006 in the EU-15, with approximately half

[124] See map of projected change in average flood magnitudes with 100-year recurrence interval: http://floods.jrc.ec.europa.eu/climate-change-impact-assessment.html,

[125] Council of Europe, European Landscape Convention, Florence, 2000

[126] For example, the protection of trees and wetland habitats under the German Federal Conservation Act, the protection of hedgerows under the Hedgerow Regulations in England and Wales (UK) and the protection of a range of landscape features from damage or removal in Sweden.

[127] The study uses the extent of protected agricultural areas, farm based tourism as well as quality products with a link to landscape. The calculated results have been mapped to show differing levels of societal appreciation of the landscape in different regions of the EU-27. Although these are still initial findings and need further, they can be used as a proxy for the value ascribed to landscape and recreation or the societal demand for agricultural cultural landscapes in different parts of Europe.

this area actually 'sealed' (EEA, 2010e). Compared with the previous decade, the rate of soil loss has increased by three per cent on average, although this rate is much higher in some countries, for example it was 14 per cent in Ireland and Cyprus and 15 per cent in Spain (Prokop *et al*, 2011, quoted in JRC and EEA, 2012). Similar overall changes are projected for 2000-2030[128].

The EEA's SOER report on land use (EEA, 2010a) notes that the results of the Second European Quality of Life Survey (Eurofound, 2009) indicated that most people, especially in Bulgaria, Hungary, Poland, Estonia, Latvia and Lithuania are dissatisfied with the size of their living space. Furthermore, the demographic trend towards smaller and thus more households will also increase living area per person. Therefore, even if the population of Europe declines after 2035 urban areas will not necessarily decline proportionately. In the face of these demands, the Commission's Roadmap to a Resource Efficient Europe sets a target for net land take to be reduced to zero by 2050.

4.3 Assessing the overall pressure on EU rural land

The way in which land is used and the ecosystem services that it supplies result from a dynamic process that changes over time and is influenced by a range of drivers. There have been some notable improvements in recent years, for example in relation to water quality, brought about by both regulation and incentives. Nonetheless, it is clear that a significant environmental deficit has been created because of the way in which rural land is managed, since standards are demonstrably falling a long way short of meeting the EU's environmental objectives and targets (see for example EEA, 2010a). Addressing this deficit will become even more urgent if agriculture and forestry land uses are to be sufficiently resilient to the impacts of climate change. In the medium term, increases in productivity will be constrained if the health of ecosystem services, such as pollination, fertile soils and adequate water resources are not improved. Paying more attention to environmental services is therefore critical for the long term sustainability of timber, crop and livestock production.

It is areas where there is competition over the use of land where the greatest pressures on the environment arise and where the environment generally tends to lose out. Whereas the market largely determines the allocation of land for private goods, with farmers responding to price signals, this is not the case for public goods. Market forces have driven an intensification of land use in the more fertile areas and marginalisation or abandonment of farmland in many other areas. Both these processes have led to significant declines in biodiversity and natural resources, such as water and soils, to the point that the degradation of environmental services threatens the sustainability of future agricultural and forestry systems.

[128] These projections are based on the B1 scenario, according to the IPCC Special Report on Emission Scenarios (IPCC, 2000) and further developed for Europe by Westhoek *et al* (2006). It combines a global orientation with a preference for social, environmental and broadly defined economic goals (i.e. more than simple profit). Governments are considered to be actively regulating and ambitiously pursuing goals related to, for example, equity, environmental sustainability and biodiversity.

There is a strong presumption in the discourse on food and environmental security that the pressures on land are intensifying and can be expected to grow in the decades ahead. Since the series of commodity price spikes, starting in 2007/8, the fear is that a combination of growing global population with its demands for food and living space, new demands for bioenergy and biomaterials produced from land-based raw materials, future water scarcity and the impacts of climate change could significantly increase the global pressure on rural land, especially for agriculture. Some of the greatest uncertainties in this overall outlook arise from the powerful but slightly unpredictable role of renewable energy policy in Europe and beyond, particularly as it affects biofuels and biomass requirements. Important aspects of EU policy are under review. Under the current policy targets, demand is projected to increase substantially over the coming decades, which will have considerable impact on both land use and intensity of land management in the EU and elsewhere. However, if the proposed changes to the RED are approved to address issues related to ILUC then this may change the future dynamics relating to land use considerably, with greater use of residues and wastes than agricultural feedstocks for biofuels. Nonetheless, in nearly all scenarios an increase in the area of land devoted to some form of bioenergy supply is expected.

The evidence in this chapter suggests that, looking ahead to 2050, the most significant demands on rural land in the EU will be:

- Clearing the current environmental deficit and meeting new demands, particularly in relation to biodiversity, water, soils and climate
- Continued demand for land for built development, including urban expansion;
- Increase in demand for cereals particularly as bioenergy feedstocks; and
- Increased demand for woody biomass, particularly for bioenergy.

The extent to which these demands are compatible and there is potential to deliver them within the EU is addressed in Chapter 5.

Conversely, with the slowing rate of increase in population in the EU-27 (and decreases in many Member States), the significant slowing of economic growth and the potential reversal of the dietary switch to livestock products, demand for land for the production of crops and livestock for food and feed looks set to continue to decline, following the downward trend of the past four decades. Despite the need for increased production of food and feed globally, it is predicted that the majority of this will be sourced close to the growth in consumption, that is, in developing countries outside the EU. This is also where there is land available and where there is greatest scope for productivity gains. It is estimated that approximately 90 per cent of the increase in production will be generated from yield growth and greater cropping intensity, with the remainder coming from an expansion in the area of land farmed (Bruinsma, 2011; OECD-FAO, 2010). Estimates of the net additional area of land required vary[129], but tend to agree that the increases in arable area will be greatest in developing countries (almost all in sub-Saharan Africa and Latin

[129] Some suggest that as much as 60-70 million hectares of arable land will be required globally, while others suggest much lower figures, assuming high yield increases as a result of CO_2 fertilisation effects, for example 10-13 million hectares of cultivated land by 2080 (Fischer, 2009).

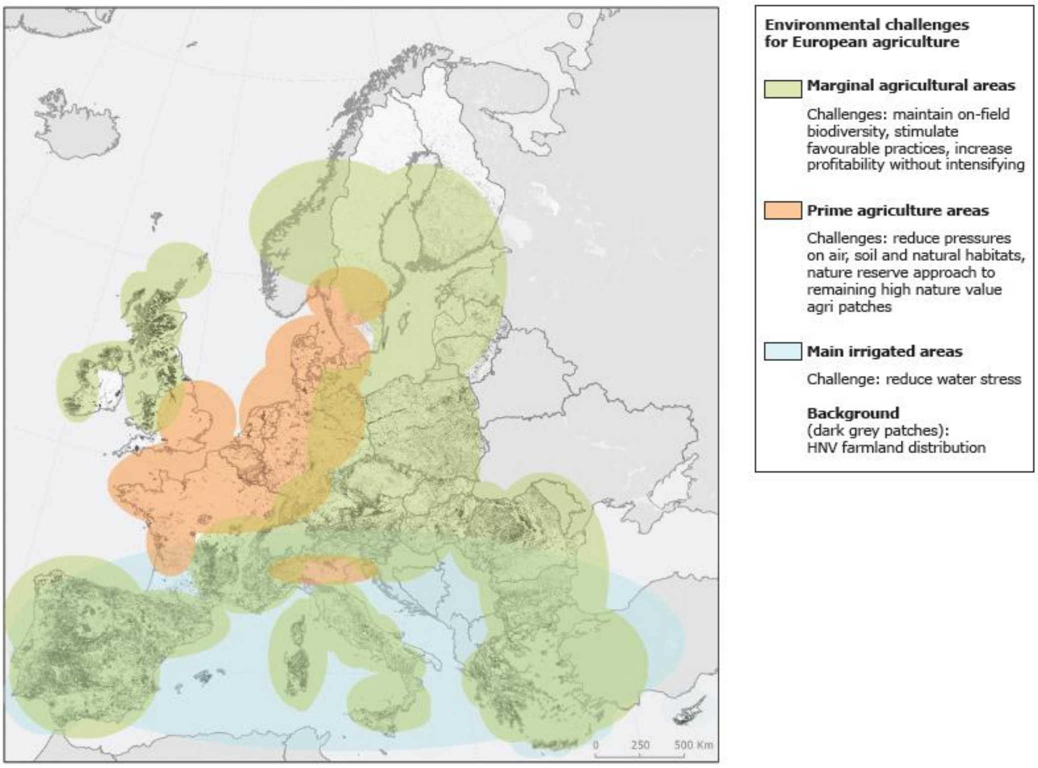
America) offset by a continued decline in developed countries, including the EU (Bruinsma, 2011).

The implications of addressing these future demands are complex and not easy to disentangle. If only market led changes are considered, the overall impact on the EU's rural land, assuming no major changes in trade patterns, is most likely to be:

- Continued overall decline in the EU's agricultural land area particularly grassland – with transfer to forest, to built development as well as the abandonment of some marginal land. The rate of decline may be stemmed by increased demand for crops and short rotation coppice for bioenergy feedstocks;
- Expansion of the forest area, although the rate of increase may decline;
- Expansion of built development; and
- Increases in the intensity of production of both forest and agricultural areas.

To take account also of the need to redress the current environmental deficit and meet the environmental challenges of the future will require significant changes in the management of both agricultural and forestry land to enable inter alia more efficient water and energy use, improved soil management and improved protection of habitats and species. These changes will be needed most in those areas where the greatest pressures on the environment are felt - namely areas of intensive timber, cropping and grassland production as well as in situations where the management of extensive agricultural land is withdrawn. An impression of the distribution of these areas, within Europe can be gained from Figure 11 below, although the categories are slightly different.

Figure 11: Environmental challenges for European agriculture



Source: EEA, 2012c

If adequate steps are taken to meet the key environmental challenges, there will be implications for the speed at which overall yields can increase in many localities and therefore the area of agricultural or forestry land that continues to be needed for production. Tensions will be greatest in more fertile areas where there are more choices available for the use of the land. Table 8 shows the potential impact of different land use and intensity changes on environmental services (indicated by the arrows) and highlights that the main land changes that are predicted over the coming decades are largely negative for the environment (cells shaded darker represent the changes likely to predominate in the future).

Table 8: Likely impact of anticipated land use change and intensity on environmental services

	To →	Forest (managed)	Cropland				Grassland		Abandoned land	Other semi-natural habitats	Wetlands	Built Development
From ↓			Intensive	Extensive	Fallow	SRC	Extensive	Intensive				
Forest (managed)			↓	↓	↓	↔	↓	↓	↖↘	n/a	↓	↓
Cropland	Intensive	↑		↑	↑	↔	↑	↑	↑	n/a	↑	↓
	Extensive	↑	↓		↑	↓	↑	↓	↖↘	n/a	↑	↓
	Fallow	↑	↓	↖↘		↓	↑	↓	↖↘	n/a	↑	↓
	SRC	↔	↔	↑	↑		↑	↖↘	↑	n/a	↑	↓
Grassland	Extensive	↓	↓	↓	↓	↓		↓	↖↘	n/a	↖↘	↓
	Intensive	↑	↓	↖↘	↑	↖↘	↑		↖↘	n/a	↑	↓
Abandoned land		↑	↓	↖↘	↖↘	↓	↖↘	↓		n/a	↑	↓
Other semi-natural habitats		↓	↓	↓	↓	↓	↓	↓	↓		n/a	↓
Wetlands		↓	↓	↓	↓	↓	↓	↓	↓	n/a		↓
Built Development		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	

Source: own compilation

Key:
- ↑ increase in environmental services
- ↓ decrease in environmental services
- ↖↘ possible increase or decrease depending on the circumstances
- ↔ no change
- likely significant change in land use with negative impact on environmental services
- likely significant change in land use with positive impact on environmental services
- likely significant change in land use with mixed impact on environmental services

However, the EU does not operate in isolation. It is unclear how global trade balances will evolve over the next 20 to 30 years. With the increasing world population and growing impacts of climate change, global market developments are also uncertain and probably more volatile. It may be that consistently higher prices for agricultural commodities would lead to a significant increase in exports from the EU onto international markets. However, most commentators have long taken the view that EU agriculture, with its fragmented structure, historically high protection, high land prices and relatively high wages will have too high a cost base to be competitive in most raw commodity markets in coming years. If commodity prices for food and feed crops were to rise significantly, this could change the trend outlined above, thereby also increasing demand for agricultural land for food and feed crops alongside bioenergy feedstocks and increasing the area of land required for agricultural use.

What is clear is that, unlike commodities such as crops and timber, environmental services are mostly non-tradable and so action to meet demand largely has to be carried out within the boundaries of the EU. The implications of doing this this will depend on policy, commodity prices and other supply side drivers (see Chapter 5). However, recalling the uncertainties noted above, two possible conclusions may be drawn. There is a question mark hanging over whether or not there will be sufficient rural land available in the future to allow for the imbalances in material and environmental service provision from land to be corrected as well as meeting expected demand for agricultural (and forest) commodities, especially if demand for bioenergy continues to rise. Second, with growing uncertainties, especially related to climate change, it is prudent to plan to ensure the EU's rural land is resilient to worst case scenarios and that productive land is protected in case greater production is needed. Tackling the manifest environmental deficit in many rural areas in the EU will also contribute to future resilience.

The next chapter considers the prospects for sustainable productivity growth in agriculture, forestry and bioenergy production and the extent to which the EU's rural land resource has the potential to address the future demands for all ecosystem services in a way that is also sustainable and resource efficient.

5 POTENTIAL FOR INCREASING PRODUCTION FROM RURAL LAND SUSTAINABLY

Key findings:

- For land use to become sustainable and resilient to a changing climate, responses chosen must meet environmental needs while balancing these with the production of other ecosystem services. Any increases in the production of food, feed or timber, therefore must be accompanied by improved resource efficiency (to avoid reducing natural capital) and improved flow of environmental services from healthier ecosystems.
- The future balance of commodity and environmental service provision will depend on individual decisions taken by the millions of farmers and foresters across the EU. They will be heavily influenced by the future trajectories of supply side drivers, such as market prices and production costs as well as by public policies.
- In the longer term increases in productivity will be constrained if the health of environmental services, such as pollination, fertile soil and adequate water resources are not maintained
- If the deficit in environmental services is to be addressed, three aspects need particular attention: 1) current forms of land management which are depleting essential natural resources must be modified to ensure that production methods are sustainable; 2) growth in agricultural and forest productivity must be achieved accompanied by an increase in the provision of environmental services – sustainable intensification; and 3) land that has a high environmental value currently should be maintained and valued for the benefits already provided and measures taken to prevent abandonment, urbanisation or intensification of agricultural or forest management.
- Current production forecasts take insufficient account of the potential future constraints on productive capacity arising from continued degradation of soil, water, biodiversity and other environmental resources.
- Estimates of potential for agriculture are set against projections for an ongoing decline in agricultural area over time, mainly to built development, forestry, abandonment or leisure. Increased bioenergy crop production may limit the level of such declines. Despite this, there are expected to be increases in the volume of most commodities produced as a result of predicted yield increases – often rather ambitious.
- For agriculture, there continues to be some potential to increase crop yields sustainably, especially in the EU-12, although the extent of the increases that are likely to be feasible without further depleting natural resources, particularly water, is far more limited.
- There is significant potential to improve the environmental performance of farms and the evidence suggests that this need not have a significant impact on output per hectare under the right conditions.
- There may also be opportunities to bring back some areas of land that have been recently abandoned. Often such areas will be appropriate only for extensive grazing because of the negative impact of cultivation on environmental services .
- Current models suggest that meeting demand for bioenergy from EU forests will involve the continued expansion of the EU forest area, increased extraction rates from existing forests as well as a small potential increase in short rotation coppice on agricultural land.
- Clear trade-offs are apparent between the production of roundwood and residues and the environmental services provided by forests. The short-term realisable output potential is therefore much lower under scenarios that include environmental sustainability criteria, than those that do not.
- The projections suggest that there is still considerable potential to increase commodity outputs from existing land, but that to do so in a sustainable way will require far more attention to be paid to the environmental management of agricultural and forest areas.
- In some cases this will impact upon yields, at least in the short term, but in other areas there is still significant capacity to adjust environmental management to reduce environmental pressures without having a significant impact on yields.
- Alongside significant increases in output from existing agricultural and forest areas, there are also likely to be tensions between different land uses in the future. Greater restrictions may need to be put in place, therefore, to limit the area of land that is built upon and more attention paid to guiding the extent and location of shifts between agricultural and forestry land uses.

This chapter considers the degree to which the EU's land has the potential to increase the supply of ecosystem services in a sustainable way from agriculture, forestry and other wooded land, with a view to understanding the degree to which this is likely to match the projections of demand that have been set out in Chapter 4. The chapter considers this issue from the perspective of the EU-27. However, the options for increasing production potential will vary between different regions depending on a range of bio-geographic, climatic, economic, social and political factors. Case studies are used to investigate in more detail the dynamics of balancing the delivery of ecosystem services to meet future demands in four situations in the EU (Chapter 6). Equally, with large scale trade in commodities in and out of the EU, there is a dynamic interplay between land uses which means that EU land use cannot be seen in isolation (see Chapter 7).

While some modelling work has been carried out to consider the sustainable future production potential of forestry land, the evidence in relation to agricultural land is less developed. Although modelling exercises have looked at yield projections and future agricultural land use under different scenarios, there is little consistency in the assumptions underpinning the models. More importantly, none have considered the environmental dimension of such changes in sufficient depth and of the modelling studies that were found there were none that considered the implications for food, feed and timber production if the existing environmental deficit were addressed. The analysis in this chapter, therefore, is based on a review of the relevant modelling outputs, supplemented by more qualitative analysis based on a review of the relevant literature and expert judgement.

5.1 Drivers influencing supply

The potential for increasing the production of ecosystem services is influenced by a number of supply side drivers, given their influence over the intensity and type of management carried out. They include market prices for commodities and inputs, technological developments, structural change, climatic changes and variability as well as policy drivers such as the CAP, energy policy, environmental legislation and policies influencing research and development and trade. Human and behavioural factors also have a major influence over land use decisions. There are considerable uncertainties about how these drivers are anticipated to change to 2030/2050 as set out below.

5.1.1 Price

Most forecasts of the future trends in agricultural commodity prices project that prices will be maintained in the medium term and remain above the historic low levels of the decade before the 2007/8 price spike until mid-century (European Commission, 2012a; OECD-FAO, 2011). These projections are based on assumptions of continued growth in global food demand, the development of the biofuel sector, continued decline in food crop productivity growth and climate and water availability constraints. If forecasts for any of these factors were to change, then so would price projections. Price volatility is likely to characterise agricultural markets increasingly in the future, with a much stronger influence from external factors, such as the increasing demand for biofuels, variable production costs, which are particularly sensitive to crude oil prices, drought- and flood-induced crop shortfalls, higher incidences of pests and diseases and market speculation. The key unanswered question is whether a further jump in prices may come about towards mid-century so that the EU finds itself in the new situation of having domestic prices at or even below, i.e. competitive with, the rest of the world. If this were to happen it would mean that the EU could, and would be expected to, reduce its imports and even switch to being a systematic net exporter of agricultural produce. This would not impact all products equally, it would mostly apply to the major food and feed crops and in the process it would raise the costs of EU livestock production.

Rising fossil fuel prices may have a greater influence on biofuel production in future than policy, by increasing the competiveness of biofuels on the open market. Oil price increases are already thought to have had some influence over EU biofuel production over the 2001-2006 period (Hertel *et al*, 2010), although policy continues to exert the strongest driver for expansion, at least in the short term.

Prices for wood products are likely to increase in the future, due to increasing wood demand and emerging scarcities (UNECE/FAO, 2011b). Prices for saw logs are strongly influenced by house construction and overall economic growth. Pulp and wood energy prices, on the other hand, are also influenced by energy policy and oil prices alongside GDP growth. The use of woody biomass for energy could increase strongly, especially if the world energy price remains at the present high levels (UNECE/FAO, 2011b).

5.1.2 Technological developments and technology transfer

Technology has played a major role in increasing productivity (yield per unit area or animal) of staple food crops and livestock over the past 50 years (IAASTD, 2008; Royal Society, 2009). Forest growth has also benefited from improved silvicultural techniques and a slower rate of increase in removals (Kuusela 1994) that rose more slowly than increased growth rates (Spiecker *et al*. 1996; Kahle *et al*. 2008).

Investment in research and development has slowed over the past decade (Thirtle *et al*., 2004). However, it is anticipated that this is now set to grow, globally as a result of the L'Aquila accord[130]and in the EU through the renewed emphasis on technological innovation, for example through the introduction of the European Innovation Partnership (EIP) on Agricultural Productivity and Sustainability[131]. There are also pressures from the agricultural industry to revisit the EU's stance on genetically modification (GMOs) for food crops as a means of encouraging high crop yields with less use of pesticides in the future.

The extent to which this driver will affect supply will depend not only on the level of investment but also on the efforts put into capacity building and knowledge transfer to make sure that information about technologies that can increase yields while also reducing environmental impacts is more widely accessible; and the extent to which new technologies are applicable and accessible to all types of farm systems, structures and sizes.

130 http://www.g8italia2009.it/static/G8_Allegato/LAquila_Joint_Statement_on_Global_Food_Security%5B1%5D,0.pdf

131 COM(2012f) 79 final, Communication from the Commission: Communication on the European Innovation Partnership 'Agricultural Productivity and Sustainability', 29 February 2012

5.1.3 Climate change

The likely impacts of climate change on agricultural and forestry land are complex, uncertain and spatially differentiated, driven by the interaction of many factors in different bio-geographic situations. It is the anticipated higher frequency of extreme weather events that will be the primary cause of impacts on agricultural and forestry production and markets up to 2030 (EEA, 2012d).

Agriculture: It is predicted that climate change and climate variability will have a substantial effect on agricultural production both in terms of crop yields and the location where different crops can be grown, although the effects of climate change will differ in different parts of Europe and in different farming systems. In Northern Europe, some positive impacts can be expected, related to longer growing seasons, the introduction of new crop species and varieties, higher yields, and the expansion of suitable areas for crop cultivation (Carter, 1998; Audsley *et al*., 2006), although other factors such as predicted increases in soil erosion and storm events, increased incidences of pest and disease outbreaks as well as water scarcity in some areas, are likely to constrain such increases in reality. In Southern Europe, increased water scarcity is predicted, alongside a greater frequency of extreme weather events leading to a loss of soil carbon content, erosion, lower harvestable yield and higher yield variability, increased pesticide requirements and crop damage, and heat stress for livestock (Olesen and Bindi 2004; Commission of the European Communities, 2009; EEA, 2012d). Temperature increases and extremes will also affect animal health, growth and reproduction. Higher temperatures and increased rainfall are also likely to lead to a noticeable increase in the incidence of disease, pests and pathogens, including the spread of invasive alien species.

Forestry: Climate change will lead to an increase in the incidence of temperature extremes in the summer period across much of Europe, which is expected to lead to more droughts in Southern Europe and a greater incidence of forest fires (Rummukainen 2012), including in regions where they have been less common. A greater incidence of severe storm events is projected (Leckebusch *et al*. 2008; Della Marta and Pinto 2009), but the latest results suggest that the increase in sustained extreme wind speed only exceeds the envelope of historical variability towards the end of the 21st century (Pryor *et al*. 2012). Storm damage is moreover likely to increase in areas with water saturated soils and decreased soil freezing, as this will reduce stand stability. This would disrupt normal forestry operations and timber markets, translating into significant economic losses and transient impacts on future harvests. It can also impact on soil carbon (Gardiner *et al*, 2010). Increasing temperatures and altered patterns of precipitation will also influence the frequency, intensity and spatial distribution of outbreaks of forest pests and pathogens. Whereas modelling studies have often shown increased productivity under climate change in different parts of Europe (Zimmermann *et al*, 2011; Reyer *et al*. 2012), several recent studies indicated observed evidence of drought-induced growth declines (Piao *et al*. 2011; Choat *et al*. 2012; Kint *et al*. 2012). It is likely therefore that climate change impacts in forests will include both negative and positive impacts, with adverse impacts dominating across most of Europe in the mid and longer term (Lindner *et al*, 2010a).

5.1.4 Social and Structural Change

The land management sector of the economy is highly fragmented and spatially diffuse[132]. With respect to ownership, the overwhelming majority of EU farmland is in private ownership, whereas forest land is partly in private and partly state ownership with some community ownership. The operational structures and land tenure arrangements vary considerably between Member States. There are fewer reliable socio-economic data about the forest sector than the agriculture sector.

In relation to agriculture, the long term trend in the EU has been increased specialisation and concentration of production on a smaller number of units of larger average size, with associated declines in small to medium sized farms. Current structural changes are perhaps most marked in the new Member States which experienced dramatic changes in political and economic systems in the last two decades. Farm size varies considerably between Member States[133]. Structural changes are predicted to continue, with a faster rate of decrease in farm size in the new Member States[134] (Nowicki *et al*, 2006). Higher commodity prices and technological developments are likely to accelerate this rate of change. Smallholdings and fragmented properties of private land owners cause problems in many European countries as these challenge cost-effective forest management (Schmithüsen and Hirsch, 2010).

In relation to agriculture, all countries have a mix of owner-occupiers and land which is separately owned and farmed by tenants. Increasingly, as farm enlargement takes place, other forms of joint venture farming have evolved, such as company farms, cooperatives, share farming, and contract farming. Three quarters of the agricultural area in the EU-27 is farmed by the owner, 22.5 per cent under a tenancy agreement and just over five per cent is in shared farming or under other types of tenure (2010 Farm Structure Survey). The area of privately owned forest increased steeply in several of the new Member States as a result of restitution of land rights[135]. Whilst the dismantling of the former state and collective farms and forests in the new Member States is now more or less complete, the process of privatisation and agricultural reform continues and farmers have varying degrees of security of ownership and tenure. The resulting mix of cooperatives, private individual farms and household plots is therefore still evolving.

The complex nature and evolving structure of EU farming and forestry is important for several reasons. First, the motives and behaviour of land managers are not the same for the different structures or types of agricultural or forest units and their reactions to changing

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[132] In relation to the agricultural sector, 2007 data (the latest year for which complete information is available) indicated there were 13.4 million farm holdings in the EU-27, of which 70.4 per cent were under five hectares, a further 11 per cent between 5-10 hectares, and only 5.1 per cent are larger than 50 hectares.

[133] over 90 per cent of farms are less than five hectares in size in Bulgaria, Romania and Malta, compared to over 25 per cent of holdings greater than 50 hectares in Denmark, France, Luxemburg, Sweden and the UK

[134] The Scenar2020 study predicted a 25 per cent decrease in the number of farms across the EU-25 (not including Romania and Bulgaria) by 2020

[135] Between 2000 and 2005, Romania and Bulgaria experienced a 54 per cent and 28 per cent increase, respectively. The increases experienced in other Central and Eastern European countries was 5–7 per cent in the same time period (Schmithüsen and Hirsch 2010)

policy, economic and environmental circumstances are likely to be different. Second, the technical and economic performance of agricultural and forest businesses varies enormously even within the same type, region and size - generally the larger land management units have the capital to invest in and the ability to employ both the equipment and the agronomic, silvicultural and environmental consultants to realise sustainably intensive production systems. Thirdly, it is generally the case that major jumps in investment and in productivity occur at discontinuities in business structure – that is, for example, when there is generation turnover, or when the land manager decides to go into partnership, join a cooperative or let contractors take over the day-to-day operations on the farm. Finally, restitution and privatisation of forest land to private owners often implies a break in management practices, as new owners often have no access to (or interest in employing) professional staff and the significantly reduced property sizes no longer offer the economy of scale needed for efficient operations based on long term management planning. In several countries (such as Estonia and Romania), harvest rates increased immediately after reconstitution, reflecting overharvesting and often a high rate of illegal logging, while in other areas forests are no longer managed due to the ownership structure (fragmented properties, shared tenure, absentee owners) and lack of adequate institutional support.

5.1.5 Agriculture, Energy and Forestry Policies

From an EU perspective, the most important policy influence on land use decisions is the Common Agricultural Policy (CAP), although increasingly climate and energy policies, with targets set through the Renewable Energy Directive[136] (RED) and the Fuel Quality Directive (FQD) and accounting rules under the Emissions Trading Directive also have an impact on, the growth of biofuel feedstocks on agricultural land and the use of biomass for energy more generally.

Although support under the CAP has been decoupled from the production of agricultural commodities since 2005, it exerts an influence over the way in which land is managed through the requirement to adhere to cross compliance standards as well as providing voluntary payments for undertaking positive actions that go beyond these standards, such as through the agri-environment measure. In the future, if the current proposals to introduce compulsory environmental measures into Pillar 1 of the CAP from 2014 are agreed, this could lead to the introduction of a basic level of environmental management over the whole farmed countryside, while the introduction of new standards of Good Agricultural and Environmental Condition for protecting soil organic matter and carbon rich soils would encourage practices that reduce soil degradation.

The targets set by the EU RED on the promotion of the use of energy from renewable sources have become a significant driver affecting land use in the EU as a result of the targets[137] . The effects of this policy have already been seen in many parts of the EU, with

[136] Directive 2009/28/EC

[137] The RED sets out two targets aimed at the promotion of renewable energy. The first requires the delivery of 20% of total energy from renewable sources by 2020, with the level of effort differentiated across the Member States. The second specifically promotes the use of energy from renewable sources within the transport

greater areas being planted to rapeseed and maize in a number of Member States. The recent proposal by the Commission to revise the RED to take account of indirect land use change (ILUC), will no doubt change the impact of this policy on land use change in the future, although precisely how will depend on the precise nature of the regulations once finally agreed.

In contrast to the agricultural and energy sectors, forest policy is almost entirely determined at the national and even regional level. EU level forest policy, comprising the EU Forest Strategy and Forest Action Plan exerts a comparatively weak influence. Indeed the majority of funding and incentives for afforestation and forest management comes from the CAP, under Pillar 2 rural development policy.

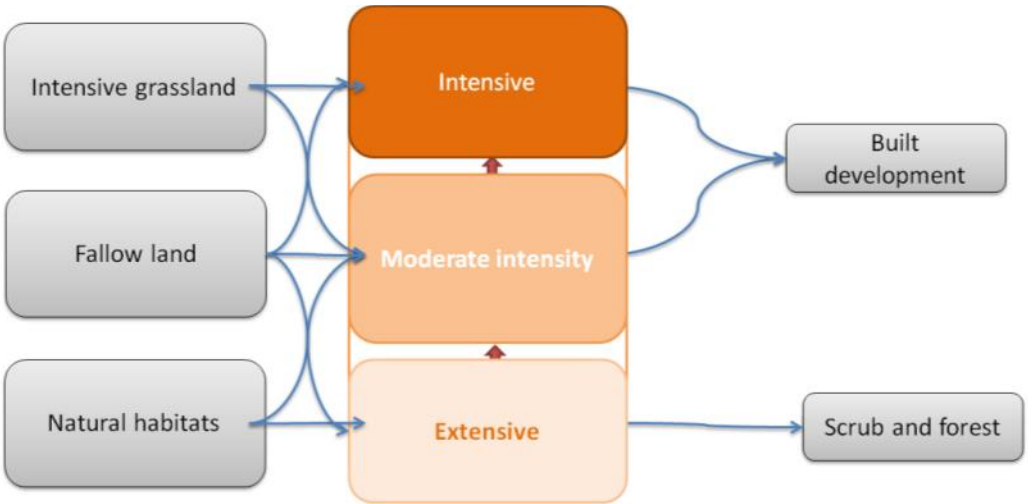
5.2 Estimating the sustainable production potential of land

Essentially there are three ways in which land can be used to respond to meet future demands:

- through changes in land use, both between different agricultural and forestry uses as well as the expansion or contraction of the land area used for agriculture and forestry, such as reduced rates of transfer to urbanisation, forest expansion or the allocation of land to priority environmental services, such as flood risk management;
- through increases in productivity per unit of land and per unit of output (needing less productive area for the same output); and
- by changing the way the same area of land is managed while maintaining the same output.

This is illustrated diagrammatically for arable land in Figure 12.

Figure 12: Options for increasing the production potential of arable land



Source: own compilation

sector, requiring 10% of all transport fuels to be delivered from renewable sources by 2020 in every Member State.

If such changes are to be sustainable, whichever response is chosen must achieve an increase in the productivity of provisioning services in conjunction with improved resource efficiency to improve the flow of environmental services from ecosystems. Within a global context, some commentators refer to a 'safe operating space', within which sufficient provisioning services can be provided (usually referring to food), without crossing critical environmental thresholds or planetary boundaries (Rockström *et al*., 2009; Bio IS, 2011; Foley *et al*., 2011). However, defining precisely what these critical thresholds are in relation to different types of crop, livestock or timber production varies geographically depending on a whole range of biophysical and climatic factors. Research to define such critical thresholds for soil, water and biodiversity is ongoing and is a priority for the future[138]. This balance can be achieved not just through changing supply response (the focus of this chapter), but also through demand side responses, such as promoting sustainable consumption patterns and reducing waste as well as finding alternatives to land for the production of some of these services, in particular energy. These are addressed in Chapter 7.

5.2.1 Estimates of future sustainable production potential in relation to forestry

The potential supply of woody biomass from forests between 2010 and 2030 has been assessed under a number of recent studies[139] and assessed in relation to several policy scenarios to take account of economic and environmental considerations. The projections first estimate the maximum 'sustainable'[140] potential supply of woody biomass was estimated using the EFISCEN and EFI-GTM models for the period from 2010 to 2030 for two different mobilisation scenarios for four different tree compartments:

- round wood;
- harvest residues (tops, branches, small trees and damaged stems);
- stumps (including coarse roots); and
- other biomass (woody biomass from early thinnings[141]).

Second, forest resource development was simulated for three different policy scenarios with an assessment of each scenario carried out in relation to a series of sustainability

[138] Examples of research that has been carried out include: a) on biodiversity, which showed that average predicted levels of species loss (21-40%) globally had an effect on primary production comparable to that of both climate warming and the effects of ultraviolet radiation, whereas if 50% of species were lost, biomass production could fall around 13% across terrestrial, freshwater and marine ecosystems, comparable to the effects of acidification, ozone, or rising CO2in ecosystem; b) A value of ~3.4 per cent soil organic matter (two per cent soil organic carbon) has been proposed as a critical minimum threshold for soil quality, although there is little evidence to suggest that this value has is founded on empirical evidence (Loveland and Webb, 2003; Verheijen *et al.* 2009)

[139] The most extensive study was the EUwood project (Mantau *et al*., 2010b; Mantau *et al*., 2010a; Verkerk *et al*., 2011b). The EUwood results were used and partly updated in the European Forest Sector Outlook Study EFSOS II (UNECE/FAO, 2011) and in Biomass Futures (Elbersen *et al.* 2012). The data in this report were taken from the EFSOS II study with minor adjustments as in the EXIOPOL project (http://www.feem-project.net/exiopol/, Verkerk *et al*., in prep.).

[140] it should be noted that the term 'sustainable' as used here is taken to mean what it is possible to sustaina in the long term, rather than referring to potential that is environmentally benign.

[141] In some countries these are termed energy wood thinnings: includes small dimension trees that would otherwise be left in the stand as well as some low diameter round wood

indicators. These scenarios were chosen to explore different developments, including also relatively extreme resource use scenarios (as described in more detail below).

It is important to highlight a number of caveats with respect to the scenarios modelled. First, it should be noted here that there is no commonly accepted definition of maximum sustainable potential (Lindner *et al*. 2010b). In the scenarios investigated, the sustainability of the scenario was only assessed with respect to sustainable wood supply, in the sense of being possible to sustain supply in the long term. The consequences of this drastic scenario on the provisioning of other ecosystem services are discussed, but possible trade-offs were not used up-front to influence the 'maximum sustainable potential', taking environmental, economic and social considerations into account. Secondly, the evidence on the likely impacts on climate change of forestry is changing quite rapidly and remains uncertain. Climate change impacts were not taken into account in the modelled scenarios and this has implications for the potentials for biomass and other ecosystem services stated here. Thirdly, it should be remembered that the scenarios were not designed as realistic projections of future situations.

Maximum realisable potential
In order to calculate the maximum realisable potential, first the theoretical potential of forest biomass supply in the 27 Member States was estimated. This theoretical potential was defined as the overall, maximum amount of forest biomass that could be harvested annually within fundamental bio-physical limits, also taking into account national forest resource inventory data as initial conditions (increment, age-structure and stocking level of the forests) (adapted from Vis *et al*., 2010)[142]. Second, multiple environmental, technical, and social constraints were defined and quantified that reduce the amount of biomass that can be extracted from forests for two different mobilisation scenarios for the future (a high and a medium mobilisation scenario). Details on the methods, models and assumptions underpinning these are set out in Annex 6.

The theoretical woody biomass potential is higher than that which can be supplied in reality from the forest due to various constraints. The theoretical potentials therefore were combined with a range of constraints associated with the different wood mobilisation scenarios derived from existing biomass harvesting guidelines. The types of constraints considered are set out in Table 9. It is recognised that many other social and economic constraints than those listed affect wood mobilisation (see for example Forest Europe *et al*, 2010), but they were not included within the scenarios and subsequent analysis due to lack of data.

[142] In the simulation a very high demand for wood was assumed for calculating the maximum sustainable potential. In most countries, current demand is at a significantly lower level. Part of the unused potential could be shifted to increase future potential supply, but this correction was not made in the assessment.

Applying these constraints, the storylines for the two mobilisation scenarios assessed were defined as follows:

- The **high mobilisation scenario** has a strong focus on the use of wood for producing energy and for other uses. This would clearly have environmental trade-offs. Recommendations for maximising wood mobilisation are translated successfully into measures that lead to an increased mobilisation of wood. This means that new forest owner associations or co-operations are established throughout Europe. Together with existing associations, these new associations lead to improved access of wood to markets. Strong mechanisation is taking place across Europe[143] and existing technologies are effectively shared between countries through improved information exchange. Biomass harvesting guidelines become less restrictive, because technologies are developed to mitigate some of the environmental impacts (e.g. machines with lower soil compaction effect) and consequently certain constraints limiting biomass extraction can be relaxed. Furthermore, possible negative environmental effects of a more intensive use of forest resources are considered less important than the negative effects of alternative sources of energy or alternative building materials. The application of fertiliser is permitted and assumed to be feasible to compensate for the detrimental effects of logging residue and stump extraction on soil fertility.

- The **medium mobilisation scenario** builds on the idea that recommendations for maximising wood extraction are not all fully implemented or do not have the desired effect. New forest owner associations or co-operations are established throughout Europe, but this does not lead to significant changes in the availability of wood from private forest owners. Biomass harvesting guidelines that have been developed in several countries are considered adequate and similar guidelines are implemented in other countries. Mechanisation of harvesting is taking place, leading to a further shift of motor–manual harvesting to mechanised harvesting where applicable. The application of fertiliser is permitted to limited extent to mitigate the detrimental effects of logging residue and stump extraction on soil fertility.

[143] In most countries, harvest residue extraction is only economically feasible from mechanised harvest operations.

Table 9: Constraints to the removal of forest harvest residue biomass used in EUwood

Constraint	Type	Explanation
Soil productivity	Environmental	The nutritional impact of biomass harvesting in forests is influenced by the degree to which foliage and small branches are extracted from a site. If soils are more productive, they can tolerate a higher degree of biomass extraction (Äijälä *et al*, 2010; Forest Research, 2009a).
Soil and water protection	Environmental	Removal of forest biomass inevitably involves vehicle operations and soil disturbances. The extraction of forest residues and stumps increases the risk for erosion, especially on steep slopes (Asikainen *et al*, 2008; Forest Research, 2009b; Vasaitis *et al*., 2008; Fernholz *et al*, 2009). Forests have an important role in the protection of watersheds. Intensive logging and residue extraction may result in the degradation of water quality (Forest Research, 2009b; Fernholz *et al*., 2009). The extraction of forest residues on sites with shallow soils could increase erosion risk (Fernholz *et al*, 2009) and depletion of soil organic carbon and nutrients. Using heavy machinery for extracting biomass can lead to soil compaction, particularly in wet soil (Forest Research, 2009a; Forest Research, 2009b).
Biodiversity protection	Environmental	To prevent loss of biodiversity a significant percentage of the European forest area is protected or managed for conservation purposes with constraints on harvesting activities (Fernholz *et al*., 2009; Fehrenbach *et al*, 2008). However, as in fire prone areas, leaving residues in the forest could increase the forest fire risk, it was assumed that residues could be harvested in protected areas that have a high or very high fire risk.
Recovery rate	Technical	Part of the woody biomass from forest is lost before reaching the point of utilisation due to, e.g., loss or damage of biomass during harvesting. The technical harvest residue recovery rate depends on the harvesting technology used (Nurmi, 2007; Peltola *et al*, 2011).
Soil bearing capacity	Technical	On soft soils the bearing capacity of soil can reduce the amount of harvestable biomass, e.g., because logging residues are used to strengthen the bearing capacity of the soil on the forwarding trail (Driessen *et al*., 2001).
Distributed forest ownership	Social/economical	Private owners with small properties may be less motivated to sell wood as harvesting may not be economically significant, transaction costs too high, or due to other management objectives than wood production (Straka *et al*., 1984; Amacher *et al*., 2003).

Source: Mantau *et al*, 2010 a and b

Quantification of environmental and technical constraints: Each of the environmental and technical constraints was quantified separately for each type of biomass (i.e., round wood, residues, stumps and other biomass) and by type of felling activity (i.e., early thinning, thinnings and final fellings) for the two mobilisation scenarios. For round wood, the environmental and technical constraints were implicitly quantified by considering only the forest area available for wood supply (FAWS)144. The environmental and technical constraints for round wood were not quantified individually in order to avoid double counting of their effect on potential round wood supply. For the other types of biomass, the potentials were limited also to FAWS, but the additional constraints listed in Table 9 were applied. General assumptions on the extraction rates of biomass from early thinning, and

[144] Defined as: 'forests where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood' (Forest Europe *et al*, 2011).

logging residues and stumps from thinnings and final fellings were made based on the recommendations set out in Member State guidelines.

Quantification of the socio-economic constraints: The effect of ownership structure on wood mobilisation was estimated by linking size-classes of privately owned forest holdings with maximum extraction rates per size-class[145]. In non-privately owned forests, it was assumed that size of the forest holdings did not reduce the biomass potential. The average availability from all ownership types was calculated using the proportions of private and public forests as weights (Schmithüsen and Hirsch, 2010; MCPFE *et al*, 2007).

The theoretical forest biomass potential at the regional level was combined with the average reduction factor for each region for environmental and technical constraints and for the constraints related to forest holding size. This resulted in the calculation of the realisable biomass potential from European forests.

Policy scenarios

Using the mobilisation scenarios described above, three policy scenarios were developed[146.] These are set out in Table 10. It is important to note that the policy scenarios were not designed as realistic projections. The wood energy scenario in particular should be considered as an extreme scenario with maximum resource use intensity[147].

For countries where inventory data were available from before 2010, the structure of the forest resources in 2010 was estimated by running EFISCEN until 2010, using historical roundwood production (Forest Europe *et al*, 2011) converted to overbark volumes.

[145] The maximum harvest level was assumed to be 50% in forest holdings <1 ha, increasing to 85% in forest holdings ≥5 ha and to 96% in forest holdings ≥80 ha – see Annex X for more details on the evidence behind these figures.

[146] A range of policy scenarios were investigated in the European Forest Sector Outlook Study (UNECE/FAO, 2011) and three of them were further improved in the Exiopol project (http://www.feem-project.net/exiopol/, Verkerk *et al*., in prep.).

[147] Maximum resource use intensity was constrained by sustainable wood yield; cf. clarification in the introduction of section 5.3.1.

Table 10: Policy Scenarios assessed for the EFSOS II projections

Policy Scenario	Description
Reference scenario	No changes of the current policies or management strategies were assumed. The future demand for wood was based on the B2 reference future as projected by the global forest sector model EFI-GTM (Moiseyev *et al*, in press), according to which demand is gradually increasing in most European countries until 2030. Rotation lengths and the share of thinning in the total harvest were based on national recommendations (Nabuurs *et al*, 2006; UNECE/FAO, 2011). The share of logging residues (all countries) and stumps (in countries where this already takes place) that are extracted during harvest operations was assumed to increase until 2020 and remain constant thereafter. These rates depend on the suitability of a site for residue and stump extraction taking into account environmental, technical and social criteria, using the medium mobilization scenario.
Wood energy scenario	Considers that the targets by the European Commission (European Parliament and Council of the European Union, 2009) for consumption and production of renewable energy in 2020 are achieved with a substantial contribution from the forestry sector, and that the woody biomass demand for energy use remains at the same level until 2030[148]. The future demand for wood was based on the wood energy scenario as projected by EFI-GTM (Moiseyev *et al*, in press), leading to a larger demand for wood as compared to the reference scenario. The share of logging residues and stumps (both in all countries) that are extracted during harvest operations was assumed to increase until 2020, in keeping with the high mobilisation scenario. Other parameters, including the minimum rotation length, were kept the same as in the reference scenario.
Biodiversity scenario	The following changes are made to the forest management regime: (i) longer rotation lengths are applied (10 years for short-lived broadleaves and 20 years for long-lived broadleaves and conifers)[149], (ii) with extended rotation lengths, the share of wood from thinnings also increases in the overall wood removals, resulting in a more diverse stand structure. The future demand for wood was the same as for the reference scenario. Extraction of logging residues and stumps were assumed to be abolished. The transition to longer rotation lengths could be implemented in most countries relatively fast, because the share of thinning removals was increased and the low felling to increment ratio during the last two decades resulted in a larger share of older stands beyond the age of the original rotation length plus 10/20 years. The area of older forest stand has increased in most countries since 1980 (Vilén *et al*. 2012).

Source: UNECE and FAO, 2011

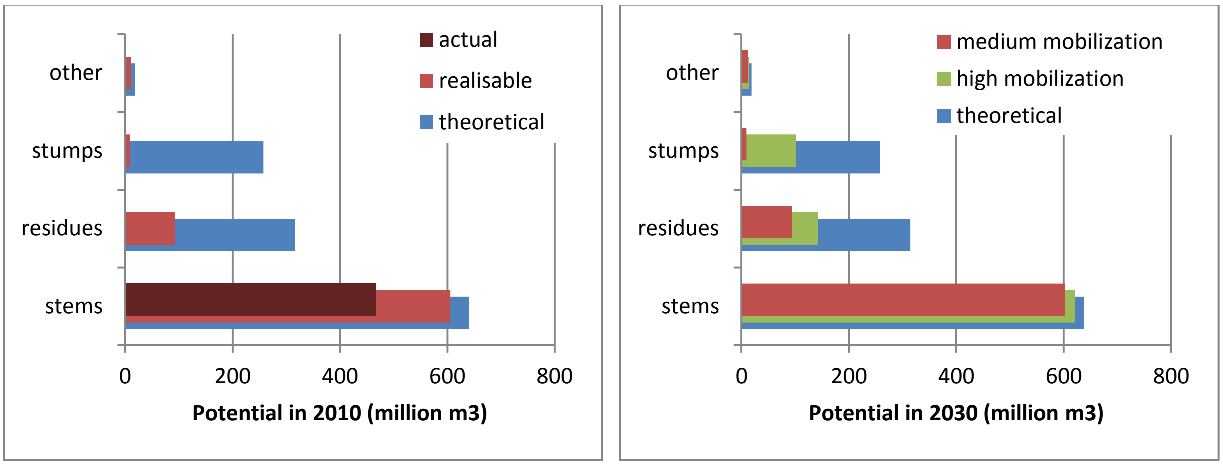
[148] Up to 2010, almost 50% of the total renewable energy production in the EU was based on woody biomass. The share of other types of renewable energy have been increasing (especially wind and solar) but no policy targets exist to specify how large the contribution of agricultural crops or woody biomass would be in 2020 and 2030. To reach the 20% target for renewable energy in 2020 the demand for woody biomass to generate bioenergy is widely expected to increase, even if its share in the renewable energy mix will continue to decline. In the wood energy scenario it was assumed that the woody biomass share in the renewable energy mix would only moderately decline from 50 per cent before 2010 to 40 per cent in 2020 and 2030.

[149] For technical reasons, the model set up did not allow the management regime to be changed only from 2010 onwards. Consequently, the changes in the rotation lengths took effect in the biodiversity scenario already from the date of the latest forest inventory – which was in most countries between the years 2000 and 2005. In some countries this resulted in somewhat reduced harvest and consequently increasing growing stock values for 2010.

Results

Maximum realisable potential: Various environmental, technical and social constraints reduce the amount of woody biomass that could theoretically be harvested from European forests. In particular, these constraints reduced strongly the potentials from logging residues and stumps (see Figure 13). The difference between theoretical and realisable stemwood harvest is small, because only forests available for wood supply were simulated and no additional environmental or social constraints were imposed on stem wood extraction (i.e. if forests are available for wood supply, the wood is considered to be harvestable[150]). Evidence suggests that about 467 million m^3 roundwood (overbark) was harvested in forests in the 27 EU Member States in 2010 (Forest Europe *et al*. 2011), although this estimate is probably an underestimate of the wood that is harvested in reality due to, for example, unregistered use of wood for household heating (Mantau *et al*, 2008). Nevertheless, considerably more woody biomass could be mobilised from EU-27 forests compared to the current harvest level (compare the actual stem harvests and the realisable in Figure 13)). Current extraction rates for residues, stumps and other biomass are not consistently reported, so no estimate can be made for those.

Figure 13: Potential biomass supply from forests in EU27 in 2010 (left) and 2030 (right)



Source: Data based on the EUwood and EFSOS II studies, slightly modified as in Verkerk *et al* (in prep.)
NB: Stems here are > 7 cm diameter and the term is interchangeable with 'roundwood' in the text

The current realisable biomass potential (all compartments including stems) from forests is estimated at 719 million m^3 yr^{-1} overbark in 2010, which represents 58 per cent of the theoretical potential in 2010 (range between countries: 51–64 per cent). The realisable potential changes only slightly over time under the assumption of a medium mobilization scenario. However, if major mobilisation efforts are undertaken, the biomass potential could increase to 880 million m^3 yr^{-1} overbark in 2030, mainly as a result of higher residue and stump extraction (Table 11). However, this would have serious environmental impacts, particularly if stump extraction is assumed and therefore could not be considered sustainable from an environmental perspective.

[150] The theoretical potential is confined by the rotation length and minimum age for thinnings according to national management guidelines.

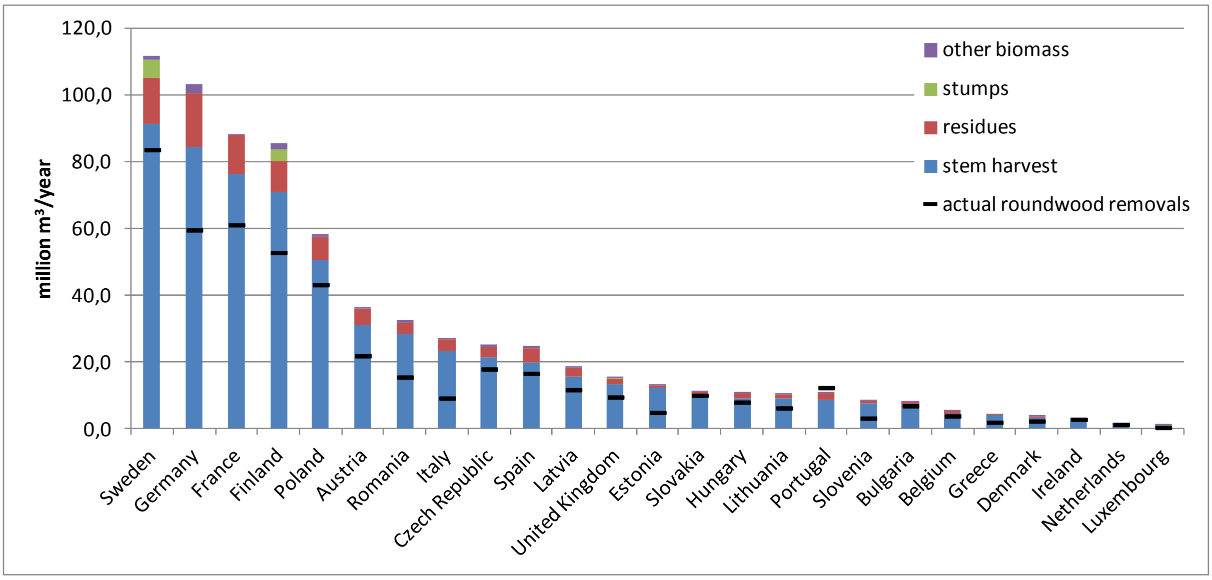
Table 11: Maximum biomass potential from forest as assessed in EFSOS II (million m³)

EU27	Realisable potential in 2010	Potential in 2030	
		High biomass mobilisation	Medium biomass mobilisation
Stems/Roundwood	605	622	603
Residues	92	143	94
Stumps	9	101	9
Other biomass	11	15	12
total	719	880	719

Source: UNECE and FAO, 2011

The distribution of the total realisable forest biomass potential across EU member states in 2010 is shown in Figure 14. The five countries that have the largest forest biomass potentials (Sweden, Germany, France, Finland and Poland) represent about 62 per cent of the EU forest biomass potentials and 56 per cent of the forest area available for wood supply in the EU. This is to a large extent due to the extent of their forest resources. The difference between actual and potential harvests is particularly high in Germany, Finland, France, Romania and Italy.

Figure 14: Distribution of the total realisable forest biomass potential (EFSOS II data) across EU member states in 2010.



Source: UNECE and FAO, 2011

Policy scenarios: Roundwood production increases over time in all three policy scenarios. In the biodiversity scenario, however the amount of roundwood harvested is 10-15 per cent lower compared to the reference and wood energy scenarios (Table 12).

Table 12: Total round wood removals in EFSOS II scenarios from forest available for wood supply in the EU-27 (million m^3 yr^{-1})

	2010	2015	2020	2025	2030
reference	465	481	499	512	532
wood energy	465	482	508	538	553
biodiversity	393	433	445	448	480

Source: UNECE and FAO, 2011

The volumes of extracted harvest residues (tops and branches) and stumps varies greatly between the three policy scenarios, from no residue and stump extraction in the biodiversity scenario, to a total extraction of more than 200 million m^3 in the wood energy scenario (Table 13).

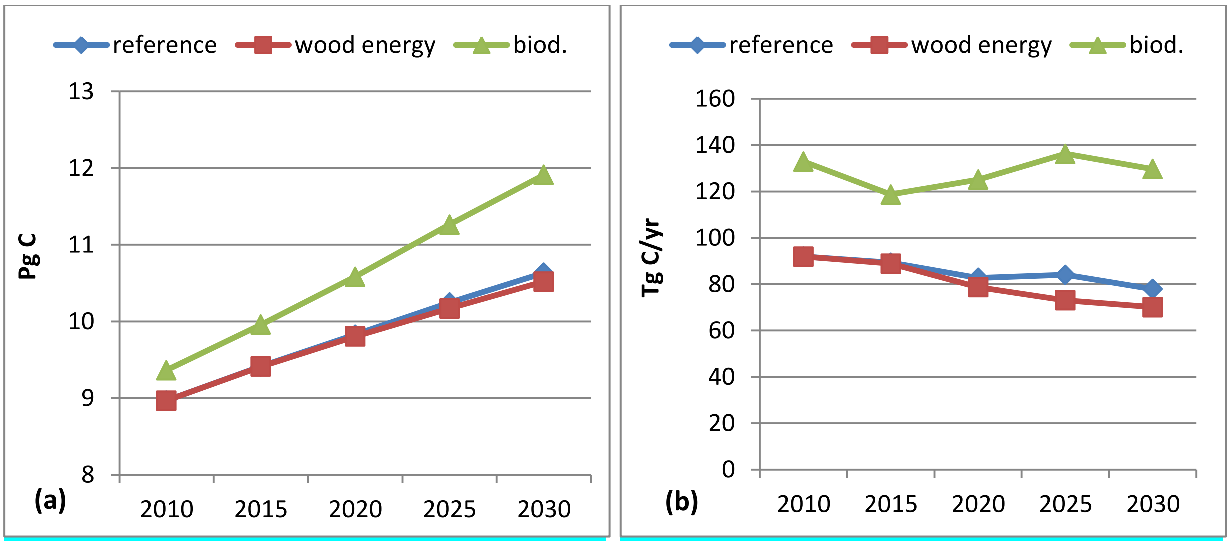
Table 13: Extraction of harvest residues and stumps (million m^3) in the three EFSOS II policy scenarios in the EU-27.

	2010	2015	2020	2025	2030
Harvest residues					
reference	27	45	66	68	71
wood energy	46	79	114	121	125
biodiversity	21	0	0	0	0
Stumps					
reference	3	7	11	11	11
wood energy	10	45	82	87	90
biodiversity	3	0	0	0	0

Source: UNECE and FAO, 2011

Carbon stocks increase in all three policy scenarios, but more in the biodiversity scenario (Figure 15a). Forests are an important carbon sink and remain a sink over the modelling period. However, the level of annual carbon sequestration decreases in the reference and wood energy scenarios due to increased removal of biomass from the forest (Figure 15b).

Figure 15: Total EFSOS II scenario biomass carbon stock[151] (a) and carbon sequestration rate (b) on FAWS[152] in EU27



Source: UNECE and FAO, 2011

Deadwood levels increase in the biodiversity scenario because of lower residue extraction rates, while they decrease by five per cent in the reference and seven per cent in the wood energy scenarios (2030 compared with 2010). The recreation score increases in the biodiversity scenario, and remains quite constant in the other two scenarios.

In summary, it becomes clear that there are trade-offs between provisioning services (roundwood and residue provision) and regulating, habitat and social services provided by forests (Table 14). When roundwood and residue removals are increased (wood energy scenario versus reference scenario), biomass carbon storage, dead wood and recreation score decrease, and vice versa.

Table 14: Percentage change in ecosystem service provision in EFSOS II scenarios compared to the reference scenario in 2030

Service	Wood energy	Biodiversity
Roundwood production	4%	-10%
Extraction of logging residues and stumps	159%	-100%
Carbon storage	-10%	67%
Dead wood	-3%	5%
Recreation	-1%	10%

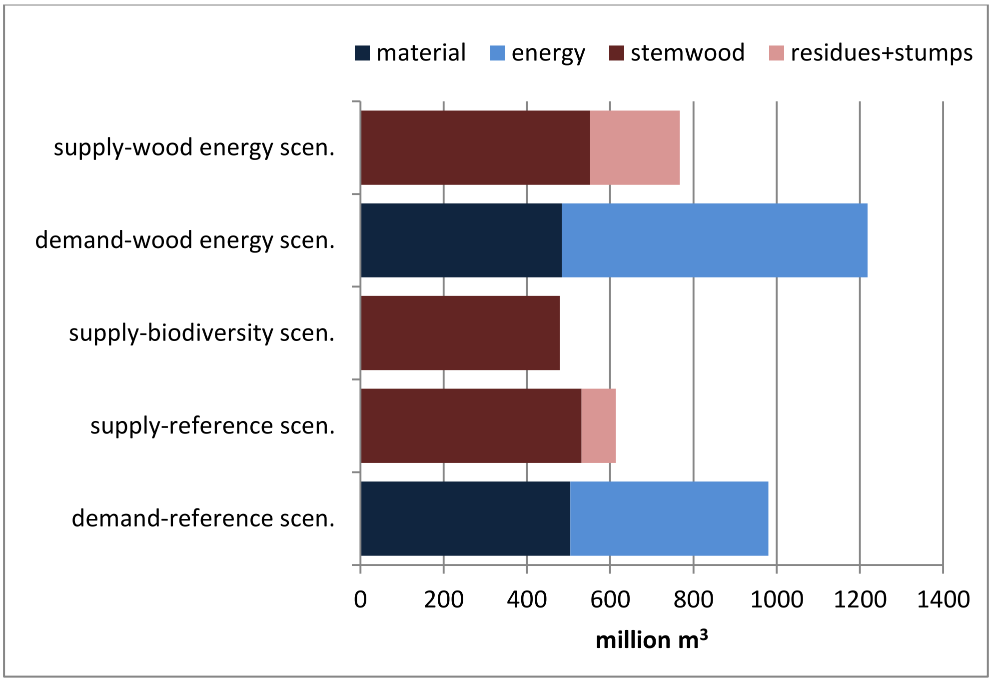
Source: UNECE and FAO, 2011

[151] The difference in carbon stocks between the reference and the biodiversity scenario is already significant in 2010 because the model runs were initialised with the latest available forest inventory data and due to technical constraints in the model, the rotation length had to be kept shorter for the complete simulation, ie. It was not possible to make the management adjustment only from the year 2010 onwards.
[152] FAWS = Forest available for wood supply

Demand versus supply: The projected supply of round wood is enough to satisfy the demand for wood for material use, except in the biodiversity scenario, where there is a small shortfall for round wood (five per cent of the demand cannot be covered). However, even when major efforts are undertaken to mobilise more wood, such as in the wood energy scenario, the supply is not enough to meet the projected demand for energy in 2030 (Figure 16). Depending on the scenario, a further 366 to 500 million m^3 of wood would be needed in the EU-27 in 2030 (the highest figures are for the 'biodiversity' scenario). This would need to come from other sources than the existing forest area, either through forest expansion, use of agricultural land for short rotation coppice or from imports from outside the EU.

Increases in forest area and relatively low felling to increment ratios led to significant increases in growing stocks of European forests over the last two decades. From 1990 to 2010, the average increase of growing stock was almost 250 million m^3 per year Average productivity of forests varies significantly in different parts of the EU and globally depending on bioclimatic factors. In the EU the annual increment can be as low as 2 m^3/ha/yr (Greece and Cyprus) to around 8 m^3/ha/yr (Austria, Germany, and Belgium). If an EU average of five m^3/ha/yr is taken (current average for the EU), the highest figure equates to 100 Mha (equivalent to 63 per cent of the current forest area in the EU).

Figure 16: Demand for wood versus supply according to the EFSOS II policy scenarios in 23 EU countries in 2030.



Source: UNECE and FAO, 2011

Discussion

Both mobilisation scenarios and the three policy scenarios are sustainable from a purely economic wood supply point of view, in that the projected level of supply can be maintained for at least 50 years. Furthermore, in all scenarios, areas which are at present (strictly) protected for conservation of biodiversity are maintained and not converted to forests available for wood supply. In addition, no changes in the species composition of forests are assumed, except for the biodiversity policy scenario. This means that, within the model, each type of forest is replaced by the same type of forest after final harvest and slower growing species are not replaced by faster growing species even in the high mobilisation scenario. Furthermore, it was assumed that the constraints or corrective measures (eg fertilisation) adopted would prevent site degradation which might otherwise result from intensive biomass harvesting, whether through loss of nutrients or by physical processes such as compaction or erosion.

However, high mobilisation of wood, including harvest residues and stumps, are likely to bring risks to biodiversity, nutrient cycles and possibly to the resilience of forest ecosystems as a whole. If a greater proportion of the forest biomass were to be harvested in the future compared to the present situation, there would be less deadwood left behind in the forest than at present, which may have negative impacts on forest biodiversity (Verkerk *et al*., 2011a; Hjältén *et al*., 2010), and carbon sequestration rates in forests would decrease (Mitchell *et al*. 2012). Extracting more wood also decreases the carbon storage in the forest, and it may also affect other (environmental) forest functions. In particular, the possible effects of stump extraction are still not well understood (Walmsley and Godbold, 2010) and these impacts need to be investigated further. Such high mobilisation may threaten the general balance between the different dimensions of sustainable forest management which prevailed around 2010 (UNECE/FAO, 2011b).

It should be noted that the policy scenarios reviewed (especially the bioenergy scenario) assumed relatively large contributions of woody biomass to the EU's 20 per cent 2020 renewable energy target. However, the effectiveness of using biomass to substitute fossil fuels and to implement climate protection targets has been questioned more recently (Haberl *et al*. 2012; Zanchi *et al*. 2012; Schulze *et al*. 2012). The capacity for forests to aid climate change mitigation efforts is substantial but will ultimately depend on their management (Mitchell *et al*. 2012; Bright *et al*. 2012). The carbon debt repay time can range from one year to more than 1,000 years depending on the previous land use and management cycles. As the effectiveness of substituting woody bioenergy for fossil fuels is highly dependent on the factors that determine bioenergy conversion efficiency (eg harvest, transport, and energy conversion technology) (Mitchell *et al*. 2012), how biomass is used in the renewable energy mix, and for what type of energy use is an important policy question.

Box 8: Wood supply and biodiversity

The maximum sustainable wood supply takes account of many 'constraints' linked to biodiversity and nature conservation: harvest only takes place on forest available for wood supply which excludes (part of) protected areas, no biomass residues harvesting from Natura 2000 areas or steep slopes, limited use of stumps, site specific restrictions on use of harvest residues etc. However, to achieve this potential from existing forests available for wood supply, it would be necessary to put in place a much more intensive management system: harvesting more trees, more often, with more parts of the tree, bringing unmanaged forest under management by mobilising private forest owners etc. This intensification would make it difficult to increase the biodiversity of Europe's forests, whether by increasing the areas protected for biodiversity conservation or by introducing more 'close to nature' silviculture. Perhaps more important, mobilising wood supply implies bringing forests under management which are hardly managed at all at present, and at least part of which are thereby becoming more and more attractive for biodiversity. There are many win-win solutions to this dilemma at the local level, with increasing levels of management to produce both wood and biodiversity, taking care of biodiversity hot spots, forest edges, species mix, timing of forest operations etc. Nevertheless, it would be naive to suppose that it is possible to expand both wood supply and biodiversity conservation indefinitely, so some trade-offs are inevitable.

At present most governments and forest managers are committed to the idea of multi-functional forest management, often implicitly assuming that all functions (wood supply, biodiversity, protection, recreation etc.) should be supplied from each forest stand, although the relative importance of the functions will vary between stands. An alternative approach is an increased segregation of forest functions, with some areas specialised in wood supply and other areas managed for high levels of biodiversity, intensive recreation and so on. This approach would make it possible to raise wood supply by converting certain forests into specialist, intensive wood supply regions, while others are specialised in biodiversity or recreation. Segregation does not necessarily lead to mono-functional forest systems. For example, there are good examples of plantation forestry with significant recreational use or biodiversity protection as well (Bauhus *et al*. 2010). The trend towards more segregation raises many issues, which should be discussed in a wide consultation of all stakeholders, as in many regions such a specialisation would represent a significant departure from present practice. However, it should be pointed out that the proposals to set up short rotation coppice on agricultural land do imply, de facto, the establishment of specialist, intensive wood supply 'forests' as the proposed short rotation coppicing methods leave little room for biodiversity and recreation.

Source: Mantau *et al*., 2010a

To mobilise the estimated potentials from forests, a significant increase in the labour workforce and machinery could be required. This could also be considered a positive impact of intensified biomass extraction, because it could lead to increased employment opportunities. The same holds true for the whole value chain ranging from the production of forest machines to the end use of biomass, ie, forest and energy industry. Furthermore, increased use of forest biomass could lead to additional revenues for forest owners.

There are several caveats and simplifications inherent in the EUWood and EFSOS II projections from which the data was taken for this analysis in this study. It is important to note that the quantified potentials under the different scenarios do not consider the costs of biomass extraction. Especially early thinnings and the extraction of harvest residues are not always cost-efficient under the current market price conditions and biomass mobilisation under such conditions would rely on subsidies or other incentives. Social factors are another major barrier to the mobilisation of the biomass, such as the fragmented ownership structure in certain regions, the increasing share of owners who are living far away from their properties with little interest in active forest management or the preference for other management objectives besides wood and biomass production. Both economic and social factors can be influenced by targeted policy measures and education, but it should be stressed that efforts to improve the mobilisation of underutilised forest resources have not always yielded the expected results[153]. Substantial improvements in such efforts would be necessary to achieve the targets of a high mobilisation scenario.

Structural changes in the forest industry may affect future wood demand for material use. If the demand for paper products were to decline, as discussed in chapter 4, this could lead to reduced production from the paper industry in Europe and subsequent smaller overall wood demand. Such changes were not considered in the underlying wood demand projections.

Another limitation of the EFSOS II resource use scenarios is the fact that climate change impacts were not considered in the resource projections. The nature, timing and regional distribution of climate change impacts remains still quite uncertain, but in future studies they would be important to include, at least to evaluate the potential uncertainties in the quantified biomass potentials and other ecosystem services.

The sustainability impacts of greatly intensified woody biomass utilisation, as assumed under the high mobilisation scenario of EUwood and EFSOS II need further investigation. The existing studies evaluated only the economic sustainability of timber supply. Other likely impacts eg on biodiversity, soil nutrient balances, water quality and future site productivity should be better understood and evaluated to contribute to more informed decision making.

The EUwood and EFSOS II scenarios underlined that, even with major efforts to mobilize more wood, projected demand for energy from woody biomass cannot be satisfied from the existing forest after 2020. To increase European wood supply from outside the existing forest sector, one option would be to establish short rotation coppice on agricultural land. This could significantly reduce the pressure on the existing European forest and help to build the share of renewables in energy supply, but at the cost of trade offs with other land uses, food production and, depending on site selection processes, landscape and biodiversity (UNECE/FAO, 2011).

[153] Conclusions and Recommendations of the Workshop on Strategies for increased mobilisation of wood resources from sustainable sources; 16 - 18 June 2009, Grenoble, France; http://www.unece.org/fileadmin/DAM/timber/meetings/Conclusions_and_Recommendations-20090630_Grenoble_workshop.pdf

5.2.2 *Future sustainable production potential in relation to agricultural land*

Chapter 4 has shown that demands for crops and livestock from agricultural land are changing, with the production of a range of feedstocks for bioenergy likely to grow in the future[154], and the demand for meat from grazed livestock such as beef and sheep declining substantially (although the demand for dairy is predicted to remain buoyant). What this means for agricultural land is contested and is very dependent on assumptions made regarding the key drivers of supply.

There is already a large environmental deficit associated with agricultural land use and this is likely to be exacerbated in the future as a result of climate change and other market pressures. The section explores the potential for agricultural land to meet future demands for food feed and bioenergy in way that also meets the EU's environmental objectives, considering the sustainability implications of first the potential technical and realisable yields that are predicted to be feasible from existing land, before examining the potential for bringing land that is currently not used for agricultural purposes (back) into production, should this be necessary.

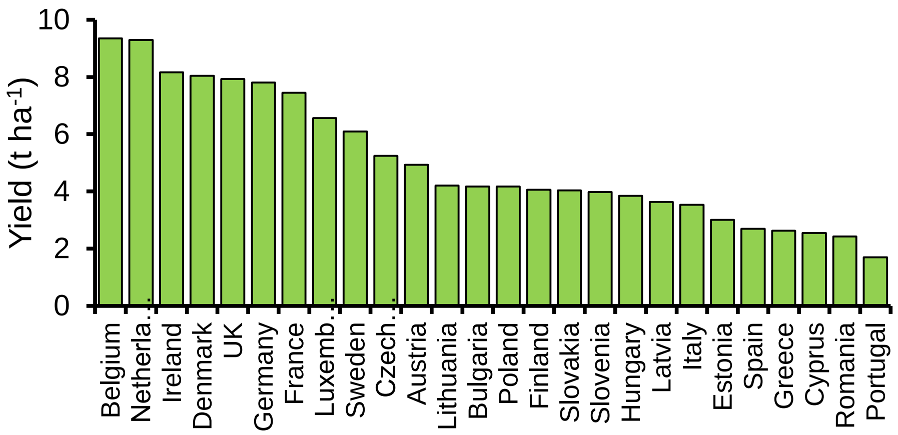
Potential for yield increases and implications for land use

Evidence suggests that many farms are operating well within their production possibilities frontier, implying that there may be considerable scope to improve overall efficiency of resource use by helping less efficient farms approach the standards of the more efficient (Groot *et al*., 2012; Kohlheb and Krausmann, 2009). However, there is a difference between what is thought to be technically feasible and what is realisable in practice, especially if sustainability considerations are taken into account.

Average yields for different crops vary considerably between Member States, with more northern and western Member States having higher yields than southern, central and eastern Member State (see Figure 17). Reasons for this vary and include bio-physical limiting factors such as terrain, soil quality or rainfall/water availability as well as the degree of technical development in the sector.

[154] If adopted in their current form, the recent Commission proposals to change the RED targets to take account of ILUC will have an impact on the feedstocks grown for bioenergy, although it is still unclear what the implications of this might be on EU land use. Some expansion in the area devoted to bioenergy crops, for example to introduce short rotation coppice, are still to be anticipated.

Figure 17: Mean wheat yield in selected EU countries in 2009



Source: Eurostat data

Over the past 40-50 years significant improvements in productivity have taken place, largely due to higher yields from crops and livestock as the result of genetic improvement in crops and animals and other technological developments, whilst there has been a steady reduction of the agricultural area. Eurostat data show that although average yields fluctuate year on year as a result of climatic events, there has been a steady increase in yields over a protracted time although the growth rate has declined since the 1990s. The projections for agricultural markets to 2020 currently assume an average annual growth rate of crop yields of 0.5 per cent (European Commission, 2012a). It is this improvement in yields which has allowed the slow reduction in the farmed and crop areas in the EU-27.

Attention is turning now towards the potential for sustainable intensification whereby agricultural output per hectare of land and environmental management simultaneously increase, requiring the use of technologies and practices which have a much lower negative environmental impact than is generally the case now (Royal Society, 2009; Foresight, 2011; Godfray *et al*, 2010).

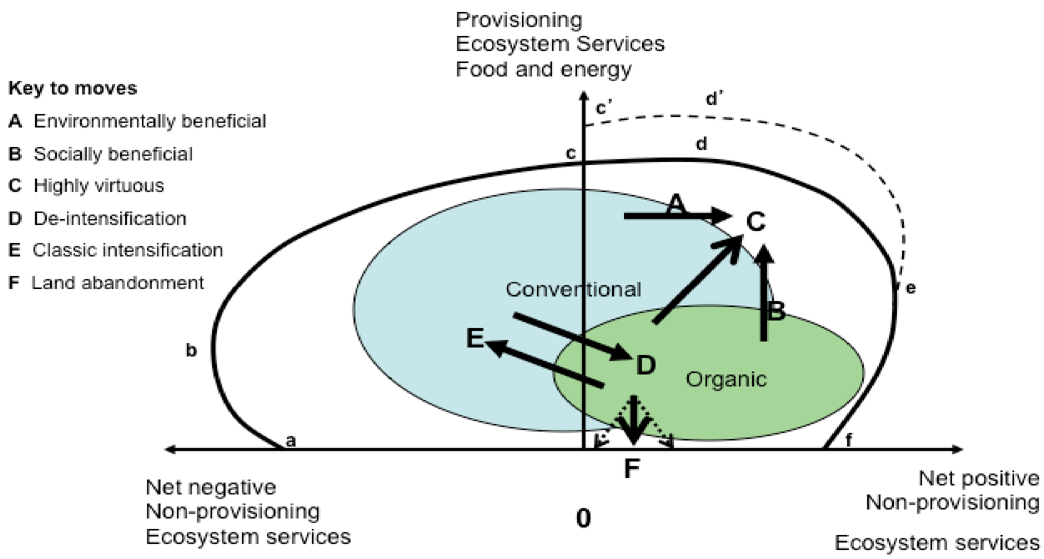
The challenge of sustainable intensification is depicted graphically in Figure 18 through the device of a production possibility frontier (PPF). The frontier (line a-b-c-d-e-f) shows, given the current state of technology, the maximum combinations of food and environment that can be produced[155]. The relative positions of the ovals depict the generally higher food output and lower environmental output of conventional farming. The concept of sustainable intensification is shown by moves A, B and C. New technology enables the PPF to move outwards. In the past the focus has been primarily to shift the frontier vertically upwards – focusing on increasing agricultural output, as illustrated in the figure by the shift to c'-d'-e. However, the concept of sustainable intensification is that, with more attention paid to research in environmental management and the delivery by farmers of environmental

[155] In conventional production economics, efficient production implies that all farms should be located on the frontier and in the sector of the PPF with negative slope, i.e. sector d – e, although in reality probably very few farms are.

services, it may be possible to shift the frontier to increase both agricultural and environmental outputs.

Another means of achieving an improvement in supply of environmental ecosystem services is illustrated is by de-intensifying production although generally this would also decrease food production to some extent[156], potentially requiring additional land to be brought into production. This is illustrated by move 'D' and interpreted in the diagram as the conversion of land to organic production. The past decade has seen the development of frameworks and models to ascertain the balance between intensifying land use and releasing land for other uses relative to maintaining extensive land use over the current area (Hodgson *et al*., 2010; Del Prado *et al*., 2011). These tools provide a means for farmers and land use planners to identify the relative benefit or cost of, for example, organic systems relative to other forms of production.

Figure 18: The food – environment production possibilities frontier



Source: Own compilation

Technical potential: The potential yield of a specific crop per hectare is determined by the site (e.g. climate, soil type, and topography), the crop system (e.g. plant species), and the level of management (eg input use). Most of the estimates of potential yields consider what is technically or economically feasible, without consideration of environmental constraints beyond the agro-climatic factors influencing production. A number of projections of potential crops yields in the EU have been carried out, although many do not take account of the full range of biophysical factors that constrain yields and as a result need to be

[156] For example, the evidence suggests that organic yields are on average 25% lower than yields from conventional farming, although there is wide variability depending on use of best practice methods, biophysical and climatic factors (Seufert *et al*, 2012)

treated with caution[157]. One such projection is based on the crop model ROIMPEL[158]. The model limits the development and growth of each crop by a number of factors (Table 15) but does not include specific environmental or management limits, such as a maximum level of nitrogen application or a minimum effect on nitrate leaching and does not include the effect of salinity, which is important in some areas.

Table 15: Factors affecting crop potentials used in ROIMPEL

Site or management factor	Description
Drought stress	If the soil water content is less than a specified amount, growth is reduced using a water deficit coefficient.
Aeration stress	If the soil water content is greater than a specified amount, growth is reduced by an moisture stress factor related to poor soil aeration
Nitrogen deficiency	A nitrogen model is used to describe soil nitrogen concentration. A nitrogen stress factor is implemented dependent on the nitrogen concentration, the nitrogen demand of the crop and the transpiration rate
Temperature stress	The model includes a minimum, optimum and maximum temperature for crop growth.
Photoperiod	Development of some crops (e.g. wheat) can be delayed by short days.
Workability	Soil workability (i.e. the capacity to sow or harvest a crop) without damage to soil structure is determined from soil water content.

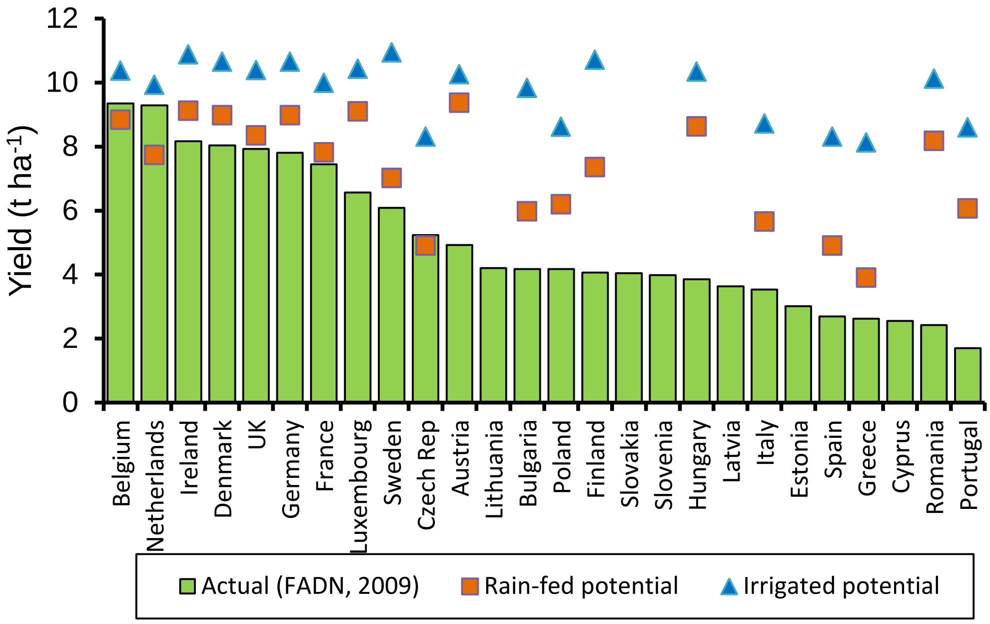
NB: Estimates of water and nitrogen deficiency are derived from information on the capacity of the soil to store and supply water and nutrients.

Accepting that environmental factors have not been taken into account, and the inherent issues of the representativeness of modelling results to the complexities of the real world, such analyses provide an indication of the scale of gap that theoretically exists in different parts of the EU between actual and potential yields. The example of winter wheat is shown in Figure 19, comparing actual yields for 2009, with potential yields under rainfed and irrigated conditions. This suggests that the current high yields of winter wheat in North West Europe (Belgium, Netherlands, Ireland, Denmark, UK, Germany, and France) are near their modelled rain-fed potential, ie the potential yield under mean rainfall conditions. By contrast, the data for Austria, Hungary, Romania and Portugal indicate that these countries may be able to increase yields by 4-6 t ha^{-1} without requiring irrigation. This analysis also suggests that wheat yields in excess of 8 t ha^{-1} are, on average, only possible in Italy, Spain, Greece, and Bulgaria with the addition of irrigation.

[157] For example, crop models typically overestimate cereal yields in areas of high rainfall because they do not address sufficiently the problems of cereal diseases.

[158] ROIMPEL model is a suite of crop models used in the ACCELERATES project (Audsley *et al*., 2006). In the ACCELERATES project it was used to establish the yield for 10 crops for spatially-related soil mapping units - Winter wheat, spring wheat, winter barley, spring barley, grass silage, potatoes, sunflower, cotton, winter oilseed rape, maize, soya beans and olives

Figure 19: Comparison of the actual mean wheat yield in 2009 with the potential rain-fed and irrigated winter wheat yield as predicted from an un-weighted analysis of the outputs from the ROIMPEL model



Source: Eurostat data

Potential yield figures have also been assessed for ten crops by Jaggard *et al* (2010), comparing average yield increases for the EU with other parts of the world. The yields and increase factors from 2007–2050 under the most conservative scenario[159] are shown in Table 16. This indicates that yields are expected to rise over the next four decades by between 20 and 80 per cent depending on the crop (equivalent of between 0.3-1 per cent per year). This scale of increase however, relies heavily on improved technology, including major changes in crop genetics, introducing novel or foreign genes that have yield impacts, as well as increased efforts to maintain soil fertility and control pests, diseases and weeds. This indicates that there is considerable potential to increase EU crop yields by mid-century but that the opportunities vary considerably between crops.

However, there are also considerable differences in the potential for yield increases in different parts of the EU, with the EU-12 still demonstrating considerable gaps between actual and potential yields, with key limiting factors being nutrient and water limitations in some places (Mueller *et al*, 2012), but also structural, financial and behavioural reasons (see below). The areas which are most likely to be able to realise improved yields (where these are technically feasible) will be those with least constraints (soil, water, temperature) as shown in in chapter 2.

[159] These calculations were based on the assumption that yield trends for each crop are modified to 70 per cent of their recent annual gain. Achievable yield was assumed to be 55–80% of potential yield and was assumed to increase by 10 per cent, stimulated by the extra demand for food.

Table 16: Predicted yields and increase factors for ten crops in the EU (2007-2050)

Crop	Average EU yield in 2050 (tonnes/ha)	Increase Factor
Wheat	8.4	1.51
Maize	9.9	1.42
Rice	8.4	1.3
Sorghum	8.0	1.37
Soya bean	5.0	1.64
Dry bean	2.7	1.8
Rapeseed	4.3	1.39
Sugar beet	79.5	1.39
Potato	40.9	1.58
Sunflower	2.0	1.2

Source: Jaggard *et al*, 2010

To consider the potential yields that might be associated with more environmentally sustainable systems that provide a better balance between provisioning and non provisioning ecosystem services, organic systems provide a useful comparator. Organic farming systems have evolved as a means of production that respects natural life-cycle systems and is therefore associated with enhanced environmental benefits when compared to conventionally managed systems. They also tend to be more resilient to stress situations, such as drought and high incidences of rainfall and are able to manage pest and diseases through the use of management techniques, such as crop rotations.

However, although organic farming practices generally have positive impacts on the environment per unit of area, for example higher soil organic matter content and lower nutrient losses, they generally have higher impacts per unit of production because their yields are lower (eg kilogramme of meat or tonne of wheat), although the results vary considerably across different farming systems (Tuomisto *et al*, 2012). To be viable, these systems also require higher prices to reflect the higher costs of production and in the EU both conversion and maintenance subsidies are available. Although energy requirements may be lower per product unit, greenhouse gas emissions and eutrophication potential are higher per product unit. Differences in yields between organic and conventional forms of production also vary depending on the organic techniques used and the crops being cultivated (see Box 9).

Box 9: Organic farming and yields

A recent innovation has been the development of frameworks and models to ascertain the balance between intensifying land use and release land for other uses relative to maintaining extensive land use such as organic farming over the current area (Hodgson *et al*., 2010; Del Prado *et al*., 2011). These tools provide a means for farmers and land use planners to identify the relative benefit or cost of, for example, organic systems relative to other forms of production. There would appear to be scope to use such tools in the assessment of new innovations and regulations

Organic farming systems are generally less productive than other systems in terms of the yields they produce per hectare. On average conventional farming methods produce 25 per cent higher yields than organic methods, although this differs depending on type of crop, soil type and the degree to which 'best practice' is carried out (Seufert *et al*, 2012; others). However, more recent research suggests that increased investment in research and innovation as well as training and advice to farmers on best practice organic management could significantly close the current yield gap. In addition, organic systems may also be more resilient to climate change impacts than some conventional systems, particularly water scarcity. It has been demonstrated also that the rate of carbon sequestration in organically managed soils are generally higher due to higher levels of soil organic matter (Gattinger *et al*, 2012). This indicates that organic systems provide a more sustainable resource base to underpin the long term productivity of agricultural land.

For example, a recent study reviewed 66 studies globally comparing yields of 34 crop types on organic and conventional farm (Seufert *et al*, 2012). This highlighted different yield ratios in different continents, with organic performance lower in the EU than in North America, for example, comparing farms with similar inputs. Indeed, a field trial undertaken in the United States over a period of 22 years found that organic farming produced the same wheat and soybean yields as non-organic farms, but used 30 per cent less energy, less water and no chemical synthetic pesticides (Pimentel *et al*, 2005).

The performance of organic farming systems varies across the type (eg fruits or vegetables) and species of crop (eg maize or barley). For example yields of organic fruits and oilseed crops are less than those for the same crop types grown conventionally but not to a significant degree (3 and 11 per cent less). In comparison, organic cereals and vegetables have significantly lower yields than their conventional counterparts (26 and 33 per cent less). Organic yields are lower in irrigated conditions (by 35 per cent compared to conventional systems) than in rain fed conditions (by 17 per cent). However, soils in organic systems have better water holding capacity and infiltration rates, therefore organic agriculture have higher yields than conventional systems under drought conditions and excessive rainfalls.

In addition, most studies under this review compare organic systems to commercial high-input systems which have predominantly above average yields. No study comparing organic to conventional subsistence farms was identified that could be included in the meta-analysis. Therefore, the claim that organic agriculture can increase yields in smallholder agriculture in regions with extensive systems cannot be either ruled out or supported convincingly (Seufert *et al*, 2012).

Assessing Realisable Potential: Despite these findings, there is a large gap between achievable yields and those realised in practice, even in the most efficient agricultural systems. This is inevitable and the result of a number of factors, including economic, technical, climatic, environmental and behavioural factors (see Table 17). Interpreting the impact of these different factors on agricultural potential is complex and is one of the reasons why there is limited reported analysis of the gaps between potential and actual yields across Europe, even though the necessary land cover maps and crop models exist (Temme and Verburg, 2011). Each of the factors is explored below.

Table 17: Factors influencing the gap between actual and potential yields

Factor	Examples
Temporal effects	The potential and actual yield may increase with time due to plant breeding and high carbon dioxide levels. Alternatively the potential and actual yield may increase or decrease with changes in the climate or changes in the constraints on crop management due to environmental limitations, ie soils, water, pollination etc.
Resource limitations	Maximum levels of production are typically achieved through effective use of the best current technology and knowledge. Low yields can result from a lack of access to agricultural equipment (perhaps due to small farm sizes) or knowledge (poor agricultural extension).
The financially optimum level of yield or of inputs is lower than expected	Growers may apply less than anticipated levels of input as a result of risk minimisation due to yield variability (for example due to inter-annual variations in rainfall). Alternatively there may be other constraints (e.g. organic standards, environmental regulation on maximum nitrogen applications).
Optimisation for other ecosystem services	Farmers may choose to constrain inputs and yields due to environmental regulation, or because of participation or interest in practices that promote non-provisioning services such as farmland birds or improved water quality.
Only a proportion of the harvestable crop is harvested	For annual crops this may be due to quality requirements. Grass yields are only financially realised if the grass is harvested or grazed. The situation is analogous to the harvesting of timber from woodlands
Inaccurate estimation of yield potential	The yield model may not accurately model the potential yield, because, for example, it ignores an important soil constraint.

Time-dependency – climate impacts and technological development: Potential crop yields are generally expected to increase as global carbon dioxide concentrations increases but the actual response will be location specific. In some parts of Europe, especially at low latitudes and altitudes, the positive effect will be outweighed by negative effects of higher temperature, greater drought stress, flood events and/or greater climate variability (Audsley *et al*., 2006) and their associated impacts on soil functionality. The frequency of droughts in some parts of Europe and flooding events in others has already increased. A UK study has shown that the photo-thermal quotient (radiation per unit of temperature- a basic physiological index of growth potential) during the cereal grain filling period has been consistently lower in the last 8 years than the average from 1961-1990, suggesting that climate change impacts may be starting to have an impact (NIAB TAG *et al*, 2012). Predicted increases in surface ozone concentrations are predicted to impact on yields, with decreases estimated from between 0.9 per cent and 11 per cent by 2030, relative to 2000 (Avnery *et al*., 2011).

Technological development has been a key mechanism for increasing crop yields. In relation to disease and pest control, this is an on-going continuous process as breeders, agronomists and agrochemical suppliers seek to remain one-step ahead of key disease and pest problems (Hollomon, 2012). Without the on-going development of new varieties or agrochemicals, yield potentials are likely to fall as diseases and pests gain resistance to current practices. Many of the estimates for potential yield increases are based on assumptions that, if prices remain high, where efficiencies in production remain to be made, this will take place and that there will be increased investment into technological innovations, such as improvements in crop genetics, cropping techniques and fertilisers and pesticides which will subsequently be translated into practice on the farm.

There remains a big question as to the extent to which any renewed investments in research will translate into increased crop yields. In many EU-15 countries, crop yields have actually declined or remained static over the past decade. There will be a number of reasons for this. Recent research has investigated some of the reasons for the apparent stagnation of crop yields for the UK, Denmark, and France (NIAB TAG *et al*, 2012; Petersen *et al*, 2010, Brisson *et al*., 2010). Partly this has been in response to policy changes and resulting lower prices in the late 1990s, early 2000s, and evidence suggests that growers may not yet be convinced that prices will stay higher in the coming decade than in the past, using surpluses from high prices on short-term investments such as machinery, rather than farm-system improvement or high yield innovations (NIAB TAG *et al*, 2012). Research in the UK has shown that the low prices of the previous decade led to significant cost cutting amongst farmers, which also had an impact on yields (for example larger tractors causing subsoil compaction) and this may take longer than has been anticipated to turn around (NIAB TAG *et al*, 2012) .

Resource limitations: High levels of production are achieved through effective use of the best available technology and knowledge. Some forms of technology, such as precision application of fertiliser and automated feeding systems, are expensive and are most easily justified on large farms or through machinery sharing and contract farming. The fragmentation of farms in Eastern Europe has been associated with an inability to justify investments in technology, thereby perpetuating lower yields (Burger, 2001). In turn this may also be linked to issues of land tenure. The development of partnership arrangements and the increased use of agricultural contractors are ways to address the issues associated with economies of scale (Morris and Burgess, 2012). Low yields may also result from a lack of knowledge, perhaps due to poor agricultural extension services.

Financial considerations/Risk Management: Climatic variations are likely also to influence farmer behaviour. Large gaps between actual and predicted potential crop yield may also be a result of deliberate decisions made by the farmer, balancing input costs against risks of crop failure. For example, financial decisions about the levels of inputs to use on a crop may be below those that would optimise yields as part of a strategy to minimise risks relating to variability in rainfall and drought (Reidsma *et al*., 2009). Climate variability may, therefore, have the effect of deterring farmers from investing in high input costs because the financial return is uncertain.

The more difficult it becomes to predict factors that cannot be controlled, such as weather patterns, the more difficult it will become to prevent crop losses. Farmers are constantly juggling their use of fertilisers, crop protection chemicals, investment in new machinery to try and cope with the uncertainties of weather, insect and fungal attacks and plant disease. Their risk management behaviour may therefore result in lower yields than those expected if these uncertainties were not present. The sheer variability of weather also means that farmers cannot access the land to perform operations at the ideal time if the land is too cold or dry to drill crops at the optimal time, or too wet to fertilise or harvest. These sorts of factors are rarely incorporated into crop models.

Environmental management: Lower yields than those that are predicted to be technically feasible may also result from restrictions placed on agricultural activities through environmental legislation such as the Nitrates Directive, the Water Framework Directive, the Habitats and Birds Directives and the Directive on the Sustainable Use of Pesticides and the GAEC standards as part of cross compliance. Although adherence to the requirements set out in this legislation may restrict yield growth for certain crops[160], it provides an important baseline to protect water quality, water availability, soil functionality as well as the state of habitats and species and should ensure that natural resources are managed in a way that improves the resilience of farming systems to future climatic pressures. The need to maintain soil carbon could also have important implications for land management, particularly for carbon rich soils used for arable production, with new management techniques needed to reduce carbon losses, perhaps through low tillage and no tillage systems. Where legislation is absent, the degraded state of natural resources (particularly soils and the availability of water) in many places will also place a constraint on yields and this will be exacerbated by climate change.

Gaps between actual and potential yield may also arise from a farmer choosing to optimise crop management for delivering environmental services alongside yield and financial returns to take account of the long term sustainability needs of his farm e.g. in terms of soil quality, pollination services etc. In addition to adhering to legislation and basic standards, farmers may also voluntarily participate or have an interest in practices that support other ecosystem services. For example farmers may enter into agri-environment schemes which encourage environmentally beneficial practices or organic certification or crop assurance schemes, which limit inputs. More research is needed on how to minimise any trade offs between management practices that are beneficial for the environment and yields. For example, evidence from Denmark suggests that an increase in use of reduced tillage systems has reduced grain yields (Petersen *et al*, 2010) and incorporating straw into the soil to improve soil organic matter has led to increased problems with pests in some wetter climates. Nonetheless, evidence from organic farming systems shows that such management does not need to result in significant yield reductions if suitable crops and management practices are carried out (see Box 9).

Harvesting practices: Actual yields may also be constrained by requirements for high quality outputs and/or harvesting practice. For example, in some circumstances the full crop area may not be harvested due to rainfall or disease. Similarly the benefits of a high grass yield are only realised if that grass is harvested or grazed. Other management practices that appear to be leading to reduced yields include the trend towards a higher proportion of winter wheat in crop rotations, increasing the frequency of wheat after wheat, which leads to an increased risk of yield losses due to soil-borne diseases (Petersen *et al*, 2010). This suggests that improved crop rotations may play an important role in increasing crop yields

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[160] Rules to restrict the use of nitrogen fertilisers in Denmark have been shown to have had an impact on yield growth, for example (Petersen *et al*, 2010).

by reducing the negative impacts of pests, as well as the recognised benefit of enhancing soil fertility.

Knowledge transfer: Research has shown that there are large differences in crop yields between farmers, even between those who have used the same resources (Jaggard *et al*, 2010). More knowledge-intense farming, for example to allow the application of inputs much more precisely according to field conditions based on accurate soil testing and mapping and GPS technology, may simultaneously improve both food production and environmental production efficiency.

Modelled future changes in land use to 2030/2050

A range of modelling exercises have been undertaken over the past ten years which have sought to investigate agricultural land use dynamics, both globally and for the EU, associated with a range of future scenarios to 2030 or 2050. Given the focus of this study, those for the EU-27 have been reviewed and the findings examined (see Table 18).

Many of the modelling exercises use a scenario approach, based on an internally-coherent set of assumptions regarding factors such as socio-economic development, the degree of focus on sustainability, and climate change. Four of the modelling exercises (ATEAM: Rounsevell *et al*, 2005; ACCELERATES: Audsley *et al*., 2006; UK Agricultural Futures: Morris *et al*., 2005; EURALIS: Verburg *et al* 2006 and Eickhout and Prins, 2008) use a similar scenario approach comprising of two axes. One axis focuses on the degree of international trade ranging from effective free-trade to a high level of regional protectionism. In general a greater level of trade (and the associated ability for each country globally to focus on those products which can it produce most cheaply and/or effectively) results in greater increases in agricultural productivity and lower food prices. The other axis focuses on the degree to which environmental sustainability in embedded in international and national plans, ranging from minimal focus to a strong environment and equity focus. In general a greater focus on environmental sustainability constrains the increase in agricultural productivity, and hence it reduces the potential release of agricultural land. None of the models take full account of the need to clear the current environmental deficit in the projections.

However, because each study has its own specific objectives, the scenarios are based on different assumptions, which make the results difficult to compare. In a number of the models, bioenergy production is not included within the calculations, so the results relate to the area needed to meet predicted demands for food and feed and any predicted decline in area required for these purposes is theoretically available to be used for other purposes, such as bioenergy production. In reality of course this may not be the case. For land to be used for bioenergy production, the bioenergy production system must make economic sense to the farmer and not all land identified will be suitable either agronomically or environmentally.

The key assumptions that affect the modelling results are yield growth projections and the extent to which the EU's import/export balance is predicted to change over time. For yield projections, a very wide variance is seen (from 0.2 per cent per year to 2 per cent per year). For those studies that have considered the EU-27 rather than just the EU-15, there are different assumptions made for the EU-15 and EU-12, with one assuming accelerated annual yield increases for the EU-12 as they catch up with their EU-15 counterparts (Fischer *et al*, 2010a) and another assuming that yield increases in the EU-12 would remain similar to or below those in the EU-15 (Eickhout and Prins, 2008). These figures compare with DG Agri/OECD estimates to 2020 of an average annual increase in crop yields of 0.5 per cent (European Commission, 2012a). As seen in the previous section, the degree to which these projections are likely to be realised in practice remains unclear and in most cases the assumptions are likely to be overestimates.

In most of the models, the prices for commodities remain above the average of the past decade for the foreseeable future. This is in keeping with the projections identified by OECD, FAO and DG Agriculture to 2020. However, how these higher prices translate into changes in the EU's import/export balance in relation to different commodities with other parts of the world is less clear. In at least one case (Fischer *et al*, 2007 and 2010b) no allowance seems to be made for EU imports to drop or for the EU to switch to a net export position under continued higher prices to 2050. This is an important assumption which heavily influences the results because it assumes that there will be no increased supply response to higher demands for food or feed from other parts of the world, such as China. This is disputed by some, who argue that higher prices will lead to the most competitive producers seeking to increase production to meet such demands. In fact, in the EURuralis study higher levels of exports, driven by increased global demand for food, minimises the amount of land that becomes available for other purposes (Eickhout and Prins 2008).

The results of the scenarios vary widely and suggest that, depending on the scenario and assumptions made, between two per cent to over 50 per cent of UAA could cease to be required for food and feed production between now and 2030/2050. The higher proportions of land that are estimated to be 'surplus' to meeting demands in 2030/2050 tend be the function of world market, high production scenarios, with high yield growth estimates, few constraints on production and do not include estimates for the area of land needed for bioenergy production or take account of the need to address environmental issues. These sorts of scenario predictions must be treated with extreme caution. They are unlikely to transpire in practice and compare with a decrease in the area of agricultural land in the EU-27 of 14 per cent over the past 40 years (FAO Stat).

For the purposes of this study, the most relevant results are related to those scenarios that are more environmentally oriented[161]. These scenarios also vary greatly and inevitably proxies are used to provide some level of protection of the environment. For example, in most scenarios, protected areas are not subjected to any changes as they are assumed to be protected from land use change by regulation. Other assumptions include the continuation of set-aside as a proxy for environmental management within cropped areas (REFUEL); greater areas under organic production (ATEAM; REFUEL); greater protection afforded to grassland – either through assumed continuation of LFA payments (EURuralis) or through assumptions that grassland is not used for bioenergy production (REFUEL).

[161] For example: environment scenario in REFUEL; Regional Environmental world from ATEAM; Local Stewardship from ACCELERATES; Continental Markets from EURuralis; Sustainability scenario from Biomass Futures.

The outputs of the environmentally-oriented scenarios tend to show agricultural land declining at a much lower rate in the future for two main reasons. Firstly lower yield increases per hectare are predicted on the basis that there will be lower levels of fertilisers and pesticides used, either through the imposition of limits or through increased extensive or organic production methods, as well as a lower uptake of technological development. Secondly the constraints placed on the use of grassland for biodiversity, carbon and other environmental reasons mean that in some scenarios this leads to less land becoming available for uses outside food and feed production (Elbersen *et al*, 2012; Fischer *et al*, 2010) or in other scenarios, it simply protects a greater proportion of land from intensification or changes in land use from grass to arable.

For example, some estimates under environmental or sustainability scenarios predict areas in the region of 17 million hectares or nine per cent of UAA (Elbersen *et al*, 2012) and 37.5 million hectares (22.4 million hectares of cropland and 15.1 million hectares of pasture) (Fischer *et al*, 2010) no longer being required for food and feed production by 2030 as a result of market forces and the implementation of current policies. This land would, according to these studies, then be available for bioenergy production. The many attempts to calculate the area of land in the EU required to meet future demand for bioenergy are no less variable (see Table 18). One of the many assumptions explaining the variation in estimates is that relating to the volumes of imported biofuels or feedstocks.

In contrast, the Local Stewardship scenario under the ACCELERATES project, which takes account of all agricultural land use (including bioenergy production) estimates that the area of farmed land would need to increase by four per cent by 2050 to address all the demands from land, although this figure is only for the EU-15 and is affected by the fact that many EU-15 Member States already have high yields with less room for increases in the future. Studies focussed on estimating the impacts of EU renewable energy policy targets on land use also provide quite large differences in projections, from an overall decline in the EU arable area of 6.5 per cent (Blanco Fonseca *et al*, 2010), to net increases in agricultural land from as low as 105,000 – 118,000 hectares (Laborde, 2011) to larger increases of 2.7 or 3.2 million hectares (with and without by-products) (Tahenipour *et al*, 2010).

None of the models incorporate environmental management across all EU farmland, even at the level proposed as the new 'green measures' proposed for Pillar 1 of the CAP. While the CAPRI model takes account of the protection of permanent pasture at a regional level as part of cross compliance, no models assume the proposed maintenance of 95 per cent of permanent pasture at the farm level, nor do they consider the effects of the proposals for a seven per cent Ecological Focus Area (EFA). The Commission's own impact assessment suggests that the EFA proposals would be likely to take approximately three per cent of arable land out of production to be managed for environmental purposes (the remainder being made up of existing features). Factoring these assumptions into the models could change the results somewhat, although given that the land used to contribute to the EFA is likely to be the lowest yielding land, the effect on production will be much lower than the proportion of land taken out of production.

These modelling exercises serve to demonstrate the large variance in the estimates of the likely technical potential of EU rural land to meet future demands for provisioning services alongside other ecosystem services in the future. Most studies suggest that predicted continued yield increases will relieve the pressure on land to deliver more provisioning services without needing to bring greater areas of land into production, although the projections of the area of land needed for bioenergy remain uncertain and not all models have taken account of the predicted impacts of climate change on productivity.

However, what none of the models can do is quantify the real implications for production of putting in place the types of management needed to meet the EU's environmental objectives (see Chapter 4). This is not surprising, as the ways in which these environmental objectives can be met are very varied and different combinations of management will be appropriate in different parts of the EU. However, this means that these modelling outputs need to be interpreted with considerable caution as none of the outputs reviewed provide a thorough analysis of future agricultural production potential that is truly sustainable or what is realisable in practice.

The models also only take account of land use for production in the EU for consumption within the EU or for export. They do not account for the land used to grow food, feed or energy crops for import into the EU and as such only provide a partial picture of the land footprint required to meet demand. Given that the EU is a net importer of many raw materials, any overall assessment of increasing the production potential of EU land sustainably, needs to acknowledge the potential environmental impacts of consumption of products imported to the EU. This is considered further in Chapter 7.

If the need to ensure the sustainable use of natural resources and healthy ecosystems is taken into account as well the implications of climate change, the pressures on rural land in the coming decades become much more apparent. This relates both to pressures on arable land to increase yields and tensions between the use of crops to be used for food, feed, bioenergy and biomaterials as well as pressures on grassland, particularly extensive grassland which is likely to become increasingly unprofitable as the market for grazed livestock weakens in the face of cheaper imports from outside the EU.

Table 18: Examples of modelled estimates of changes in EU agricultural land use to 2020, 2030 or 2050.

Model/Study and Timeframe	Scale	Key focus; key scenarios and assumptions							Key results	
ATEAM 2000 to 2050 Rounsevell *et al*, 2005	EU-15, Switzerland& Norway	**Scenarios: impacts on agricultural production and land use of four socio-economic scenarios and associated climate change**	**Increase in demand for cropland products**	**Increase in demand for grassland products**	**Effect of climate on crop yield**	**Effect of CO_2 on crop yield**	**Annual technological development: Crop yield/yr**	**Annual technological development: Animal yield/yr**	**Results: change in cropland area[a]**	**Results: change in grassland area[a]**
		A1: Global economic world + A1F1 climate	+51%	-23%	-8%	+16%	+1.3%	+0.6%	-28%	-36%
		A2: Regional economic world + A2 climate	+31%	-33%	-3%	+13%	+1.2%	+0.5%	-36%	-46%
		B1: Global environmental world + B1 climate	+39%	-33%	-2%	+9%	+1.0%	+0.4%	-15%	-9%
		B2: Regional environmental world + B2 climate	+9%	-33%	-2%	+11%	+0.5%	+0.35%	-13%	-38%
		Key assumptions: a greater demand for crops and a smaller decline in grassland-derived products was assumed with free trade scenarios (A1 & A2). Whilst high greenhouse gas emissions result in a negative effect of temperature and rainfall on crop yields, this is outweighed by the positive effects of higher carbon dioxide emissions. Lower rates of yield increase due to lower rates of technological development are assumed for the environmental scenarios (B1 & B2), due in to measures to promote extensification and organic production. A lower level of "oversupply" (-10%) was also assumed for crop production in A1 and A2. [a]: results are interpolated from a figure presented for 2000-2080. **Key results**: based on the assumptions, potentially large areas could be released from agricultural production by 2050. The greatest land release is predicted for free trade scenarios (A1, A2) primarily because of the high rates of technological development. In B1 and B2, it is assumed that the released land will remain in production but be used for bio-energy production. Large regional differences in land use change occur with the A1 scenario, with large declines in agricultural area in Spain, Portugal and Greece. The results are sensitive to the assumed change in demand for products.								
ACCELERATES 2000 to 2050 Audsley *et al*, 2006	EU-15	**Scenarios: impacts on agricultural production and land use of four socio-economic scenarios and associated climate change.**	**Annual increase in crop yield**	**Increase in production over 50 years: Crop**	**Increase in production over 50 years: Animal**	**Results: change in area of intensive agriculture**				
		A1: World market + A1F1 climate	+2.0%	+350%	-50%	-28%				
		A2: Regional enterprise + A2 climate	+1.2%	+100%	+170%	-1%				
		B1: Global sustainability + B1 climate	+1.2%	+80%	+150%	+2%				
		B2: Local stewardship + B2 climate	+0.2%	+50%	-30%	+4%				
		Key assumptions: The modelling procedure predicted the effects of climate change on yields and land use and prices were then modified to achieve current levels of production.								

		Key results: Global warming in the A1 scenario was predicted to bring substantial new areas into crop production in Finland (+12.4-15.8 million ha). By contrast low profitability of meat and dairy production was predicted to result in a halving of livestock products, and a substantial release of agricultural land. For the other scenarios, the release of agricultural land was minimal.

		Scenarios: effects of global demands and EU policies on land use impacts on agricultural production	**Approximate increase in crop yields in EU15 (2001-2030)[b]**	**Approximate annual growth of total crop production[b]**	**Approximate annual growth rate of livestock production[b]**	**Result: Proportion of agricultural land abandoned**	**Results: Change in agricultural area[b]**
EU RURALIS 2000 to 2030 Verburg *et al*, 2006; 2010; Eickhout *et al*, 2007 ; van Meijl *et al*, 2006 ; Eickhout & Prins, 2008	EU-27	A1: Global economy	30%	0.7 to 0.9%	0.9%	4.4%	-9% to -3%
		A2: Continental markets	10%	0.6 to 0.7%	0.5%	2.2%	-2% to +1%
		B1: Global co-operation	17%	0.5 to 0.7%	0.1 to 0.7%	6.7%	-12 % to -10%
		B2: Regional communities	4%	0.1 to 0.4%	-0.2 to 0.3%	5.9%	-11%
		Key assumptions: [b]: Values derived from graphs from Eickhout *et al* 2007, van Meijl *et al* 2006, and Eickhout & Prins, 2008 A study sponsored by the Dutch Ministry of Agriculture. The global economy scenario assumes removal of single farm payments and less favoured area payments by 2030. Scenarios A1 and A2 place no restrictions on urban development. Meat consumption is assumed by 10% lower in the B1 and B2 scenarios than the A1 and A2 scenarios. Real agricultural prices assumed to decline between 25-40% over the period 2000 to 2030. The increases in crop productivity (EU15) over 30 years range from about 4% (B2) to 30% (A1). The increase in crop productivity in the new states (EU12) was generally assumed to be equal or lower than in the EU15. **Key results**: EU27 export levels tend to be greatest in A2 and A1, and the increase in the global demand for food (in line with greater global GDP growth) is greatest in A1 and B1. Hence the greatest demand for land occurs under the A2 scenario, and little or no land is predicted to become available. Although the level of productivity increase in B2 is low, lower levels of international demand and exports tend to result in higher levels of land being abandoned. A spatial analysis showed reductions in agricultural land were greatest in marginal mountainous areas and in densely-populated areas.					

		Scenarios: effect of four socio-economic scenarios on lowland agricultural land use	**Change in technical efficiency during period**	**Annual change in technical efficiency**	**Proportional change in self-sufficiency**	**Result: Proportional change in land use for agriculture**
UK Agricultural Futures 2002 to 2050 Morris *et al* 2005 (UK study)	UK (England & Wales)	Business as usual	+19%	+0.35%	+6%	-20%
		A1: World markets	+34%	+0.6%	-3%	-34%
		A2: National enterprise	+39%	+0.7%	+26%	-18%
		B1: Global sustainability	+12%	+0.25%	+8%	-2%
		B2: Local stewardship	-7%	-0.15%	+23%	-0%
		Key assumptions: The results shown for this study focused on lowland England and Wales assume no bioenergy crops. The effect of climate change was included in a qualitative way. The Business as usual scenario assumes agricultural support continues as in 2002. The world market scenario assumes market-driven free trade. The National enterprise scenario assumed protected markets and a low level of environmental				

<table>
<tr><td></td><td></td><td colspan="5">regulation. Global sustainability is market driven but includes strict environmental regulations. Local stewardship comprises locally defined schemes.
Key results: The proportional release of land is primarily driven by the assumed annual increase in technical efficiency and any change in self-sufficiency.</td></tr>
<tr><td rowspan="6">**REFUEL**
2030
Fischer *et al, 2007, 2010b*</td><td rowspan="6">EU-27</td><td>**Scenarios: impacts on agricultural production of a base-line and three socio-economic scenarios**</td><td>**Annual increase in crop yield in the EU15**</td><td>**Proportion of utilisation agricultural area allocated to organic production**</td><td>**Result: Change in area of cultivated land**</td><td>**Result: Change in area of pasture**</td></tr>
<tr><td>Baseline</td><td>+0.2-0.5%</td><td>+7%</td><td>-24%</td><td>-23%</td></tr>
<tr><td>High productivity growth</td><td>+0.9%</td><td>+7%</td><td>-31%</td><td>-27%</td></tr>
<tr><td>Environment</td><td>+0.2-0.5%</td><td>+12%</td><td>-17%</td><td>-23%</td></tr>
<tr><td>High energy</td><td>+0.2-0.5%</td><td>+7%</td><td>-24%</td><td>-23%</td></tr>
<tr><td colspan="5">**Key assumptions**: The level of self sufficiency in the EU for crop and livestock products was assumed to stay constant. The annual crop yield increase in the new member states (EU12) was assumed to reach 80% of EU-15 values by 2030 equivalent to annual yield increases of about 2%. The analysis did not include any predicted effect of climate change on yields. In line with the conclusions of Searle and Malins (2012) it was assumed that arable bioenergy crops would not be cultivated on existing pasture land because of the resulting loss in soil carbon. The Environment scenario also assumes the continuation of set-aside and that no crop residues are used for bioenergy production.
Key results: The assumption of high yield increases, particularly in Eastern Europe, results in the potential to release a substantial area of land from crop and grassland production. Most of this occurs in Romania, Poland, Bulgaria, and Hungary. Higher levels of environmental regulation were assumed to restrict the increase in crop yields and hence reduce the release of land from cultivation</td></tr>
<tr><td rowspan="5">**CAPRI & Dyna-CLUE**
2020
(Renwick *et al* 2013)</td><td rowspan="5">EU-27</td><td>**Scenarios: three trade liberalisation scenarios**</td><td>**Change in cereal production**</td><td>**Change in meat production**</td><td>**Result: Change in area of arable land**</td><td>**Result: Change in area of pasture land**</td></tr>
<tr><td>Removal of all pillar 1 payments</td><td>-1.2%</td><td>-1.2%</td><td>-6.5%</td><td>-10.4</td></tr>
<tr><td>Trade liberalisation based on WTO (2008) proposals</td><td>-0.3%</td><td>-1.1%</td><td>-0.2%</td><td>-0.1%</td></tr>
<tr><td>Combination of the above</td><td>-3.3%</td><td>-2.3%</td><td>-7.1%</td><td>-10.7%</td></tr>
<tr><td colspan="5">**Key assumptions**: A land use study for the UK Department of the Environment using the CAPRI model and the Dyna-CLUE land allocation model.
Key results: Overall the study indicated that the removal of all pillar 1 payments would result in 10% of the currently utilised agricultural area in the EU27 will be released from agricultural use by 2020. Olive (area decrease of 19%) and sheep and goat production (area decrease of 25%) were particularly affected. The decline in the area of arable land was low in the UK and Spain (-2%) and large in Poland (10%) and Greece (13%). Renwick *et al* suggests that market liberalisation would increase economic efficiency and provide environmental benefits such as reduced greenhouse emissions and reduced nitrate loading.</td></tr>
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<tr><td rowspan="4">Biomass Futures 2030 (Elbersen et al., 2012)</td><td rowspan="4">EU-27</td><td>Scenarios: impacts of biofuel standards on the area of land used for bioenergy production</td><td>Release of good agricultural land</td><td>Release of good quality land unsuitable for sustainable biofuel production</td><td>Release of low quality land</td><td>Result: Proportional release of agricultural land</td></tr>
<tr><td>Reference</td><td>5.1 Mha</td><td>Not applicable</td><td>13.7 Mha</td><td>-10% (18.7 Mha)</td></tr>
<tr><td>Imposition of biofuel GHG mitigation standards</td><td>4.0 Mha</td><td>2.6 Mha</td><td>9.5 Mha</td><td>-8.6% (16.1 Mha)</td></tr>
<tr><td colspan="5">Key assumptions: it is assumed that dedicated cropping for bioenergy cropping with perennials only takes place on land not needed for food, feed or crop-based biofuel production. The imposition of biofuel greenhouse gas emission standards reduces the amount of land suitable for biofuel production by about half because of the need for biofuel from crops to meet a greenhouse gas mitigation target of 70-80%. Proportional changes based on an EU agricultural area of 187 million ha
Key results: the Biomass Futures study predicts the release of about 18.7 million ha of agricultural land (about 10% of the total), potentially for bio-energy production, by 2020</td></tr>
<tr><td>Land Use Change Consequences of European Biofuel Policies MIRAGE-Biof (Laborde 2011) ‘IFPRI study’ 2020</td><td>Global</td><td colspan="2">Key focus: Impacts of mandated EU biofuel use as predicted in NREAPs (National Renewable Energy Action Plans). Alternative policy scenarios one with status quo trade policy and one with full trade liberalisation (focus here on scenario without trade liberalisation)
Key assumptions:
Yield projections taken from 2010 Aglink-Cosimo baseline used in DG AGRI’s Agricultural Outlook (see Laborde, 2011, p35 for details; EU average wheat yield of 8 ton/ha by 2020 called ‘strongly optimistic’).
Biofuel policies/use: fixed 2008 consumption in the EU in the baseline; 35% ethanol blending in Brazil; full implementation of US biofuel policies; 5% mandate by 2020 in China, Indonesia and Malaysia, and the rest of the OECD in both scenarios.
EU 2020 biofuel use: 27.2 Mtoe in policy compared to 11.7 Mtoe in baseline (+15.5 Mtoe) (EU policy 2008-2020 use: +17 Mtoe)

Key baseline results:
Crop land under the baseline scenario for 2008-2020: Global: +3.6% (or +442,000 km^2), EU: -1.7%</td><td colspan="3">Key policy scenario results:
Out of this, EU biofuel production is 20.9 Mtoe in 2020 (without trade liberalisation), giving an import share of 23%.

Cropland in 2020:
EU biofuel policy is estimated to lead to global additional cropland in 2020 ‘policy’ compared to 2020 ‘baseline’ of +1.73 or +1.87 Mha (the latter under full trade liberalisation).

EU additional cropland represents under 6% of global cropland extension and less than 0.15% of EU cropland. In absolute terms. The additional effect on land requirements in the EU27 in 2020 ‘policy’ compared to 2020 ‘baseline’ is +105,000 or +118,000 ha (Figure 7 in Laborde, 2011).

EU crop land under the policy scenario for 2008-2020: ~ -1.6%
(own calculation using 2007 EU cropland figure of 1,156,943 km^2)</td></tr>
</table>

GTAP-BIO, Taheripour *et al* (2010), 2015	Global	**Key focus**: Investigating the agricultural sector impacts of simultaneous EU and US biofuel policies in scenarios with and without by-products. **Key assumptions:** ***Biofuel policies***: US 15 billion gallon and EU 6.25% mandate in 2015; Brazil included as biofuel producer. ***Yield projections:*** Not evident from the paper. Yield assumptions are inherent to the construction of the GTAP agro-ecological zones (AEZ), the land use module employed in the paper Lee *et al* (2009) explain that AEZs are constructed using inter *alia data* on harvested land cover and yields from Monfreda *et al* (2008a, 2008b). Looking at the Monfreda *et al* (2008a) data shows very low yields for an aggregate region 'Europe and Former USSR' of eg 3.0 ton/ha for cereals. It is unclear what the assumptions are in GTAP-AEZ and its applications about yield development over time.	**Key results**: Cropland changes in the presence of US and EU biofuel mandates (reported changes are over 2006-2015): Global cropland change: +15.6 Mha without and +12.3 Mha with by-products. **EU cropland change**: +3.2 Mha without and +2.7 Mha with by-products **Per crop area changes**: EU coarse-grains area: -0.5 Mha (-1.5%) without and -2.3 Mha (-6.7%) with by-products EU oilseeds area: +35.8 Mha (+5.1%) without and +39.1 Mha (+5.6%) with by-products EU other-grains area: -0.1 Mha (-0.4%) without and +0.2 Mha (+0.6%) with by-products
AGLINK-COSIMO, Blanco Fonseca *et al* (2010), 2020	Global	**Key focus**: Investigating the agricultural sector impacts of EU biofuel policy **Key assumptions:** ***Biofuel policies/use***: EU 10% mandate in 2020 (2nd generation, modelled as non land using, contribute 30%, implying a 7% 1st-generation share due to double counting); global use accounted for (existing and announced policies modelled in all scenarios). EU 2020 biofuel use: 33 Mtoe in policy compared to 4.9 Mtoe in policy 'off' (+28.1 Mtoe) (EU policy 2008-2020 use: +22.4 Mtoe). The increase in biofuel use between policy 'on' and 'off' is considerably higher than in Laborde (2011).	**Key results:** ***Trade in biofuels***: In the policy scenario in 2020, 16% and 14% of EU demand for ethanol and biodiesel, respectively, are imported. Also raw materials are imported leading to a 'more than 2.5-fold surge in net ***vegetable oil*** imports from 5.5 to 20 million tonnes' (p35). ***Coarse grains***: slightly increased production accounts for a third of higher 2020 consumption, EU turns into net importer; ***wheat***: EU remains a strong exporter but exports are around a third lower in 2020 policy scenario as roughly half of higher demand for wheat is met by imports (p36). ***Changes in cereal, oilseed and sugar crop area in 2020 policy 'on' vs policy 'off'***: EU: +2.2% (sugar beet and oilseed area with highest % increases) World: +0.7% Slight decline in EU pasture area of -0.9% due to increases in cereals, oilseeds and

		Yield projections: Aglink-COSIMO, see p58 for a table on yields. Comparing this to the Laborde (2011) yields, while not entirely straight forward due to different aggregation, Laborde (2011) yields seem to be higher in 2020, most strikingly EU27 wheat yield of 8 t/ha vs 6.3t/ha here. **Model-specific features AGLINK-COSIMO**: EU267 disaggregated into two blocks only; biofuel production modelled in a few number of countries; by-products included (DDG and oil meals).	sugar beet area. ***Changes in cereal, oilseed and sugar crop area over 2008-2020***: EU policy 'off': -8.6% vs EU policy 'on': -6.5% World policy 'off': +2.6% vs World policy 'on': +3.4%

Likely land use changes and issues of sustainability

The evidence suggests that if demands for environmental ecosystem services are to be addressed alongside those for agricultural commodities, then historic declines of agricultural land will need to be reduced significantly. The uncertainties surrounding the likely rate of productivity growth in agriculture, the impacts that changes in EU renewable policy could have on the supply of bioenergy feedstocks, the unpredictability of climate change impacts, and the degree to which changes in commodity prices might encourage and increase in the EU's production of cereals for food and feed to meet demand from outside the EU means that to meet the demands for all ecosystem services agricultural land may even have to increase slightly in the future. This would have implications for those land uses which are predicted to expand at the expense of agricultural land (forest and built development).

However, examining the overall capacity of EU land to meet future demands at the EU-27 level inevitably masks the pressures that face particular land uses in different geographic locations. Patterns of land use and changes in land cover will take place locally to address geographically specific demands and pressures. These could include: changes in land cover between grassland and arable, with extensively managed and semi-natural habitats subject to increased pressure to become cultivated or agriculturally improved; the possible return to use of fallow or semi-abandoned land; as well as changes in the intensity of management or type of cropping - from highly intensive use at one extreme to partial or complete abandonment at the other. All of these changes will have impacts on the local provision of ecosystem services. Examples in recent years include the conversion of grassland to arable for maize production as a bioenergy feedstock in Northern Germany, or the loss of extensive arable and grassland systems of High Nature Value either through increased fertiliser inputs, loss of natural features and higher stocking densities or through their abandonment due to their lack of financial viability.

If progress is made in achieving sustainable intensification in practice, then there will be more scope both to satisfy the EU's demands for provisioning services and non-provisioning services from existing land. However, if there were to be an expansion in the area dedicated to organic farming or other extensive forms of agriculture, then equally this might require a greater area of land, given the lower yields from these sorts of systems. Both of these scenarios are likely to occur but in what combination it is impossible to predict.

Equally, the effects of climate change and increased carbon dioxide concentrations are likely to alter the location of different land uses – for example arable production is anticipated to become less viable in southern Europe and shift northwards over time and indeed this shift is already becoming evident (EEA, 2012d). However, the future magnitude of such shifts is unclear and will depend on the flexibility of land use systems to respond to such drivers and that the potential increases are not negated by the effects of extreme weather events.

In considering the potential land use changes that might occur and their environmental implications, cultivated land and grassland should be considered separately as their dynamics in future decades looks quite different.

Cultivated land: Although the overall area of arable land for the EU-27 is predicted to remain stable, in reality there will continue to be significant shifts of land in and out of cultivation. For growth in demand for cereals to be met sustainably and if yield increases are lower than anticipated, it would seem likely that additional agricultural land would be needed for crop production, including SRC, than would otherwise be the case. If demand for cultivated land for the production of food, feed and bioenergy were to exceed the existing area available in a given region the most likely land covers that would be brought into cultivation, if profitable, would be existing fallow land, grassland or even natural/semi-natural habitats not currently in agricultural use**Error! Reference source not found.**. This is already the case in more productive regions, both to increase the production of bioenergy feedstocks and to increase the area of feed crops for livestock, particularly dairy cows. The degree to which previously abandoned land is brought back into production, however, will depend very much on its location and the reasons why it was abandoned originally (Keenleyside and Tucker, 2010).

Any ploughing of land that is currently not cultivated will have some negative environmental impacts, first and foremost through the release of carbon stored in the soils and vegetation into the atmosphere, but also potentially increasing the loss of soil organic matter or soil erosion, leading to increased run off of fertilisers and pesticides into water courses. Where fallow or semi-natural habitats and features are cultivated, these will also have serious impacts on biodiversity. Chapter 3 shows the importance of different land covers for delivering a range of ecosystem services. Fallow land and patches of semi-natural habitat within arable farming systems are extremely important from an environmental point of view and are elements of the arable landscape that have been lost over the past decades. Those that remain therefore are often the last vestiges of habitat for biodiversity in an otherwise sterile environment and any further loss of fallow land and semi-natural habitats and features from the farmed environment would have serious environmental consequences (see for example: Hodge *et al,*2006; IEEP 2008; Poláková *et al*, 2011).

Any ploughing of semi-natural grassland, fallow land, patches of semi-natural habitat or landscape features to increase the production potential of provisioning services from agricultural land could not therefore be seen as sustainable given the significant pressure placed on biodiversity, regulating and cultural ecosystem services in the majority of cultivated landscapes. Cultivating intensive grassland which is regularly fertilised, ploughed and reseeded may have less of an environmental impact however, especially from a biodiversity perspective as such habitats are associated much less frequently with high biodiversity value. However their carbon storage value will be reduced and there would also be impacts on soil quality and potential water quality issues depending on factors such as soil type and slope. In particular, the cultivation of soils with high carbon content, such as peatlands, would have extremely negative impacts on soil carbon and the release of CO_2 into the atmosphere. Indeed cross-compliance, the proposed new green direct payments and agri-environment schemes are being used actively to promote the maintenance of and increase in the area of fallow land and semi-natural habitats / features within the arable landscape and to prevent the ploughing of carbon rich soils. These sorts of measures will remain critical to guard against localised pressures for environmentally damaging land use change in the future.

Grassland: Demand for meat from livestock that are grazed, rather than housed, is predicted to decline over the coming decades with the exception of dairy and therefore there is unlikely to be significant pressures to increase the overall area of grassland to deliver provisioning services. Indeed, the trend is rather one of decline with serious negative implications for the environment. In the future, the issue for grassland, particularly extensive semi-natural grassland of High Nature Value, will be to prevent its loss, either through abandonment, agricultural improvement or conversion for other purposes, such as arable, forestry or built development. This will be critical also to improve the protection of currently uncultivated carbon rich soils (peatlands and many areas of permanent grassland) by preventing them being drained or ploughed[162].

Bringing abandoned land back into production: It has been suggested that land that is currently abandoned or subject to minimum cultivation offers an opportunity to increase crop production by bringing it back into use, for example for bioenergy production. The environmental implications of this are likely to be damaging environmentally unless the land use chosen were extensive grazing. Many of the soils concerned are relatively fragile or on steep slopes and if crop cultivation were required, water supplies may need to be augmented and infrastructure expanded to secure reasonable yields. Clearance of natural vegetation often will have negative biodiversity impacts, although if the land had been abandoned recently, there may be additional biodiversity gains from removing some scrub by re-introducing livestock grazing. As a result, the environmentally sustainable potential of such land is in fact much less than the area of apparently available.

Discussion

Given the fact that environmental services are already undersupplied on agricultural land and that the pressures facing them are likely to be increased in the future as a result of climate change and other market pressures, meeting predicted future demands for food feed and bioenergy in way that also meets the EU's environmental objectives is set to remain a challenge for the foreseeable future. How much of a challenge is unclear, however, and depends on the future trajectory of a range of factors including yield growth, future market prices, adoption of technological advances and climate impacts.

Unlike for forestry there is no one modelling exercise that considers the implications on agricultural land use of meeting future demands for agricultural commodities and environmental ecosystem services. Instead models have focused on potentials for increasing agricultural productivity but without considering the environmental implications in any depth. In part this is because of the complex nature and geographic specificity of the ways in which land is managed in different farming systems, the spectrum of intensities of land use and their relationship with the delivery of different environmental services from biodiversity to carbon storage to water quality and availability. This makes it difficult to model likely outcomes with any degree of accuracy.

During the past 40 years, increases in agricultural productivity have allowed countries in the EU to expand areas dedicated to urban development, afforestation, and conservation, whilst at the same time increasing or maintaining levels of agricultural production. Models of future land use developed before 2007 have generally assumed more of the same, i.e.

[162] Protection for carbon rich soils is proposed as a new standard of Good Agricultural and Environment Condition (GAEC 7) as part of the CAP Reform proposals for cross compliance.

there is a presumption that agricultural productivity in Europe will continue to increase steadily against a backdrop of static or declining demand for crops and livestock for food and feed, resulting in the release of land for urbanisation, forestry, conservation, and even biofuel production.

However, the evidence suggests that increases in yields per hectare, for cereal crops, have remained static or declined over the past decade in some countries in Western Europe, but could start to increase again given sufficient investment in research and development and technology/knowledge transfer to farmers. Nonetheless yields in the EU-15 are much nearer their modelled potential than in Eastern Europe. Here, cereal yields and crop inputs declined following the demise of planned economies, although they are beginning to increase slowly again, although what is realisable in practice is often nowhere near what is technically feasible due to a range of economic, technical, climatic, environmental and behavioural factors.

Increasingly attention is turning to the opportunities offered by sustainable intensification to increase yields and provide direct environmental benefits. This will be an important means of improving the sustainability of rural land use in core productive areas. Some technological innovations already exist that could be more widely adopted (e.g. precision use of fertiliser, pesticides and animal feed), although they tend to be financially attractive mainly to larger farm businesses currently. Continuing to develop new means of achieving sustainable intensification alongside a much greater investment in capacity building and advice should help with uptake of such techniques, but appropriate options are needed for all farm sizes and structures. However to achieve a balanced provision of ecosystem services, it will also be important to find ways of maintaining or even increasing the area of land that are managed more extensively, such as through organic farming. In these systems, yields are typically lower than in conventional systems, but given the continued potential for yield increases in some parts of Europe (particularly Eastern Europe) there may still be capacity to expand the area under organic farming or other environmentally benign forms of agriculture while still meeting future demands for food, feed and bioenergy.

Although increasing yields may help resolve some of the tensions and pressures facing arable areas and should avoid the need to increase the area of cultivated land significantly, it will not necessarily resolve the pressures facing grassland, particularly areas of extensive grazing. These pressures are largely economic and land will continue to be converted to other land uses or abandoned unless there is sufficient policy support to maintain them for their public good value. The significant value of these sorts of HNV farming systems for the environment should be more full recognised and promoted as part of an overall strategy for improving the sustainability and resilience of rural land in the future and should not be eclipsed by the current political and research emphasis on sustainable intensification.

5.3 Strategies for sustainable production in the EU

If demands for all ecosystem services are to be met in a balanced way, then environmental services need to be prioritised and not subjugated to food, feed, timber and bioenergy demands at present levels. Although it may not be possible to deliver all demands for all ecosystem services in all places, it will be important to pursue these goals in parallel and recognise that the sustainable management of land is key to ensuring its long term productive capacity, improving its resilience and allowing it to adapt to the impacts of climate change in the longer term.

Compared to the past 40 years, we are entering an era of new uncertainties affecting land use at a European and global level with the bioenergy dimension adding to agricultural supply side questions and the unpredictability arising from climate change. In particular, three areas of uncertainty can be highlighted that could change the nature and sustainability of the production response to future demands. These are: (i) the implications of climate change on land use; (ii) the extent to which land will be used for the production of biomass for bioenergy and other bio-based materials, given emerging research on the extent of climate benefits of current supply chains and an evolving policy context; and (iii) whether or not global energy prices and world agricultural commodity prices are raised and expected to persist further above their current high levels.

In estimating future sustainable production potential, three points are worth noting. First, the starting point in Europe is already unsustainable as there is a significant imbalance in the provision of commodities and environmental goods and services from agricultural and forest land, with the undersupply predominantly on the side of the environment. This means that current land use would need to change significantly to me*et al*l current ecosystem service demands, l*et al*one those in the future, with variations according to the agricultural or forestry system as well as its geographic location.

Second is the issue of scale. Given competing demands it is unrealistic for a perfect equilibrium of all ecosystem services to be achieved at the scale of the individual holding or unit, however desirable this may be. Nonetheless, it will be essential to have not less than a certain floor level of environmental services on all farm and forest land to prevent any further environmental degradation. Action to clear the current deficit and meet future demands will also require concerted action on most parcels of land, not just a few. Beyond this, however, consideration must be given to the scale at which it is necessary to seek an equilibrium so that no ecosystem service is undermined and falls beneath a particular threshold. This may be within a particular agro-climatic zone, landscape unit, watershed or region. Debates on land sharing versus land sparing are relevant here.

Third, the efficiency of resource use varies considerably as a result of the fragmented, spatially diffuse and decentralised nature of land management in Europe and the huge range in skills, knowledge, motivation, regulatory framework and institutional settings for land management. The impact of these human and policy factors, therefore, is an important consideration that has to be taken into account in any discussion about the future production potential of land.

The projections reviewed in this chapter suggest that there is still considerable potential to increase commodity outputs from existing land, but that to do so in a sustainable way will require far more attention to be paid to the environmental management of agricultural and forest areas. In some cases this will impact upon yields, at least in the short term, but in other areas there is still significant capacity to adjust environmental management to reduce environmental pressures without having a significant impact on yields.

However, looking at the future production potential of rural land at the EU scale masks significant differences in local pressures and likely responses. For example, there are likely to be changes in the location of production over time as a result of climatic as well as economic developments. Land uses can be expected to evolve, generally towards more intensively managed systems in productive areas facing fewer production constraints. Localised abandonment of land is also anticipated in more extensively managed, less accessible areas with greater natural constraints.

For **forestry**, the models used in this study suggest that to meet the increased demands for timber sustainably, there is the potential to increase extraction rates from existing forests to a much greater extent than is currently the case. However, even with higher extraction rates, a far greater volume of timber is needed than is available from the current managed forest area, even taking into account a small increase in the forest area over time. This means that either a greater proportion of the EU's rural land area needs to be converted to forest, or there needs to be significant expansion of SRC on agricultural land or a greater proportion of woody biomass will need to be imported from outside the EU. However, future forest expansion in the EU will in future start to compete with the need to constrain declines in agricultural land necessary to meet increased demands for bioenergy feedstocks as well as improving the provision of environmental services from farming.

For **agriculture**, there continues to be some potential to increase crop yields sustainably, especially in the EU-12, although the extent of the increases that are likely to be feasible without further depleting natural resources, particularly water, is far more limited. There is significant potential to improve the environmental performance of farms and the evidence suggests that this need not have a significant impact on output per hectare under the right conditions. These include the choice of appropriate crop types and use of management techniques that improve soil functionality, reduce the incidence of pests and disease, creating more resilient systems at points of stress (eg droughts, high rainfall), or by leaving the less productive areas of land for wildlife. There may also be opportunities to bring back some areas of land that have been recently abandoned. Often such areas will be appropriate only for extensive grazing because of the negative impact of cultivation on environmental services.

Nevertheless, historic declines of agricultural land will need to be reduced significantly and may even have to increase slightly in the future to deliver the range of ecosystem services required. This would have implications for those land uses which are predicted to expand at the expense of agricultural land, particularly forest and built development.

Consequently, alongside significant increases in output from existing agricultural and forest areas, there are also likely to be tensions between different land uses in the future. Greater restrictions may need to be put in place, therefore, to limit the area of land that is built upon and more attention paid to guiding the extent and location of shifts between agricultural and forestry land uses.

To resolve such tensions requires a more coherent and strategic approach for sustainable land use to be developed, in the EU and at other levels of governance. This is considered further in Chapters 8 and 9.

6 LOCAL LAND USE DYNAMICS IN DIFFERENT PARTS OF THE EU

Key findings:

- Options for increasing production potential vary geographically, depending on a range of bio-geographic, climatic, economic, social and political factors. In some situations substantial improvements to environmental services can be made simply by changing aspects of land management, in others complete changes in land use may be needed.
- Increases in the provision of crops or timber nearly always require some sort of trade-off with environmental services, unless the increases in yields can be brought about through neutral changes in management, crop variety, livestock breeds or improved technology.
- When nested within a coherent EU strategy, regionally differentiated approaches are likely to be more effective than a blanket approach. Unwelcome trade-offs can be minimised through more sophisticated decision-making and well-informed local assessments.
- Scale is an important factor in balancing the provision of different ecosystem services from rural land. Approaches that might be untenable at a European scale could be appropriate in a specific locality and *vice versa*.
- The impacts of decisions regarding land management also need to take account of impacts at the wider territorial scale.

This chapter illustrates the different types of ecosystem services provided from rural land in four different geographical situations across the EU. Using quantitative and qualitative data, the synergies and trade-offs between ecosystem services in these areas are explored and the implications of different choices that are made at the local or regional level in the face of competing pressures and demands are considered.

These case studies attempt also to demonstrate the optimal or sub-optimal use of rural land in different situations. However, determining what optimal or sub-optimal means in practice, particularly in quantitative terms, is challenging. One of the key findings of the case studies is that the interactions of rural land vary within and between land uses and at a range of different scales. The relative ability of rural land to support ecosystem services can vary at the individual holding or field level. The analysis provided here provides some insights into the relative trade-offs between services in a given locality.

The four case study areas (North Karelia in Finland, Catalonia in Spain, the Great Plains of Hungary and Wales in the United Kingdom) are discussed in turn.

6.1 Provision of forest-based products and services in North Karelia, Finland

This case study examines the potential to increase production of forest biomass to meet demands from regional and national renewable energy targets. The synergies and trade-offs between different ecosystem services are considered, focussing in particular on the harvesting of woody biomass in relation to biodiversity protection and carbon sequestration.

6.1.1 Introduction and context

North Karelia is Finland's fourth largest and easternmost region covering 2.16 million hectares (National Land Survey of Finland, 2012). The average population density of 0.09 people per hectare is significantly below the EU27 average (1.12 people per hectare). The majority of the population is concentrated in and near the town of Joensuu, the region's capital (Statistics Finland, 2012). North Karelia has a continental subarctic or boreal climate characterised by severe winters and short and cool summers. The mean annual precipitation is 650-700 mm and is distributed uniformly around the year. The majority falls as snow and covers the area for 175-200 days per year (Finnish Meteorological Institute, 2012).

The natural vegetation of North Karelia is dominated by boreal mixed-forest and the area lies in the southern and middle boreal vegetation zone (Ahti *et al,* 1968). Around 73 per cent (1.59 Mha) of North Karelia is covered by forests[163] and 18 per cent by water (Finnish Forest Research Institute, 2010; National Land Survey of Finland, 2012). Around 55 per cent of the forests in the region are privately owned, with an average size of 32.4ha, with most between 20 and 50 ha (Finnish Forest Research Institute, 2011). Given its northern latitude the daylight duration ranges from five hours in mid-winter to 20 hours in mid-summer, which, combined with the prevailing climatic conditions, has significant impacts on timber and crop production. The area of agricultural land in North Karelia is estimated at only four per cent of the region (85,711 ha)[164] (Tike, 2010).

[163] Of this area, 1,446,000ha was classified as forest land, 56,000ha as low productivity forest land and 71,000ha as unproductive land. Of the unproductive land, 53,000ha can be classified as treeless mires (Finnish Forest Research Institute, 2010).

[164] Including cultivated areas and fallow, temporary and permanent grass meadows, permanent horticultural crops, greenhouse and kitchen garden cultivation and uncultivated areas (Tike, 2010).

6.1.2 Demands on rural land in North Karelia

The key demands for ecosystem services from rural land in North Karelia are primarily associated with forests and forest management. Timber production and wood products are an important element of the region's economy. Demand for bioenergy (from woody biomass) is significant, driven largely by policy targets to reduce the region's reliance on fossil fuels[165]. However, the demand for woody biomass is not considered in isolation to all other ecosystem services. The North Karelian forests are home to a wide range of biodiversity, have important regulatory functions for water, soil and carbon stocks as well as being important landscapes providing foraging resources and recreational space. Recreational use of forests is expected to increase in future years as ecotourism and adventure tourism take a more significant role in the region's economy. There is a societal demand for biodiversity, partly driven by ecotourism but also by policy drivers such as the targets for the EU Biodiversity Strategy. The environment is highly valued by the local population and continues to feature as significant demand.

6.1.3 Ecosystem services from rural land in North Karelia, Finland

A full description of the volume and type of ecosystem services provided by rural land in North Karelia can be found in Annex 7. This covers both agricultural land use as well as forestry and includes a list of limiting factors. In this section we focus on the land use that supports the key demands from rural land in the case study area, forestry.

The area covered by forest and other wooded land in North Karelia has slowly increased in the past sixty years and is classified into three categories based on the potential for wood production[166]. Since 1951, the average wood productivity of forests under management in North Karelia has increased[167]. This has been mainly a result of intensified management[168], drainage of less productive forests and peatlands and further afforestation on peatlands. The annual increment, in particular for Pine (*Pinus spp.*) in North Karelian forests has been generally higher than the average drain[169], which has remained stable.

On average the annual volume of wood available[170] for wood supply per hectare of all forest land in the region is 3.2 m^3/ha of commercial round wood, 0.3 m^3/ha of fuel wood, 0.2 m^3/ha of harvest residues and 0.1 m^3/ha of stumps (see Table 17 Annex 7). The net annual increment in North Karelian forests available for wood supply is high (5.8 m^3/ha) compared to that of the rest of Finland (4.6 m^3/ha) and the EU (4.7 m^3/ha) with the main limiting

[165] The North Karelian Climate and Energy Programme has set the target to become an oil free region (for heating and power generation) by 2020 (Regional Council of North Karelia, 2009).

[166] Forest land is land where the potential mean annual increment of wood exceeds 1 m^3/ha/yr. Low productivity forest land is land with a potential mean annual increment between 0.1 - 1m^3/ha/yr and unproductive land has a mean annual increment less than 0.1m^3/ha/yr.

[167] Productive *forestland* has increased by 18 per cent (to 1.44 Mha), *low productivity forest land* decreased by 77 per cent (to 56,000 ha) and *unproductive land* decreased by 40 per cent (to 71,000 ha).

[168] Such as regular thinning, fertilisation, the use of biocides (banned, but used in the 1960s) and removal of broadleaved trees with little or no economical value such as aspen, willow and rowan.

[169] Annual increment = the volume of wood that grows each year; Annual Drain = the volume of wood and timber harvested or lost through natural mortality

[170] The term available refers to the allowable harvest, ie what is in theory possible within sustainability limits. Most years it is the same as the actual harvest.

factors relating to soil quality and length of the growing season (Forest Europe *et al,* 2011). The felling rate (fellings as percentage of net annual increment) in this region is around 60 per cent, which is quite low compared to other regions in Europe and also compared to the situation in 1990, when this ratio was over 80 per cent in Finland. The current average felling rate in Northern Europe is 70 per cent and for the whole EU-27 it is 64 per cent.

North Karelia is one of the forerunners in the use of renewable energy in both Finland and Europe with 38 per cent of woody biomass used for heat and power generation (Regional Council of North Karelia, 2011; UNECE, 2012). Small diameter trees from thinnings are used as firewood in households or as wood chips to be used in heating and power plants. Harvest residues and stumps from final felling are also increasingly used for energy. Industrial chips, sawdust and bark are side products from the forest industry and their use for energy depends on the production of the sawmilling and pulp industry and the demand for wood and forest-fibre products. Currently, forest chips, produced from small trees, harvest residues and stumps, are the fastest growing source of bioenergy in the region[171].

North Karelian forests act as a significant net sink for carbon. The carbon stock in trees is estimated to be around 4.06 kg/m^3 (40 tonnes/ha) and the annual uptake around 0.28 tonnes/ha/yr) (Liski *et al,* 2006). In national inventories ground-layer vegetation, soil and litter are described as a carbon sink but this has not been evaluated regionally. Peatlands[172] are also an important carbon stock and play a significant role in carbon cycles, acting both as a source or sink of carbon, depending on their management. Draining for agricultural or forest use leads to a loss of carbon from peatlands (Regional Council of North Karelia, 2009; Maljanen *et al*, 2007).

Changes in the forest environment, such as a reduction in the amount of dead wood, are the primary cause of threat for a large number of species (Rassi *et al,* 2010)[173]. The volumes of dead wood in forests today are only a small fraction of the amount in the early 1950s[174]. North Karelia has witnessed a decrease in fallen dead wood[175] but an increase in standing dead wood as a result of leaving green-retention trees[176] after harvesting (den Herder M*, pers comm*). Protected forest areas contain around twice the amount of dead wood (12.5 m^3 per hectare) compared to other forest areas. However, even in these areas this is very little compared to old-growth forests in their natural state where the amount of decaying wood is significant (20-120 m^3 per hectare) (Siitonen, 2001).

[171] Industrial side products (eg sawdust and bark) are used for energy production by the paper industry with everything else being utilised for making paper. Harvest residues, small trees and stumps were previously underutilised, but are now used in power plants to heat public buildings and private houses.

[172] Including those under woodlands, shrublands, treeless mires or wetlands with peat soils.

[173] Biodiversity in northern Scandinavian forests is often measured using the proxy of available deadwood, as a source of habitat for a variety of taxa including wood-decaying (Saproxylic) beetles and fungi, epiphytes and cavity-nesting birds and mammals (Jonsson and Kruys, 2001).

[174] www.biodiversity.fi

[175] When taking into account all forest and scrub land. Reductions in fallen deadwood are probably due to more intensive forest management resulting in lower natural mortality rates or the efficient removal of timber following recent (significant) storm damage (den Herder *pers comm.* 2012)

[176] Trees left in otherwise clear-cut areas to provide refuges for forest species and improve structural heterogeneity in forest stands. In Finland these can often be old or decaying trees, which are particularly important for Saproxylic invertebrates (Junninen *et al,* 2007)

Forests in North Karelia are important for recreation. Nature tourism has expanded in recent years and with the decline in traditional forms of livelihood linked to primary production it has become an important aspect of regional development in eastern Finland (Kolström *et al,* 2007). Nature tourism has opened up new ways of combining nature conservation and economic activities. Visits made to forest areas outside national parks are also significant.

6.1.4 Synergies and trade-offs between ecosystem services in North Karelia

To help inform decisions on how to balance the different demands on forestland in the region, three different scenarios[177] were explored by regional stakeholders[178] to demonstrate the relative trade-offs and synergies associated with the production of woody biomass and other environmental services. The scenarios illustrate the potential to extract greater amounts of woody biomass from the existing forest area, either by harvesting more of the net annual increment across the entire forest stand[179] or by intensifying forest management in certain areas. However, only the biodiversity and the combined scenarios did not cause significant negative impacts on other ecosystem services. Quantified results from these scenarios can be seen in Table 19.

The *bioenergy scenario*[180] was defined by the stakeholders in a way to improve the economic performance of biomass utilisation. As the most cost-effective biomass resource for energy comes from harvest residues, the scenario included a change to the management of the forest stand towards a longer rotation, which is expected to result in better quality and higher value timber (for timber products), and an increase in harvest residue volumes (tops and branches) that could be used for energy production. This change in management is predicted to result in an increased use of stumps, residues and fuel wood of $0.1m^3$/ha/yr and an increase in timber extraction of $1.5m^3$/ha/yr. Taken as a whole this has the potential to increase biomass extraction by 48 per cent[181]. It should be noted that t extension of the rotation length is feasible in this region because of the low felling rates over the past two decades. In many other regions in Europe it would not be possible to simultaneously increase biomass extraction and extending rotation lengths.

Despite being seen as sustainable in economic supply terms, trade-offs with other ecosystem services were evident. The total proportion of old forest would decrease from four per cent to 2.8 per cent and there are expected to be negative impacts on biodiversity from reduced deadwood and a reduction in small mammal numbers. Water and soil run off rates are predicted to increase and there is expected to be an increase in the amount of carbon lost from the forest system, both from soils and above ground biomass. Despite the increase in woody biomass feedstock to meet energy production targets, the loss of carbon

[177] The three scenarios were a bio-energy scenario, a biodiversity scenario and a combined scenario
[178] Including scientists, forest managers and owners, regional and national decision makers, the forest industry and nature conservation organisations.
[179] All three scenarios are a comparison to current (2009) production approaches, or business as usual, with average annual values presented to avoid complications with cumulative increments and temporal changes.
[180] Extraction of wood and by-products to meet biomass energy targets
[181] The extended rotation periods might also have the potential to improve biodiversity in the forests, but there was limited information on which to make this assessment in the scenario.

may impact on the overall ability of North Karelian forests to aid in the reduction of GHG emissions and improve carbon sequestration, particularly if significant quantities of tree stumps are extracted (see for example Wihersaari, 2005)[182]. This scenario shows some of the potential trade-offs that take place when provisioning services are prioritised over regulating and cultural services across the whole forest.

Under the *biodiversity scenario* the total output of woody biomass is expected to remain the same or marginally increase. This is achieved by expanding the area of forest devoted to nature conservation from seven to 12 per cent[183] whilst increasing the harvesting intensity of wood and woody biomass in the remaining forest area. An overall net gain in regulating and cultural services is anticipated from this type of approach. These gains are expected to come from the protected forest area, illustrated by the projected increase in old forest from four to just under five per cent by 2029. However, where there are gains to certain environmental services within the protected forest area, there are likely to be losses to biodiversity and other regulating services from those areas under more intense management. Clear trade-offs are also expected with provisioning services in the protected forest areas, as the overall timber production does not increase. This scenario shows the potential to increase the supply of regulating and cultural services without reducing current production, provisioning and market driven services[184]. However, the net gains and trade-offs between services need to take into account the actual changes under the different management systems in different parts of the forest.

A *combined scenario* was also explored to see if it was possible to meet both bioenergy targets, which require an increase in biomass extracted from forests, whilst also increasing conservation efforts. In this scenario, rotation periods were extended to improve tree size and the volume of side products generated, harvesting levels were increased, while at the same time the share of protected forests was increased from seven to 12 per cent of the forest area. As a result total wood output was increased by 43 per cent[185] with harvesting levels still below the net annual increment and the percentage of protected forest remains below EU- average. Recreation visits were predicted to increase but trade-offs are still seen with other services such as carbon retention, run-off rates and the share of old forests, which remain unchanged. This scenario demonstrates that when both energy and environmental services are prioritised together the net gains across both service types are lower than if either is prioritised individually.

[182] The Climate and Energy programme of North Karelia has set as a target to be an oil free region (in heating and power generation) by 2020 (Regional Council of North Karelia, 2009). This target has prompted an increase in the use of forest biomass for energy, supported by the North Karelian Forest Programme, which contains targets and guidelines for forest use in the near future. According to these programmes, harvesting levels for roundwood and bioenergy will increase in the near future while at the same time management will be focussed more on the multiple-use functions of the forest (North Karelian Forestry Centre, 2011).

[183] Which still remains below the EU average of ~19 per cent (MCPFE classes 1.1, 1.2, 1.3 and 2). It is also recognized that simply increasing the protected area will not necessarily result in gains in biodiversity.

[184] This result was also favoured by the low felling rate of 60 per cent in 2010. In regions with more intensive harvest pressure this would likely be more difficult to achieve.

[185] An increase of $0.1m^3$/ha/yr for stumps, and fuel wood, $0.2m^3$/ha/yr for residues and an increase in timber extraction of $1.6m^3$/ha/yr

Across all scenarios it is also important to consider the increase or decrease of different ecosystem services in relation to the demands for these services and their current supply. For example, despite the introduction of relatively successful regulatory measures and restoration projects, biodiversity protection in the region is not yet sufficient to ensure the overall preservation of biodiversity (Kolström *et al,* 2007). Therefore in the bioenergy scenario, the decline in biodiversity indicators[186] is exacerbating the current undersupply. Even if these indicators were to remain stable in comparison to the current situation, this would still not help to increase the supply of these services.

Realising the projections under these different scenarios is heavily dependent on the motivations and decisions taken by forest owners. A significant proportion of forests in North Karelia are privately owned (55 per cent) with a further 21 per cent owned by commercial organisations. The sizes of the holdings in private ownership are relatively small, which places economic limits on the types of products that are grown, harvested and sold. For example with these kinds of small holdings it may be attractive to sell saw logs (around €40-60/m^3) and maybe even pulpwood (around €14/m^3) but the returns for bioenergy feedstock are relatively low (small-diameter trees €2-5/m^3, residues €0.50/m^3, and no financial reward for stumps). Despite such low returns for bioenergy feedstock the removal of stumps, residues and thinnings can be beneficial for the regeneration and improvement in the quality of the forest stand[187]. The removal of stumps and residues makes the preparation of the harvested site[188] easier when establishing a new forest stand[189]. Thinning or harvesting of small-diameter trees is important for improving the structure of young forest stands by reducing crowding and shading. From an economic perspective, there is also a financial incentive to carry out these actions, the removal of stumps and residues leads to lower costs for site preparation and the thinning of small-diameter trees on young forest stands is incentivised through management subsidies[190]. It is understood that as a consequence of such limited returns the harvesting of energy wood is only profitable to forest owners when subsidised.

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[186] Deadwood, forest species and small mammals.

[187] Depending on site conditions and technology applied, stump removal can have several negative environmental impacts with uncertain consequences for long term stand productivity (Walmsley and Godbold 2010). Intensive biomass removals after thinning with whole-tree harvesting has been shown to reduce stand productivity if not combined with compensatory fertilization (Helmisaari *et al*. 2011).

[188] Through soil preparation, such as ploughing and tree planting.

[189] However, the removal of stumps and harvest residues is normally only recommended on relatively fertile soils, such as those under spruce forest, to prevent significant nutrient losses.

[190] Only the management of young forest stands is subsidised (through national and regional funding), there is no subsidy for final fellings.

Table 19: Quantified effects of modified management on key ecosystem services per hectare in North Karelian forests

Service	Service class	Ecosystem service type - detailed	Current (2009)	Bioenergy scenario	Biodiversity scenario	Combined scenario	Factors affecting the provision of ecosystem services	Source
		Forest area (1000 ha)	1,573[i]	1,573[i]	1,573[i]	1,573[i]	-	a
		Forest land available for wood supply (1000 ha)	1,383	1,383	1,307	1,307	-	a
		Nitrogen input (kg N/ha)	150[j]	150[j]	150[j]	150[j]	Management approach	b
Provisioning	*Nutrition*	Bilberry (kg/ha)[k]	22.3	↘	↗	→	Productivity of natural or managed vegetation, harvesting pressure, management intensity, pollinators, climatic variability	c
		Cowberry (kg/ha)[k]	22.7	↘	↗	→		c
	Materials	Potential timber production (m^3/ha/yr)	5.6	5.5	6.0	5.6	Management intensity, rotation length, soil quality, input use, temperature and climate	a
		Actual harvested timber (m^3/ha/yr)	3.2	4.7	3.4	4.8		a
		Harvested fuelwood (m^3/ha/yr)	0.3	0.4	0.3	0.4		a
		Harvested residues (m^3/ha/yr)	0.2	0.3	0.2	0.4		a
		Harvested stumps (m^3/ha/yr)	0.1	0.2	0.1	0.2		a
	Energy	Gross energy of woody biomass (GJ/ha/yr)	4.2	6.9	4.4	7.4	Vegetation yield and quality	g
	Flow	Runoff (mm/yr)	310	↗	↘	→	Slope, harvesting, management approach.	d
Regulating	*Physical*	Soil carbon sequestration (t/ha/yr)	0.11	↘	↗	→	Management intensity, rotation length, soil quality, input use.	e
		Above-ground carbon sequestration (t/ha/yr)[l]	0.28	↘	↗	→		e
		Soil carbon stock (0-150 cm)(t/ha)	63	↘	↗	→		e
		Above-ground carbon stock (t/ha)	40	↘	↗	→		e
	Biotic	Old forests > 120yrs (% of total forest area)	4.0	2.8	4.7	4.0	Protected area, management intensity, accessibility.	a
		Protected forest area (1000 ha)[m]	115	115	190	190	-	a
		Protected forest area (% of total forest area)	7	7	12	12		
		Dead wood (m^3/ha)	4.1	↘	↗	↗	Protected area, management intensity, accessibility.	a
		Retention trees (m^3/ha)	2.8	3.4	2.5	3.2	Management approach	a
		Number of forest species benefiting from forestry practices / species impacted by forestry practices.	81/108	↘/↗	↗/↘	n/a	Protected area, management intensity, fragmentation and habitat degradation	f
		Small mammals (per 100 trap nights)	12	↘	↗	n/a	Highly variable and context specific	g
Cultural	*Intellectual*	Recreation (Number of visits to national parks and hiking areas, x 1000)	250	→	↗	↗	Proximity to population centres, accessibility. Culturally specific	h

Key: **Red text** and arrows = negative changes; **green text** and arrows = positive changes; **black text** and arrows = no change from baseline. **Notes:** [i] All forestry land (forest, scrub and waste land); [j] Fertiliser is applied in about half of the forest area, and only once per rotation period (Finnish Forest Research Institute, 2011) (recommended amounts: 100kg/N/ha on peat soils, 120-200kg/N/ha on mineral soils[191]); [k] Average yield 1997-2008 in whole Finland; [l]Carbon stored in trees on forest and scrub land; [m] Total protected forest area on forest, scrub and waste land. **Sources:** [a]Finnish Forest Research Institute 2011, including MELA simulation data; [b] Yara, 2012; [c] Turtiainen *et al,* 2011; [d] Kämäri *et al,* 1998; [e] Liski *et al,* 2006; [f] Rassi *et al,* 2010; [g] Hämäläinen *et al*, unpublished; [h]1 m^3 = 2 MWh = 7,2 GJ; [i] Number of visitors in national parks, hiking and recreation areas in North Karelia 2003-2011 (data compiled from Finnish Forest Research Institute, 2011; Finnish Forest and Park Service, visitor numbers (http://www.metsa.fi); Finnish Tourist Board (http://www.mek.fi).

The population of forest owners is aging rapidly and the new generation of forest owners live mainly in the cities and often do not have the knowledge or interest to do anything with their forest. At present this is not considered to be a limiting factor on wood production, however if such trends continue then it could become so. There are discussions on-going about how to activate private forest owners, to both manage their forests and mobilise bioenergy feedstock.

Summary

The different forest management scenarios have shown that synergies between the production of biomass for energy and the provision of environmental services are only seen where forest management intensity is reduced or removed. Where management approaches seek to maximise the synergies between all service types, the gains in service provision are lower than where individual services are prioritised.

At present, harvesting regimes are optimised for pulp wood production to supply the large paper industry in Finland. However, this industry is expected to decline in the future and demands for energy production are increasing. Longer harvest rotations are proposed as being more suitable, producing high quality timber for use in construction and timber products and increasing the flow of side products (tops and branches), which are used as a bioenergy feedstock. However, changing the rotation length of forest operations can take significant time, for example from 70 – 90 to an 80 – 100 year rotation. During this transition timber supply could be constrained especially if young and medium aged forests prevail[192].

The choice of land on which to grow forests has also been highlighted as significant in the potential for changes in forest management to meet climate change related targets. For example, the draining of peatlands to expand the forestry may release more CO_2 than could be saved by planting forests for bio-energy generation. However there is limited data and information on which to make this assessment for North Karelia. In relation to site preparation, the scenarios presented here have also touched on the financial motivations for making changes in forestry management. For example, stump harvesting is generally seen as uneconomic (without subsidies) on any but the most fertile soils.

What these different scenarios do not show is the synergies and trade-offs between services in different parts of the forest. For example, both the combined and the biodiversity

[191] Source: http://www.farmit.net

[192] In the North Karelia case study the investigated scenarios were not causing any shortage of projected timber supply despite of the prolonged rotation length because sufficient area of older forest stands was available. However, it should be noted that the scenario assumed full mobilisation of forest resources, which might be unrealistic in a part of the private forests.

scenarios involve increasing management intensity in some parts of the forest, whilst reducing management intensity elsewhere. Although such approaches lead to an overall net gain in different services, there are likely to be greater synergies in some areas and more severe trade-offs in others. Further research is required to fully understand some of the complex dynamics operating in forest systems, particularly under different management approaches. In particular the trade-offs between provisioning and regulating services needs further investigation, and the number of indicators that can be used to assess the overall impact on the whole forest area needs to be improved.

6.2 Water as a limiting factor in ecosystem service delivery in Catalonia, Spain

Pantà de la Llosa del Cavall, ©Montserrat Canal

This case study examines the synergies and trade-offs between different ecosystem services in relation to three interrelated demands: improved agricultural output, the scarcity and pressure on existing water resources, and the continued abandonment of marginal agricultural areas.

6.2.1 Introduction and context

The region of Catalonia is situated in northeast Spain. It covers 3.2 million hectares and is home to approximately 7.54 million people (IDESCAT, 2011a). The majority of the population (85 per cent) is located along the coast and in the wider metropolitan area of Barcelona (IDESCAT, 2011b). The agricultural sector is located in inland areas and along the river Ebro[193] and has a low population density (0.57–0.83 inhabitants per hectare)(IDESCAT, 2011b).

Catalonia's rural land is predominantly covered by forest and shrubland (44 and 10 per cent respectively) and cropland (38 per cent)[194] (DAAR, 2007; LUCAS 2009). Around 27 per cent of the cropland areas are rain-fed and the rest irrigated (DAAR, 2007). Grassland areas in Catalonia cover only six per cent of the region. However, large areas of forest (three per

[193] Source: IDESCAT: Agricultural census 2009
[194] Cropland accounts for 69 per cent of UAA with permanent grassland covering only 31 per cent. Around 57 per cent of the utilised agricultural area is privately owned, 30 per cent is under tenancy and around 12 per cent is under some form of land share or other type of agreement (IDESCAT, 2010a).

cent) and shrubland (ten per cent) are under agricultural use, often for grazing[195]. With its Mediterranean climate, mean annual rainfall ranges from 1,300 mm in the mountain area in the north to 500 – 700 mm in the coastal region and less than 400 mm in the Central Basin in the west (Lana *et al,* 2009). The seasonal distribution of rainfall has significant impacts on plant growth as the evapotranspiration rates during the main growing period, March-October, on average exceed precipitation levels.

6.2.2 Demands on rural land in Catalonia

The main demands placed on rural land in Catalonia relate largely to agricultural production. Increased competition from imports from other EU countries is leading to a downward pressure on commodity prices, in particular cereals and fodder, and placing pressure on farmers to increase their agricultural outputs and yields. Catalonia's population is increasing, raising the domestic demand for food production and recent energy plans are stimulating the growth of some bioenergy crops[196]. In contrast to the demand for greater agricultural production in some areas, there is a prevailing trend of agricultural land abandonment in the region. This is leading to the encroachment of scrubby vegetation and development of forest areas, which are increasing the risk of forest fires, causing changes to biodiversity composition and reducing water availability through interception and increased evapotranspiration. Urbanisation, particularly around coastal population centres, is also placing pressure on rural land, and constraining further the areas available for agricultural production (see Box 10).

All these demands are placing significant pressures on water resources in the region, compounded further by increased demands for water from a growing population. The pressure on water resources is also being exacerbated by climatic changes, such as higher temperatures and reduced precipitation events (IPCC-AR4, 2007). In response to water scarcity there are anticipated and interrelated impacts on rain-fed food production, further pressures on natural habitats, and increased potential for wildfire.

[195] Based on an assessment of LUCAS land cover and land uses data for the NUTS1 Este (East) region, covering Catalonia and Valencia. In the past few years, for economic and productivity reasons the number of livestock farmers has decreased along with grazing as a form of agricultural production (Pampalona, N. *pers comm*. 2012),

[196] These include largely oilseed rape and small areas of sunflower crops on arable land, as well as Eucalyptus, Poplar and Paulownias. The latter, although currently occupying only 80 ha (2010) grows well on poor soils is becoming more common in the region.

Box 10: Urbanisation and soil sealing in Catalonia

One significant pressure on rural land in Catalonia is urban expansion. During the last 16 years, the population in Catalonia has increased by almost 1.5 million and is projected to increase further in the future, particularly along the coastal plain. This population expansion is leading to high competition for rural land on the coastal plain, further exacerbated by increasing tourism to the area. This is increasing the competition for water between sectors, exacerbated by issues of water scarcity.

Quantifying the increase in urbanisation on rural land is challenging. In a review of maps of Catalonia from 1993 and 2005, cropland areas reduced by 12 per cent (~10,000 ha per year), partly through some abandonment and loss to forests, but primarily as a result of urbanisation. Urban areas increased by around 24 per cent in the same period[197]. Forest area increased at the expense of agricultural land, largely as a result of agricultural abandonment and natural succession (Ibàñez and Burriel, undated).

Source: Own compilation

6.2.3 Ecosystem services from rural land in Catalonia, Spain

Quantifying the current supply of ecosystem services in Catalonia has, as with other case studies, been limited by data availability, particularly for many of the environmental services and the types of land from which these services are derived. Table 20 provides a summary quantification for a range of different ecosystem services in Catalonia. Further information on these figures, including limiting factors, is provided in Annex 7. Here we focus on food production, water flow and sedimentation and water pollution in relation to rainfed and irrigated agriculture.

Table 20: Quantification of ecosystem services by land use/cover type in Catalonia, Spain

Service	Service class	Ecosystem service type - detailed	Cropland		Livestock, Grassland	Meadows, Grassland	Forest	Factors affecting the provision of ecosystem services	Data source
			Rain	Irrig'					
Provisioning	Nutrition	Cereal (t/ha)	3	6.9				Primarily water availability, but also nutrient use and management intensity	a
		Vineyard (t/ha)	8	7.6					a
		Olive tree (t/ha)	0.74	1.87					a
		Fodder (t/ha)	18	55					a
		Vegetables (t/ha)	6.9	41					a
		Tubers (t/ha)	25	52					a
		Fruit – Citrus (t/ha)	18*	40					a
	Materials	Average timber increment (m^3/ha)					1.4	Water availability, woodland management, stand density, nutrient availability in some areas	b
		Annual increase in timber biomass (million m^3)					4.3	Lack of woodland management (leading	b

[197] It should be noted that there was a change in mapping accuracy during this assessment which has led to a larger increase in urban areas (increased map resolution and the identification of detached housing). However, the decline in cropland area remains significant.

							to an increase in biomass).	
		Pine seed (t/ha)				30	Productivity of natural or managed vegetation, harvesting / hunting pressure	c
		Cork (kg/ha)				8.36		c
		Comestibles mushrooms (kg/ha)				15		c
		Truffles (kg/ha)				<1		c
		Hunting (big game) (pieces/yr)				21,0 10		c
		Hunting (small game) (pieces/yr)				1,28 0,00 0		c
		Above ground biomass (kg/ha)		4,000				d
		Below ground biomass (t/ha)		30,000				d
	Energy	For industry (thousand m^3)				550	Management practices, harvesting regime, annual timber increment (see above)	e
		Firewood (thousand m^3)				190		e
Regulating and maintenance	Waste	CO_2 in million tonnes	1				-	f
		CH_4 in million tonnes CO_2e	3.1				-	f
		N_2O in million tonnes CO_2e	206				-	f
	Flow	Annual supplied water (hm^3)	1,800				Climatic variables and vegetation in upper catchment.	g
		Runoff contribution (m^3/ha)	1,884	962	962	643	Vegetation density and type, slope, soil type, topography, management practices	h
		Sedimentation (t/ha)	3.78	0.7	0.7	<0.4 2*		h
		Soil erosion on erodible surfaces (t/ha/yr)	Averaging from 2.33 - 325					i
	Physical	Soil organic matter (quantitative)	Low	Low/ Med	Med	High	Management practices (including manure application, organic agriculture and irrigation), soil type, vegetation compositions	
		Contaminant pig slurry (m^3/yr)	150,000				Intensity of livestock management.	j
		Sodic soil	Low				-	
		Saline soil (near Ebro Delta % of soil)	Range 17.3 to 39.1 with high temporal variability.				Sea level, ground water level, sedimentation impact on ground level and accumulation.	d
		Water quality (quantitative)	Decreasing					
		Average nitrate concentration (mg/l)	50				Vegetation and soil type, land management activity and intensity, rainfall, nutrient application rate	j
		Carbon - Soil (agricultural land) (%)	0.6-2.3 / 1.2 - 2.3				Soil type, management practices	d
		Carbon – Soil (0-10cm) (kg/t)	8.1	15.2	15.2	25.9	Soil type, vegetation composition, land use, management practices	k
		Carbon - Forests (million t of C)				49.2		d
		Carbon - Sequestration (t/ha/yr)				1.3 – 5.4		d

	Supporting	Biodiversity - Total species abundance	26,000**			Highly variable and context specific	l
Cultural	Symbolic	Conservation natural areas	Low	Mod’	Mod’/High	Culturally specific	
	Intellectual	Leisure/learning (including recreation)	Low/Mod’	Mo’	High		
		PEIN protected areas (% of surface)	33				m
		% of visits to Catalan parks recorded as a proportion of all Spanish parks.	57				m
		Visits in forests area			Increasing		

Notes: Where comparable values are presented, green cells show the land uses providing the most ESS and red cells the least. Yellow cells show moderate provision of ESS. *0.42 is for dense shrub cover; forest run-off is expected to be lower; **In seeking to understand species abundance by different land use types we have been given the following information from the biodiversity department in the Catalan Government. ‘Unfortunately there are few studies about biodiversity, showing the species which are in Catalonia. In this territory, although it is quite small comparing to other countries, there are plenty of habitats with many different species. There is no quantification per hectare, only the classification of the species. Furthermore, no official classification exists by land use type.’ **Sources:** [a]GENCAT, 2011; [b]Ministerio de Medio Ambiente, 2007; [c]INE, 2008; [d]LLEBOT, 2012; [e]IDESCAT, 2010b; [f]OCCC, 2012; [g]IDESCAT, 2011c; [h]Nadal-Romero *et al,* 2012; [i]Ministerio de Agricultura, Alimentación y Medioambiente, 2004; [j]Peñuelas *et al,* 2003; [k]Boix-Fayos *et al,* 2009; [l]Font *et al,* 2012; [m]IDESCAT, 2011d.

6.2.4 Synergies and trade-offs between ecosystem services in Catalonia

The synergies and trade-offs between different ecosystem services throughout the Catalan region are highly interrelated (see Figure 5, Annex 7). Water availability is one of the main issues generating social and environmental conflict in Catalonia. The increased demands on water for agricultural use[198] and from both an increasing population and seasonal tourism[199], are placing pressure on existing water resources[200]. The greatest demand for water from all sectors tends to occur at the same time of year, in summer. During this period water resources are also at their lowest resulting in conflicts between demands and water scarcity.

Limited water resources are having a significant impact on food production. Irrigation is seen as one means of overcoming this limitation. Yields from irrigated land are on average three to four times higher than those from rain-fed cropland, the most noticeable differences being for fruit (20 times greater) and vegetables (six times greater). Yields for cereals and fodder crops are around two to three times greater. These differences are particularly evident when the total outputs of commodities for both irrigated and rain-fed land are compared. Rain-fed land, covering 67 per cent of cultivated area provides 29 per

198 75 per cent of all water consumed, approximately 2,141 cubic hectometres per year (hm^3/yr). Source: Water Framework Directive reporting in Catalonia. October 2005

199 19 per cent of all water consumed, approximately 541 hm^3/yr.

200 Industrial water use in Catalonia is relatively limited at only 188hm^3/yr, seven per cent

cent of the total cropland output[201], whereas irrigated land (33 per cent of cultivated area) provides 71 per cent[202].

Currently there are plans to increase the irrigated cultivated land area by a further 30 per cent[203]. However, increasing irrigation when water resources are already severely limited will only divert more water away from natural ecosystems and demands from a growing population and may become particularly acute with the added impacts of climate change (GENCAT, 2008). The development of irrigated agricultural production may also exacerbate the existing trend of land abandonment in more marginal or un-economic areas of the region[204], leading to the encroachment of scrubby vegetation and development of unmanaged forest communities. In contrast the intensity of agricultural management within irrigated areas is likely to increase.

The impacts of irrigation for agricultural production, expansion of forests surrounding headwaters and increasing pressures from climatic changes can already be seen. The increase in scrubby and forest vegetation as a result of agricultural abandonment is a common feature in Catalonia, particularly in higher watershed areas. Abandonment can lead to further impacts on water resources and other ecosystem services[205], but the relationship is both complex and site specific (see Chapter 3). Tall herbaceous and woody vegetation tends to absorb more water and can reduce run-off rates to a third of those seen on cropland (see Table 20). The increase in forest area in the high watershed areas of Catalonia has already been attributed to lower river flow rates[206] (see for example Poyatos *et al,* 2003; Bosch and Hewlett, 1982; Delgado *et al,* 2010). With decreased water flow, exacerbated by the construction of reservoirs to store water, the levels of sedimentation reaching the Ebro delta (designated under the Ramsar convention) have declined significantly. This has caused the delta area to reduce in area with negative impacts on natural habitats, with further reductions expected as a result of climate change induced sea level rise. Further impacts are expected on rice production in the area[207].

[201] As measured in tonnes

[202] Own calculation based on the rain-fed and irrigated areas and average crop yields for cereals, fodder crops, legumes, tubers, vegetables, industrial crops, fruit, citrus, vineyards and olives. Area and yield information sources form the Catalan regional statistical department, 2011, unpublished. Significant differences are observed between crop types (see Table 20).

[203] An additional 70,000ha

[204] Increased intensification of production through irrigation can lead to increased competition for markets. In such situations, those areas that are less profitable, and thus less competitive, may lose out. The abandonment of farmland in Catalonia is a complex issue however farm profitability is highlighted as a general driver in the region (Pamplona N, *pers comm*. 2012).

[205] These areas have been attributed to increased risk of wildfire, particularly where the developing woody vegetation is not managed (see for example Badia *et al,* 2001).

[206] For example the mean annual flow of the lower part of the River Ebro has declined by almost 40 per cent over the last 50 years (Delgado *et al,* 2010). Changing from grassland to forest cover in mountainous areas has been observed to reduce water resources, as a result of increased rainfall interception by up to 20 per cent (see Gallart and Llorens, 2004; Poyatos *et al,* 2003).

[207] Decreased sedimentation, which used to increase soil levels by around 0.2mm per year (Ibáñez *et al,* 1997), is having an impact on rice cultivation in the Delta area through increased water logging and salt intrusion.

The use of irrigation in agriculture tends also to involve more intensive farming practices. These can involve increased fertiliser and pesticide use, resulting in further negative impacts on soil functionality and water quality[208], which are being seen already in the Lower Ebro basin. These areas receive significant amounts of pollution, particularly from pesticides, coming from irrigated cropped areas, in particular from fruit and vegetable crops, as well as, rice fields in the lower delta. Water quality is also affected by heavy metals, both from industrial and agricultural sources (Terradas *et al*, 2004). One specific concern in Catalonia is pig slurry, used as an agricultural fertiliser, causing increased soil and groundwater nitrification. The nitrate concentration in ground water has increasingly reached values over 50 milligrams per litre, exceeding the threshold value deemed to be safe for human health and the limit stipulated under the Nitrates Directive (Peñuelas *et al,* 2003).

One option to meet demands for increased agricultural production without further impacting on water resources would be to promote the use of rain-fed agriculture. As a consequence of reduced yields, in comparison to irrigated areas (see Table 20) the area of cropland would need to expand in order to increase agricultural output. For example to produce 1000 tonnes of cereals would require either 143 hectares of irrigated land or more than twice this area as rain fed land (333 hectares)[209]. The economic incentives to expand rain-fed agricultural production may prevent such an option being realised in all but a few fragmented areas. Furthermore the consequences and feasibility of increasing the cultivated land area in Catalonia are unclear. Some agricultural land abandonment may be reversed where it was previously suitable cropland, but this is likely to be limited. Bringing abandoned land back into production may have negative impacts on semi-natural habitats and cause further environmental impacts such as losses of carbon from soils and above ground biomass, erosion and increased surface run-off. The extent of these trade-offs would depend on the land being cultivated and the type of agricultural production pursued.

There are a number of options that would promote the more sustainable use of water resources to help meet demands for increased crop production whilst reducing environmental pressures. Reducing the volume of water used for irrigation, to levels that match natural recharge rates, would help to reduce pressures on the wider ecosystem and ensure the future continuity of water supplies. The use of more advanced, drip or precision irrigation technology could be one way to utilise the available water more effectively. In the long term natural habitats and ecosystems are likely to benefit, with increased opportunities to adapt to climatic changes. Aquifers and reservoirs would face fewer pressures and allow increased access to water resources for domestic and industrial use[210].

Water storage is another option to help reduce pressure on water resources during times of drought. Despite the prevailing drought conditions throughout the summer period, rainfall

[208] It has not been possible to quantify the level of regulating and cultural services provided between irrigated and rain-fed land in Catalonia.

[209] Own calculations based on irrigated versus rain fed yield figures. The calculation assumes all other land and input conditions are the same.

[210] With the information available to the study it has not been possible to evaluate the current irrigation technology used in the region.

events in the late summer can be torrential[211], leading to localised flooding and erosion with more sustained periods of rain during the autumn period. Capturing excess water during such events could help to improve irrigation capacity throughout the drier periods and limit flood events. Capture and storage could be achieved through a range of different approaches such as the terracing of traditional slope vineyards, through on-farm water capture ponds, or in large scale reservoirs already present in the region. Water capture and storage can also be applied in urban areas in order to meet local and domestic population needs[212]. Trees and woody vegetation can result in a more gradual release of water for aquifer recharge or into rivers. However, care would need to be taken when capturing and storing water so as not to further reduce run-off and sedimentation rates which are necessary for downstream agriculture, naturally rain-fed systems, and the health of the Ebro delta.

In relation to forest land, better use could be made of the existing timber resource. Despite timber production in Catalonia being relatively low (only 1.4 cubic metres per hectare per year) the accumulation of woody biomass on scrubland and need to better manage forests to reduce fire risk, could result in increasing the volume of timber harvested, with limited trade offs.

Demand reduction is another possible approach, one that is already being seen in some areas with bans on certain uses of water during droughts[213].

Summary

This case study has highlighted the interrelated and often delicate relationship between the demand for increases in food production and demands placed on the natural environment to continue providing water supplies. Irrigated agricultural areas have been shown to significantly increase yields when compared to traditional dry-land or rain-fed production. However, the increased use of water for agriculture is leading to a wide range of trade-offs including reduced sedimentation and flow rates in water courses, with knock-on impacts on natural habitats and biodiversity in downstream areas.

The study has also shown that promoting irrigated agricultural production in more fertile areas may exacerbate further existing trends of farmland abandonment in more marginal areas. Therefore, despite some increases in food production there are likely to be net trade-offs with other ecosystem services elsewhere in the region, such as water availability, biodiversity or increased forest fire risk as a result of scrub encroachment. The encroachment of woody vegetation and unmanaged forest communities can also put further pressure on crop production by limiting water availability further. These impacts

[211] High intensity and short duration

[212] In 2002, Sant Cugat del Vallès was the first municipality in the Metropolitan Area of Barcelona (MAB) to introduce a building code that required rainwater harvesting systems on houses over a certain size (JRC and EEA, 2012)

[213] In some drought periods the Catalan government has banned the use of water beyond that required for human consumption and agriculture. For example, water in urban fountains, public gardens etc. Farmers could still use water for irrigation and animals, but under restrictions. There were also campaigns to raise public awareness (Pamplona N, *pers comm*. 2012)

may then place further pressure on more extensive and rain-fed agriculture leading either to abandonment or further intensification.

6.3 Increasing arable production in the Great Plains, Hungary

Straw on the Great Plain, Hungary © Anetta Szilágyi

This case study considers the demand for increased arable production from the Hungarian Great Plains. By looking at the agrarian history of the region under a planned economy it has been possible to gain an insight into some of the trade-offs between ecosystem services with a view to understanding how to minimise such trade-offs in the future.

6.3.1 Introduction and context

The Great Plain in Eastern Hungary, forming part of the Carpathian Basin, covers approximately 3.6 million hectares and is surrounded by mountains to the north. The average population density for the Great Plain area is 0.78[214] people per hectare with the majority of the population living in rural areas (76 per cent).

Cropland is the dominant land cover at around 55 per cent of the region (1.996 million hectares) with grassland accounting for 23 per cent (834,000 ha). Forests cover 14 per cent of the area (480,000 ha). Agriculture is the main land use (73 per cent or 2.6 million hectares[215], primarily arable cultivation with extensive grazing a feature of the grassland areas (NHRDP, 2007). The region's continental climate has an average annual temperature of 9.5°C and the average annual rainfall is low, at 550 mm. There are large seasonal fluctuations in air temperature from -2°C in February to 22°C in August and large inter annual variations in rainfall with both flood and drought events common.

6.3.2 Demands on rural land in the Great Plains

The main demand on rural land in the Great Plains area is agricultural crop production, partly driven by local and national demand for food but also for export, given its importance

[214] Substantially lower than the EU average of 1.12 people per hectare

[215] All figures are from LUCAS (2009). According to the LUCAS data, approximately 67 per cent of grasslands in the Great Plain are in use for agriculture. The remaining 33 per cent appear under different uses including: Forestry (three per cent); the services and residential category (which includes nature reserves) (16 per cent); and some areas do not show any visible signs of use making it difficult to determine their current function (10 per cent).

to the region's economy. The Southern and Northern Great Plains have the highest proportion of agricultural area (22-23 per cent) of any region in Hungary. The area produces more than 40 per cent of Hungarian agricultural output (in terms of value) and agriculture accounts for around eight per cent of the employment in the Great Plains (NHRDP, 2007). Yet despite this, agricultural productivity remains significantly below levels that have been achieved in the past twenty years. This is highlighted by the change in yields since 1990 following the reforms to land holdings[216]. Removal of direct support to production following accession to the EU may have been another factor.

Where five tonnes of wheat per hectare was once common, average yields are now only four tonnes per hectare[217]. At the same time, Hungary is among the main EU countries experiencing an expansion of biofuel production based on agricultural crops. The prevailing biofuel feedstocks produced in Hungary are grain maize and sugar beet for bioethanol[218] and rapeseed for biodiesel[219] (Diaz-Chavez *et al,* forthcoming). Maize is projected to become the dominant biofuel feedstock in 2020, reaching a level close to three times as much as rapeseed use for biofuels in 2020. These plans rely on continuing surpluses in the existing maize cropping systems, rather than on expansion into other land uses or changes in cropping patterns[220]. Anecdotal evidence also suggests that due to the declining livestock sector, the areas under grass fodder crops often tend to be used for biofuel feedstock production.

6.3.3 Ecosystem services from rural land in the Great Plains, Hungary

In the late nineteenth century, drainage and control of flooding from the River Tisza, the longest tributary of the River Danube, opened the plain to grazing and a wide range of arable crops. Before 1989, high yields were achieved through state-led land consolidation into efficient, large integrated farms employing professional staff, high-level input use, such as fertiliser and mechanisation and well organised research and extension infrastructure. The transition to a more market-led economy has been difficult, with the fragmentation of land holdings and ownership and a dismantling of integrated systems (essentially separating livestock from feed production). The process of re-distribution of land ownership has marginalised businesses and co-operatives and resulted in considerable uncertainty about farm leases. Since 1990, many farmers have adopted more extensive crop and livestock systems and the area of uncultivated land has steadily increased[221].

[216] This involved the preservation of some very large farms and the fragmentation of land ownership on the remaining agricultural land.
[217] However, the decline in average yields between crops has not been uniform.
[218] With bioethanol crop outputs being diverted into the energy production from between two and 38 per cent of the respective total crop areas (Diaz-Chavez *et al,* 2013).
[219] With biodiesel crop output being diverted into the biofuel production from 61 per cent of the total crop area (Diaz-Chavez *et al,* 2013).
[220] Production surpluses in the Hungary's total maize sector amounted to 2.5 to five million tonnes/year over the years 2005-2010, according to Hungarian Institute for Soil Science and Agricultural Chemistry, quoted in Diaz-Chavez *et al* (forthcoming).
[221] Uncultivated land increased by seven per cent between 2002 and 2009.

provides a summary quantification of the different ecosystem services provided per hectare of land in the Great Plain. The key factors that limit the provision of different services are set out in Annex 7. There is a relative paucity of consistent data available to quantify the provision of environmental services, particularly in relation to different land cover or land uses.

The average wheat and maize yields (2006-2010), the two most important crops in the region, are around four and 6.2 tonnes per hectare respectively (FAOSTAT, 2012). Hungary (along with Romania) has the largest share of total cropland under maize cultivation in the EU and is one of the four Member States with largest total area under maize. Maize production plays a major role in the overall domestic crop output, with the Dél-Dunantul region alone accounting for over two per cent of EU total maize production and thus representing one of the leading EU maize producing regions (Diaz-Chavez *et al,* forthcoming). Maize is typically produced in continuous crop systems relying on intensive pest management and high pesticide inputs compared to other crops. Due to agrochemical inputs and row cropping, maize puts considerable pressure on soils, in particular resulting in increased risk of soil erosion, depletion of soil organic matter and pressure on biodiversity. Several ethanol plants located on the river Danube plan to utilise domestic maize production to supply wider EU ethanol markets. However, one of the main limiting factors for crop production in the region is water availability (relating to both flooding and drought).

As part of the Carpathian basin, almost all of the Great Plain is subject to flooding[222]. However, water shortages are also common in the region, with crop production constrained by drought in three years out of every ten (NHRDP, 2007; Pepó and Kovačević, 2011). It is predicted that a sequence of severe drought years interrupted by wet ones is likely to be a lasting pattern[223]. This high variability makes it increasingly doubtful if stable crop yields can be sustained in the future[224]. As a result of climate change it is predicted that water runoff levels will decrease, lake areas will decrease, and underground water supplies will be reduced in the Great Plain area (Hungary Government, 2009).

Nutrient availability is also a significant factor limiting crop production. Despite the area often being known for its relatively fertile soils, these vary throughout the Great Plain. Part of the southern Great Plain comprises free-draining sandy soils, which limit nutrient and water retention, whereas the soils to the east are characterised by low water conductivity, and areas to the north are associated with high salinity and alkalinity[225]. The impact of nutrient availability is particularly obvious when comparing agricultural practices during the

[222] Apart from higher areas in the west, and around Debrecen and Nyíregyháza in the northeast

[223] 2011 and 2012 have been the driest year in Hungary's long-term records (mean precipitation below 400mm in 2011). By comparison, 2010 was very high in precipitation, around 900 mm on average, which is higher than the mean of the wettest parts of the country).

[224] Due to the 2012 drought, maize production barely covered domestic demand and Hungary's bioethanol plants had to use imports. Hungary's existing export obligations had to be covered from imports from Poland and the Ukraine. This steeply increased the prize of maize for several weeks (Népszabadság Online, 3/10/2012, http://nol.hu/gazdasag/20121003-keleti_kukorica_a_piacon

[225] The salinity problems are often associated with high water tables (Magyar Tudomanyous Akademia, 2012), and despite a relatively small area identified as high salinity, salinity is a potential issue across much of the Great Plain (Várallyay, 2005).

late 1980s with those since accession to the EU. During the 1980s, the mean annual nitrogen fertiliser consumption in Hungary was around 598,000 tonnes, with an average wheat yield at the time of 5.1 t/ha. The high nutrient loading (nitrogen, phosphorous and potassium) during this period was often greater than the amount taken up by crops. Some estimates suggest that up to a third of nitrogen was surplus to requirements, with negative impacts on water quality (see for example Szabó, 1999). Since 1990, annual nitrogen fertiliser consumption has decreased by over 50 per cent (330,000 tonnes)[226]. This reduction in input use can account for much of the decline in wheat yield (22 per cent) (FAOSTAT, 2012), but there is also anecdotal evidence to suggest improvements in water quality in the Great Plains (see for example Somlyódy and Simonffy, 2004). Nutrient limitations are not uniform for all crops, for example average maize yields have remained relatively stable throughout the same period, largely as a result of maize being more resilient to a range of different soil conditions[227].

Compared to other regions in the EU, the inter-annual variation in crop yields on the Great Plain is substantial (Pepó and Kovačević, 2011). Crop experiments have demonstrated maize yield decreases of up to 60 per cent due to drought stress (assuming the application of adequate nitrogen), and excess water in wet years can decrease yields by 30 per cent due to nutrient loss, where no nitrogen is applied (see Széles *et al,* 2012). There is a paucity of information on water use in Hungarian agriculture. Significant areas of the Great Plains region had access to irrigation equipment in the pre-1989 era, but many of the irrigation systems have fallen into disrepair or are unused because of the fragmentation of land ownership. The total irrigated area continues to increase, however, from five per cent of Utilised Agricultural Area (UAA) in 2007 up to eight per cent in 2010[228].

Livestock production on the Great Plains faces similar constraints to that of crop production in terms of input use and water availability. Beef and sheep production in the region is largely grass based and under extensive management (Wagenhoffer *et al,* 2003). From the mid-1980s to 1995, the number of cattle, sheep and pigs across Hungary almost halved with cattle and pigs declining by a further 15 and 30 per cent respectively to 2011[229]. By contrast the number of sheep in the Great Plains has increased in the same period (1995-2011) by 44 per cent[230]. The mean livestock density is relatively low (0.63 livestock units per hectare (LU/ha) in 2011) and the contribution of grass to total agricultural output is only one per cent (Nagy, 2006). The high variability and poor distribution of rainfall means that grass yields are unreliable, and although grass growth may be high in the spring, it is typically

[226] There has also been a small decline in the arable and permanent crop area over this period. Eurostat data (ef_lu_ovcropaa) was not available from 1990 for the Great Plains, but from 2000 – 2007 there was a seven per cent decrease in land under arable and permanent crops. The overall decrease in UAA in Hungary from 1990 – 2011 was 17.5 per cent -. Hungarian central statistics office. http://www.ksh.hu/agriculture Accessed: October 2012.
[227] Maize can be grown on a much wider range of soil types and survives well on lower nutrient available soils.
[228] Eurostat 2012 - ef_poirrig
[229] From 309,000 to 266,000 and pig numbers decreased from 2.6 million to 1.8 million.
[230] Sheep numbers increased from 570,000 to 823,000 - Data from Eurostat agricultural statistics - Livestock: number of farms and heads of animals of different types by agricultural size of farm (UAA) and NUTS 2 regions (ef_olsaareg). Available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database Accessed: October 2012

insufficient for much of the year[231]. Unlike beef cattle, dairy cattle are primarily fed on arable crops and dairy farms are found more in arable rather than grassland areas (Nagy, 2006). Milk production in the Great Plains has declined by nine per cent over the past eight years, similar to the national trends and those seen in some other Member States.

The majority (94 per cent) of drinking water in Hungary is derived from ground aquifers (Kádár, 2010)[232]. Measured nitrate levels in the Great Plains are highest under permanent crops and arable land, both exceeding the nitrate standard of 50 mg NO_3/litre set by the Groundwater Directive[233]. Despite the relatively low average levels of current fertiliser use throughout the region, high levels of nitrogen use up to the 1990s may still be working its way through to the aquifer and could have a delayed impact on water quality. Groundwater levels in the area between the Danube and the Tisza rivers have fallen by several metres in the 20th century (Szabó, 1999; Békés County Library, undated). The past use of groundwater for irrigation is one of the causes of this, although others date back to the early 20th century and include the draining of the region, the gradual deepening of the rivers bordering the region to regulate water courses and the ongoing drying and warming of the mezoclimate.

The reduction in the area of arable land and the increase in unused agricultural land and woodland in recent decades, across Hungary as a whole, has been estimated to act as a sink for greenhouse gases equivalent to about 3.3 million tonnes CO_2 equivalent per year (after Barcza *et al,* 2009) and there is further evidence to suggest that more extensive production approaches have contributed towards an increase in biodiversity in the region.

Levels of biodiversity in habitats in the Great Plains are relatively well explored, particularly in relation to farmland birds, invertebrates, and arable and grassland plants. Extensively grazed grassland areas are considered particularly species rich (Nagy and Vinczeffy, 1993; Láng, 1995). However, demands for increased agricultural output, particularly from maize can have adverse impacts on biodiversity due to the high dependence of continuous maize cropping systems on agro-chemical inputs, particularly pesticides. Where maize cropping replaces grass fodder areas in rotated systems, risks to biodiversity are associated with the depletion of available soil nutrients and increased use of inputs agro-chemicals[234].

[231] Typical dry matter grass yields are only about 1.5 - 2.5 tonnes per hectare, as only small areas have been reseeded and nitrogen is only applied to a small proportion of the land. With increased input use, grass yields could be improved four-fold to 6.9-9.2 t/ha (Nagy, 2006) with the potential to increase livestock density.

[232] Most drinking water is from deep aquifers, tens to hundreds of meter deep, whereas the nitrate measurements are recorded at one meter under the water table. However drinking water supplying Budapest (20 per cent of the country's population) comes from the river Danube through wells in the river's gravel bed.

[233] Measured nitrate levels in the Great Plains are highest under permanent crops (164 milligrams of Nitrate per Litre (mg NO_3/L)) and arable land (71 mg NO_3/L) exceeding the nitrate standard of 50 mg NO_3/L set by the Groundwater Directive (2006). Nitrate levels were lowest under forest (2 mg NO_3/L) (Leone *et al,* 2009).

[234] Hungarian Institute for Soil Science and Agricultural Chemistry, quoted in Diaz-Chavez *et al*, forthcoming

Table 21: **Quantification of ecosystem services per hectare of land in the Great Plains, Hungary**

Service	Service class	Ecosystem service type - detailed	Orchard	Arable	Grassland	Forest	Factors affecting the provision of ecosystem services	Data
Provisioning	*Nutrition*	Wheat grain (t/ha/yr)	-	4.0 [a]	-	-	Water and soil fertility	a
		Maize grain (t/ha/yr)	-	6.2 [a]	-	-		a
		Grass (tonnes dry matter/ha/yr)	-	-	2.0 [b]	-		b
	Materials	Annual timber increment (m^3/ha/yr)	-	-	-	7.3 [c]	Water availability, woodland management, stand density, nutrient availability in some areas	c
		Actual roundwood harvest (m^3/ha/yr)	-	-	-	3.7 [d]	Area of forest under management and forest management intensity	d
	Energy	Potential gross energy of crop or wood if used for heating (GJ/ha/yr)	-	91	-	60	Crop yield and quality	
Regulating	*Water*	Groundwater nitrate levels at 1 m (mg NO_3/L)	164 [e]	71 [e]	-	2 [e]	Fertiliser application rate, soil conditions, rainfall	e
		Groundwater nitrate levels at 4-5 m (mg NO_3/L)	65 [e]	15 [e]	-	1 [e]		e
	Physical	Annual C emission (t C/ha/yr)		0.9[f]	-0.2[f]	-1.3[f]	Figures based on model results. see Barcza *et al* 2009	f
		Ground water levels	Decreasing				Climatic Variability and abstraction rates	
	Flow	Flood events	Significant and extreme				Climatic variability	
		Drought events	Significant and frequent					
	Biotic	Bird species richness (number of species within ~3ha) [g]: Extensive	-	-	4.7	-	Complex and variable, see Verhulst *et al*, 2004; Lóczy, 2010	g
		Intensive			2.5			
		Fertilised			1.9			
		Abandoned			8.3			
		Bird abundance (number of individuals within ~3ha) [g, h]: Extensive	-	-	10.2	-		g, h
		Intensive			5.5			
		Fertilised			3.1			
		Abandoned			15.8			
Cultural		Sense of place	Significant in protected areas				Culturally specific	i

Notes: Where comparable values are presented, green cells show the most beneficial land uses and red cells the least beneficial. Yellow and amber cells show moderately beneficial land uses. **Sources:** [a] FADN, 2012; [b]

Nagy, 2006; [c] HMEW, 2005; [d] Eurostat, 2012a [e]: Leone *et al*, 2009; [f] Barcza *et al,* 2009[235]; [g]: Verhulst *et al*, 2004[236]; [h]Lóczy, 2010; [i]Békés County Library, u.d.

There is little evidence for the impact of farmland abandonment on biodiversity, however. Some evidence suggests that the species richness and diversity of farmland birds may be higher in abandoned grassland areas than in grasslands under more intensive grazing (Verhulst *et al,* 2004). However, the species composition in these abandoned areas includes more woodland and scrub specialists, therefore in terms of species richness, abandonment may not necessarily result in losses, but may have adverse effects similar to intensification on the conservation of rare and threatened birds. Anecdotal evidence also suggests that initial increases in species richness in abandoned grasslands are temporary. In the long term, populations of invasive species tend to replace grasslands with high biodiversity value after the withdrawal of livestock grazing (Poláková *et al,* 2011). Recent declines in grazing livestock have led to invasive species occurring on 21 per cent of the protected grasslands in Hungary, such as like *Solidago* spp, *Ailanthus altissima*, *Elaeagnus angustifolia* and *Asclepias syriaca* (Stoate *et al,* 2009). The Hungarian Rural Development Programme highlights agricultural abandonment in certain areas as a threat to the region's biodiversity. Further detailed information would be required in order to make an accurate assessment of the relative trends in biodiversity provision in the Great Plains.

Cultural services also remain under quantified. There is anecdotal evidence to suggest that local inhabitants value the designation of certain areas as national parks, such as the Kiskunság National Park UNESCO world heritage site and Körös-Maros National Park[237]. These areas are valued for recreational purposes as well as their effect on tourism, and the national and international marketing of local products (Gómez-Baggethun and Kelemen, 2008; Bekes County Library, u.d.). These areas, and some of the wider areas of the Great Plains are valued for their sense of place and history, as a cultural resource 'our greatest heritage given free of charge' (Békés County Library, u.d.).

6.3.4 Synergies and trade-offs between ecosystem services in the Great Plains

With crop production limited by nutrient input, poor soils in some areas, and drought stress, there is clear potential to increase both crop yields and overall crop outputs from the Great Plains. Unlike the previous case studies discussed in this chapter, evidence from Hungary's recent past can be used to look at the potential synergies and trade-offs between different approaches to increasing crop production on a range of different ecosystem services.

Given the changes in the agricultural area and yields since the political changes in the late 1980s, improving the agriculture output from the region could be achieved by reversing these two trends. With crop yields limited largely by soil fertility and water availability, there is the potential to increase fertiliser use and expand irrigation practices. However, both approaches would be associated with negative impacts on water quality and availability. Indeed, the full impact of previous production regimes, in particular high nitrate use, is still having an effect of water pollution.

[235] Based on model results
[236] Study carried out in the Kiskunság National Park and surrounding areas in the Great Plains.
[237] With a considerable proportion protected under the Ramsar Convention

One option to reduce these impacts is to use more modern agricultural technologies such as precision fertiliser application only in the right locations and at the levels required by the crop. More advanced irrigation technologies such as drip irrigation could also be used to minimise the amount of water used, ensuring that crops do not suffer from drought stress and that groundwater recharge rates are sufficient. However, such approaches only help to limit the impacts rather than remove them altogether. Such approaches may require significant investment. In addition further structural changes may also be needed to increase field and farm size in order to achieve the economies of scale necessary to make this more modern, intensive and high input approaches economic[238].

More intensive management practices would also be likely to impact negatively on biodiversity and carbon and GHG emissions would be likely to increase through greater input use and soil cultivation (see Table 21). Although there are some approaches, which can help to reduce these pressures, most have an impact on overall crop yields (such as organic farming, for example). One partial solution is to use targeted agri-environment schemes to improve the levels of biodiversity or carbon sequestration in and around areas of more intensive agricultural production. The incentives, advice and support provided through such schemes could also help to improve the overall economic viability of farm businesses[239].

One option for increasing the overall agricultural output for the region without further use of chemical inputs[240] or mechanisation is to expand the area under cultivation to the scale seen in the 1990s. This expansion is already taking place, with a small increase in the UAA, including the cereals area since 2003. Table 21 provides only limited information to assess the impacts of such land use changes within the region. This information shows that a shift from grassland to arable production would result in an increase in ground water nitrate concentrations (by up to 162mg NO_3/litre) a reduction in carbon sequestration capacity (with losses of up to 2.2t C/ha/yr) and decrease in farmland biodiversity where management intensity is increased. Evidence provided in other regions of the EU suggests that it is also reasonable to expect impacts on GHG emissions, water availability and natural habitats.

The promotion of more extensive agricultural practices would not increase crop yields, but they could help to increase the added value of crop products from the region and address some of the key environmental issues, in particular the need to improve soil functionality[241]. For example, the organic sector has benefited from the process of agricultural restructuring and extensification in the region over the past two decades. It became relatively competitive[242]although some support to the sector is provided through rural development funding (NHRDP, 2007). Up to 97 per cent of certified organic products are used to supply food markets elsewhere in the EU, and the period between 1996 and 2004 saw a twelve fold

238 Something that had previously been achieved through collectivisation in the 1950s

239 Agri-environment schemes are already available in the Hungarian RDP but may require additional or sub-schemes tailored specifically at the Great Plains area and focussed on specific ecosystem services.

240 Such as chemical fertilisers or plant protection products.

241 Soil degradation and inadequate nutrient management continue to be issues for agricultural production in the Great Plains area. In Hungary overall the area treated with organic manure decreased by 21 per cent between 1994 and 2005, and the quantity of manure used dropped by nearly 25 per cent.

242 Including wine, fruit, vegetables, dairy and meat

increase in the area of organic land[243] to around six per cent of UAA (NHRDP, 2007), since when it has remained stable (FiBL, 2012).

The current low profitability of arable agriculture in the Great Plains provides an opportunity to allow the restoration of natural wetlands and grasslands, increasing the overall area devoted to conservation (see Deák, 2007). In some areas, habitat restoration is already taking place, such as in the Egyek-Pusztakocs marsh and grassland system where arable areas are being restored to grassland (Lengyel *et al,* 2012). Some of these approaches require a significant change to the current land use pattern of the region to those that preceded the more specialised and conventional agricultural production throughout the mid 20th century. These changes may not result in an increase in agricultural production, but they could help to revitalise declining rural areas through tourism and local job creation, increased animal husbandry and diversification of production and income streams, such as traditional fisheries (see Box 11).

Box 11: EU LIFE project - Integrated water management system in the Great Plains

EU LIFE pilot project FOK WATMAN – Integrated (Multi-level inundation) water management system solving flood-protection, conservation and rural employment challenges in the Great Plains of Hungary.

This pilot project was located in the southern part of Kis Hortobágy in the Hungarian Great plain, bordered by the River Tisza. The project aimed to implement the fok water regulation system (using natural depressions for the retention, use and controlled release of flood water) and a new land use system to help manage flood risk, reduce river contamination, improve nature conservation, support agricultural production and improve the overall development of rural areas. This involved restoration of existing sluices, construction of dykes, maintenance of flood defences and the implementation of a new land use plan, including extensive cattle breeding and fisheries.

Before the project, the land of Borsodi mezõség was dry and unproductive. After site rehabilitation, the land can now be used for different purposes, ensuring incomes for the local population, including extensive animal husbandry and rural and green tourism (line-fishing, hunting, bird watching, rowing, etc). With a similar geography of surrounding areas, this approach could be transferred to other areas of the Tisza river basin (Ukraine, Romania, Slovakia, Hungary and Yugoslavia). Source: EC LiFE project database - Project number: LIFE03 ENV/H/000291 Further information: Layman's guide. Link

Source: Own compilation

Summary

This case study has provided an insight into some of the potential future synergies and trade-offs between ecosystem services based on an examination of the impacts of agricultural production in Hungary's political past. The agricultural land management under large-scale and intensive agricultural production of the post war era, practised until the late 1980s, led to significant impacts on water availability and water quality, partly as a result of irrigation and the overuse of chemical fertilisers. Some of these effects are still affecting the water status today.

Since the early 1990s and in particular following Hungary's accession to the EU, agriculture in the Great Plain has become more extensive. This has resulted in an improvement in the

[243] From 11,400 hectares to 133,000 hectares

environment throughout the region. In particular the pressure on water resources has reduced. However, improvements in water quality and availability have been at the expense of food production, with significant decreases in the yields of some crops. These findings suggest that the use of rural land in the Great Plains has not yet found an optimal balance between food production and environmental service delivery.

The decline in crop production has had an impact on farm economies. Significant growth in certified organic production has been an outcome of trends towards extensification, driven by political, macroeconomic and structural factors. Organic production gives economic value to the environmental benefits provided by agriculture managed for relatively low yields. It is a partial but not fully satisfactory solution to the decrease in farm revenues, but it may provide other ecosystem services, which in turn can stimulate the vitality of rural areas.

With agricultural production representing one of the key demands on rural land in the region, there are strong social and cultural incentives to increase production intensity. The markets respond in different ways across the case study region and it is not easy to predict whether the economic incentives are strong enough to overcome various structural, institutional, macro-economic, climatic and biophysical constraints on intensification. The yields and area devoted to arable crops have already begun to increase, driven also by the increased demand for biofuel production, particularly bioethanol.

There does however, remain an opportunity for agricultural production in the Great Plain to take a more sustainable approach to increase agricultural output. By learning from past experience, agricultural production and farm incomes could be improved whilst also providing better synergies between ecosystem services. Achieving this will require a range of different responses, including more advanced irrigation systems which take account of natural recharge rates, the precision application of fertilisers only at levels required by the crop, a continuation of organic production and the restoration of natural wetlands.

6.4 Reducing greenhouse gas emissions in rural Wales, UK

Sheep grazing in the Black Mountains, Wales, UK © Ben Allen

This case study examines the implications of using woodland planting as a means of meeting ambitious greenhouse gas emission reduction targets in rural Wales, UK.

6.4.1 Introduction and context

Wales covers 2.08 million hectares and is home to around three million people. The majority of the population are found in urban areas along the coast either in the north or south of the country, with the Cambrian Mountains[244] forming a central massif running across the centre of Wales. Approximately three per cent of the working population are employed in agriculture, compared to one per cent in the UK (WAG, 2012a) although this can be as high as 14 per cent in some areas.

Wales has an Atlantic climate with rainfall throughout the year, ranging from 3,000 mm in the Cambrian Mountains to lower than 1,000 mm in coastal areas and along the English border (Met Office, 2012). Grassland covers 58 per cent of the region (1.2 million hectares), over 90 per cent of which is under agricultural management[245]. Forest, heathland and moorland are also significant land covers (14.3 and 11 per cent respectively; FC, 2011; Russell *et al,* 2011)[246]. The relatively acidic soils, steep terrain, and poor drainage constrain the cropland area to seven per cent[247], found in the southeast and the northeast. Natural vegetation ranges from small areas of broadleaved deciduous woodland in the lowland areas to tundra-like heath lands in upland areas (Russell *et al,* 2011).

The distribution of land use in Wales is constrained by a range of bio-climatic and edaphic factors. This has in turn influences the distribution of ecosystem services across the region, particularly provisioning services. As with many grassland-dominated areas of Europe, Wales has a highly multi-functional landscape, providing food, timber, biodiversity, many regulating services and recreational opportunities. Although agricultural management dominates much of the grassland and shrubland areas, primarily for sheep meat, beef and milk production, tourism and recreation also play a significant role in the region's economy.

[244] Including the Elenydd Mountains, Snowdonia, the Brecon Beacons and the Black Mountains.
[245] Based on LUCAS 2009 land use and land cover data
[246] 308,900ha of Forest (FC, 2002) and 227,700ha of shrubland (Russell *et al,* 2011)
[247] 162,800 ha, based on Farm Structure Survey figures for total Arable and permanent crop land in 2007

The forest area, although small, provides timber and other wood products and is important for recreational activities, particularly in the publicly owned forests.

6.4.2 Demands on rural land in wales

There are many demands for services from rural land in Wales. However, this case study considers one of the key elements of the Welsh environment strategy, targets for the reduction of greenhouse gas emission reductions, as a means to explore the synergies and trade-offs between meeting this target and delivering other ecosystem services.

The Welsh Government has committed to reduce greenhouse gas emissions in Wales by at least 40 per cent by 2020 relative to 1990 levels through a three per cent annual reduction target. Existing evidence suggests that agricultural operations and land use change contribute around 11 per cent of Wales' total greenhouse gas emissions[248]. Of this, about 45 per cent is in the form of methane from ruminant animals (both their enteric emissions and manure) with an approximately equivalent contribution from nitrous oxide, mainly released by soil micro-organisms as part of the nitrogen cycle[249]. To combat these emissions, reduction target ranges have been established for the agriculture and forestry sectors[250] (WAG, 2012b). One of the proposed approaches to meeting these targets is through the creation of new, sustainable woodlands at the rate of 5,000 ha per year for 20 years[251]. By 2020 this could expand the woodland area in Wales by 32 per cent (100,000 ha)[252].

These GHG reduction targets do not stand in isolation from other demands on rural land. Across the region there is an increasing drive to improve the delivery of a wide range of services. This can be seen in the five key priorities are set out in a government vision for Wales in 2026 (WAG, 2006). These are to:

- minimise greenhouse gas emissions and adapt to the impacts of climate change;
- conserve and enhance biodiversity, while respecting the dynamics of nature;
- monitor and regulate known and emerging environmental hazards;
- tackle unsustainable practices; and
- conserve and enhance land and sea, built environment, natural resources and heritage, developing and using them in a sustainable and equitable way and for the long term benefit of the people of Wales.

The ecosystem approach has been put forward as a way of meeting the balance of these priorities and as a means of managing the natural environment in Wales (Watkins, 2012)

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[248] Around a net 5,200 kt CO_2e

[249] The release of nitrous oxide is influenced by a range of factors including: grazing and cutting regimes, nitrogen fertilizer application, water levels and pH.

[250] By 2050 an 80 per cent cut: equivalent to reaching total net annual sectoral emissions of about 1,650 kt CO_2e from the whole food system, or 1,040 kt CO_2e from those emissions reported in the Agriculture and LULUCF Inventories. This equates to an annual decrease in emission of 160-280 kt CO_2e from the agriculture and LULUCF sector. The aspiration to achieve a 'carbon-neutral' rural Wales by 2020 exists also (WAG, 2007).

[251] In 2005 only 44 per cent of woodlands in wales were certified as under sustainable production (FC, 2006)

[252] Based on woodland areas figures quoted above of 308,900 ha.

6.4.3 Ecosystem services from rural land in Wales

Comparisons of the relative potential of different land uses to deliver a number of these services are set out in Table 22. A more detailed description of this table, including the factors that limit the potential of land to support different services, can be found in Annex 7.

Table 22 shows that the current area of arable and intensive grassland is important for food production, generating higher per hectare yields when compared to extensive grassland areas. However, these areas contribute up to six times as much in land based GHG emissions when compared to extensive grasslands. Woodlands, both coniferous and deciduous are generally seen as a net sink. Arable land tends to have lower soil carbon content and higher surface water run-off with intensive grassland areas having greater methane, ammonia and nitrate emissions per unit of land. Species diversity is also generally poorer in comparison to deciduous woodlands and extensive grassland areas.

There are however differences between the two woodland types. Coniferous woodlands tend to support higher timber yields than deciduous woodlands, largely as they are more widely managed and harvested. Coniferous woodlands are important for some recreational services, but are comparable with arable and intensive grassland area in terms of the low levels of biodiversity they provide and store a lower volume of surface soil carbon(0-15 cm) than all land uses except arable. The major concentrations of coniferous woodland are located on poorer soils, mainly in upland areas[253], whereas the vast majority of Wales's broadleaved ancient semi-natural woodland and native woodlands are small and fragmented, often unmanaged, and generally set within an intensively managed agricultural landscape. Although coniferous woodlands currently support a greater volume of timber production, the current timber harvesting rate does not reflect the potential harvesting rate, and deciduous woodlands, if managed more effectively, could produce a significant volume of timber (WAG, 2011a).

Across the LULUCF sector there is estimated to be a current net overall 200 kiloton CO_2e sink of greenhouse gas emissions. However, projections show that within a decade, under current management approaches, forest holdings could become an annual emission source (Wyn Jones, 2010)[254].

[253] Although, significant areas of coniferous plantation can be found in south Wales valleys.
[254] Based on the 2007 GHG source and sink values as set out in the Wales GHG emission inventory. It is unclear why forest holdings could become an annual emission source.

Table 22: Quantification of ecosystem services associated with six land uses in Wales, UK

Service	Service class	Ecosystem service type - detailed	Arable	Intensive grass (milk)	Intensive grass (beef)	Extensive grassland (sheep)**	Woodland (deciduous)	Woodland (coniferous)	Factors affecting the provision of ecosystem services	Sources
Provisioning	*Nutrition*	Wheat grain yield (t/ha/yr)	7	-	-	-	-	-	Soil fertility and acidity, topography, rainfall	m
		Grass yield (dry matter basis) (t/ha/yr)	-	11	9	3	-	-		m
		Milk production (m^3/ha/yr)	-	8.3	-	-	-	-	Grass quality, limited by soil fertility, topography, rainfall and nitrogen application, stocking density and management approach	m
		Beef or lamb production (t/ha/yr)	-	-	0.35	0.1	-	-		m
	Materials	Timber annual increment (m^3/ha/yr)	-	-	-	-	3-4	10-13	Woodland management, stand density, nutrient availability in some areas	i
		Actual harvested timber portion (%)	-	-	-	-	5-8	75-76	Woodland management and demand for products	i
	Energy	Potential heat energy in harvestable biomass (GJ/ha/yr)***	131	96	78	26	55	55	Vegetation yield, limited by soil fertility and other bioclimatic conditions	b
Regulating and maintenance	*Waste*	Methane emissions (kg CH_4/ha/yr)***	-1.5	205	112	30	-3.5	-3.5	Livestock numbers, husbandry practices, soil type, vegetation composition	c
		N_2O emissions (kg N_2O-N/ha/yr)	10	10	8	2	0	0	As above + fertiliser application rate and method	a
		Ammonia emissions (kg NH_3-N/ha/yr)	7	36	29	4	0	0	Livestock numbers, husbandry practices, soil type, vegetation composition, fertiliser application rate and method, rainfall	d
		Nitrate losses (kg NO_3-N/ha/yr)	31	46	49	18	0	0		d
	Flow	Runoff contribution (m^3/ha/yr)	169	150	150	150	101	101	Vegetation height and density, planting orientation, slope.	e
	Physical	Soil carbon (0-15 cm) (t/ha)	33	62	62	75	71	61	Soil type, vegetation composition, land use, management practices	f
		Soil carbon (0-100 cm) (t/ha)	120	142	142	189	189	189		g
		Above-ground carbon (t/ha)	2.4	0.9	0.9	2	36.8	36.8	Vegetation composition, land use, management	g

									practices	
		Global warming potential (kg CO_2e/ha/yr)	5,190	9,190	5,530	1,400	net sink	net sink	Soil type, vegetation composition, land use, management practices and input use (fertilisers and pesticides).	c
	Biotic	Vegetation (species richness/200m^2)	11.8	14.7	14.7	21.1	21.5	13.9	Highly variable and context specific	h
		Bird food plants (species richness/200m^2)	6.6	9.1	9.1	11	9.6	4.4		h
		Tree species richness	-	-	-	-	0-2.2	0-1.6		l
Cultural	Symbolic	Conservation and heritage (0 low – 4 high)	3	3	3	4	4	3	Culturally specific	i
		Sense of history and place	High*	High*	High*	Med*	Med*	Med*		j
		Spiritual benefits	Med*	Med*	Med*	High*	High*	Med*		j
	Intellectual	Recreation (proportion of visits %)	8	8	8	11	14	14		k
		Leisure/learning	Med	Med	Med	Med	High	High		j

Key: Where comparable values are presented, green cells show the most beneficial land uses and red cells the least beneficial. Yellow and amber cells show moderately beneficial land uses. ***Notes:*** ** Highly location specific. **Extensive grassland includes semi-natural grasslands as well as moorland and heathlands, almost all of which is used for grazing. ***see Annex 7 for descriptions.*

Sources: **[a]:** derived from Williams *et al*, 2006; [b]: derived from Burgess *et al,* 2012; [c]: derived from Williams, A. *pers comm,* 2012); [d]: derived from Misselbrook *et al,* 2000; [e]: Bouffier *et al,* 2012; [f]: WAG, 2011b [g]: Abson *et al,* 2010; [h]: Smart *et al,* 2009; [i]: Russell *et al,* 2012; [j]: derived from a study in neighbouring England by Norton *et al,* 2012; [k]: CCW, 2009; [l]: WAG, 2011a - Index of tree diversity per hectare 0 means that only one species is present in the 1 ha square; [m] Indicative yields based on model results supported by Eurostat recorded values where available;

6.4.4 Synergies and trade-offs between ecosystem services in Wales

Any strategies that seek to meet the ambitions greenhouse gas emission reduction targets in Wales will need to consider not only the impact of certain land uses on the target but their importance for other ecosystem services. For example, intensively used grasslands are important both for food production as well as maintaining culturally valued landscapes. Therefore any strategies that seek to meet greenhouse gas reduction targets should do so whilst also maintaining food production potential (Wyn Jones, 2010).

Recognising this need, a special task force, the Land Use and Climate Change Group (LUCCG) was set up in 2007 by the Government, to tackle the issue of greenhouse gas emission reductions from the agriculture and LULUCF sector. The task force proposed 20 recommendations to the Welsh Government. These include the increase of sustainable forestry[255] by 100,000 ha whilst also adopting technologies and practices to improve the GHG efficiency of agricultural operations, such as Anaerobic Digestion (AD), better animal

[255] Consisting mainly of deciduous species but including a small proportion of conifers for high quality and enduring end uses (Wyn Jones, 2010)

husbandry and more efficient nitrogen fertiliser use. Other recommendations cover the increased use of renewable energy, improved research and government capacity, and public awareness. Our analysis here focuses on this woodland planting target, now adopted by the Welsh Government as a key element of its land use policy and the impacts of increasing woodland coverage in Wales. However, the woodland planting target should not come at the expense of delivering against other, equally important, priorities for land use in Wales (as set out in the 2026 vision). Minimising this risk requires the proactive engagement of land managers, sufficient levels of advice and targeted incentive payments.

Increasing woodland cover in Wales is not without precedent. Woodland planting on private estates can be traced back to the late 17th and 18th Centuries (Smout, 2002; Linnard, 2000). Substantial re-afforestation efforts began in the 20th Century with successive governments supporting the creation of large plantations of non-native conifer species. Re-afforestation rates peaked during the early 1960s at over 5,000 ha per year, but since the early 1990s planting levels have averaged around 500 ha and are currently much lower (Osmond and Upton, 2012). There was considerable criticism of planting on upland habitats (Avery, 1989) and on existing ancient woodland sites (NCC, 1984; Humphrey and Nixon 1999) due to loss of valued habitats, and pace of change in upland areas (Russel *et al*, 2011). The proposals set out by the LUCCG task force recommend that tree species adapted to the projected climatic conditions in Wales would be used and that planting should take place almost entirely on low- fertility, acid upland soils, including bracken-dominated slopes on pastureland. Additionally, the task force proposed that the Government forestry agency (Forestry Commission Wales) should bring forward plans to ensure that the current public and private forest holdings do not become an annual greenhouse gas source and that Wales' forests are managed to optimise their long-term greenhouse gas abatement capacity (Wyn Jones, 2010).

In terms of the expected improvements in ecosystem services, the 100,000 ha woodland expansion target could create an additional major greenhouse gas sink of 1,600 kt CO_2e annually by 2040, with a net sink of 1,200 kt CO_2e[256], and an additional fuel wood potential[257] off-setting emissions of a further 350 kt CO_2e of fossil fuels. A total potential GHG sink of 1,550 kt CO_2e annually would surpass the Wales target. Other benefits could include harvested wood products to substitute for high energy materials such as steel and concrete, additional habitat, improved landscape structure, better water-resource management, flood control, and creation of new employment and recreational opportunities (Wyn Jones, 2010).

Wales is prized for the high quality agricultural produce associated with the livestock sector including meat, milk and cheese, with the management of many of these areas adding to the cultural and symbolic history of the region as well as regional employment[258].

[256] Harvested wood products should substitute for high energy materials such as steel and concrete.
[257] With a potential of 1.4 TWh/year by 2030-2040 (Wyn Jones, 2010)
[258] The traditional landscapes of Wales are particularly valued for their spiritual, symbolic and recreational value, both in woodland and non-woodland areas. National parks and Areas of Outstanding Natural Beauty cover around a quarter of the land area, largely open and grassland areas maintained by grazing. Even the land

Respecting the need to preserve food production and cultural landscapes, the LUCCG did not propose woodland planting on high fertilise soils and improved agricultural grasslands. As a consequence, planting to meet this target would not tackle directly the negative impacts on ecosystem services caused by these systems (see Chapter 2)[259]. However, individual land managers could still choose these more productive areas for afforestation, supported through Glastir or private initiatives[260]. With planting targeted at low-fertility soils care will need to be taken to ensure that areas of semi-natural grasslands and heathlands on organic soils, which tend to be more extensively managed, are excluded from planting targets. This will help to maintain the ecosystem service benefits provided from these areas whilst improving synergies between services elsewhere. Strategic woodland planting could preserve also much of the character of the landscape and, by encouraging some additional arable (including minimum- or no-tillage or tillage) land, create additional farmland habitats if managed sympathetically (Wyn Jones, 2010)[261].

The Pontbren initiative can be used to illustrate further the potential synergies and trade-offs between ecosystem services from strategic woodland planting (see Box 12).

Box 12: Benefits of strategic woodland planting seen through the Pontbren initiative

The Pontbren initiative is a long term project by a group of neighbouring farmers in mid-Wales who are using woodland management and tree planting to improve the efficiency of upland livestock farming and the quality of the environment in which they live. The initiative started in 1997 when farmers used hedge and tree planting to provide more shelter for livestock grazing the steep, windswept land. Suitable, native species of broadleaved trees were chosen to provide the effective shelter needed. In addition to woodland planting, sheep grazing was concentrated on the best land areas, avoiding step valley sides and wet and waterlogged grassland[262], which were converted into riparian habitat areas and ponds.

The benefits seen across the initiative, which now covers ten farms, have been significant. Farm businesses have improved, through greater efficiencies in livestock enterprises[263] and farmers feel that the successful integration of woodland management into upland livestock farming has also 'future-proofed' their farms[264] (Woodland Trust, 2013 in press). Better management of existing woodlands has lead to improved habitat conditions and biodiversity (supported by Woodhouse *et al,* 2005; Walsh and Harris, 1996) as well as a steady

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outside of these areas forms part of the cultural history of Wales and the source of much of its tourism, food production and livelihoods of its farmers and land managers.

259 For example, if woodland planting were to be encouraged on more intensively used grasslands, methane emissions could be reduced by around 205 kg CH_4/ha/yr, ammonia emissions could be decreased by about 36 kg N/ha/yr, nitrate leaching losses could be reduced by about 46 kg N/ha/yr, and above-ground carbon storage could increase by up to 4,747 t/ha. However, the LUCCG task force has put forward recommendations to directly combat emissions from intensive livestock and arable production (see Annex 7).

260 The Pontbren example provided in Box 12 included some woodland planting on improved grassland areas (Keenleyside, C. *pers comm*. 2012).

261 The LUCCG task force has put forwards recommendations to directly combat emissions from these land uses (see Annex 7).

262 These areas were not only a poor source of grass production, also contained potential animal diseases such as liver fluke.

263 Data relating to the agricultural yields is yet to be released from the Welsh Assembly Government.

264 By improving the capital value of the land, making it more resilient to the effects of severe weather events as the climate changes, and substantially reducing the risk of accidental breaches of biosecurity and water pollution standards

supply of woody material for livestock bedding and firewood. Recreational benefits from game shooting have also improved in woodland and wetland areas, and could be a potential source of additional future income. The increase in woods, hedges and ponds in the Pontbren landscape has restored some of the pattern and diversity that had been lost during the 20th century, but as a fully functioning modern agricultural and forestry landscape.

The Pontbren farms are located in part of the upper catchment of the flood-prone River Severn, and one of the most interesting improvements in ecosystem services has been on reducing surface water run-off from improved grassland on sloping land. Where belts of mixed, native broadleaf woodland had been planted across the slope, during heavy rain soil infiltration rates inside the woodland were 60 times higher than those on the adjacent pasture (Bird *et al,* 2003). A programme of hydrological research carried out on the Pontbren farms suggests that tree shelter belts, located in the right place on improved land could help to reduce peak water flow by around 40 per cent (Jackson *et al*, 2008) with improvements in reduced sediment loss and nutrient run-off from the catchment (FRMRC, undated; Carroll *et al,* 2004). The data and information recorded through research carried out in the Pontbren area is now being used elsewhere in the UK to develop better ways of predicting the impact of upland land use on the risks of flooding downstream, a risk that is expected to increase as a result of climatic changes (Woodland Trust, 2013 in press).

On the basis of the proposals put forwards by the LUCCG task force, the quantitative information in Table 22 and the benefits seen in the Pontbren example, strategic woodland planting would seem to be an efficient means of improving synergies and ecosystem service potential from rural land. If all farmers in Wales were to plant broadleaved woodland on five per cent of their land, a proportion similar to that already planted by the Pontbren farmers, this would achieve more than three quarters of the 100,000 ha target[265]. It should however be noted that woodland planting has to be seen as part of a wider picture of land use and land management changes. Simply increasing the proportion of woodland area on rural land will not necessarily lead to improvements in all services.

Delivering the desired range of different ecosystem services from new woodland depends on the detailed and sometimes complex decisions about what, where and how to plant and manage the trees and their relationship with other land uses. In many cases, farmers will have the autonomy[266] to plant trees in a range of locations and on different types of land. These choices could mean the difference between improving synergies between ecosystem services and causing further trade-offs. For example, if farmers choose to plant fast growing, non-native tree species on extensive grassland areas, this could result in biodiversity declines and reductions in soil carbon content (see Table 22). Furthermore, if planting is not carried out in relation to existing hydrological pathways then the water run-off benefits, as seen in the Pontbren example, could be non-existent.

Advice and incentives, such as those provided through the Welsh Government's new Sustainable Land Management Scheme for Wales, *Glastir* could help to encourage woodland planting in the most beneficial locations to improving a range of ecosystem services, both on farmland, and elsewhere in the wider landscape[267], for example near urban areas where there is little woodland. If appropriately targeted, such advice and incentives could prevent

[265] And thus contribute significantly to overall greenhouse gas reduction targets
[266] With certain restrictions in relation to designated areas, EIA regulations and grant support conditions.
[267] A woodland planting map produced for Glastir, showing unsuitable, potentially suitable and suitable areas for woodland planting, is currently undergoing revision.

the planting of fast growing non-native species and support infrastructure investments, such as fencing, which can be costly and as such a barrier to woodland planting. However, these grants need to be appropriately tailored at delivering a wide range of ecosystem services, not just timber production, and be available to small-scale as well as large-scale schemes.

By taking a broader view of land use and environmental priorities, incentive schemes such as Glastir, can help to ensure ecosystem service trade-offs between land uses are minimised. For example, another option to help reduce greenhouse gas reduction targets and improve the synergies between different ecosystem services would be to improve the environmental management of existing grasslands. Moving towards more extensive grassland management could result in significant improvements to both greenhouse gas reductions (per unit area) as well as other services such as improvements in species diversity and soil carbon levels and reductions in water run-off[268]. However, care would need to be taken to ensure that reduced supply in food did not lead to a displacement of emissions elsewhere[269].

Summary
Overall, it appears theoretically possible that the agricultural and LULUCF sector in Wales could meet the ambitious GHG reduction targets set out by the Welsh Government. Significant contribution towards targets and improvements in ecosystem services can be achieved through changes in rural land use and land cover. However, meeting these targets whilst ensuring synergies between ecosystem services are improved will not come from woodland planting alone and instead requires a variety of responses. Strategic and well-informed decisions about land use are critical to achieving these synergies to ensure land management, including woodland planting, is carried out effectively and in the right locations (see Chapter 8).

The study has also shown that evaluating per hectare supply of different services is complex. The potential for rural land, such as that seen in Wales, to support different types of ecosystem services is dependent on the spatial configuration of features such as woodland, hedgerows, ponds and wetlands (Woodland Trust, 2013). These configurations are often seen at the sub-hectare scale and can vary between and within field parcels.

In summary, the different land use and land cover types found in Wales support different ecosystem services to differing degrees. The current configuration and use of rural land in Wales is capable of delivering of only a subset of ecosystem services. A more systematic approach to land use is required if greater synergies between services are to be realised.

[268] An extreme version of this approach was explored by the LUCCG whereby ruminant animal numbers were reduced by u to 70 per cent. This was dismissed as impractical, given the dependence of Welsh agriculture on pastoral systems, the comparative climate change advantages of Wales for food production, the social and economic barriers and the likelihood of displacing emissions to production systems elsewhere in the world (see Wyn Jones, 2011).
[269] Lifecycle assessments may provide an effective means of assessing overall greenhouse gas emissions in such cases.

Such an approach to decision making is already being considered but is yet to be put into practice[270].

6.5 Summary

The four case studies have demonstrated the variability in the synergies and trade-offs between ecosystem services that result from different land uses and land management decisions in different geographical areas across the EU. This highlights why it is important to look beyond generalised assessments for the EU-27, EU-15 or EU-12 (Chapter 5) when making judgements about how to achieve sustainable land use in the future and why regionally differentiated approaches are likely to be more effective.

One of the key issues in carrying out this type of assessment remains the lack of comparable data to quantify ecosystem services, even across relatively small areas. This information is fundamental to understanding and informing decisions about how to better balance the supply of ecosystem services from different types of land. There is a particular paucity of information surrounding environmental services, partly as these are generally not recorded in relation to economic activities. This has clear implications for the balance of assessments and decision-making at the local, regional, national and supra-national level.

There is a general recognition across all case study areas, of the need to improve the balance between ecosystem services. However, this recognition does not necessarily influence those who decide how land is used and managed. Different drivers have different levels of influence on the demands from rural land. Market based and economic drivers, which tend to focus on provisioning services always dominate to the detriment of the environment. The impacts, economic or environmental, of undersupplying environmental services is not always felt immediately by land managers and therefore does not necessarily feature as a significant decision making priority, leading to their undersupply.

The current land use, cover and cultural history of a region can play a significant role in determining the key demands from rural land and forms the backdrop to many of economic, social and environmental decisions. Despite these influences, there is a common range of services demanded from rural land in all case studies. These include food, timber, biomass for fuel, biodiversity, water availability and quality, GHG and carbon sequestration and recreational space.

Some ecosystem services, can be increased without necessitating a change in land use, for example by further development of the potential that already exists, such as increasing recreation visits to an area or carbon sequestration through greater accumulation of woody biomass in forests. Many ecosystem services can benefit from improved land management. For example, fire risk can be reduced through improved woodland management and greater environmental benefits can be seen on agricultural areas undertaking organic management, or low intensity grazing of agricultural grasslands. Improving agriculture and forestry yields requires often an increase in production-oriented management, such as greater irrigation or

[270] The recently published Natural Resources Management Plan will provide a common framework for decision-making in all of the areas of renewable energy, flooding, water quality and resources, waste infrastructure, landscape and nature conservation (WAG, 2012c).

fertiliser use, or more frequent harvesting patterns, although, improved yields can result also from a change in crop variety or livestock breed, which need not result in the deterioration of other ecosystem services.

However, improving the supply of ecosystem services can require a change in land use or land cover in some places. Some of these approaches are more sustainable than others and are very context specific. For example, increasing food production could require an expansion of the cropped area, bringing previously abandoned arable areas back into production. This may be preferable environmentally than expanding bio-energy crop production into grassland areas. Similarly protected forest areas could be increased in order to provide environmental protection and improve the natural functioning of ecosystems.

When one ecosystem service is prioritised over another there are inevitable trade-offs (see also Chapter 3). The extent of these trade-offs can be minimised through more sophisticated decision-making and an assessment of what level of provision of different ecosystem services is required to be sustainable (economic, environmental and social) in a given area. For example forest management in North Karelia shows that a greater proportion of woody biomass can be harvested whilst also improving conservation activities and maintaining or improving other regulating and cultural services.

However, not all services can be provided or improved necessarily from within the same unit of land. Issues of scale therefore arise**.** For example, timber production can be increased in one part of the forest whilst other areas are dedicated to conservation management. Although this can result in a net gain in ecosystem services over a given area, there will be localised trade offs between services - wood production will be constrained by conservation activities in one location and biodiversity, carbon sequestration and water quality will be constrained by increased timber harvesting elsewhere.

It is therefore important to consider the scale at which synergies between ecosystem services are required, if this is within the same hectare, water catchment, region or country. Furthermore, the use of a particular resource, such as water, can have impacts beyond the location in which it is consumed. For example, in the Catalonia study, the use of water for irrigation on previously rain-fed cropland leads to a reduction in water availability elsewhere in the river catchment, causing negative impacts on habitats and crop production in and around the Ebro Delta. Similarly the interception of water by different vegetation types in the upper river catchment lead to reduced flow rates downstream.

Understanding how to respond to an undersupply of specific services requires multi-scale thinking considering trade-offs and synergies between services. From the brief insight into some of the more detailed land use and ecosystem service interactions provided in this chapter there is clearly a need to think more strategically about how rural land is used. This will help policy makers and land managers to optimise the use of rural land to meet growing demands and ensure greater synergies between different ecosystem services.

7 OTHER APPROACHES FOR RECONCILING THE CONSUMPTION AND PRODUCTION OF LAND BASED SERVICES

Key findings:

- There are several alternative ways of sourcing the services associated with land in Europe other than by altering the overall area, land cover or management. Those of particular interest are:
  - changes in trade patterns, particularly increased imports;
  - adopting production technologies that require very little land; and
  - changing demand, including consumer preferences for food.
- Europe is already dependent on large scale imports of food, feed, timber and biofuels, which in turn has impacts on the way that natural resources are managed and the state of the environment in the countries from which they are sourced.
- Any change in the way that EU land is used and managed to balance future demands for ecosystem services that shifts the import/export balance will also have implications for the EU's global environmental footprint.
- Any increased imports from outside the EU are mostly likely to arise in relation to biomass for bioenergy, particularly wood pellets, biofuels and biofuel feedstocks as well as commodities imported to replace domestic crops diverted to biofuel production.
- In relation to finding alternatives with lower land requirements, the main opportunity lies in replacements for alternatives that could replace bioenergy as the source of renewable energy for heating and cooling, electricity generation and transport. There are possibilities, including certain wastes and residues. There are fewer land based alternatives for wood products as timber tends to be a much more sustainable material than many of the alternatives and within the timescale covered by this study it is unlikely that there will be a major shift to alternative systems of food production that do not use land.
- Finding ways of changing behaviour to encourage more sustainable consumption patterns is equally important, although beyond the remit of this study. This includes changing diets as well as reducing waste, particularly of food and energy.

Previous chapters have demonstrated that there may be some abatement of demand and supply for the principal land-based services of food, feed and wood products for material use in the future from EU rural land, although there remain significant uncertainties surrounding the future demand for biomass for bioenergy and there continues to be a large unsatisfied demand in relation to biodiversity and other non-provisioning ecosystem services. The reconciliation of EU demand and supply of land-based services does not take place in a vacuum. International prices for oil and core agricultural commodities as well as EU obligations in international environmental agreements will increasingly influence land allocation between competing uses in Europe. European choices about the future use of rural land in the EU will also have international repercussions.

This chapter considers alternative ways of sourcing the services associated with land in Europe in order to maximise the opportunities for addressing the environmental sustainability of different land uses. Those reviewed are:

- the implications of changes in trade patterns, particularly increased imports
- the potential for expanding domestic EU supplies of provisioning services through novel routes which do not require land, or so much land.
- reducing demand by promoting more sustainable consumption, both through reducing waste in the food supply chain and changing consumer behaviour.

A full analysis of the possibilities and environmental implications associated with each of these options was not within the scope of this study, with other sources providing a much fuller analysis (for example: Global 2000 *et al*, 2013; BIO IS; FAO, 2012; Faber *et al*, 2012; SERI, 2011)

7.1 The increased use of land outside the EU and implications for the EU's global environmental footprint

The EU is an important trader of food, agricultural and forest products - particularly fruit, beverages and oilseeds, timber and wood-based products and, increasingly, of feedstocks for biofuels and biofuels themselves. It is also an important exporter of land–based products, especially of value-added processed food and forest products[271]. How this trade evolves has significant environmental implications, both within the EU and globally. These have to be taken into consideration in assessing the net impacts of policy options for EU land use.

The EU-27 trade balance has tended to be slightly negative in value terms (ie a small excess of imports over exports) over the last decade. The scale of total trade flows has increased over time, but this is mostly because of higher prices rather than quantities. The USA is the principal destination of the EU's exports of spirits, liqueurs and wine and cereal preparations. Northern Africa countries (Algeria, Egypt and Morocco) are the most important importers of EU wheat. The principal sources of the largest volume of agricultural imports are Argentina and Brazil for oilcakes and animal feed, Brazil for coffee, and Indonesia for vegetable oils (palm oil). The pattern changes slightly when imports and exports are considered in relation to the embedded land requirements, with the greatest imports expressed as equivalent land area being from China, followed by Brazil and Argentina. The largest areas of 'land' exported from the EU are to Saudi Arabia and Turkey, followed by Japan, Egypt and North Africa (see Figure 20 below).

It is uncertain how global trade balances will evolve over the coming decades. However, although the balance of imports and exports is likely to change between countries and continents, the EU will undoubtedly continue to import significant volumes of agricultural commodities, and materials for bioenergy. The trade balance for wood products is perhaps less predictable as the EU has in the past switched between being a net importer and net exporter of wood products.

If there were to be a concerted effort to improve the depleted state of the EU's natural resources, meet the unmet demands for environmental services in the EU and this were accompanied by lower than predicted yield increases, then there would be a significant possibility that the EU's dependence on imports would continue and might grow in some areas more than others (for example livestock, animal feed).

[271] In 2010 the EU-27 accounted for 25.6 per cent of global agricultural imports, the next largest being NAFTA (USA, Canada and Mexico) at 18.3 per cent. The EU and NAFTA account for identical shares of agricultural exports in that year, 25.8 per cent

Policies which set out to improve the sustainability of EU agriculture and which, in the process, reduce EU domestic production and increase imports, therefore must take account of the global environmental impacts.

Life cycle assessment for individual product supply chains can be a useful tool for this purpose. These arguments have been intensively discussed in the context of EU biofuels policy, particularly through the ILUC debate and there have long been concerns over the ecological footprint of the EU's demand for agricultural products, particularly feed for livestock. In the context of growing global demand for food, new choices about the use of rural land in Europe may bring about land use change somewhere in the world. If the EU makes a smaller contribution to global crop production and output shifts elsewhere, it is likely to spark agricultural intensification or land use change elsewhere in the world and these indirect effects should be part of the EU policy assessment. Often the greatest environmental concerns arise when the change in land is from forest to grassland, or permanent grassland to arable crops, usually associated with large greenhouse gas emissions and significant biodiversity loss.

Making a robust assessment of different production impacts is a non-trivial challenge but it is increasingly necessary, both for policy reasons and because of increased interest by consumers and retailers in this information. It means being able to assess differential environmental impacts of additional production, potentially in different parts of Europe, Latin America, North America, Africa and Asia. Various approaches can be applied, some holistic, others focussed on specific environmental patterns. For example for relative GHG emissions or carbon and water consumption associated with agricultural production, the methodological bases for doing this on either a country or product basis are being constantly improved. Life cycle analysis is an increasingly widely used method. For biodiversity and other ecosystem services there are a number of systematic empirical assessments available using standardised approaches and applied on a global basis. There are also efforts being undertaken to assemble ecosystem capital accounts (EEA, in progress), part of a wider body of work on incorporating sustainability criteria into systems of national economic accounts (Stern, 2006; ten Brink *et al,* 2011; EEA, 2011a).

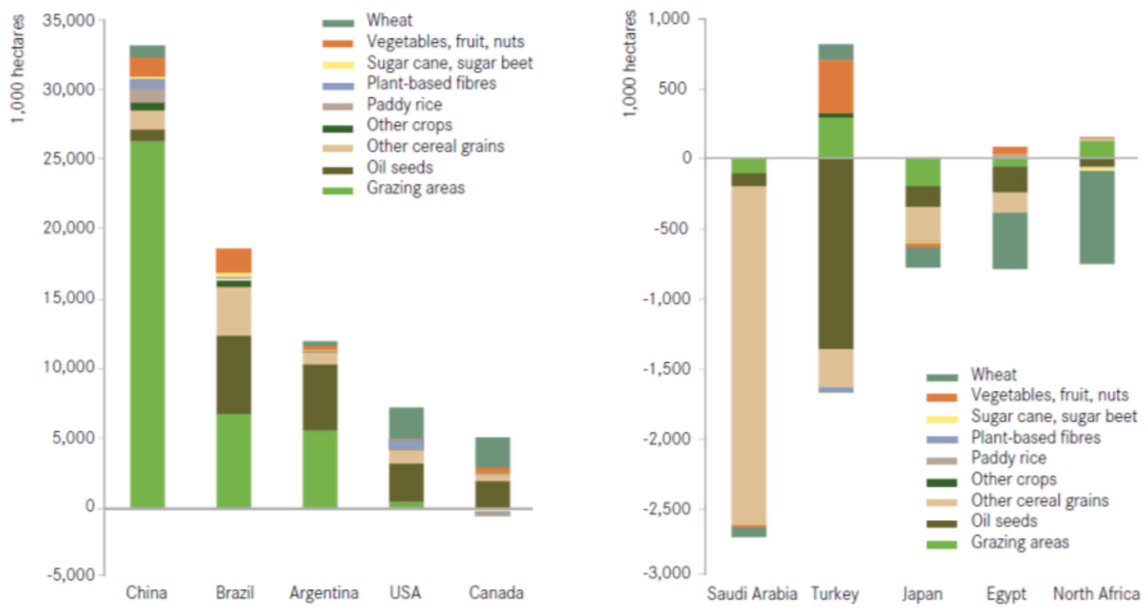
As these tools develop and the data to utilise them improves, there is a growing opportunity to apply them to policy processes and choices. They will help to underpin more robust measures at a European level. Several mechanisms can be envisaged whereby the EU could seek to minimise environmental impacts of supply chains in other parts of the world. These might include:

- the development of sustainable certification standards for food, akin to those that already exist for fish (via the Marine Stewardship Council) or timber (via the Forest Stewardship Council);
- efforts to influence the sustainability of production through international agreements and their subsequent enforcement (eg the Convention on Biological Diversity and the Kyoto Protocol);
- initiatives through bilateral trade agreements with other countries; and
- encouragement of voluntary and private sector standards and sustainability initiatives.

The net environmental effect of any downward adjustment in EU production in pursuit of sustainability would be dependent on the environmental improvements achieved in Europe compared to any negative environmental impacts which result from the increased overseas production, with the environmental impacts of the increased transportation factored into the calculation. This of course can only be assessed on a case by case basis. It depends on the products in question, the production systems in the EU compared to the exporting region, and the local environmental regulations.

Equations of this kind are receiving greater attention. One way of exploring them is through the concept of 'virtual' or 'embodied' land. This has been developed to demonstrate the land footprint that the EU effectively imports from other parts of the world in association with the commodity concerned (Bringezu, 2012; SERI, 2011). Figures from 2007 show that 40 per cent of the land used for crop and livestock production for consumption in the EU was located outside Europe, a greater proportion than for any of the other countries considered, other than Japan (Global 2000 *et al*, 2013).

Figure 20: Top five worldwide sources of net imports of land to Europe (left) and net exports of land from Europe (right) in 2007



Source: Global 2000 *et al,* 2013

This concept provides a graphic way of showing that by virtue of importing food the EU will be contributing to environmental pressures as well as economic activity in other countries. It is especially cited in the context of EU imports of soyabeans and oilcake from Brazil, and animal protein imports more generally (see SERI, 2011). Comparing biomass consumption per capita with estimated land demand per capita for the EU-27 indicates that on average almost six tonnes of biomass are derived from just over one hectare of land in the countries producing the biomass required (this includes both EU and non EU countries). Given the high level of imports of raw materials, this suggests a relatively high level of productivity on the land from which biomass for EU consumption is sourced (SERI, 2011).

However, measuring the EU's footprint in this way tells us about the implications the EU's consumption patterns on land elsewhere, rather than about the actual environmental impacts of the production methods in other countries. This is partly because land is not the only, or necessarily the scarcest, input into agricultural production. Water, nutrients, genetics resources, labour, capital and management are also key inputs, and in different parts of the world any of these may be a limiting factor in production. In addition, the productivity of land is extremely variable, within and between countries. It is not possible to assume, therefore, that importing commodities from other countries necessarily causes an increase in levels of ecosystem service decline. In some situations, production may be more resource efficient outside the EU. The impact of any adjustment in EU trade involving more impacts depends on a range of factors, which include:

- the source country for additional imports;
- the impact on land use of that an increase in demand for a particular product might have in that country, for example whether it increases the intensity of production or requires new land to be brought into production; and
- the associated environmental impacts that might then arise, for example whether it would put stress on water resources, particularly in arid countries, whether would it lead to grazing beyond the carrying capacity of the land, whether it would lead to an increase in greenhouse gas emissions etc

Of course there is certainly unsustainable use of land taking place in the production of some agricultural commodities destined for the EU market. Land-use changes which have taken place in some agricultural exporting countries have destroyed high value biodiversity and significantly added to GHG emissions in a number of circumstances. Equally there can be major socio-political concerns, for example where large agri-business operations are wielding excessive market power or small subsistence farms are being displaced by large scale plantations with an export focus. These environmental and social justice concerns are often greatest where there is new and concentrated production of a relatively narrow range of commodities on a large scale. The displacement of semi-natural vegetation is particularly critical in environmental terms. Although there are no global analyses which allow quantification of all of these questions, there are specific and localised studies on many issues in a range of countries. It is undoubtedly the case, for example, that there are strong environmental impacts of the expansion of soy and beef production in Latin America and palm oil in Indonesia. However the current political view is that each of these issues is better handled by direct policy action rather than by seeking to regulate trade. This implies alternative approaches through national agricultural and environmental policy in exporting countries, through international policy for biodiversity and climate action, and competition policy for example.

The sections that follow identify the commodities for which the greatest pressure for increased imports may arise and reflects on the potential environmental impacts that might ensue.

7.1.1 Wood products, including woody biomass for energy

Trade in roundwood and all its products has almost doubled within the EU and externally between the EU and its trading partners between 1990 and 2005, and decreased somewhat since then due to the economic crisis and the introduction of Russian roundwood export taxes (Forest Europe *et al.*, 2011). In 2010, total EU imports of timber and wood-based products from outside the EU were around 130 million cubic metres (roundwood equivalent) (Eurostat, 2012a). The EU also exports wood products and over the years the overall trade balance has been switching between net imports and net exports of roundwood equivalents. The EU is a net importer of pulp, mostly from the Americas. Most of the pulp imported into the EU comes from Brazil, the US, Canada and Chile (European Commission, 2012c). Pulp producers in the southern hemisphere are playing an ever-increasing role, due to lower material and labour costs, and increasing production capacity (Judl *et al*., 2011). It is foreseen that the relative advantage in wood production is moving away from countries with large forest resources in the northern hemisphere toward countries where trees grow more rapidly. The future supply of wood and fibre will therefore increasingly depend on the availability of land for forest plantations and their environmental and social costs (Jonsson, 2011).

The expansion of managed timber plantations in South America can have negative environmental and social impacts. For example, the large expansion of timber plantations in Chile during the last 30 years has been a direct cause of deforestation and biodiversity loss, due to the loss of native forest (Nahuelhual *et al*., 2012). In Brazil, social conflicts over the country's large scale eucalypt plantations have escalated (Kröger and Nylund, 2012). However, due to improved industrial safeguards, certification schemes, REDD+ schemes, and improved corporate social responsibility, it is likely that much of the future expansion of plantations will take place in areas in need of restoration, i.e. degraded tropical lands (Bauhus *et al*., 2010). In addition there is a high share of monoculture plantations based on fast growing species, eg Populus, Salix, Eucalyptus and acacia species cultivated using chemical inputs (fertilisers, pesticides). Some of the social and environmental implications of the increasing number of biomass plantations, involve reduced access of rural communities to land and water, food and local energy security, environmental impacts and land degradation (Wunder *et al*, 2012). In relation to environmental impacts in particular, the study points out that the current internationally accepted definition of 'forest' allows for monoculture plantations to replace primary forests without having to report such a land use change as deforestation, so that the impacts on carbon stock, biodiversity, soil and water associated with biomass imports may go unaccounted for (Wunder *et al*, 2012).

Trade in illegal timber is a global problem, with significant environmental, social and economic impacts. The effects of illegal logging include loss of habitat and biodiversity, erosion and land degradation, desertification, social disruption and adverse economic impacts both in terms of theft of resources from the lawful owner and lost tax revenues for governments (Markus-Johansson *et al*., 2010). In 2003, the European Commission adopted the Action Plan for Forest and Law Enforcement, Governance and Trade (FLEGT) to address the problem of illegal logging and the trade in illegally logged timber (Commission of the European Communities, 2003). In the follow up, the European Union adopted a regulation which prohibits trade of illegally harvested timber on the EU market, and requires operators to provide information about the origin of timber and timber products harvested and/or traded within the EU (European Parliament and Council of the European Union, 2010). The EU Timber Regulation (EUTR) will come into force in March 2013.

Even though the amount of biomass extracted from EU forests in a sustainable manner could be increased, this will not be enough to satisfy the increasing European biomass energy demand according to the EFSOS demand scenarios discussed in Chapter 5. Given that it is unlikely that there will be the scale of increase in the area of short rotation plantations on agricultural land in the EU that would be needed to satisfy this demand , the other alternative will be to increase imports from other world regions.

Fuelwood has in the past seldom been traded internationally as it is relatively low in value relative to bulk and has high transport costs. Wood pellets, however, are already traded internationally. Of the 16 million tonnes of wood pellets consumed in 2010 globally, 13 million tonnes were consumed in Europe. This trade is likely to increase markedly in the future (WBGU, 2009). Analysis suggests that at least 15 per cent of biomass for energy in Europe will be imported in 2020, much in the form of wood pellets (Uslu *et al*, 2012). The UK Climate Change Committee (CCC, 2011) suggests the EU could consume up to 90 million tonnes of wood pellets by 2020, equivalent to 45 per cent of total global demand. This has significant implications for forestry production in third countries. Most of the increase in imports would be likely to come from Canada, the USA, and perhaps also Russia, with associated concerns about the risk of damage to ecosystems (Hewitt, 2011). There are also concerns about the carbon emissions from the associated transport. For example, Magelli *et al*. (2009) showed that 14 per cent of the total energy content of the wood pellets is associated with long-distance ocean transportation.

If these were insufficient, there could be some reallocation of wood to energy production from the manufacture of traditional wood products (e.g. construction). However this would merely displace domestic supplies with imports for these manufactured products.

7.1.2 Agricultural commodities, including bioenergy from agricultural feedstocks

Existing agricultural production and trade patterns already have a significant impact on the environment. For example, considerable evidence has demonstrated the environmental impacts of soy production on soil carbon, biodiversity and water resources, which continues to be the main cause of deforestation globally, particularly in South America (for example, WWF, undated; Friends of the Earth, 2010; Global 2000 *et al*, 2013). Because of the environmental impacts associated with the conversion of woodland or grassland to cropland, the UK Foresight report suggests that it is necessary to 'work on the assumption that there is little new land for agriculture' in the future (Foresight, 2011). One estimate suggests that 'there is only about 10 per cent more potentially arable land that is not forested, highly erodible or subject to desertification. Expansion beyond this would involve destruction of forests, and with them, wildlife habitat, biodiversity and carbon sequestration capacity, which would accelerate global warming. Most of the potentially arable land is inferior to that already in production and is located in remote areas of sub-Saharan Africa and South America where infrastructure is minimal' (Thompson, 2011).

Agricultural commodities (excluding biofuels): The evidence on future demand for agricultural commodities in the EU suggests that, in addition to existing import levels, in the future imports of protein rich animal feed may well increase in response to the growth in the production of pigs and poultry in the EU, although this may be offset to a small degree by the decrease in beef production. This assumes that consumption patterns do not change and that there is no significant expansion of protein crop production in the EU. Having said this, the actual likely future dynamics are difficult to ascertain as prices adjust to shifts in demand and supply and trade flows react. It should be noted, however, that significant areas of land are used to produce food and feed that is imported into the EU and that these already have a significant environmental impact. Therefore, future decisions about rural land use in the EU should attempt to reduce this ecological footprint, not exacerbate it.

Biofuels from agricultural feedstocks: The production of biofuels is mainly policy driven and therefore projections on likely future imports are influenced heavily by changes in the nature and detail of the policy targets. The anticipated imports meeting the EU's renewable energy targets by 2020 under the current policy framework is substantial and the biofuel sector is very import dependent. An analysis of the NREAPs suggests that anticipated imports could amount to 44 per cent of bioethanol and 36 per cent of biodiesel requirements in 2020 (Bowyer, 2011). It is unclear from the NREAPs whether the anticipated imports refer to feedstock for 'domestic' processing into biofuels as well as imports of processed biofuels. Therefore, actual imported levels of feedstock might be even higher. However, these projections and those set out below are likely to change substantially if the recent proposals for changes in the EU's RED to take account of ILUC are approved, both in terms of the mix and feedstocks imported and their volume, which is likely to be much reduced. However, it is too early to be able to predict accurately the likely nature and extent of such changes.

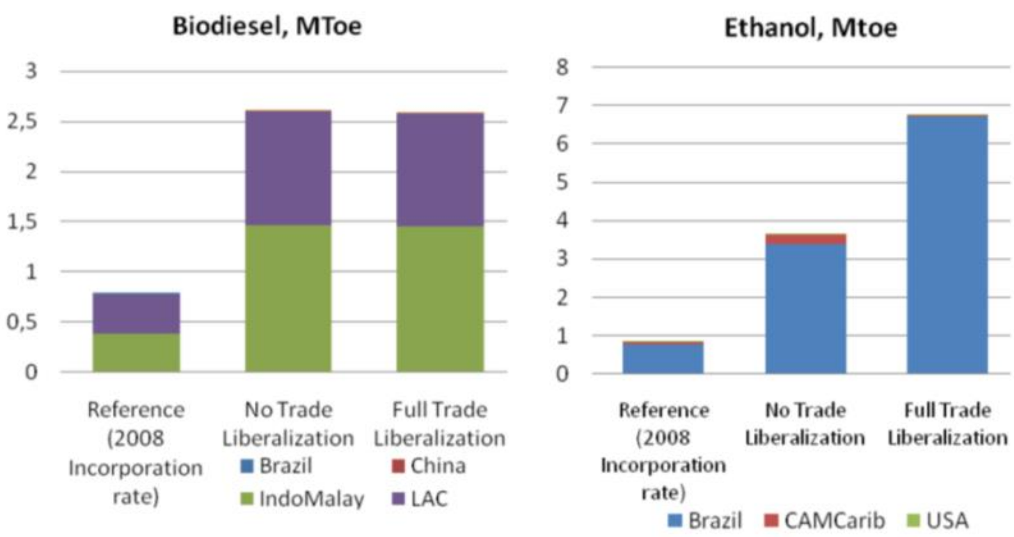
Europe is a small player on the market for ethanol imports, (FAPRI-ISU, 2011). This is not the case for the biodiesel market where the EU is projected to import most of world trade of supplies, with Argentina currently the largest source and Malaysia and Indonesia growing steadily more important. The modelling studies assessing the ILUC impacts of EU biofuel use shed further light on where imported biofuels will come from. Results from a recent IFPRI study (Laborde, 2011) show that EU biodiesel imports triple to meet biofuel targets (with or without trade liberalisation), with 60 per cent coming from Indonesia and Malaysia, the rest from Brazil (see Figure 21). Ethanol imports increase even faster, especially under the full trade liberalisation scenario. The dominant source of ethanol imports is Brazil from which imports increase five and nine fold in the target scenarios. Imports of biofuel feedstocks for processing in the EU are also expected to increase, particularly rapeseed and palmfruit.

In turn it is calculated that these EU biofuel induced trade flows lead to a significant expansion of cropland of between 1.73 and 1.87 million hectares worldwide (under no- and full-trade liberalisation, respectively). Half of this growth in cropland takes place in Brazil, CIS and Sub-Saharan Africa. The main habitats being converted to cropland are pasture and managed forest, contributing just over and under 40 per cent, respectively (the shares are similar in both scenarios with somewhat more pasture conversion under full liberalisation).

However, the environmental impacts of outsourcing biofuel production cannot be estimated directly from these projections of cropland expansion. The picture is much more complex. Outsourcing the cultivation of agricultural crops for EU biofuels can be done by either importing processed biofuels or the crops for EU processing. If less land were used for biofuel production in the EU, but demand remained the same, such a move would release land in the EU and therefore increase the availability of land for domestic food and feed production. The environmental impacts would also depend on the type of habitats being converted to arable. For example, the conversion of extensive pasture areas, especially in Brazil and other Latin American countries that is projected to happen in response to EU biofuel policy might translate into losses for species dependent on semi-natural grassland. However, given that this might mean that more food and feed crops could be produced in the EU this should reduce the demand for imports of these crops, subsequently reducing pressure from, for example, soy area expansion in Latin America. Economy-wide models are thus essential to understand these impacts more fully.

What can be said without the help of models, however, is that an increased share of imported raw materials and processed biofuels would require EU sustainability criteria to be understood and respected to a correspondingly greater extent in third countries. There would have to be sufficient trust that the criteria that *inter alia* prevent direct land use change of high biodiversity and high carbon stock areas are effectively implemented and enforced.

Figure 21: EU imports of Biofuels, Mtoe, 2020



Source: Mirage-Biof Simulations; taken from Laborde,2011(p46)

7.2 Alternatives with lower land requirements

If the EU is committed to reducing its environmental impacts associated with its use of rural land for the production of food, feed, timber and bioenergy, then one alternative is to consider whether there are alternative or novel approaches which can lower the land requirement for the production of these goods.

Agriculture and forestry are fundamentally the management of photosynthetic processes of harnessing atmospheric carbon dioxide plus water to produce carbohydrate for human consumption. For centuries agricultural and forest science has tried to improve our understanding of the underlying biology of this process and to breed plants best able to capture carbon and turn the biggest fraction into usable forms of energy. Inevitably the process of photosynthesis requires sheer leaf area, and this in turn means a demand for space to grow the crops or trees required. The productivity of this process can be improved and the area of land needed to produce a given quantity of output can be reduced up to a point, as discussed in Chapter 4. However, in some situations there may be alternative ways of creating the end product that do not require land to the same extent.

7.2.1 Alternatives with lower land requirements for bioenergy

To combat climate change there is a wide literature on the intensive search for non-nuclear, renewable energy sources which enable the displacement of fossil fuels (see BIO IS *et al,* 2011; EG FTF, 2011; IPCC, 2011). This search concerns energy for heating and cooling, electricity generation and for transport. A major contribution can be made by improving the efficiency of energy use in all applications. This can be done in transport by modal shifts (road to rail, combustion engines to electric) and behavioural change (lower speeds). It can be done for heating by district heating, combined heat and power, and by insulation and renovation of buildings. For power generation the greatest hope is for carbon capture and storage.

To replace fossil fuels the other main sources of power are solar energy, wind, geothermal and hydro power and harnessing ocean energy. Whilst onshore wind power and solar power do take up some land space, these developments are not seen as adding significant pressures to the use of land as a resource per se (although other environmental issues may be significant, see below). The combined footprint area of even large numbers of wind turbines is not large, and they can be sited in forests allowing multiple use of the land. Whilst field-scale solar panels could conceivably add to the competition for land, the preponderance of these will be sited in arid areas with few competing uses, or they may be in grazed areas but sited such that some grazing can continue.

Given these alternative energy sources, the question then emerges to what extent they could be expected to deliver up to 2050. At present the EU has binding renewable energy targets only up to 2020. This question has both a demand and supply dimension:

- What is the predicted future demand for alternative renewable energy sources beyond 2020 (as, for instance, dictated by decarbonisation scenarios), taking into account their (relative) costs?
- Will the supply be sufficient to meet the demand for renewable energy?

Some studies shed light on these questions. The aim of most of those reviewed below is to take both dimensions into account and to determine equilibrium solutions that take into account the constraints regarding resource availability, investment and operating costs, infrastructure requirements and decarbonisation pathways, to name a few of the key determinants.

The contributions to bioenergy expected to be delivered via the National Renewable Energy Action Plans (NREAPs) were reported above in Chapter 3. Under the 'Biomass Futures' project, ECN employed energy sector modelling tools to validate the NREAP predictions and investigate if Member States' projections could be expected to be met in 2020 (Uslu *et al*, 2012). Estimates of potential for a range of biomass categories have been derived at least for some Member States and in many instances at the NUTS2 level. Table 23 sets out the estimates of potential for the feedstock categories which do not primarily rely on land use (in italics). These represent a significant share of the overall potential in all scenarios. Agricultural residues are the single most important feedstock, making up a quarter up to almost a third of the total potential in the different scenarios.

Based on these estimates of potential, the least-cost allocation of biomass across the heat, electricity and transport sectors have been analysed (Uslu *et al*, 2012). The results indicate possible use patterns for European sourced biomass. Interestingly, with regard to non-land using biomass alternatives, the analysis suggests that cheaper European domestic feedstocks will be fully utilised by 2020. These include: wood residues, black liquor, post-consumer wood, used fats and oils. However, domestic production of straw and dry manure, as well as of roundwood, additional harvestable roundwood and grassy perennials for bioenergy will remain largely under utilised relative to technical potential. This is either due to logistical reasons or to the cost of the commodity or both. This pattern remains in 2030. Figure 22 illustrates the particularly low mobilisation of the potential of the principal agricultural residues on this assumption (around 12 per cent in both 2020 and 2030). Technical obstacles in transportation and combustion are likely explanations. So while a considerable potential from such bioenergy sources exists, enhanced efforts to mobilise this potential are needed to make this a real alternative to land-using biomass sources[272].

[272] See Kretschmer *et al* (2012) for an analysis of straw supply chains to feed advanced biofuel production. The report suggests that in particular advice and guidance to farmers is needed to understand better what proportion of straw can be extracted safely without jeopardising soil quality.

Table 23: Scale of technical potential for a range of biomass based renewables under various scenarios and timescales (Mtoe)

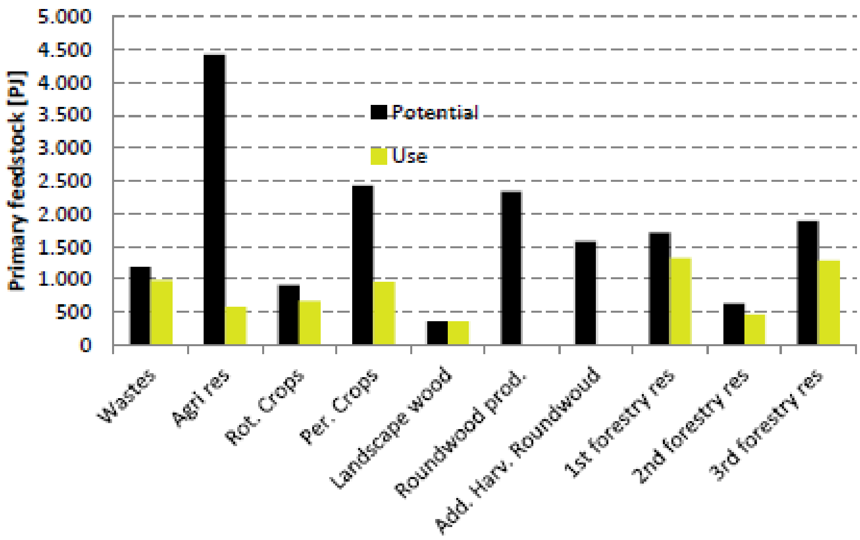
Class of bioenergy resource	Description of class ie examples of biomass sources included	Current Availability (Mtoe)	2020 Use – reference scenario[c]	2020 Use – sustainability scenario[c]	2030 Use – reference scenario[c]	2030 Use – sustainability scenario[c]
Wastes[a]	*Grass cuttings, residues from food processing, biodegradable municipal waste, sludges, used fats and oils and used paper and board*	*42*	*36*	*36*	*33*	*33*
Agricultural residues[a]	*Inter alia manure, straw, other residues including prunings and cuttings from permanent crops*	*89*	*106*	*106*	*106*	*106*
Rotational crops[b]	Crops grown meet bioenergy needs such as maize for biogas and crops used as biofuel feedstocks such as rape.	9	17	0	20	0
Perennial crops[b]	Dedicated energy crops providing lingo cellulosic material	0	58	52	49	37
Landscape care wood[a]	*Residues ie cuttings etc from landscaping and management activities*	*9*	*15*	*11*	*12*	*11*
Roundwood production[b]	Stem wood from forests currently harvested	57	56	56	56	56
Additional harvestable roundwood[b]	Additional potential for the harvesting of stem wood within sustainable limits	41	38	35	39	36
Primary forestry residues[a]	*Logging residues, early thinnings and extracted stumps*	*20*	*41*	*19*	*42*	*19*
Secondary forestry residues[a]	*Residues from the wood processing industry ie black liquor, sawmills and other industrial residues*	*14*	*15*	*15*	*17*	*17*
Tertiary forestry residues[a]	*Post consumer wood waste ie from households, building sites*	*32*	*45*	*45*	*38*	*38*
Total		**314**	**429**	**375**	**411**	**353**

Source: Elbersen *et al* (2012), p5; *Notes*:

a – Denotes potential resources that could be deemed as waste materials or residues
b – Denotes potentials based on primary production either through agriculture or forestry systems to deliver resource
c – The scenarios refer to the two main scenarios modelled under the Biomass Futures project, ie a reference scenario applying the RED sustainability criteria for biofuels as the one in place in early 2012 and a sustainability scenario that extends sustainability criteria to all forms of bioenergy, imposes more stringent greenhouse gas saving targets and introduces crop-specific ILUC factors.

The principal advantage of using wastes and residues is clearly that they do not rely on the direct use of land, at least not fertile crop land to a large degree. They therefore compete less with the supply of other ecosystem services. However the most important challenge that is stressed in the studies of using wastes and residues is the high, sometimes prohibitive, costs associated with certain renewable energy sources. By definition these are spatially diffuse sources of relatively bulky, low value material. This poses significant logistical and transportation challenges to keep both the economic and environmental costs acceptable. A further consideration is that there are increasingly active policies to reduce waste, in homes and in the food chain. To the extent that they are successful the availability of these raw materials for bioenergy production will diminish. However, working in the opposite direction are developments to recover and recycle nutrients from human, municipal waste. As the technical problems of dealing with pathogens, smell and heavy metals are overcome then, suitably mixed with other waste streams and residues, processes are under development to digest such materials providing energy, recovered phosphate and nitrate fertiliser and organic material as soil improver. The remaining barriers are then institutional and attitudinal. For example, there has been long-established nervousness about returning materials derived from human waste to agricultural land.

Figure 22: Domestic EU-27 primary feedstock: estimates of potentials vs utilisation in 2020



Source: Uslu *et al* (2012), p18

However, such alternative sources of bioenergy are not without their environmental impacts. The impacts of different low-carbon energy sources on biodiversity have been investigated for the UK context, but also looking at the global impacts of the different pathways chosen (BIO IS *et al*, 2013). The most notable impacts for energy sources other than crops include the following:

- ***Agricultural and forestry residues***: Direct habitat loss is likely to result from the intensive extraction of dead wood. Over-extraction of straw can lead to losses in soil functionality, decreasing soil carbon stocks and have potential knock-on effects on biodiversity.
- The construction of ***onshore wind*** capacity: the key issue here is to find suitable locations where wind power can be harnessed most efficiently and that are not in

conflict with the interests of citizens and property owners (with regard to noise pollution and disfigurement of landscapes) as well as conservation interests (with regard to placing wind turbines in habitats important for birds). There is no compelling evidence to expect systematic mortality in migratory birds due to wind turbines, either onshore or offshore, instead, environmental impacts are largely limited to the construction (and decommissioning) phase. These issues can be remedied by careful siting (Bowyer *et al,* 2009; BIO IS *et al,* 2013).

- ***Ocean energy*** technologies have largely not been tested at commercial scale and therefore biodiversity impacts are difficult to predict, although there is some evidence for loss of intertidal habitats and species from tidal range applications.
- Some impacts on marine biodiversity are expected from undersea electricity cables that will be needed for transmitting electricity to Europe from, for example ***offshore wind*** installations as well as ***solar power*** capacity installed in North Africa.

The findings show that impacts from (in particular land-using) bioenergy sources on biodiversity and the broader environment are potentially much greater than from any of the alternatives (BIO IS *et al,* 2013). Having said this, some of the technologies have not been demonstrated at commercial scale or in large-scale applications. Future developments of, for example, large-scale wind turbine fields will need to be sited carefully in order to mitigate potential risks, for example in relation to intermittency of supply.

The overview of renewable energy sources above shows that alternatives exist for most sectors and uses. The advantages of alternatives are clearly the fact that they do not rely on the use of land, at least not on fertile crop land to a large degree, and therefore compete less with the supply of other ecosystem services. The other renewable energy source where the land use dimension is most present is the construction of onshore wind capacity.

The most important challenge that is stressed in these and other studies are the high, sometimes prohibitive, economic costs associated with certain renewable energy sources. This provides a rationale for policy support as indeed exemplified by the Renewable Energy directive. Most technologies have furthermore specific technical, regulatory and infrastructure related barriers to overcome. Alternatives are less readily or not at all available currently for heavy and long-distance road transport, shipping and aviation as well as certain industrial processes. Having said this, these sectors and uses can be fuelled by advanced bioenergy pathways that make use of residues, but their mobilisation remains underexploited. Some renewable energy technologies require further research, development and demonstration efforts before they become economically viable (and before any potential negative impacts on the environment can be assessed).

Both energy efficiency improvements and renewables deployment are contingent on infrastructure improvements. This includes most notably improvements and extensions of the electricity grids, in order to connect European regions with each other providing balancing capacity (important with increased shares of variable energy sources such as wind and solar), connecting offshore wind capacity to the main demand centres, installing demand side management devices such as ‘smart metering’ and introducing charging infrastructure for electric vehicles, to name a few.

In the light of these requirements, it is not surprising that bioenergy is seen as a 'cheap' way of meeting renewable energy targets. This financial aspect becomes all the more important in times of economic austerity, putting Member States under significant pressure to find low-cost solutions to meeting renewable targets. Estimates for the UK suggest excluding biomass from the energy mix would significantly increase the cost of decarbonising the energy system, representing an estimated increase of £44 billion[273]. Of course it is possible to meet energy supply requirements in other ways, which might be cheaper than bioenergy but not renewable. Gas is perhaps the most obvious example.

1.1.2 Alternatives with lower land requirements for food production

Currently, around 99 per cent of global food supplies (calories) for human consumption come from land-based food production (FAO, 2007). However, as far as food production itself is concerned, although there are a number of alternatives either that are starting to be used in some sectors or are under development, the degree to which they may make a contribution in the time period considered in this study is fairly limited. Nonetheless they could signal a new direction of travel in the future. These include:

- Hydroponics – the growth of crops in mineral nutrient solutions without the need for soil substrate – this technology is already in widespread use for the production of fruit and vegetables.
- Hydroponics combined with vertical production systems, which essentially create multi-storey stacked environments using a combination of hydroponic and glass house technology. There are examples of this approach already being piloted, for example a vertical greenhouse is under development in Sweden to grow pak-choi, which is planned to be operational from 2014[274]
- In vitro meat production, whereby muscle tissue is gown in a lab based environment to provide an alternative to farmed meat. There is considerable research effort being put into developing edible tissue grown from stem cells in laboratories in both the Netherlands and the UK, however, this is slow, complex and expensive work and therefore it is unlikely that this technology will provide realistic scaled up solutions for some time to come. Having said that, studies show that artificial meat could have significant environmental benefits, using far water and energy as well as land.
- Nanotechnology to produce new tools to increase the nutrient absorption capacity of plants or for the molecular treatment of diseases, for example.

The success and potential uptake of these technologies will depend, first on whether they can be scaled-up from experimental to commercial level to produce products that are saleable on the market. From there their penetration will be highly conditional on their relative costs of production, consumer attitudes and their environmental credential, particularly in relation to energy use. Generally they involve replacing land by capital

[273] UK Bioenergy Strategy from April 2012: http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/bio-energy/5142-bioenergy-strategy-.pdf (last accessed 20 June 2012). Using an exchange rate of 1.239 from 21 June 2012 (http://www.oanda.com/currency/converter/), this converts into €54.5 billion.

[274] See http://www.businessgreen.com/bg/news/2202910/can-a-swedish-skyscraper-greenhouses-solve-the-worlds-food-crisis

equipment, requiring considerable investment. Whilst land prices probably will continue to rise over time, the additional costs and need for investment at a time of credit constraints suggests that many of these novel approaches may not be competitive on a large scale for a long time to come.

7.2.2 Alternatives with lower land requirements for timber

Alternatives may also be viable to replace wood and wood products in a variety of applications at a variety of scales but clearly this is a large topic. There would be significant impacts on the environment in different parts of the world from any substantial shifts. For example, it is clear that alternative materials for construction could be used to reduce the demand for timber. However, given the environmental impacts of alternatives, such as steel, concrete and bricks which are energy intensive in production and thus associated with heavy greenhouse gas emissions, and the impact of sourcing the raw materials themselves, the debate more usually centres on the issues of how to increase the use of wood as a more sustainable substitute for these materials in construction rather than vice versa (Gustavsson and Sathre, 2006; Lippke *et al*., 2011). Paper recycling rates are already reasonably high, although a large proportion of the recycled material is exported rather than used in the EU. Improving the use of recycled paper within the EU may reduce the demand for fresh pulp wood, therefore.

The use of wood fibre could theoretically be reduced by substituting paper with electronic media, although so far this has not happened to any great extent contrary to expectations. It should also be noted, however, that decreasing pulp and paper production in Europe currently is linked with simultaneous reduction of renewable energy production from wood residues in the industry. During the recent financial crisis in Finland, for example, difficulties were experienced to meet the high renewable energy target of their National Renewable Energy Action Plan (NREAP), because many pulp mills were temporarily taken out of production.

7.3 Changing consumer behaviour - reducing waste and changing diets

Trying to alleviate pressure on land by finding alternatives on the supply side is only one part of the picture. Just as important could be changes in consumer behaviour aimed at achieving more sustainable consumption patterns. There is great technical potential to reduce the amount of waste, particularly in relation to energy and food including, potentially, demand for land and other resource intensive forms of food, notably meat. To date governments have committed to make efforts to improve energy efficiency and thereby contain the growth in energy demand in a range of ways but attempts to influence consumer habits on food waste are still in their infancy. For the medium term therefore, it is more realistic to plan for larger reductions in energy consumption for than food consumption, particularly where this involves changing dietary preferences by policy interventions.

Of course, the need to reduce waste does not solely relate to food and is not the sole responsibility of consumers. Significant improvements remain to be made in post harvest waste and along all parts of the supply chain. In addition, evidence shows that 20 to 40 per cent of Europe’s water is wasted and water efficiency could be improved by 40 per cent through technological improvements alone, with further savings possible through changes in water consumption patterns (Dvorak *et al*, 2007).

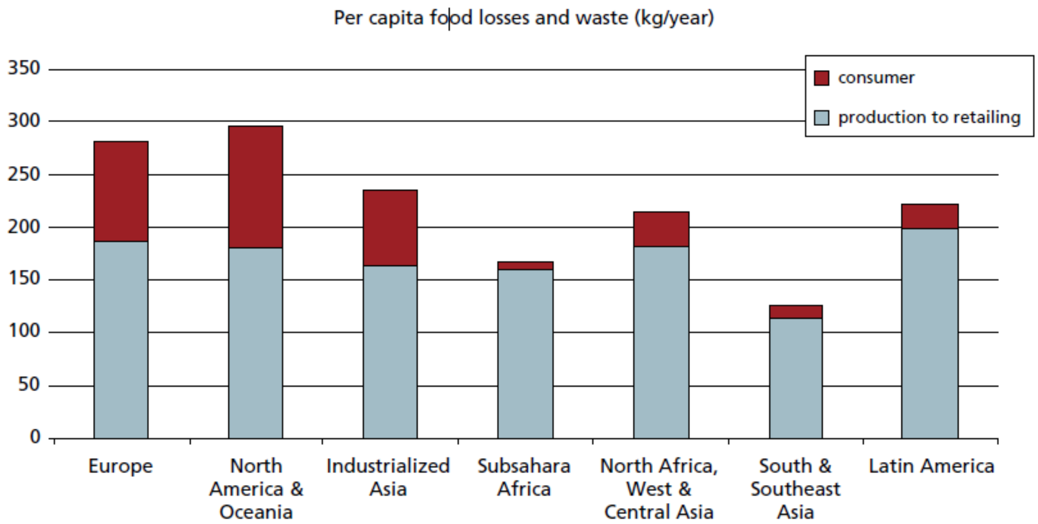
7.3.1 Reducing food waste

It is estimated that around 30 per cent of all food produced in developed countries is discarded, in part by the final consumer and even these figures are thought to be underestimates (Gooch *et al*, 2010; Lundqvist, 2009, Kantor *et al*, 1997, all quoted in OECD, 2012). Household consumption is the dominant but not the only source of food waste, in developed countries. Wastage or food loss (FAO, 2012) also occurs all along the supply chain from production, post-harvest through to processing and distribution. It is noted that 'these losses are mainly caused by inefficiencies in the food supply chains, like poor infrastructure and logistics, lack of technology, insufficient skills, knowledge and management capacity of supply chain actors, no access to markets. In addition, natural disasters play a role' (FAO, 2012).

In the EU-27, annual food waste is estimated at approximately 89 million tonnes representing 179 kg per capita (BIO IS, 2010), although this increases to approximately 275 kg/capita if all sources of food loss are taken into account (FAO, 2011) – see Figure 23. In the UK, for example, by 2008 as much as 25 per cent of purchased food was found to be wasted in the home (Foresight, 2011). The Foresight study reviews the findings of a number of studies in the UK, USA and Australia to look at the reasons for this wastage. They indicate the low cost of food as a primary driver, and highlight a complex array of consumer attitudes, values and behaviours towards food and how varying degrees of food knowledge affect individuals' propensity to waste food. They attribute most of the avoidable waste to two factors: too much food prepared and cooked in the home, and food being prepared badly and discarded. A poor understand of food labelling and the difference between 'best before' and 'use by' dates also played a significant role (Foresight, 2011). Efforts are being made to adjust labelling systems in the UK, and to work on food waste in the Netherlands.

Work undertaken for the Commission in preparation for the Resource Efficiency Roadmap highlights the fact that food waste represents about 3 per cent of the GHG emissions of the EU-27 (170 Mt CO2 eq./year), 45 per cent of which is attributable to household waste. To quantify the impacts of food waste on ecosystem services and to demonstrate the economic and environmental savings that might be achieved through reducing waste, the FAO have set up a project to analyse the embedded water, soil, biodiversity, greenhouse gases in food wastage at the global level in order to produce the first global Food Wastage Footprint (FWF) (FAO, 2012).

Figure 23: Per capita food loses and waste, at consumption and pre-consumption stages in different regions



Source: FAO, 2011

These studies also suggest that the great majority of food losses and waste in principle could be avoided at all points along the supply chain, including household waste, although this would require significant behavioural change, which can be difficult to achieve through policy intervention. Nonetheless, research in the UK suggests that up to 60 per cent of the food wasted by households could in principle be avoided, saving more than €500 per year per household (WRAP, 2010). The recent EIP on Agricultural Productivity and Sustainability suggests that the establishment of sustainability criteria, at pivotal points throughout the supply chain, would contribute to increasing transparency, trust, and knowledge.

7.3.2 Dietary Preferences

Changing dietary preferences, particularly the increase in meat consumption in countries such as China and India have a significant impact on global demand for land, particularly for growing the crops needed for livestock feed and hence on resource use and ecosystem services. Meat consumption in particular has a much higher land demand than plant based products, due to the combination of the area needed to graze/house animals as well as the area required to grow the crops needed for animal feed. Livestock, particularly ruminants, are also responsible for a significant share of agriculture's green house gas emissions. Evidence also suggests that livestock production is one of the largest sources of water pollution globally, again as a result of the water demands of feed crops as well as livestock wastes. So, reducing meat consumption both in the EU and globally could have a significant effect on reducing the pressures on land use and their associated environmental impacts globally.

Governments can play a significant role in promoting healthy eating to the public, including eating less meat and dairy products, and can operate across a wide sphere from directly providing nutritional advice and information to regulating the advertisement of unhealthy foods to certain groups such as children. This is the subject of much debate in the UK, and in Germany, In 2009, the federal environment agency issued an advisory[275] suggesting people eat less meat and model their diet on that of Mediterranean countries. According to Destatis, the federal statistics agency, meat consumption has already fallen in Germany from an annual 64kg a head in 1991 to 58.7kg in 2009, mainly due to health reasons, although this level of consumption is still relatively high.

However the policy tools for influencing dietary behaviour are limited mostly to the relatively soft devices of information, education and public health messages. Denmark introduced a surcharge in October 2011 on foods containing more than 2.3 per cent of saturated fat[276], but abandoned it a year later following strong public and food industry criticism that it inflated food prices, put Danish food industry jobs at risk and induced consumers to cross the border and purchase in Germany. In general, even if such taxes encourage some reduction in local consumption this may merely encourage more exports with no reduction in pressure on land locally and no reduction in pollution either. There seems therefore to be political limits on raising food prices by taxes on unhealthy components of the diet, even though this approach has been used extensively for alcohol and tobacco.

A recent EU study examined four policy options for changing food consumption behaviour with a view to reducing associated GHG emissions (Faber *et al,* 2012). The policies examined were: mass media, mandatory nutrition labelling, financing school-based intervention programmes and introducing consumption taxes. The school-based approach was the most effective, but also the most expensive. None were found to be very effective alone, but a combination of all four was estimated to be twice as effective as the best single intervention (through schools).

The experience in the Europe is that it takes a long time to establish the scientific basis of claims about health and diet, and then further time to coordinate with, and to get the engagement of, the partners in the food chain, particularly food manufacturers and distributors. This has certainly been the experience with nutritional labelling. However, such approaches can have impacts in the longer term. If it is slow and difficult to influence consumer behaviour when there are a potential direct personal health benefits from doing so, it seems likely that it will be slower and more difficult to motivate diet change in order to protect the environment – either locally or globally. These cautious conclusions do not argue against trying to achieve these behavioural changes, only to suggest realism about the time it takes to achieve noticeable results.

[275] http://www.guardian.co.uk/world/2009/jan/23/german-diet-meat-environment

[276] Agra Europe Issue AE2541 (20 November 2012).

8 STRATEGIC APPROACHES FOR PURSUING SUSTAINABLE RURAL LAND USE IN EUROPE

Key findings:

- Increasing the supply of ecosystem services from land generally relies on a set of appropriate policy interventions, since market forces play only a limited role in this regard.
- Whilst there are constraints on environmental policy initiatives at a time of economic downturn, some conditions for a new strategic emphasis on public goods are more favourable. For example the stabilisation of Europe's population is now in sight. Furthermore, our improved understanding of the extent of the damage to natural capital and the threat this poses to the sustainability of our food and timber production systems now has improved.
- A range of policy tools and mechanisms is available currently or could be developed to guide the rebalancing of rural land use and management in Europe at different geographical scales. These can be divided into three groups: 1) spatial allocation tools that seek to determine how and where certain land use activities are most appropriate; 2) implementing/influencing tools, including the use of environmental regulations and incentives; and 3) monitoring and evaluation tools.
- The policy approaches to integrated rural land use decision making vary significantly between Member States. Generally, the integration of ecosystem service considerations into spatial planning is still relatively undeveloped and the cumulative effect of different policies in a particular location tends to receive very limited attention until after decisions have been made.
- Some common issues and barriers affecting the implementation of more strategic approaches to rural land use include: a) political sensitivities about the role of planning and encroachments on private property rights in rural areas ; b) limited awareness amongst the general public and land managers about the effects of land management on the environment; c) determining the most appropriate scale at which a coherent territorial approach should be applied; and d) issues with the quality and availability of data to support the development, implementation and subsequent monitoring and evaluation of more sophisticated approaches.

This chapter considers a range of policy tools and mechanisms that are available to influence the allocation of rural land to different uses and to guide land management in a sustainable and resource efficient way. This is followed by an analysis of the role of adopting more strategic approaches to steering land use, such as integrating ecosystem services into rural land use planning, that could be adopted at different geographical scales. Examples from four Member States are used to explore some of the advantages and barriers to developing such approaches.

8.1 Property rights and their allocation in rural areas

The ownership of rural land in the EU has a major influence on its use and management. Private ownership is the predominant model in agriculture and most other uses. For much of the rural land in the EU property rights are well established and, in the case of agricultural land, held mainly by individuals and legal persons. A significant proportion of forest land is in public ownership, around 40 per cent overall[277] although there are large variations between Member States.

Property rights allocate ownership of land and its associated resources, defining the way that the land can (or cannot) be used and who can benefit from the products of that land.

[277] Figure is for EEA region, not just EU Member States (MCPFE, *et al*, 2007).

Ownership of the land and its products may be separated, for example between owners and tenants, or between owners and those with common rights (to grazing or harvesting wild plants). The state can restrict the use of private rights through a range of policy tools including regulation (for example on building, environmental pollution, timber harvesting, water abstraction, protection of habitats and landscape features), financial measures (selective taxation of agricultural and forest land), or via requirements linked to payments to land managers (cross-compliance requirements, land management contracts, investment aids).

The way in which property rights are allocated and their use restricted reflects complex historical processes. Some of these are long standing and others quite recent. In many EU-12 Member States the balance has shifted from collective to private ownership of agricultural land within the last 25 years, and the consequences for land use allocation and management are still being experienced as a dynamic process of adjustment.

The extent of state regulation of the exercise of private property rights differs markedly not just from one jurisdiction to another, but also across the EU for different land uses, both in terms of the type of land use and the intensity of use. In the case of ecosystem services with strong location-specific characteristics (for example, urban development, conservation of internationally important habitats and species, and protection of water resources) property rights are often highly regulated within closely defined spatial zones. In contrast, on the majority of rural land in the EU that lies outside these zones, there is a comparatively low level of regulation of property rights for agricultural and forest production. Figure 24 is a diagrammatic representation of the comparative levels of regulation of property rights for different land uses. It reflects both regulation of land use change (vertical scale) and regulation of land use intensity (horizontal scale). In general terms this illustrates that the majority of rural landowners and managers have a large degree of freedom to determine the intensity of use of their land and also considerable scope to change some land uses (for example between arable crops and from agriculture to agroforestry or forest).

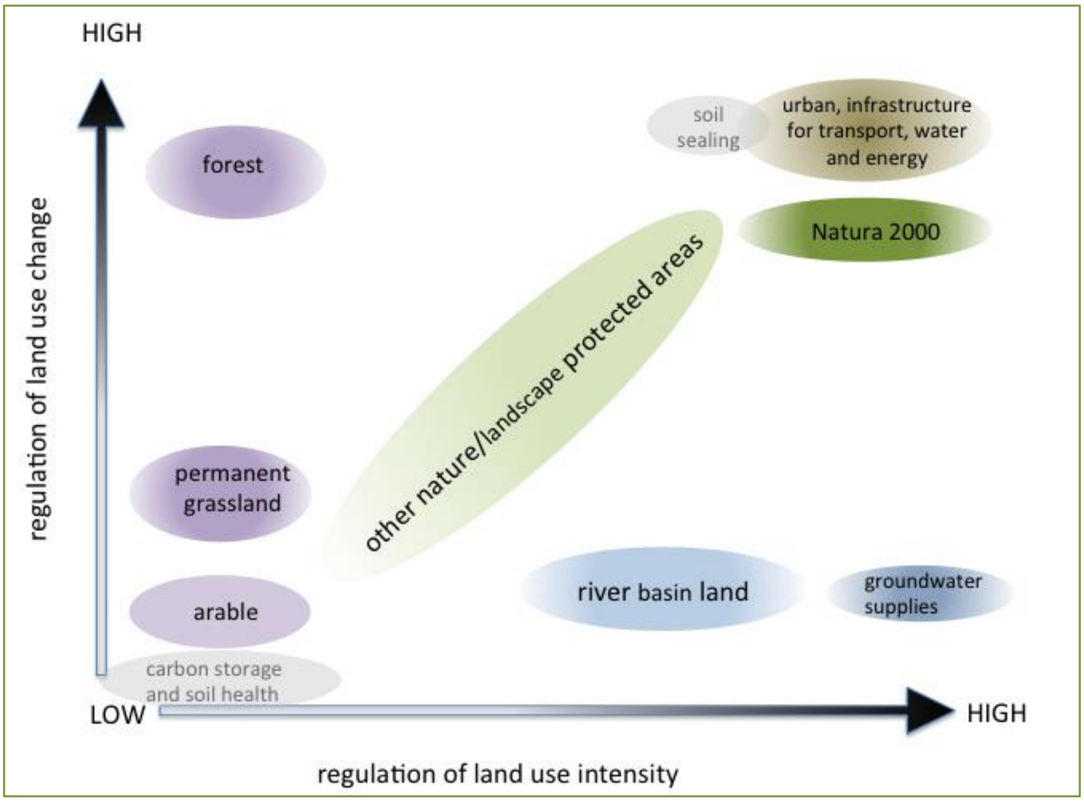
8.1.1 Interaction of property rights with market drivers

Chapter 4 has shown that global commodity markets for agricultural products are strong drivers of both the choice of agricultural land use (crop) and the intensity of management of that use, especially in the case of arable land where short-term changes in cropping are relatively easy to implement. Global markets are also an important factor in determining the type and intensity of forest production but change on the whole is slower, because forest production cycles are normally measured in decades, although the levels of production (harvesting) and the end use of timber and by-products can be changed much more quickly.

Decisions about how land is used, including the intensity of the production system, rest almost entirely with millions of individual land owners and land managers. Their decisions have profound consequential effects for other ecosystem services both in terms of demand (for irrigation water for example) and production capacity (of biodiversity, unpolluted water, carbon sequestration). Most of these individuals rely on market returns for the major part of their income, although income and other direct aids through the CAP are also significant. In making business decisions there is no reason for these land managers to account for the full costs of providing ecosystem services, beyond the regulatory baseline that applies to all land users.

The interaction of location-specific ecosystem services and private property rights clearly affects the choice and potential 'reach' of policy tools which might be used to plan and implement a more sustainable approach to rural land use and management in the EU.

Figure 24: Extent of regulation of private property rights to land use and intensity of use



Source: Own compilation

8.1.2 Policy tools to influence allocation and management of rural land for different uses

Policies for influencing land use range from the more systemic to the rather small scale, incremental and site specific. It is possible to make a broad distinction between three types of policy tools available. The first group are *land-allocation policy* tools to allocate rural land to specific uses or types of management to produce the range of goods and services required. These tools include formal land use planning systems familiar in the context of urban and infrastructure development, where private property rights are more curtailed than is the case for most rural land uses. The second group can be regarded as *influencing tools* used to influence directly or indirectly the use and management of farmland and forests where property rights remain largely with the owners or managers of the land. A third group of tools comprises those required to *monitor and evaluate* the implementation and impact of the spatial planning process.

Mechanisms that have been developed to steer land use and land management in rural areas have grown in number and expanded in their focus over time. Historically, there has been a process of introducing more public intervention and advice to influence decisions that have remained largely in the hands of private owners, although in some Member States direct ownership of land by public authorities, predominantly in forestry, has been and still is significant. In Central and Eastern European countries where communist regimes were in place, state ownership and direct control of land was widely introduced in the post war years, then much (but not all) of this has been dismantled subsequently. In the EU-15 there has been a much more gradual process of recognition that public interest in rural land use needs to be expressed in policy terms, accompanied by the development of appropriate instruments. In doing so, generally there has been a reluctance to adopt highly interventionist measures or to encroach too far upon private property rights, which are highly valued and vigorously defended through the political system in most Member States.

Policy development has occurred at all levels from the local to the national, with considerable differences between Member States, depending on how legal and administrative competencies are distributed and on socio-political and cultural differences. Since the 1970s an EU level has been added to these other tiers and this has become progressively more important, particularly with respect to environmental regulation and the setting of environmental objectives and targets.

In parallel there have been changes in agricultural policy, driven primarily at the EU level by the CAP. Since the 1980s the environmental component of the CAP has grown in importance, particularly influencing the pattern and scale of incentives offered to farmers. Agricultural policy drivers interact closely with market mechanisms in influencing farmers' decisions and need to be considered alongside more explicit planning tools in the spectrum of measures that can contribute to a more integrated approach to the use of rural land to provide ecosystem services.

More strategic approaches to planning rural land use in the sense discussed here are not commonplace in EU countries. Those which have been established are often either weighted towards setting principles and priorities rather than guiding specific land allocation, or are still at an early stage of development. To be effective they need to interact constructively with the range of mechanisms already in place. From a pan-European perspective, a number of tools are available to influence decision-making at all levels of governance from EU to local, and these interact to varying extents with formal planning processes. The choice of policy tools will vary enormously from Member State to Member State; some of these approaches have been firmly embedded in a country's policy framework for decades whereas others may not use them at all; other approaches are more recent, innovative or experimental. Some of principal measures used in different parts of Europe are summarised below.

Land-allocation tools

Land allocation tools refer to measures and mechanisms used by Member States to allocate rural land to specific uses or types of management to produce the range of goods and services required. These tools include formal land use planning systems and controls as well as land purchase by public bodies and regulatory requirements imposed through legislation.

Public ownership: In every European country public authorities own and manage areas of rural land that are relevant to the provision of ecosystem services. In most countries there is some public ownership of nature reserves or other conservation areas, and in many there are forests owned by the state or agencies dependent on it. Public ownership is not uncommon in coastal and mountain areas, and substantial areas of military land of significant environmental interest can be found in several countries. Active land purchase can be undertaken by the state itself or by charities and public bodies drawing on public sector funds. While purchase on a large scale is uncommon, the acquisition of individual sites is more frequent, as is the disposal of land currently in public ownership.

Planning and/or zoning of rural land: This can take a range of forms, including:

- *Broad zoning of rural land use*. Land may be classified by the state as being in a broad use such as agriculture or forestry, with a presumption against it being used for another purpose. This is one of the simplest forms of planning, generally based on a detailed map, although in some cases the land allocations may no longer match the actual use.
- *Physical planning*. More elaborated versions of a simple zoning system can be found almost everywhere in Europe. Formal planning methods have long applied to specific land uses irrespective of whether these are located in urban or rural areas. Some are in the form of national plans indicating appropriate uses of land in the countryside, others comprise much more detailed local plans showing envisaged pathways for future land use and often the preferred location of development. Some plans are purely advisory, others are indicative, creating a strong presumption about uses which will be tolerated, some may be binding. There are many variants of this theme, including detailed local plans which set out how land can be transferred into urban development and the infrastructure required.
- *Infrastructure plans*. Unlike the more generic development plans referred to above these focus on a particular theme, for example transport or energy networks, hydrological and flood defence works, new airports and ports etc. There are often implications for rural land use. In a number of countries green (and blue) infrastructure plans are being developed.
- *Development control*. In most parts of Europe land owners who wish to create new built structures need to obtain some form of consent via a process of development control. Usually this is linked to the relevant physical plans for the area. Development control does not usually apply with the same intensity to non-urban uses. It is common for farmers and foresters to have considerable latitude in developing their property, albeit within a more limited framework than applies in urban areas. Usually it is possible to change land use, for example from arable to grassland or to agro-forestry without consent, although this does vary between countries and localities and may be constrained by regulation (for example via the EIA Directive) or by policy (for example the permanent pasture cross compliance requirements under the CAP).
- *Planning for forest expansion*. Whilst practice is extremely variable in the EU, some Member States have planning measures with the purpose of directing any new afforestation to appropriate areas, taking account of both environmental and silvicultural considerations. This may involve mapping or other support tools.
- *Protected areas for landscape and biodiversity*. In all countries there are several different categories of protected areas, many focussed on nature protection, but not infrequently concerned with broader protection of the rural landscape and cultural

features and sometimes with the promotion of recreational and leisure pursuits. Often the most highly protected areas are either owned by public bodies or subject to relatively stringent controls on land management as well as land use. Through implementation of the Birds and Habitats Directives there is an important EU dimension to the protection of land of particular importance for the conservation of key habitats and species, including the Natura 2000 network, which can have significant implications for land use and management.

- *Water management plans*. This category includes detailed plans for the management of specific catchments, drainage, irrigation and flood control projects, integrated coastal management plans and larger scale plans to manage water on a national scale, potentially including long distance transfer between catchments. The River Basin Management Plans (RBMPs) developed under the WFD fall into this category.
- *Land consolidation projects*. As part of efforts to modernise agriculture by creating more efficient farm structures (usually by amalgamating small dispersed holdings into larger units) and improve infrastructure, governments in many countries have invested in local land consolidation schemes. These may involve major changes in water use and management (drainage and irrigation) as well as altering the scale and structure of farm holdings. Environmental components may be included to a lesser or greater degree. State funding is usually involved, although this has now declined in many countries.

Regulations controlling land use and management:

- *Environmental Impact Assessment (EIA)*. Under EU legislation, as implemented and developed within the Member States, a considerable range of measures affecting land use are subject to an impact assessment procedure. This requires the assembly of a body of information and a certain level of consultation. Routine agricultural and forestry works are covered only to a very limited degree by impact assessment rules although these do apply to the conversion of significant areas of semi-natural land cover to agricultural use.
- *Forestry regulation*. This may apply only to public sector forests or to all forests within a territory, including that owned by private individuals. The level of regulation is extremely variable, but in most Member States there are often restrictions on the use of forest or its conversion to other land uses and on their regeneration after harvest. In most Member States, felling operations usually need to be notified or preauthorised and most include strong rules on regeneration timeframe, establishment methods, species composition at particular sites, permitted harvesting regimes, extraction methods, etc. With the rise of voluntary labelling and certification schemes for timber products, mandatory controls are being supplemented by voluntary measures working through the market but in some cases linked to public procurement.
- *Other environmental regulations.* These impose obligations on land managers arising from EU, national or regional legislation to prevent loss of land and environmental resources (habitats, landscape features, wetlands)

Influencing tools

In the absence until recently of any attempts at integrated decision-making about allocation of rural land to deliver ecosystem services, the most important EU policy tools have been those which influence the decisions of individual landowners and mangers about how they choose to exercise their property rights on rural land. Some of the most relevant influencing tools are set out below.

- *Taxation.* Land use patterns can be influenced by property tax regimes which may favour certain uses, such as agriculture or forestry, rather than others.
- *Renewable Energy policy*. Given a combination of national policy and targets for renewable energy in individual Member States under the Renewable Energy Directive, the level of incentives for utilising bioenergy has been increasing, with impacts on agriculture and forestry. These policies may not be intended to have land use consequences but increasingly it is recognised that they do so. National policies for other renewable energy sources, such as solar, wind and hydro may have more limited impacts on land use.
- *Agriculture policy.* Many aspects of agriculture policy, most of which fall within the CAP, have some influence on land use and in some cases on land management. Examples include trade policy affecting market conditions and the choice of crops and livestock by farmers, support policies which are differentiated between farms and influence their viability, the declining but still significant number of coupled payments for specific production activities, explicitly zonal payments, notably in Less Favoured Areas and conditions imposed by cross compliance, notably rules on Good Agricultural and Environmental Condition (GAEC).
- *Agri-environment policy*. This is a sub-category of agricultural policy with a particular influence on land management through the use of incentives for farmers and land owners. Public authorities can choose the scale and ambition of their agri-environment measures, specify the practices to be followed, determine how incentives are targeted, devise rules to exclude certain land managers and steer the pattern of incentives in other ways.
- *Regional and rural development policy*. Within this broad array of policies some components will have an influence on land use, including the extent to which local industries are developed, markets created for local agricultural produce, investment aid granted to farmers and foresters, agro-tourism developed and diversification out of agriculture encouraged.
- *Other indirect influencing tools.* These mainly take the form of policy interventions in markets or regulatory frameworks for the inputs and products of land management, rather than the land management itself. These are potentially powerful but somewhat unpredictable tools, especially for globally traded products. Examples include government targets for market share (renewable energy, biofuels), investment aids in processing sectors (woodfuel), and the potential to create markets for ecosystem services (such as through labelling and environmental certification schemes or Payments for Ecosystem Services) or carbon accounting (LULUCF)

Monitoring and evaluation tools

Monitoring the implementation and evaluating the impact of the planning process is essential to provide evidence to allow the land use plans and implementing tools to be refined and adjusted to improve cost-effectiveness and efficiency. It also identifies the need to adapt to changing circumstances, for example in the wider policy context or in response to the effects of markets and climate change. It is important to define indicators and set up data collection systems at the start of the process, and helpful to involve stakeholders in an on-going feedback dialogue to complement the formal monitoring process. While most measures are established at the national level there is also an EU level arising from the monitoring and evaluation requirements of the CAP and Structural Funds.

This synopsis of different policy tools certainly is not comprehensive. There are many variations and combinations of measures being employed by national, regional and local authorities in Europe reflecting the diversity of cultural and governance differences across the EU. However, it is apparent that land use planning *per se* occurs in different contexts with a range of objectives and processes and operates alongside other public interventions, including a range of sectoral policies. At one level this panoply of policy measures reflects the increasingly specific demands on rural land and on rural land managers and the need to formalise them either in narrowly focussed interventions or in more holistic approaches. Nonetheless, it does underline the point that interventions need to be coordinated and coherent, avoiding contradictions and building synergies. In addition they need to be able to be communicated to those concerned as clearly as possible. Hence the value of seeking a more integrated approach to rural planning.

At EU-27 level perhaps the policy tools that have the greatest potential to influence sustainable management of rural land are legally binding, quantified, time-limited targets for the provision of location-specific ecosystem services by Member States. Examples include the requirements to achieve: ‘positive conservation status’ of the Natura 2000 network (Habitats and Species directive), ‘good ecological and chemical status’ of surface waters (Water Framework directive) and groundwater with nitrate levels below 50mg/litre (Nitrates directive). In some cases geographically delimited priority zones are defined by Member States to allocate areas of rural land where the exercise of private property rights should be controlled and/or incentivised to achieve the Member State’s targets[278].

There are of course other EU level strategies with mainly qualitative targets for improving ecosystem services that are much less location specific. These may improve awareness of the issues and influence the design of national and regional implementation policies but in the absence of legally binding targets they are less likely to have a direct influence on land allocation. Examples include the EU Biodiversity Strategy to 2020 and the EU Forestry Strategy. An indirect but arguably more influential EU level policy is the CAP, simply because to a greater or lesser extent it has an effect on individual decisions about the use and management of almost all agricultural (and some forestry) land in the EU.

[278] For example Nitrate Vulnerable Zones under the Nitrates Directive or Natura 2000 sites under the Habitats Directive.

8.1.3 Support tools and data for rural land planning

An important element of strategic decision making about rural land use is access to land information systems and up-to-date, relevant and accurate data about rural land, its resources and potential. This includes, for example, the current land use and management, provision of ecosystem services, land capability for the future provision of ecosystem services, and potential threats and risks. The data available are not comprehensive, and there is limited coherence across different types of data, levels of governance and geographical scales. Some Member States are investing in new, more holistic approaches, such as the National Ecosystem Assessment in the UK. Nonetheless, generally there is a notable bias towards market relevant land use data (production of crops, livestock, timber) and relatively little information about levels of ecosystem service provision from different land uses, or even the extent of these uses (for example HNV farmland and forests, abandoned land). This bias may be remedied on a site-by site basis, for example in the course of an EIA assessment but this is a localised and often expensive tool which is essentially a reactive process to a land use change that has already been initiated, rather than a proactive land allocation tool.

Historically land capability maps have been used to identify the most suitable areas for certain uses, and to identify target areas for policy. For example, in the UK detailed soils maps were used for both purposes, in planning policy to define high quality agricultural land where there was a presumption against built development, and in agricultural support policy where poor quality agricultural land was one of the defining criteria for Less Favoured Areas. There are several ways in which land use maps and surveys could be used to help reduce the environmental impacts of commodity production by ensuring compliance with sustainability criteria, for example those for biofuels in the Renewable Energy Directive. A range of overlapping and interacting approaches have been identified as having potential in this regard and can be grouped into three broad categories of approaches (Kretschmer *et al*, 2013). Indicative guidance maps could provide information on environmental status and values (eg protected areas, biodiversity values), without making explicit judgements on the whether the commodity should be produced in a specific location. Compliance maps could demarcate areas deemed to be compliant with the RED land related sustainability criteria and are therefore suitable for biofuel feedstock cultivation, i.e. RED 'go areas', and/or areas that are not compliant with the RED criteria, i.e. 'no-go areas' (e.g. protected areas, primary forest and other forested land, biodiverse grasslands, wetlands and peatlands). Such maps could potentially also include areas of uncertain status or specified risk status. On-site assessments could form the basis of a more site specific approach to decision making about land allocation for production of specific commodities. These are likely to form part of a process that evolves from coarse indicative mapping, complemented by information gained from on-site assessments, to more detailed risk maps or even definitive compliance maps (Kretschmer *et al*, 2013).

The need for a well developed and reliable information base is a common requirement for both targeted and more holistic plans. While the information required will vary according to the objectives it is clearly inefficient to duplicate efforts, but there remain very considerable gaps in the databases which, if filled, would allow better exploitation of synergies and trade offs between different ecosystem services. With increasing sensitivity to climate mitigation and adaptation for example, it is becoming more important to collect appropriate data on soil conditions, soil management and associated vegetation so that the consequences of different land use decisions can be understood, predicted and used to inform public policy.

8.1.4 Using a variety of policy tools within an overarching framework

Current policy approaches to integrated rural land use vary enormously from Member State to Member State. In addition to socio-political differences there are differences in the scale and governance of land use planning. Policies that affect how land is used are, even now, often made by different government departments with different priorities which may be in conflict or even indirectly cancel each other out. The cumulative effect of different policies where they converge on the ground, usually at the level of an individual land management unit, will be unknown until after the decisions have been made and the land use changes implemented.

Whatever tools are chosen these must be implemented in a coherent way, both in terms of policy coherence (between levels of governance and across sectors) and territorial coherence. For this purpose it can be helpful to establish a framework of underlying principles to guide the design and use of relevant tools and also act as a template for the effective integration of different measures. For example, in seeking to improve the provision of biodiversity on farmland, well designed generic measures that help to maintain key forms of land management and certain practices of widespread value over a sizeable area have the potential to complement more tailored and targeted measures. Integrating these at the point of delivery could help to provide more efficient, robust and coherent programmes of interventions (Poláková *et al,* 2011).

Ideally, an integrated approach needs to address both land use issues and the critical aspects of land management, such as the intensity of input use discussed in earlier chapters. In addition it can add value by guiding spatial aspects of land use decisions that otherwise may be taken by individual owners and managers without reference to the actions of others, including their neighbours. Whilst there has been some progress in sectoral policies towards more spatially coherent approaches, such as whole landscape initiatives within agri-environment policy, these have been relatively limited to date.

8.2 The role of spatial planning for improving the sustainable use and management of rural land

As highlighted above, although they sit within an overarching policy and regulatory framework, agricultural and forest land tends to sit outside Member States' formal land use planning processes. As a result, land managers have relative freedom to take decisions on the type and nature of their land management activities as long as they adhere to legislative requirements. With the continued undersupply of environmental services from rural land and demands to increase outputs of certain commodities for food and energy in some locations, attention is turning increasingly to look for ways of managing land use to prevent further decline of environmental services. Within this context, the extent to which there is a role for land use planning policies and processes is starting to be examined. Indeed a recent study concluded that spatial planning could help to avoid threats to ecosystems such as fragmentation and diffuse water pollution, maximise the benefits of land use by integrating several functions in one spatial unit and optimise land use intensity (BIO IS, 2011). An explanation of what is meant by spatial planning is set out in Box 13.

Box 13: Spatial Planning

The application of formal planning methods to the efficient allocation of rural land resources falls within the definition of **spatial planning,** a term used around the world to describe pan-national, regional, strategic and even aspects of local planning processes. In the EU, one of the first published documents to refer to spatial planning[279] viewed this as working '*towards a balanced and sustainable development of the territory of the European Union*', through the adoption of Member States' planning policies promoting polycentric development, balanced competitiveness, economic and social cohesion, and the management of the natural environment and cultural assets. Not only are there many very different approaches to spatial planning across the EU but their functions differ. For example:

- spatial planning can be a governance mechanism, a 'plan of plans', designed to integrate spatially formerly disparate policies of separate government departments;
- spatial planning has been used to provide intelligence, modelling and scenario work and trend analysis over a long term perspective; and
- spatial planning has also been viewed as a delivery mechanism, achieving a mediation role between different public and private sector agencies on key development projects.

Despite the potentially valuable role of spatial planning, the legal and professional relationship between land use planning and ecosystem services remains relatively under-assessed and undefined (Harris and Tewdwr-Jones, 2010). Relatively few examples of integrated rural land use planning operating successfully in practice exist in the EU. However, it is possible to distinguish four consecutive stages of the process of achieving an integrated approach which are relevant at all geographic scales. These reflect the preparatory work which should be undertaken to initiate what is, often, a new process and are set out in Figure 25.

Figure 25: Stages of integrated rural land use planning

Understanding and accepting the need to plan for and implement integrated land use, and commitment to the process by land managers and civil society

⇩

Identifying the appropriate scale(s) and levels of decision-making, the scope of goods and services to be considered, and the actors involved

⇩

Critically reviewing potential planning methods before choosing the most appropriate, collecting data, preparing the plan, and identifying the implementation tools and processes

⇩

Achieving commitment to these processes, followed by implementation on the ground

To explore practical examples of the policy tools and approaches used to reconcile competing demands on rural land, examples of land use planning in action in four Member States have been chosen for further investigation. The examples, from the Netherlands, France, Sweden and the UK (Scotland), were chosen to represent a range of geographical scales and systems of governance, with the aim of drawing out examples of success and identifying any barriers encountered in what is a relatively new process for many. They are

[279] The European Spatial Development Perspective (CEC 1999:3)

examined in relation to their progress with developing a fully operational approach to integrated rural land use planning, in keeping with the stages identified in Figure 25. Not all the examples have yet reached the final stage of implementation.

From these a number of key issues are highlighted in relation to each stage of the process, which provide useful pointers as to how ecosystem services might be integrated further into spatial planning in the future and the relative merits of pursuing such approaches. The key features of the examples are summarised in Table 24 and each described in more detail in sections 8.2.1 to 8.2.4.

Table 24: Key features of four rural land use planning initiatives

	The Netherlands	France	Sweden	Scotland
scale of plan	national	regional/local	national	national to local
scope of goods and services	planned national ecological network of habitats (NEN) to protect biodiversity	*Trame verte et bleue* (green and blue infrastructure) to address habitat and landscape fragmentation	cross-sectoral Environmental Quality Objectives as a means of achieving coherence of environmental policies	a national Land Use Strategy, taking an ecosystem approach to all land-based use of natural resources
length of experience	86 years	14 years	13 years	2+ years
successes	clear targets for land allocation (in terms of use, quantity, location) cultural acceptance of land banking and state management of certain sites	in one region, success of campaign to raise public awareness of biodiversity needs, and intention to develop a rural observatory	in response to the perceived problems of a top-down national approach, some examples of voluntary local initiatives are emerging	land use strategy supported by an action plan, with indicators and built-in monitoring and evaluation
problems	new decentralised, participative planning process making implementation more difficult than in the past	vegetation maps not sufficiently detailed: value of biodiversity not always recognised: lack of regional coherence	low public awareness of environmental aims, decentralised governance lacks power to implement	difficulties of integration of national plan with local/regional planning process
comments	land allocation process that worked well for private goods (agriculture) has proved more difficult to use for public goods	similar initiatives had very different responses in two different regions	ambitious objectives but requires more effective implementation tools	good start, but difficult decisions on implementation in the future

8.2.1 Sweden - problems of achieving national objectives within a local planning system

Rural land use planning in Sweden sits within the context of two key regulations. The 1987 Planning and Building Act, gives responsibility for land use planning to municipal authorities, while the Environmental Code of 1999 introduces an overarching framework law covering human health, natural and cultural environments, biodiversity and land, water and resource management. With the aim of creating a society in which all major environmental issues have been addressed in time to pass on a sustainable future to the next generation, the Code establishes a suite of 16 national Environmental Quality Objectives (EQOs) . Those most relevant to rural land use are: flourishing lakes and streams, good quality groundwater, thriving wetlands, sustainable forests, a varied agricultural landscape and a rich diversity of plant and animal life. The EQOs are intended to provide a strategic and holistic cross-sectoral framework for environmental management, and are accompanied by national guidelines and a programme of monitoring.

When the EQOs were first introduced indicators were developed identifying explicit implementation measures (for example, the indicator for 'a varied agricultural landscape' was the area of pasture land receiving agri-environment payments). The indicators were viewed as a good tool for monitoring progress and useful for developing strategies to meet the EQOs. However, since 2011 these indicators have been replaced by a suite of 'milestone targets'. There is concern that what were considered to be concise and relevant targets are being replaced with administrative visions that are not expected to deliver much in practice. For example, one states that the value of ecosystem services should be included in the budget but provides no tangible means of achieving this (pers comm, Wahlstrom, 2012).

The EQOs are intended to set an environmental framework for other policies and their achievement is non-binding on planning authorities. However, 13 years after their introduction the level of both cross-sectoral integration and awareness among civil society and land managers does not meet the ambitious aims of the policy. For example, although farmers and foresters are generally aware that delivering 'a varied agricultural landscape' and 'sustainable forests' applies to them, they often overlook the relevance of their activities to the objective of 'thriving wetlands'. The EQOs are also criticised for being too broadly defined, and poorly integrated with rural land use planning. This is viewed partly as a failing of the Swedish institutional structure, because the decentralised system of governance has effectively created a 'municipal planning monopoly' in which there is no mechanism in place to ensure regional or national coherence (pers comm, Granvik and Anders, 2012). With no specific monitoring of the current objectives, it is felt that there is scope for municipalities to claim that they are working toward the EQOs without actually implementing much that is meaningful (pers comm, Granvik and Anders, 2012).

To overcome this drawback, it is thought that more actors need to be involved in the planning process and that greater authority should be allocated to the regional County Administrative Boards to enable them to engage and participate with the municipal land use planning process. Furthermore, as with the EQOs, it can be argued that improvements are needed in public awareness and understanding of the new sets of demands from agricultural land (pers comm, Granvik and Anders, 2012).

8.2.2 Scotland – A strategic approach to land use planning

The first National Land Use Strategy (LUS) for Scotland was launched in 2011 based on the principles of sustainable development and an ecosystem services approach. It is a strategic document intended to inform decision making in all areas, from policy and funding to land management on the ground. The strategy has three overall objectives:

- to achieve economic prosperity from land-based businesses working with nature;
- to ensure responsible management of natural resources; and
- to establish better urban and rural connections.

The Strategy outlines ten principles for delivering these objectives, including multi-functional land use based on an understanding of land capability and ecosystem services, contributing to climate policy, managing landscape change sympathetically, restoring unused land to environmental, economic or social use, providing accessible green spaces, giving people the opportunity to contribute to land use and management decisions that affect them, and broadening the links between land use and daily living (Scottish Government, 2011a).

The Strategy is accompanied by an Action Plan, with commitments to policy processes, research and evidence gathering, and provision of facilitation, demonstration projects and information. There are thirteen proposed actions, seen as milestones in progress towards the three strategic objectives (see Box 14 below). Key policy actions are to 'align land use regulations and incentives with Land Use Strategy Objectives' and to use these objectives 'to influence negotiations on CAP reform'. Evidence will be gathered on land capability for tree-planting (Scotland has an ambitious target of planting an additional 100,000 hectares every year until 2022). The first of the annual progress reports, for 2012, has been published[280].

The political acceptance of an ecosystem services approach as a guiding principle for land use planning across different government departments and sectors is an important achievement. However, there is no systematic way in which this approach is being integrated in regional and local land use planning, and considerable apprehension about how a balance between local flexibility and inter-regional coherence might be achieved without dictating local level action from the national level (pers comm, Thomas, 2012). There are a few emerging examples of bottom-up initiatives to integrate ecosystem services in regional land use planning, such as the Tweed Forum[281], established in 1991 'to promote the sustainable use of the whole of the Tweed catchment through holistic and integrated management and planning'. Although it began 21 years ago as a liaison group, the Forum now works at both a strategic and project level and has developed a reputation in the area as the honest broker in land use planning decisions beyond water protection. The Living Landscape Scheme[282] for woodland habitat restoration in Coigach and Assynt is another example of a local initiative, but so far no firm plans have emerged for pilot projects to explore the means of achieving coherence across regions for bottom-up land use planning (pers comm, Thomas, 2012).

There is a strong sense of optimism that the monitoring and evaluation provisions within the Strategy, and specifically the statutory requirement to review it in five years' time, will ensure that land use planning is informed and coordinated at a national level. One current

[280] http://scotland.gov.uk/Publications/2012/06/4649
[281] http://www.tweedforum.org/
[282] http://www.wildlifetrusts.org/living-landscape/living-landscape-schemes/scheme-directory/coigach-and-assynt

uncertainty is how the LUS will interact with the forthcoming CAP reform because the CAP is viewed as a critical policy in steering land management in Scotland with as much an influence on land-based businesses as commodity markets (Scottish Government, 2011b).

Box 14: Proposals for action for the Scottish National Land Use Strategy

The thirteen proposals for action are to:

1. Publish an action plan following publication of the Strategy.
2. Provide an annual progress statement on the Land Use Strategy.
3. Align land use regulations and incentives with Land Use Strategy Objectives.
4. Further encourage land-based businesses to take actions that reduce land-based greenhouse gas emissions and that enable adaptation to climate change threats and opportunities.
5. Use the Land Use Strategy Objectives to influence negotiations on CAP reform.
6. Use demonstration projects to determine the best means by which land use and land management practice can contribute to climate change objectives.
7. Identify more closely which types of land are best for tree planting in the context of other land-based objectives, and promote good practice and local processes in relation to tree planting so as to secure multiple benefits.
8. Demonstrate how the ecosystem approach could be taken into account in relevant decisions made by public bodies to deliver wider benefits, and provide practical guidance.
9. Develop a methodology to take account of changes in soil carbon for carbon accounting purposes; improve understanding of potential benefits from conservation and management of carbon-rich soils; and deliver measures to help secure long-term management of all land-based carbon stores.
10. Investigate the relationship between land management changes and ecosystem processes to identify adaptation priorities.
11. Develop the land use aspects of our Climate Change Adaptation Framework to support communities as they adapt to change.
12. Identify and publicise effective ways for communities to contribute to land use debates and decision-making.
13. Provide a Land Use Information Hub on the Scottish Government website.

(Scottish Government, 2011a)

8.2.3 France – Creating ‘green and blue’ infrastructure for biodiversity

The decision in 2007 to implement a new green and blue infrastructure initiative of ‘Trame verte et bleue’ (TVB) across France by 2012 was intended to reduce biodiversity loss, stop habitat fragmentation and restore degraded areas (Allag-Dhuisme, 2010). A national committee of 50 stakeholders was set up in 2011 to oversee local TVB initiatives and an on-line hub created to provide support and information for those involved (Allag-Dhuisme, 2011). The type of outcome envisaged is shown in Figure 26.

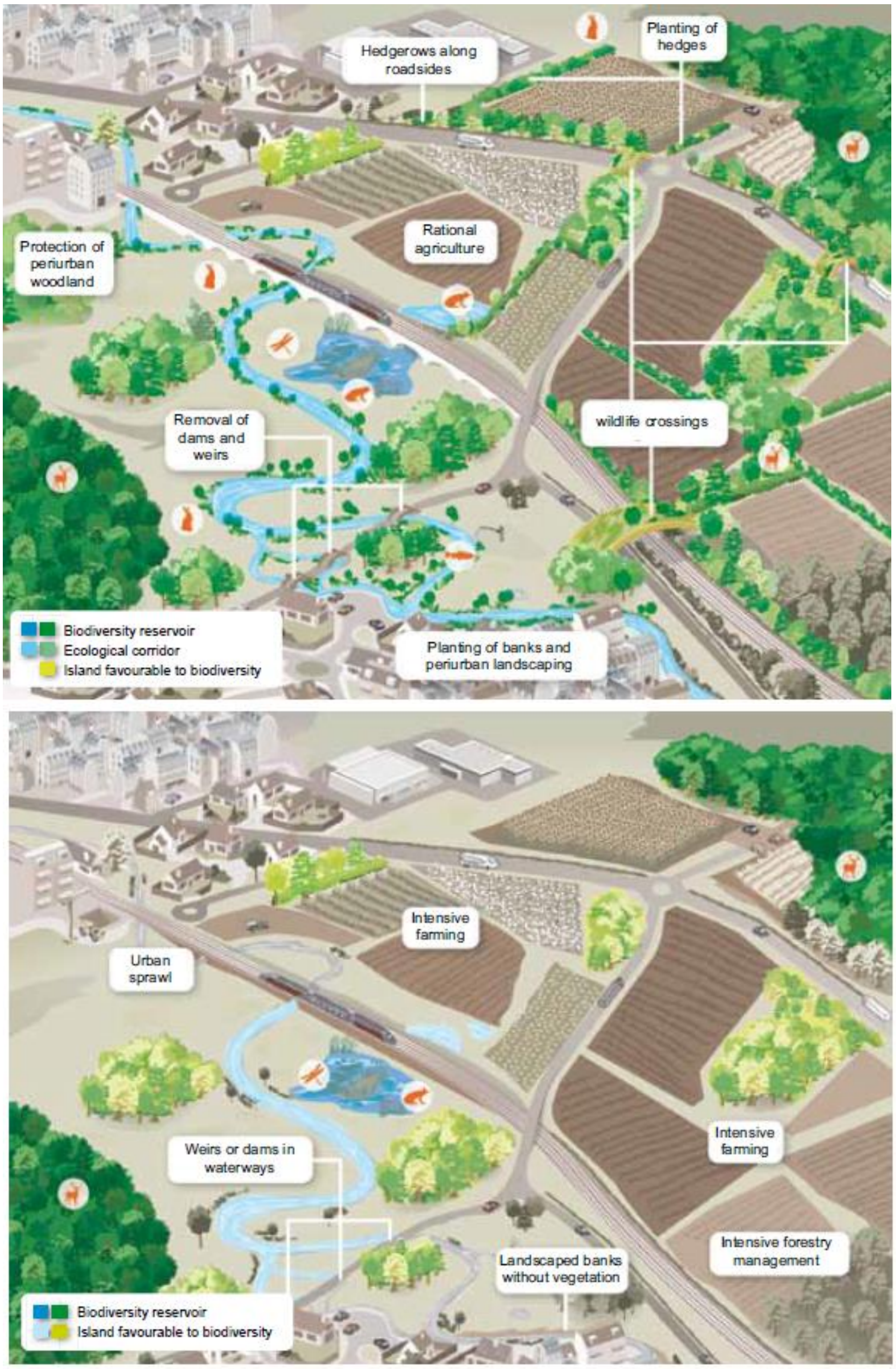
It was recognised at the outset that inter-regional coherence was important to create a national biodiversity network, and the process of planning the TVB is threaded through all levels of land use planning. At regional level, the TVB is broadly defined in the regional plans for ecological coherence *les Schémas Régionaux de Cohérence Ecologiques* (SRCE), following central guidance on the inclusion of nationally important species, types of habitats and areas of nature protection, forests, cultural landscapes and coastal areas. Based on these broad regional plans, the local details of the TVB are set out in the local town or inter-commune plans *Plan Local d’Urbanisme/d’Urbanisme Intercommunale* (PLU/PLUI) (Flipo *et al*, 2012). The involvement of the local communes (of which there are 36,000 in France) is seen as particularly important to take account of local ecological priorities (Allag-Dhuisme, 2010). Once the local land use plans have been agreed, these are brought together under the regional plans for territorial coherence *les Schémas Régionaux de Cohérence Territorial* (SCoT).

Although local land use planning is considered important in the development of the network, not all towns or communes see the TVB as a priority. For example in Languedoc-Roussillon, where areas of 'natural importance' already account for approximately 40 per cent of the land area, there was little recognition of the value of the TVB and priority was given to addressing local unemployment problems instead (*pers comm*, former scientific and technical support editor to the operational committee for the TVB, 2012).

Despite the 2012 deadline, the TVB is largely still being developed at the local plan level with just a few completed SCoT regional plans, and the rest likely to be delayed until 2013 or 2014. The inter-regional element of the process will also be delayed, as it can only begin when all the SCoT plans are ready. One of the problems has been the lack of consistent, detailed land cover maps for communes and regions. These are being developed but will not be ready for regional use until 2025-2030 (pers comm, as above). Nord-Pas-de-Calais is one of the first regions to have established a regional TVB plan and has followed this with a regional biodiversity observatory and a regional land agency. The latter will ultimately provide 'the foundations for a principled environmental reallocation of land in Nord-Pas-de-Calais'. However, the early years of this regional TVB project were spent raising public awareness and ensuring a good understanding of the key issues among the key local stakeholders, and from concept to implementation took 14 years (Cau, 2010).

There are some concerns about the effectiveness of the TVB infrastructure for biodiversity (for example monitoring in Isere shows that just five species have been recorded using the infrastructure in place (Michelot and Croyal, 2011)). It is thought that more research is needed to understand the implications of habitat fragmentation and to design an effective green and blue infrastructure (see Blanchet *et al*, 2011). In developing the integration of the TVB in national, regional and local land use planning, it is believed that local input will continue to be critical in attempting to ensure that local biodiversity needs are addressed (Flipo *et al*, 2012) but more work will be necessary to raise awareness of the value of biodiversity at a local level. The issue of coherence with neighbouring countries has arisen, but examples of transboundary green infrastructure projects are few, such as the network between the French Rhone-Alpes and the bordering region in Switzerland.

Figure 26: Example of a town without and with a *Trame verte et bleue*

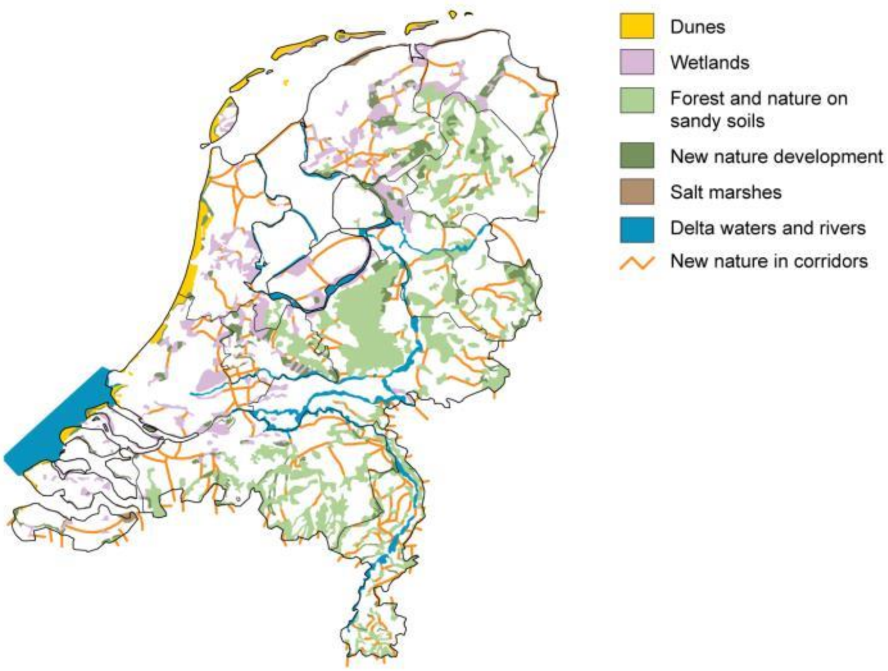


Source: http://www.developpement-durable.gouv.fr/IMG/pdf/plaquette_tvb_english-june2010.pdf

8.2.4 The Netherlands – land consolidation and voluntary action

A well-established process of land consolidation for agricultural purposes has been used to acquire land for the National Ecological Network (NEN) in the Netherlands but now is facing conflicting public/private interests and a new planning system.

Figure 27: National Ecological Network in the Netherlands, 1990



Source: Veen *et al*, 2010

The NEN is a biodiversity policy aimed at enlarging and improving the quality of natural areas, and establishing linkages between them. Due for completion in 2018, the NEN will cover 728,000 hectares (278,000 hectares more than in 1990 (Figure 27) when the project began). There are three ways of adding land to the NEN: government acquisition and management, private acquisition and management, and farmer participation in agri-environment schemes (Netherlands Court of Audit, 2009). Public acquisition has been used in a number of cases, often of marginal farmland, or land facing considerable environmental constraints. The land was bought by the Government Service for Sustainable Rural Development on behalf of the provinces, then managed by specialist organisations[283].

Voluntary land consolidation has been a feature of Dutch land planning legislation since 1924. Used primarily for restructuring agricultural plots and associated infrastructure to improve efficiency, it offers an underlying economic incentive for farmers to participate voluntarily (Lemmen *et al*, 2012). No such incentive exists for the NEN, and a recent project to acquire land linking the Hoge Veluwer National Park with the flood plain of the Rhine illustrates the limitations of the policy. On a 12 hectare industrial area in the middle of the

[283] For example, the State Forest Service, the Society for the Preservation of Nature and the Provincial Nature Conservation Societies

proposed corridor, the majority of the companies agreed to voluntary relocation but a few objected. An extended period of negotiation culminated in the Council of State rejecting their appeals, forcing them to sell and relocate (Biemans *et al*, 2008). This suggests that in the absence of an associated economic benefit to the seller, the use of voluntary land consolidation for environmental land use planning requires back-up compulsory powers.

A key concern for the future of the NEN is the lack of central government authority (Netherlands Court of Audit, 2009; pers comm, R Pouwels, 2012). The National Spatial Strategy (2010) sets out a new governance approach, with a decentralised system that will provide local and regional stakeholders more scope to determine land use. Whilst this new 'steering philosophy' for land use planning is intended to ensure greater stakeholder participation across all tiers of government, the shift from a centralised to a more decentralised approach has particular relevance to the NEN. In the past there has been criticism of the apparently poor integration of the NEN in local zoning plans by municipalities and provincial authorities. Another issue arising from a decentralised approach is that there is no mechanism in place to ensure inter-provincial consistency which is problematic where the NEN is a priority for one province but not another (pers comm, R Pouwels, 2012).

8.2.5 Factors influencing success of these spatial planning initiatives

Each of the four examples is very different in nature, both in terms of the objectives they set out to achieve, the approaches taken, their stage of implementation and their degree of success. They raise some interesting issues that are more widely applicable. These include lack of understanding among key actors, problems caused by distribution of land use planning functions at different levels of governance, the need for improved land information data and the difficulty of finding policy tools to implement provision of public goods when the decisions of individual owners and managers are responding primarily to powerful economic drivers.

The key issues are examined in more detail below, focussing on factors that have influenced success and any barriers that have been experienced.

Understanding and accepting the need to plan for and implement integrated land use

In all four examples there appears to be an understanding amongst policymakers of the need for a level of more integrated rural land use planning, and an acceptance of the principles. In marked contrast, key actors, land managers and civil society seem to be much less aware of why and how land should be managed to deliver public goods, and of their role in this. In Sweden, where cross-sectoral environmental objectives have long been an established part of public policy, most farmers and land managers still have a relatively limited view of the scope of environmental management expected of them and of the wider effects of their management activities on ecosystem services, such as water quality.

In one example from France a 13-year long awareness building campaign seems to have resulted in public acceptance of the need to improve biodiversity management in an industrialised area with intensive agriculture. In the other French region studied it is suggested that the plan stalled before it could reach implementation stage because employment was prioritised over investment in green infrastructure for biodiversity. In

Scotland the newly launched spatial plan has a strong focus on public awareness and policy discourse, and the government proposes to use demonstrations and pilot projects to show how the ecosystem approach to land use planning can work in practice.

It would be easy to overlook the need to start by focussing effort and resources on improving civil society's understanding of the benefits of integrated land use, when there are so many technical problems to overcome, but neglect of this stage this could jeopardise the whole planning process. The difficult decisions often necessary in planning and implementing integrated land use will require long-term public and political support, and the well-informed, active involvement of rural land owners and managers is essential given the relative importance of private property rights in determining both the type and intensity of land uses.

Identifying the appropriate scale and level of decision-making
Rural spatial planning is a relatively new concept and exists in the context of other planning instruments. It is primarily about the integration of different sectoral plans (or their creation where none exist) and must operate at a range of scales, to accommodate existing governance structures (a 'plan of plans') and/or to meet the needs of location specific ecosystem services. This is not an easy task and in particular these four examples, which are primarily national initiatives, reveal considerable problems in retrofitting land use planning at national scale into existing decentralised planning systems. This is evident in the examples from Sweden, Scotland and (as a result of recent decentralisation) in the Netherlands too. Where the legal instruments and political powers for planning are delegated to regional or local level and 'traditional' planning systems dominate the legal framework this can be a major barrier to integration.

There is some limited evidence of local successes in overcoming this disjunction between national land use planning and regional or local decision-making powers, for example by a community-led approach in Scotland and joint working between municipalities in Sweden, but in most of the examples concerns remain. The alternative to taking a 'top-down' national approach is to work within current governance structures and to plan land use entirely locally or regionally. However that can create a problem of coherence across administrative boundaries. Even where there are institutional systems in place to bridge the gap, as in France, regional differences in timing can frustrate the integration process. With a local approach it may be difficult to meet national targets because of variations in local resources, or to ensure that outcomes which make sense in national terms are pursued if they do not appeal to local interests.

It is clear that there is a need to address issues of spatial coherence at all scales from local to transnational, especially for location-specific services that function at a broad geographical scale, including green infrastructure and water management, although this can imply an increase in regulation of private property rights as the Netherlands example illustrates.

Quality and availability of data to support the planning and implementation process
Most of these examples raise the question of the capacity of current land information systems to support the land use planning decisions and implementation. Of the four examples, only the Netherlands, with long experience of land allocation and very detailed

data on land use and capability, does not appear to have a problem with land information. Elsewhere data problems are making it more difficult to plan effectively. In France the planning authorities trying to improve biodiversity networks have struggled with insufficiently detailed regional data based on CORINE land cover maps and do not expect to have more detailed local vegetation maps until 2030. In Scotland, where the spatial plan has a strong emphasis on rural land uses that will deliver improved carbon storage, there is an urgent need to fill major gaps in data needed to make land use decisions, including the location of carbon-rich soils and land capability for tree planting.

The effectiveness of plans in driving change

The plans considered here are not designed to set binding targets or force through substantial changes on the ground. They represent frameworks within which appropriate decisions should be taken. The strategic initiative in Scotland is also in its early stages. Consequently, it is not wholly surprising that results on the ground are relatively limited and clearly disappointing in some cases (the Netherlands, with its specific focus is rather different). Nonetheless the barriers faced by some of the plans do raise the question of whether spatial land use planning for provision of public goods on this model may be too weak a tool in the face of economic drivers of production from private rural land. It seems clear that markets and policies affecting the farming and forest sectors, where property rights remain largely within the control of the landowner, remain key drivers of land use. The example from the Netherlands is interesting, where the success of a well-tried system of land allocation and consolidation in the agriculture sector appears to depend on clearly recognised benefits for the landowner in terms of improved land quality and efficiency of the farming operation. It has proved much more difficult to use the same system in the context of relocating an industrial business with a less functional relationship with the land, where there was no apparent benefit to the business in moving simply to make way for conservation management of the land it occupied.

In Scotland it is expected that CAP payments may be a more powerful influence on land management decisions than the new Land Use Strategy. Although the Scottish Government intends to *'align land use regulations and incentives with the Land Use strategy Objectives*' there is limited scope to do this in the case of farm income support payments, which are a significant element of farm income in many areas of Scotland. This has wider implications for land allocation for public goods provision, if it proves difficult to find more powerful implementation tools to achieve the desired management.

In the Netherlands public ownership and management of nature protection areas has been an important implementation tool of conservation management in the past. Incentive payments to private landowners are now more widely used but have led to concerns that the standard of biodiversity management will not reach that achieved by the state institutions. Although it is suggested that authorities in the Netherlands may resort to compulsory purchase to meet targets for the creation of biodiversity networks, this is unlikely to be a realistic option in many other countries, although one French region may be considering the role of public ownership.

Monitoring and evaluation

It is important to consider the data requirements to monitor and evaluate the effectiveness of the different stages of plan preparation and implementation, and to assess the impact of the plan on the provision of goods and services from rural land. Information will also be needed to adapt land use plans to changing circumstances, for example the effects of climate change. Evaluation tools may range from well-established techniques (for example, to assess the effect of awareness raising efforts on the attitudes of land managers, or to monitor changes in biodiversity) to the development of new monitoring techniques. In Scotland the government proposes to develop a methodology to take account of changes in soil carbon, and to investigate the relationship between land management changes and ecosystem processes, to identify adaptation strategies.

9 ACHIEVING SUSTAINABLE RURAL LAND USE – THE ROLE OF THE EU

Key findings:

- It is evident that there is a need to think more strategically about how rural land is used in Europe - more so still in the longer term.
- To assist policy makers and land managers to make more optimal use of rural land and address location specific conflicts more effectively, appropriate analysis and policy tools at an EU level are needed alongside national measures.
- The danger of inaction is that sub-optimal land uses may become more prevalent
- A combination of approaches will be required, including: 1) strategic target setting; 2) traditional land use planning; 3) more creative means of planning and allocating rural land use to achieve greater synergies; 4) appropriate environmental regulation; 5) steering agricultural and forestry land use and management through appropriately designed sectoral policies (such as the CAP); and 6) the development of new policy tools (eg for soil).
- All approaches should work as part of a coherent framework, informed by a more strategic vision.
- Five different types of measure where the EU could make a worthwhile contribution by virtue of its policy competences, its existing web of influences on land use and management and its scale are identified.

In light of the analysis in preceding chapters, the question arises as to how far the EU can contribute to steering rural land use to ensure its sustainability in the face of the challenges of the next few decades.

To improve the sustainability and resource efficiency of rural land management in the future is essential, not simply to increase the supply of environmental goods and services, but also as a means of strengthening the resilience of the rural land resource to the impacts of climate change. There is a need to think more strategically about how rural land is used in Europe from a longer term perspective. This requires multi-scale analysis, considering trade-offs and synergies between different ecosystem services. Appropriate policy tools at an EU as well as national level could assist policy makers and land managers to make more optimal use of rural land and address location specific issues more effectively in the light of changing demands and increased uncertainties.

The danger of inaction is that sub-optimal land uses may become more prevalent and greater stresses imposed on ecosystems, with associated constraints on productivity. Examples could include persistent poor management of certain soils, failure to take account of carbon sequestration in land management, as in the case of peat soils, and inappropriate bioenergy developments detached from the best long term use of the land resource.

To achieve progress towards agreed EU objectives, particularly with regard to biodiversity and climate change, requires effort at several geographic and administrative scales to seek to influence the nature of land use in given locations more actively than in the past. This will require a combination of approaches, including: continued land use planning at a variety of scales; more synergistic and creative means of planning and allocating future rural land use with a stronger focus on the delivery of ecosystem services, with soil a key issue; appropriate environmental regulation; and steering agricultural and forestry land use and management by means of well focused incentives provided within sectoral policies (such as the CAP).

The best use of limited land is an important component of the growing agenda on improved resource efficiency. This is putting a stronger focus on reducing food and other waste, scaling back Europe's dependence on high levels of imports of national resources, lowering the inputs of supply chains on GHG emissions, biodiversity and other public goods and, over time, diminishing the size of the EU's 'ecological footprint'. Increasingly this is becoming embodied in policy, as in the Roadmap to a Resource Efficient Europe (European Commission, 2011c), the new agenda on sustainable consumption and production and in the thinking of civil society (WWF, 2012; ENDS February 2013). Linkages are being made between potential changes in the location of crop production, for example more production of protein crops in Europe, developments in consumer choices, such as preferences for a higher quality meat of clear origin but potentially in smaller quantities and new patterns of land use. Political interest in food quality and safety, new consumer paradigms and the role of European producers in a changing world is animating this debate. It is opening new and pertinent questions which could shift both policy and market behaviour significantly, with real opportunities to increase sustainability. Land use analysis needs to keep pace with this new agenda, clarify the nature and scale of these trade-offs and steer debate away from over-simplistic conclusions about the merits of apparent solutions. Premature assumptions about the merits of new strategies can be unhelpful, as underlined by the biofuels debate.

The EU level is key as it is where so many drivers of trade, agriculture and energy policy are located and a large element of environmental policy is determined. The challenge will be to mesh these more strategic strands with the local and regional levels where specific decisions will continue to be taken and appropriately so.

New policy tools may be needed, raising questions of where to focus the effort at EU, Member State or more local levels. It will be important to be realistic about the scope and extent of influence that government at any level can exert on rural land use, given that so many decisions about the use and management of rural land are in the hands of individual landowners and managers and will remain there. Broader economic influences such as commodity prices and fiscal policies are also strong and unpredictable and it will be a major challenge to find policy tools that can balance these effectively.

A developing range of different levers should be designed to work together to form a stronger framework that both promotes sustainable rural land use and discourages unsustainable practices. This framework needs to be informed by a more strategic vision of how far it is possible or desirable to meet long-term requirements for food, fibre, energy, biodiversity and ecosystem services from the limited land resource within Europe and a sustainable share of the planet's overall stock of land (IEEP, 2012). Much improved analysis and data, in terms of scope, quality and availability is required both to support the emerging debate, for example on the CAP, bioenergy and sustainable consumption and production (SCP) and to provide the foundations for future policy.

The extent of the EU's role in measures to drive or influence these different approaches to achieving the necessary changes is a key question. Decisions about land allocation and use will be made in many different ways by different groups of actors, reflecting the diversity of governance and other factors across the EU. For example, the EU plays a key role in providing a strong body of environmental legislation, developed over the past few decades, and increasingly is seen as a leader in terms of environmental governance more globally. Although there is no EU competence in the Treaty for an over-arching role in land use planning, the EU could play a more strategic role in identifying issues and risks while also supporting the sorts of actions and initiatives that Member States could take and investing in the research needed to allow practical approaches for the whole Union to be developed and ultimately agreed (IEEP, 2012). This is foreseen to some extent in the European Commission's recent proposal for the Seventh Environmental Action Programme, 'Living well within the limits of our planet (European Commission, 2012d)

Here we consider a range of possible approaches and levers that could then be taken forward at EU level to help Member States and regions to adopt processes and policy tools of their own to pursue key objectives and to reduce tensions between competing land uses.

9.1 An over-arching role for the EU in supporting a coherent territorial framework

It is timely to envisage a strategic and substantive role for the EU in improving the sectoral and geographical coherence of rural land use policy and implementation through a coherent, transnational EU territorial framework for the provision of mixed public/private goods from rural land. This would bridge sectoral and environmental policies and include a spatial planning dimension. It would complement existing planning processes for transport corridors, energy and water supply networks, which would provide experience on which to build.

Such a framework would aim to prioritise the building of resilience into the rural land resource. This requires addressing significant environmental deficits whilst allowing the producers of marketable goods the flexibility to respond to changing conditions. The evidence suggests that there may be the capacity in the future to address this environmental undersupply, as noted in previous chapters. The clear priority for the longer term therefore should be to prioritise the sustainability of the resource base including soil, water, carbon stocks and biodiversity, rather than pursuing shorter term agricultural production increases for example. The framework should emphasise the following priorities in particular:

- increasing the efficiency of natural resource use in all agricultural and forest systems;
- sustaining specific farming and forestry land uses that deliver high levels of environmental services – this is particularly important for extensive grazed land (predominantly permanent pasture), which includes habitats that face the greatest risk of degradation; and
- improving the long-term environmental sustainability of land use in core agricultural or forest areas where productivity is highest.

This involves stronger linkages at the EU level between agricultural, energy, environmental and related policies with a strong spatial dimension. Key components would include:

- **Agricultural policy**, where land use is now a significant element of Pillar One of the CAP, through both cross-compliance and the proposed greening of direct payments, as well as being important in rural development policy. Climate objectives are to play a larger role in CAP support after 2014, both in agri-environment payments and through the commitment to allocate 20 per cent of expenditure through the EU funds to climate mitigation and adaptation related activities. This calls for a more integrated approach, in addition to the growing need for coherence between agricultural and forestry policies within and beyond the CAP.

- **EU climate and energy policy**, where the land use dimension is continuing to expand, encompassing a range of issues outside the EU as well as within it. Key issues for land use include the existing incentives for bioenergy and specifically biofuel production and imports under the Renewable Energy and Fuel Quality directives and the associated environmental safeguards, relating to biodiversity and grassland for example. There are new Commission proposals concerned with diminishing indirect land use change (ILUC) from biofuels and incentivising the use of residues, including straw and other material derived from land management. These are in addition to obligations to reduce emissions from the non-ETS sector, including agriculture, by 2020, new EU provisions on Land Use and Land Use Change (LULUCF) and a growing debate on EU climate policy beyond 2020, with Commission proposals expected in 2014. At the same time ecosystem-based approaches to adaptation, which increasingly are being promoted by national and EU policy, also have land use implications.

- **EU water policy**, particularly the Water Framework Directive, under which good water status is required in all catchments in the next few years, requiring considerable reductions in diffuse water pollution and river restoration in many Member States. This will affect both land use and management. In parallel, efforts to improve marine water quality under the Marine Strategy Framework Directive also have implications for land use in catchments draining into the sea.

- **Biodiversity policy**, including the existing birds and habitats directives and the targets established for 2020 under the EU biodiversity strategy. These will require appropriate land management in significant areas outside the current Natura 2000 network as well as within it. Enhanced connectivity between sites is expected to be a greater priority in the face of continued fragmentation of habitats and climate change. The need to promote green infrastructure at the European level already has been demonstrated in a number of studies (Mazza *et al*, 2011). A move in this direction has been signalled by the European Commission in their proposals for a Seventh Environmental Action Programme (European Commission, 2012d).

- **Other elements of EU environmental policy** with a specifically spatial focus, such as the modified Environmental Impact Directive and the Strategic Environmental Assessment Directive, which have a clear bearing on land use.

Taken together these measures embody a web of policy objectives that can be met only by achieving appropriate land use decisions, utilising the policy levers available in a coherent way, informed by an understanding of the dynamics and trade-offs involved. This is increasingly demanding, more so in the absence of more strategic coordination

The EU could provide specific support and coordination of Member States' efforts to develop coherent territorial (and potentially transnational) land use plans. Clear EU objectives and support would be especially relevant to Member State plans for guiding investment in green/blue infrastructure and securing the coherent use of key location-specific resources, such as carbon rich soils, semi-natural forests and HNV farmland that are not already covered by the Natura network but where there is a European as well as more local interest in a sustainable outcome.

9.2 Setting targets and specific measures to strengthen provision of location specific ecosystem services

There is a case for setting targets at the EU level for the protection of critical land resources, as has occurred with the 2020 targets in the Biodiversity Strategy. This principle of establishing targets could be extended to measureable aspects of land use where there is a European interest beyond the purely local and a need to take action to address unsustainable trends. Targets for 2030 for example might be particularly useful for some critical parameters, as proposed in the Roadmap to a Resource Efficient Europe (European Commission, 2011c), aiming to present the scale of loss to artificial surfaces which is severe in many Member States. One model would be to have EU targets which were broken down for individual Member States. These national targets could be differentiated to reflect local conditions and measurements would build on existing datasets. It would be a direct, powerful and transparent way of addressing the issue and exposing trends and more effective than simple guidance.

Targets could be set for loss of semi-natural habitat, a critical resource for biodiversity in Europe for soil sealing through urbanisation and for aspects of soil quality. Targets related to soil could involve preventing the drainage of carbon rich soils and wetlands, maintaining or improving soil organic matter content and reducing erosion. Given political will, broad targets could be set for soil conservation and management and the maintenance of carbon reserves on agricultural and forest land. Targets for carbon reserves could include no net loss of the existing proportion of carbon in soil and the protection of a minimum proportion of vegetative carbon in European forests[284]. Soil assessment and target setting measures could be incorporated in a revised version of the Commission's existing proposals for a soil framework directive. This could also address soil sealing and contamination issues. Associated with such targets could be more systematic monitoring of European land use, including permanent pasture for which maximum rates of loss already have been fixed for agricultural land within the CAP.

In addition to possible targets, several specific measures with a European dimension can be envisaged to complement an overarching territorial framework. The first priority must be to secure improved and timely implementation by Member States of existing EU legislation, including the Water Framework Directive and the Habitats directive. At present relatively few Member States have implemented Article 10 of the Habitats directive which refers to networks beyond and between core sites. There is now an opportunity to press ahead with

[284] In so doing, however, it would be important to revisit the thresholds regarding what constitutes carbon rich soils to ensure that they are adequately protected (Poláková *et al*, 2012, forthcoming). Of course, the problem with using thresholds is that soils can be degraded until just above the threshold before any loss is registered and this would need to be taken into account.

more active implementation of this article and to consider ways of incentivising land managers and public authorities, with particular reference to biodiversity but also adaptation to climate change.

A number of EU measures already exert an influence on land use planning in the Member States. As well as the EIA and SEA directives these include aspects of water and waste policy, initiatives on Integrated Coastal Zone Management and funding for infrastructure projects through the TENS and other initiatives. The Habitats and Birds directives have shown the value of integrated European networks of local sites and this principle lies behind the current consideration of a more active policy of supporting green infrastructure. This would link rural and urban ecosystems and reflect European as well as local priorities, seeking to optimise specific land use decisions within a wider fabric of integrated objectives.

There are also two opportunities to amend existing EU legislation to provide more effective incentives for Member States to use existing powers to encourage better provision of integrated ecosystem services. Firstly, the provisions for reinforcing the coherence of habitat networks in Article 10 of the Habitats directive could be strengthened significantly. For example, Member States could be required to take this Article into account in all their relevant land use policies (not just formal planning policies), to encourage the creation as well as protection of landscape features.

Secondly, since the CAP will continue to be the major source of funding and incentives for environmental management of farm and forest land it is important to align it with emerging new priorities. There is an opportunity to strengthen the current proposed Common Provisions Regulation to require Member States to use CAP Pillar 2 funding in ways that support integrated rural land use policies and spatial planning. A similar requirement already exists for the use of the European Maritime and Fisheries Fund[285]. In parallel, measures to support landscape scale approaches could be incorporated within the Pillar 1 greening payments adopted by Member States after 2014, particularly EFAs, so that these areas are positioned appropriately in the farmed landscape.

9.3 Raising public awareness of the need for and means of planning sustainable land use

The examples in Chapter 8 showed a widespread lack of understanding of the role of rural land use in the provision of ecosystem services, and of the wider environmental, economic

[285] The proposed amendments to the **Common Provisions Regulation** establish the thematic objectives and content of the Common Strategic Framework (CSF) which, via Fund-specific rules, will guide Member States' use of EU funds, including EAFRD. The CSF thematic objectives include '*supporting the shift towards a low-carbon economy in all sectors; promoting climate change adaptation, risk prevention and management; and protecting the environment and promoting resource efficiency*'. The CSF will establish *'arrangements to address territorial challenges and the steps to be taken to encourage an integrated approach that reflects the role of urban, rural, coastal and fisheries areas, as well as the specific challenges for areas with particular territorial features'* (Articles 9 and 11 of COM(2012) 496 final). Given the ubiquity of EAFRD funding across rural land and its importance as a driver of land use and management decisions it is surprising that there is no reference to integrated rural policy in this context. This is in contrast to the requirements on use of the European Maritime and Fisheries Fund, where Member States must '*ensure that synergies are also sought in support of the priorities of ....spatial planning*' (Annex I, 4.2 of COM(2012) 496 final).

and social benefits of promoting more sustainable approaches. This lack of awareness extends not just to civil society but also to many of the individual land managers who are responsible for the key decisions. The EU could play a major role in raising awareness, as well as supporting research into the most effective methods of improving awareness and motivation and supporting Member States and relevant stakeholders in using these methods.

9.4 Improving the quality, coherence and availability of rural land information

The EU needs to recognise the extent to which policies already in place impact upon the delivery of ecosystem services inside and outside Europe. This requires an analytical capacity and appropriate support tools in the shape of coherent data sets, maps, access to relevant economic modelling capacity, and exchange with leading scientific institutions. Making decisions about sustainable rural land use and management requires data on land capability, current land use and productivity (for many different ecosystem services), intensity of management, and legal constraints on changes of use. Improved forest information systems would be part of this suite. Where such information exists it is often not coherent with other data sets at the same level of governance, or across larger geographical units. Comprehensive and consistent forest information is especially important to monitor healthy and sustainable forest conditions under climate change and increasing demand for woody biomass.

The Commission could take a leading role in assessing the best available technology to map the information required for planning rural land use (especially in relation to environmental services) and increasingly act as a co-ordinating data centre, supplying information to Member States and to its own services, to inform policy development. Although some Member States have relatively sophisticated rural land use data systems of their own, this is not universal. Data sets should take account of new policy requirements in relation to carbon sequestration and soil management alongside existing priorities. Member States can be encouraged to undertake their own research and monitoring exercises inside and beyond EU frameworks and make their data accessible and compliant with established rules. For example national ecosystem assessments could contribute to knowledge at a European scale as well as informing national governments. In addition, the current round of revisions to the CAP and the process of drawing up rural development programmes is an opportunity to encourage a more integrated approach at Member State level. This applies both to the preparations made for rural development programmes and the design of instruments. During and after this process of programme design issues of synergies and trade offs can be addressed specifically, particularly in the monitoring and evaluation process and in networking between Member States.

EU institutions such as Eurostat, the Joint Research Centre and the European Environment Agency have a potentially important role in standardising, collating and monitoring spatially explicit data on rural land use at EU level, at geographical and temporal scales which can support decision making at much more local scales. Linked to this, the EU has a potentially important role in ensuring the quality of maps and other criteria used to guide the allocation of land to market determined uses (such as biofuel feedstock production and afforestation) in a way that protects other resources and causes least environmental harm. Although it is difficult for external organisations to conduct independent assessments of national or regional land capability maps and impact assessments, the EU could ensure that these and other land allocation tools are endorsed by the relevant responsible environmental authority. This could occur in consultation with appropriate environmental data holders and other environmental stakeholders (see for example Kretschmer *et al*, 2013).

More effective use could be made of current data in addressing the imbalance between traded commodities from rural land and environmental ecosystem services in terms of the evidence of costs and benefits to society of different land uses. An overall framework for ecosystem capital accounting for Europe has been designed as a fast-track initiative, based on the use of existing data and statistics. This framework includes indicators, for example the 'ecosystem resource accessible surplus', which shows the level of resources that can be used without jeopardising ecosystem reproduction functions (EEA, 2011a). Such capital accounts could be part of a toolkit to help Member States to measure the provision of ecosystem services and unused resource potential but, like other land information systems, are not yet able to capture the intensity of land management and the effect of this on the provision of ecosystem services.

9.5 Enabling information exchange and innovation in sustainable land use planning

The EU could encourage best practice in Member States in developing integrated approaches to ecosystem service provision and link this to the forthcoming initiative on green infrastructure. This could be incentivised through support under the Structural Funds and through technical assistance measures as well as supported through EU funded research programmes. Guidance documents on maximising ecosystem benefits could be produced and disseminated and the merits of a more regulatory approach, including EU standards evaluated. Encouraging and supporting information exchange and innovation in sustainable land use planning by institutions and communities at all levels of governance within Member States will help in adoption of best practice techniques and tools of land use planning and management. A number of existing policy tools could be extended and improved to achieve this, for example the revised EU Forest Strategy and Action Plan, and guidance on the use of innovation funding in the new EAFRD legislation (building upon the proposed CSF amendments referred to above). An additional possibility is the provision of an EU observatory and time-limited one-off funding for demonstration projects in developing local scale sustainable land use strategies and the tools to implement them, comparable to the successful use of LIFE+ and INTERREG funds and the LEADER Observatory.

In summary, land use is addressed, often indirectly, in a spectrum of European policies extending well beyond the environment into agriculture and energy. At present there is a danger that conflicting signals are being generated unintentionally and opportunities to optimise the use of land, increasingly recognised as a scarce resource, are not being seized. Hence there is a challenge to strengthen coherence in the EU policy framework, to improve the capacity to address land use issues, investing in research and data acquisition in the process and to adopt a more proactive approach. Whilst there are sensitivities about EU engagement in the sphere of land use planning, the Union is an appropriate level at which to take certain measures which would be less effective if advanced solely at the national and local levels.

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