Paper 2: Scoping the Development of the Environmentally Sustainable Production Agenda

Paper prepared by IEEP for the Land Use Policy Group

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EXECUTIVE SUMMARY

There is wide acceptance of the general principle that both agricultural and forestry production in Europe need to become more sustainable in the long term. However, this notion is interpreted in many different ways and there is no real consensus about the steps required to attain a higher level of sustainability. The overall aim of this paper is to scope out some of the principal issues and questions that need to be considered as part of drawing up an environmentally sustainable production agenda for European agriculture and forestry - and to consider the implications of these for policy development within the EU. The analysis is concerned particularly with the period up to 2020.

For the purposes of this paper, the concept of "sustainable" refers to production systems that do not damage the environment, do not rely on non-renewable resources, and play a positive role in managing the natural environment as well as enhancing it where possible. At a very minimum, production needs to comply with existing and prospective legislation as well as the codes of practice covering farming and forestry. This is something of a moving target with both legislative and commercial standards relating to water quality, soils, pesticides and biodiversity becoming more demanding over time. In addition, new requirements are likely to emerge aiming to increase the contribution of both agriculture and forestry to climate change mitigation, for example by reducing emissions of greenhouse gasses and increasing the rate of carbon sequestration.

There is a range of different challenges within the sustainability agenda. These include:

- Maintaining production of food, fibre and raw materials as well as ensuring that the capacity exists to sustain these outputs over time;
- Reducing damage to air, water or soil, by addressing both point and diffuse sources of pollution;
- Improving resource management by taking account of soils, water, energy and carbon in an integrated way as well as seeking to reduce reliance on non-renewable resources such as mined phosphates.
- A rapidly growing agenda surrounding the contribution of agricultural and forest industries to the supply of renewable energy and industrial raw materials.
- Developing a more effective approach to the maintenance and enhancement of landscapes and biodiversity. There is still a long way to go in halting the current declines in biodiversity, whilst at the same time more attention is now being paid to maintaining the health of entire ecosystems, as well as to their component parts.

Four topics are picked out for particular attention. The first of these concerns food security and future production requirements. It is argued that whilst temporary supply shortages may well continue to occur within world markets, the currently available forecasts stop short of anticipating that an absolute global shortfall in supplies will occur before 2020. Rather than increasing supply in Europe, the aim in the next decade should be to reduce poverty and increase access to food in low income countries and regions. The EU has a role to play in increasing food security in several policy spheres, including trade, development assistance and technology transfer. The EU should also contribute to food security by maintaining its capacity as a producer of food, fibre and energy, thus retaining the option of increasing outputs in future should this be necessary, as may well be the case by 2050. An active programme of protecting agricultural land and other resources for future use; sustaining and enhancing skills, as well as investing in research and development is a priority for the food security component of sustainability.

A second priority is to reduce the environmental footprint of agriculture in particular but also of forestry. This will require the application of a range of different measures, including improved adherence to legislation at farm level; the extended use of voluntary agri-environment schemes, an emphasis on investment aids and greater use of both training and knowledge transfer programmes. Prior to 2020, it will be particularly critical to address greenhouse gas emissions as well as the management of soil, water and biodiversity. The standards that will continue to be developed by retailers and others within the food supply chain can also play a major role. A gradual rise in both legislative and commercial standards should form a key element of a future sustainability programme.

The third topic to be considered concerns the rather unpredictable impact of technological change, Whilst the pace of growth in agricultural yields has slowed in recent years, there is now a wide range of technologies likely to influence the environmental performance of agriculture in the near future. Many of these are aimed at increasing the productivity of the crop and livestock sectors, but others are designed to increase the resistance of crops to pests and diseases; enhance the nutrient value of crops for human and animal consumption, as well as reduce the emissions of greenhouse gases and other pollutants from both livestock and soils. A number of key technologies, including GMOs, are briefly considered. Many of these will underpin the current trend towards agricultural intensification in the livestock and cropping sectors, but overall, the use of certain inputs notably inorganic fertilisers, fuel and, in many places, water is likely to be reduced and emissions of greenhouse gases per unit of production scaled back. The wider use of precision farming and reduced tillage could deliver significant environmental benefits, but such techniques could also introduce new pressures by incentivising increases in field size for example. The take up of appropriate technologies needs to be encouraged by improvements in the delivery of advice, information and training. An expanded role for pilot projects and demonstration farms can also be envisaged.

The fourth set of issues to be explored centre on future land use in Europe. These are set against a background of continuing urbanisation and a net transfer of land from agriculture into forestry. It is expected that the area devoted to forestry will continue to expand in response to increased demands for multi-purpose woodland and the anticipated abandonment of economically marginal farmland, both on individual holdings and at the landscape scale. Effective impact assessment procedures and incentives are needed to guide woodland expansion to the best locations whilst ensuring that suitable species are chosen where new plantings are involved. A case exists for more actively exploring the different forms of agro-forestry now available whilst at the same time taking greater account of carbon management requirements and the balance that needs to be struck between the proportion of farmland and woodland in any given location.

Over time it will be necessary for the farming and forestry sectors to produce more energy in order to replace the current dependence on fossil fuels and reduce greenhouse gas emissions in Europe. The application of sustainability criteria will be required in seeking to ensure that bioenergy supply chains (involving domestically grown as well as imported raw materials) are effective in terms of reducing greenhouse gas emissions as well as being acceptable in broader environmental and social terms. These requirements may well place limitations on the range of crops and technologies appropriate for use in energy supply. Unrealistic projections of the potential of biofuels and other bioenergy sources should therefore be avoided.

Changes in agricultural land use in Europe can be expected as a result of structural changes combined with the operation of an increasingly open internal market. Some forms of production such as milk and white meat production, are likely to become increasingly concentrated in highly competitive regions, such as the Netherlands, Denmark, Northern Italy and North West France. Safeguards will be needed to constrain the potentially negative

environmental consequences of this process, including an improved capacity to reduce pollution, regulate the use of water supplies and protect permanent grassland from being ploughed. At the other extreme, policies will also need to address land abandonment in those areas where farming and forestry still play a major role in managing biodiversity and traditional landscapes, often underpinning rural communities and a sense of place.

Looking ahead, existing trends towards intensification of production in the most competitive areas (coupled with increased efficiencies in the use of both wastes and inputs such as nitrogen) and the withdrawal of management from those regions with higher costs seems likely to continue. Reducing the use of energy, fertilizer and agrochemicals per unit of output will be a priority for the sustainability agenda, as will the encouragement of a positive role for more extensive systems, including organic farming. A mixture of both intensive and extensive production systems will be needed to maintain output and to provide a range of environmental public goods and attention will need to be paid to the sustainability of both. Improving intensive management practices will be particularly important as part of reducing greenhouse gas emissions. Extensive systems have a particular role with respect to the management of landscapes and biodiversity, but many will not be economically viable without considerable ongoing support. Provision for such systems will be amongst the main calls on the CAP under a policy with a stronger focus on environmental and social public goods.

A range of different policy interventions will be required to take forward the sustainable production agenda. It is suggested that a “policy roadmap” should be developed as a means of setting out the steps necessary to achieve a more sustainable pattern of agriculture and forestry by 2020. Such a roadmap would include measures to stimulate innovation; steer research and development in the direction of making more effective use of finite resources and seek to secure an appropriate level of environmental management over a significant proportion of all farmland. Utilising the measures available within EAFRD, there should also be a role for investment aids designed to improve sustainable competitiveness at the farm level as well as in associated supply chains. Research and development activity is likely to be taken forward by measures largely outside the scope of the CAP, but there is room within EAFRD to invest to a greater extent in applied research and the practical application of technical advances through earmarking funding for pilot projects, establishing field trials that stimulate innovation and paying more attention to the monitoring, evaluation and dissemination of results. Sustainable production at both the European and national levels requires a long term perspective, pointing in turn to the importance of capacity building within both public administrations and at the farm level, with less of an institutional separation between those responsible for guiding the development of agriculture, forestry and renewable energy supplies.

1 INTRODUCTION

We are, or should be, at a time of strategic thinking about agricultural and rural land use policy in Europe, having reached a crucial point in the cycle of decision making on the CAP. The future prospects and issues facing agriculture in Europe need to be examined not only in relation to traditional priorities such as commodity trends and farm incomes but also in the context of the wider rural and environmental agenda. The overall aim of this paper is to offer a short synthesis of the principal issues and questions to be considered in drawing up an environmentally sustainable production agenda for European agriculture and forestry. Such an agenda would follow from the new objectives for the CAP proposed by the Land Use Policy Group (LUPG) in its "Vision for the future of the CAP post 2013", published in 2009 (LUPG 2009). These new objectives are:

- *To provide environmental security through the management of soil, air, water quality, biodiversity and cultural landscapes as well as addressing the challenges posed by climate change;*
- *To achieve sustainable farming and forestry sectors that have the capacity to help deliver long term food and timber security as well as other non-food services, thus contributing to environmental security and wider social benefits.*

In this context "sustainable" refers to production systems that are neither reliant on non-renewable resources nor damaging to the environment and in addition play a positive role in the management and, where possible, enhancement of the natural environment. This is a step beyond the level of sustainability yet attained by agriculture and forestry in Europe.

The implications of such objectives need to be considered in the context of the current economic climate and policy debate. The paper therefore seeks to scope out and identify the most pertinent strands in this debate, covering a spectrum from the global context and expectations over future commodity prices and the role of food production in Europe to considerations about the meaning of sustainable production in a concrete sense – in relation to specific issues and some key technologies. Questions of future land use and different forms of production and management intensity are located within this rather broad canvas. Since agricultural policy moves relatively slowly it is necessary to try to anticipate a future set of needs and any potential dilemmas as far ahead as possible. This is far from easy and a large element of conjecture and judgement is required. This paper runs the risk of being partial, like others in the genre, and it must be acknowledged that any future agenda will contain issues not even considered in the margins here.

The next period for the implementation of the CAP spans the years 2014 to 2020, giving a broad time frame for the analysis in this paper. Developments in the period 2010 – 13 are also of interest not least because of their influence on the political climate in which the decisions on the next version of the CAP and the EU Budget will be made.

The paper begins with a short review of the context for the sustainability agenda and the challenges of maintaining an appropriate level of European production of food, fibre, timber and (at some level) bioenergy while improving the sustainability of European agriculture and forestry, taking account of potential synergies and conflicts. This leads to a discussion of the sustainability challenge for agriculture and forestry in Europe over the next two decades.

Four issues are then considered in more detail. These are:

- The level of food production required in Europe, taking account of the food security debate and also aspects of energy security.

- Questions of environmental sustainability. This is a concept that may evolve over time, for example in relation to climate change, biodiversity and new technologies such as GMOs, all areas where public attitudes and policy are evolving.
- The role of technology in sustainable production. This is a large topic and the focus is on technologies that appear likely to have an impact on sustainability questions, although their scale, direction and significance is not necessarily clear. The aim is to gain some perspective on how far the production and environmental management goals in agriculture either could be reconciled more easily or, alternatively, aggravated by changes in technology in the next decade or so.
- The land use equation in Europe, with new pressures on agricultural, forestry and other rural land uses needing to be considered. Spatial location and agricultural structural issues arise alongside land management questions and the different conditions found within the EU need to be taken into account.

Finally, the implications for policy intervention are considered, with the role of some different policy tools and specific measures being addressed. Variations in issues within Europe are noted, but the main focus is on the EU agenda and the kind of interventions that could be made through the CAP in particular.

2 THE CHANGING CONTEXT FOR ENVIRONMENTALLY SUSTAINABLE PRODUCTION WITHIN EUROPE

The sustainability of production in Europe, extending to forestry, bioenergy and agro-industrial products as well as food, is of more than local interest. Europe is the world's largest importer of food as well as a major production region and has 155 million hectares of forest, covering about 37 per cent of the land area. Production and land use decisions in this densely populated continent have more than trivial consequences for other parts of the globe.

At the birth of the CAP in the 1960s the main challenges for agricultural policy in Europe were seen as maintaining food supplies and farm incomes while gradually modernising an agricultural sector dominated by small producers. Food accounted for a much larger proportion of household expenditure than it does today and constraining food prices was a major priority, to be balanced against farm income considerations (Godfray *et al.* 2010). Forestry was marginal to the European agenda.

While there are still several countries with very small farms and the price of food is an important consideration, especially in some newer Member States, the agenda for 2013 looks very different. There is much more confidence about food supplies in Europe but new questions about price volatility and how European farmers will fare in a more liberal environment with potentially increasing international competition if the WTO Doha round is completed. This core debate about the competitiveness of European agriculture is now accompanied by a set of concerns often gathered under the banner of "food security". One strand of this is an argument that Europe should aim to increase its exports of food not only for economic reasons but as a response to possible global food shortages (Skidelsky 2009). As a relatively well endowed region, with more robust soils, plentiful water and less exposure to adverse climate change than many other parts of the world, advanced technology, a skilled workforce and attention to product quality, Europe can be seen as one of the regions most able to contribute to continuity of supply in an uncertain world. This narrative is in effect a new version of a productionist agenda.

On the other hand is an environmental critique which points to considerable dependence on imports of both non renewable fossil fuels and feed for livestock and the continuing pressure on many elements of the rural environment – soils, water, biodiversity and landscape. Appropriate forms of agricultural management could both alleviate these pressures and contribute to improvements, such as restored ecosystems. For example, while there are major variations between Member States, it has been estimated that about 55 per cent of the total quantity of nitrogen leaching into surface and groundwater in Europe is estimated to come from agriculture (EEA 2006).

Moreover in the last five years the climate change agenda has added a significant new element to the appraisal of farming's environmental footprint (IPCC 2007). Agriculture is the second largest sector with respect to greenhouse gas emissions contributing 9.2% of the EU's annual total (EEA, 2009). Farming practices will need to change to adapt to the consequences of climate change, particularly in dry areas where further constraints on water availability are expected. At the same time agriculture is also likely to be required to contribute to reductions in greenhouse gas emissions, to play a larger role in carbon sequestration in soils and vegetation, and to produce a larger volume of bioenergy in the period to 2020.

Some aspects of the agenda for addressing climate change are parallel to those of the more established environmental concerns such as good soil management, efficient use of water, improved nutrient management and energy conservation. Progress in cutting nitrogen emissions from organic and inorganic fertiliser for example, is beneficial to climate goals as well as water quality and biodiversity. At the same time there are new dilemmas and trade-offs. Is it preferable to chop up straw and plough it into the soil to raise carbon content or to burn it as a new source of energy?

The new elements in the climate debate might be summarised as:

- The focus on adaptation to new climate conditions, likely to grow over time as climate impacts become clearer and perhaps more pronounced
- The goal of increasing carbon sequestration in soils and vegetation, including woodland
- The case for producing bioenergy from conventional and more novel crops and agricultural by products, such as straw and manure
- Measures to cut greenhouse gas (GHG) emissions over and above those actions required for other environmental reasons (e.g. reducing ruminant numbers to cut methane emissions)

The bioenergy debate, which extends beyond biofuels to a range of crops and by products from agricultural and forest land in itself opens a further agenda. At one level there are questions about the efficiency of various forms of bioenergy as a means of displacing fossil fuels (FAO 2008) given their varying performance in reducing the carbon intensity of the supply chain. At the second level are issues about the costs of different supply chains (Doornbosch and Steenblik, 2007), which tend to be higher than other forms of mitigation. At a third level are concerns about the impact of bioenergy supplies on the environment and on food supplies, both within Europe and in third countries, from which a significant proportion of European consumption is likely to be sourced. As part of this is a major question of how large an area of land can be devoted to bioenergy supply whether from agriculture, from woodland or other habitat types (Royal Society 2008).

The pursuit of increased carbon efficiency has helped to draw attention to a more holistic and integrated view of land use at many levels from the local to the European and indeed the global. The benefits of forestry are no longer seen as related largely to the production of

traditional materials but extend to renewable energy supply, substitution of industrial materials, water catchment management, new forms of recreation and enhanced human health.

For these reasons there can be said to be new elements in the environmentally sustainable production agenda that appear likely to be more prominent beyond 2013 than they are today. Whilst the focus remains on agriculture it is clear that other land uses are affected by the dynamics of new policies and new demands and that forestry has an important role alongside farming in the climate agenda as well as more traditional domains such as water quality and biodiversity.

The enlargement of the EU since 2004 and the prospective entry of further members, such as Croatia, prior to 2020, also alters the context. The processes of agricultural intensification have advanced considerably in parts of several of these countries, but rather little in others and substantial changes in management can be expected in future. There are sizeable areas of High Nature Value (HNV) land associated with less intensive farming that could become less viable both socially and economically by 2020 or before and small semi-subsistence holdings still account for a significant share of the farm population and the land in agriculture.

As this new agenda emerges it is clear that not all of it fits within agriculture policy or the CAP. There are other policy domains bearing on production, land use and subsequent environmental impacts. One of these is climate and energy policy, which now has growing importance for land use. Another is environmental policy – the Water Framework Directive for example is being implemented in a series of steps, stretching beyond 2020. While much depends on the measures taken by individual Member States, this Directive has the potential to constrain the use of certain agricultural techniques because of more demanding standards for controlling diffuse water pollution. New environmental measures, such as a revision of the proposed EU Framework Directive on soils, may add to this portfolio of legislation well before 2020.

Agriculture will also be influenced by the economic climate in Europe, with the current focus on cutting public expenditure and the longer term aim of smart and sustainable growth. The Commission's "Europe 2020" strategy puts considerable emphasis on resource efficient, low carbon futures and on innovation. This does not imply that there is no place for more traditional sectors, such as agriculture and forestry, but that they will need to contribute more to this agenda in ways that are appropriate, not least by reducing carbon emissions, improving resource efficiency and contributing to sustainable employment.

The CAP remains critical as an influence on the viability of agriculture and the forms of land management pursued. However, it is now less concerned with specific production patterns than previously because of the continuing move to the decoupling of support from the output of crops and livestock. While there remain important exceptions, such as milk quotas, these are being phased out and the trajectory of the CAP is towards a less production-based approach. An important priority for the future CAP and broader land use policy will be to ensure that both the overall approach and the more specific measures adopted complement those of a growing circle of related policy domains.

3 THE SUSTAINABILITY CHALLENGE

A sustainable agriculture and forestry sector can be understood in various different senses all of which have some value. For example in a theoretical framework based on the ecosystem approach, the goal might be to optimise the provision of ecosystem services within a particular location including the “provisioning” services of food, fuel and fibre. From an environmental economics perspective the goal might be a form of agriculture that does not reduce the stock of natural capital while respecting environmental benefits.

From a policy perspective, at a very minimum production needs to comply with current and prospective legislation and codes of good practice. This is a moving target, currently becoming more demanding over time in Europe, for example in relation to water quality and pesticide use. However, there are several discrepancies in standards between different parts of the EU, some of which are likely to persist, in the light of different political priorities. Second, a truly sustainable agriculture should not rely on non renewable resources, whether these are agricultural soils, certain types of inorganic fertiliser, such as mined phosphates, energy inputs, feedstuffs grown at the expense of tropical forests, local water resources or other inputs. At present it is not clear how far this precept is being respected and more precise measurement, evaluation and analysis is required, taking account of global as well as European resources. In terms of the resilience of soil and water resources relative to current production levels and practices it is difficult to make a very precise judgement about contemporary agriculture. These natural resources are under substantial pressure and the trajectory is not sustainable but it is less clear when, where and to what extent this will be translated into a significant physical constraint on production. At a third and less narrow level of sustainability is the goal of pursuing forms of land management that are compatible with the maintenance of local landscapes, a variety of biodiversity and other environmental benefits such as protection from floods and forest fires.

A strategy for sustainable agriculture needs to have a number of different elements. These can be catalogued according to the primary environmental media concerned, such as air and water quality, landscape protection, the maintenance of soil quality etc. However, a new agenda for 2020 might categorise these issues in a different way and help to identify the types of policy measure that might be required to address the core sustainability questions. One approach would be to group the issues around five themes as follows:

- Maintaining production of food, fibre and raw materials as well as ensuring that the capacity exists to sustain these outputs over time.
- Reducing agricultural pollution, whether of air, water or soil by addressing both point and diffuse sources. This is an agenda pursued mainly through regulation, particularly for point sources of pollution but with the need for information, advice and support for farmers, as standards are raised and management choices and trade offs become more complex. In some cases there may be a justification for the payment of incentives in order to change land use in sensitive areas; to cushion the impacts of more demanding requirements being introduced within a regulatory regime or to accelerate progress towards new goals.
- The challenge of improved resource management in the countryside which in principle embraces forestry as well as agriculture. This is concerned with appropriate soil, water and waste management and increasingly will need to take account of different aspects of carbon management, including sequestration and the supply of bioenergy. Reducing reliance on non-renewable resources, such as the world’s rapidly diminishing stock of phosphate and on imported crops grown to the detriment of the environment in their country of origin will need to be given more attention. Here there are clearly trade offs between different goals within Europe and a further set of trade offs between pursuing European objectives in isolation as opposed to taking a

global perspective. It is possible to reduce national inventories of greenhouse gas emissions by reducing livestock numbers for example but if this is accompanied by an increase in imports derived from livestock in other countries, there is no overall benefit for the global environment and the overall level of emission may even rise. This agenda crosses the divide between different uses of rural land and suggests a role for a wide range of policy instruments, including trade related measures, land management incentives, cross compliance and possibly new forms of land use planning and integrated local initiatives of a kind that have not been familiar in agriculture policy in recent years.

- Within the resource management framework there is a specific agenda expected to grow in significance over the next two decades about the contribution of agriculture and forestry to renewable energy and raw materials. This is not driven primarily by the CAP or by forestry policy; energy and climate policies have a leading role. On current targets, bioenergy feedstocks will become a more important agricultural commodity and give rise to a new generation of environmental concerns. There will also be impacts on forestry. It seems likely that the incentives for bioenergy production will arise mainly from outside the CAP but will need to be coordinated closely both with energy and environmental policy. For example, appropriate standards will need to be set for new products such as biofuels, together with efficient ways of monitoring land management and land use change.
- Quite separate from this are the more traditional objectives of maintaining and enhancing landscapes and biodiversity where success depends heavily on securing appropriate agriculture and forestry management practices. In this domain the market has a relatively modest role but incentive payments are a critical part of the policy armoury.

All these measures need to be pursued whilst maintaining the productive capacity of European agriculture, accommodating some transfer of land to urban uses and woodland and recognising the differing characteristics and aspirations for agricultural production of different Member States. This in turn implies the pursuit of synergies and a willingness to accept trade offs in addressing the sustainability challenge.

4 FOUR TOPICS FOR THE NEW AGENDA

One starting point for considering sustainability in the agriculture sector up to 2020 is to make an appraisal of the overall level of output that might be required or incentivised through the market, taking account of possible changes in consumer preferences, difficult though this is to forecast. If future production levels are likely to be quite different from those of today, environmental factors and technological choices may appear in a different light as well. Food prices and security questions are therefore the first of the four topics examined below. The global nature of sustainability issues is immediately apparent in this discussion. While the paper focuses on the domestic European agenda this needs to be seen within a shifting global context which could impinge more heavily on EU production in future – not least because farmers are now more exposed to world market conditions than previously.

4.1. Food Prices, Production and Security

Amongst the many contributions on the future of the CAP there are few, if any, that anticipate a major decline in overall European production by 2020, although European competitiveness and output could fall in some sectors, such as beef. There is, however, active debate about how world and European prices will move in future, the consequent responses by European farmers and the policy issues that arise. Beyond this is the political

question, flagged earlier, of whether special measures are required to ensure that European production is maintained or increased over time for more strategic food supply reasons, rather than in response to day to day market or farm income concerns.

Over the long run, in the next fifty years or so, many believe that global supply constraints, aggravated by climate change and loss of arable land, may lead to a global failure to keep pace with growing demand for food and other agricultural outputs arising from population growth, economic development and changing consumer demand (e.g. IAASTD 2008). Nonetheless, there is uncertainty about future agricultural price levels over the next five years and even more so over the period to 2020. The majority of commentators take the view that average world prices will rise over time in real terms for a number of reasons:

a.) Continuing increases in demand, including for livestock products, not least from China and India where disposable incomes are rising particularly fast
b.) Certain constraints on the supply side, notably water limitations in important agricultural supply regions, likely to be aggravated by climate change
c.) The reduced rate of growth in crop yields in recent years suggesting a potential structural change in the pace with which scientific and technical advance can raise productivity particularly in the West. In some countries where productivity is increasing, such as in US maize yields, this is associated with technologies that are not universally accepted e.g. GMOs
d.) The growing wave of policies designed to incentivise bioenergy production which, together with higher oil prices, will lead to a growing market demand for several agricultural commodities, e.g. oilseeds and increase the competition for cultivated land and other resources
e.) A new linkage between global energy and agricultural commodity prices that may well persist. It is widely assumed that this will bring about increases in agricultural commodity prices because of long term adjustments in the energy market.

On such arguments organisations such OECD-FAO have suggested that agricultural prices for oilseeds for example might be significantly higher than the average in the decade before 2007 / 2008 (OECD and FAO 2009). However, perspectives on this topic vary and some of the analysis published recently (e.g. HM Treasury 2009) presents a more cautious picture. The Treasury paper points to the short duration of most of the previous price spikes in agricultural commodities and the rapid response to high prices in the wheat market since 2007/08. Average wheat prices may not increase significantly in real terms even if there is more volatility and less predictability. There also may be more spare capacity than at first appears. For example, there are said to be 23 million hectares of prime agricultural land in Russia, Ukraine and Kazakhstan that was abandoned during the break up of the Soviet Union but could be returned to production in the future. Others argue that the rates of growth of demand per capita are not rising, with the exception of ethanol (Haniotis, 2009). It is not clear whether current policies to encourage bioenergy production will continue to be applied to 2020 although the US administration has recently announced a significant increase in the bioethanol mandate to 2015.

The conclusion seems to be that there are significant forces driving prices upwards but the supply response is uncertain and prices may increase less than some have suggested in the coming decade or so (Godfray *et al*. 2010). Policy makers cannot assume higher world prices, although they should expect more fluctuations affecting European farmers, unless countervailing policies are put in place. Whilst it is possible that there will be episodes of severe supply shortage, even with better management of stocks, this seems more likely to be temporary than permanent. On this basis, it is not apparent that Europe should aim to increase its supply level on a permanent basis in order to anticipate a forthcoming global shortfall by 2020 that may have adverse consequences for many poorer countries.

Does the debate on food security alter the policy conclusions that arise from this judgement of market trends? Is there a moral imperative to increase output substantially in the next 10 – 15 years, even if this were possible? First there is the need for clarity about the concept. As defined by the 1996 world food summit "Food Security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2006). According to the FAO about 800 million people are hungry or "food insecure" and the number rose to 1.02 billion in 2007/08 because of price increases (FAO 2009).

Trying to eliminate hunger by increasing the level of access to affordable and safe food is a central priority for policy and so for appropriate government intervention. It is not simply a question for the market. There are hazards arising from a potential shortfall in supply that do not arise with other commodities less central to human welfare. Indeed, there is a strong social preference for the avoidance of hunger and malnutrition in others, as a moral imperative which is different in nature from the fulfilment of personal satisfaction through consumption. As such, it can be argued that food security at a global scale is valued in a way that "security" is not in most other supply chains. There is also a significant option value associated with retaining the capacity for food production in light of the anticipated effects of climate change. In other words some additional costs are clearly worthwhile if they provide insurance against a potentially serious hazard. Without question there is an onus on policy makers to address food security.

There are various reasons for food insecurity. Uneven access to food or food shortages is often the result of a lack of purchasing power or inadequate distribution both within and between countries, rather than the result of an absolute shortage in supply (Sen, 1997; 1999; Swinnen, 2009a). Indeed, global food production has risen three per cent per year over the past decade, surpassing population growth and leading to an increase in per capita food availability (USDA, 2006). These factors mean that the threat of food insecurity is disproportionately severe on food importing developing countries (Boddiger, 2007; Cabinet Office, 2008) and also affects a proportion of deprived citizens in EU Member States (EU Commission Social Protection Committee, 2009). Absolute food shortages are unlikely in Europe – in the short to medium term at least – and there is sufficient wealth to purchase food from elsewhere if shortages appear or become more likely. The propensity to be risk averse with regard to food supply remains, but the overall level of risk is much lower at a European than a global scale and the prospect of malnutrition more remote compared to most other parts of the world.

If higher prices for staple foodstuffs, including grains, oilseeds and milk, do materialise this will stimulate supply in competitive regions but will also lower the purchasing power, and probably nutritional intake, of people in the developing world and poorer citizens within the EU. The answer is not increased food supply in Europe or the developed world but more economic security and access to food supply amongst those with limited purchasing power. Improvements in living standards, a fairer distribution of income in developing countries and the deployment of sustainable production technologies all have a part to play. The aim would be more reliable markets, supply chains and public interventions in parallel with sustainable local production. At the same time there is a role for improving international stock management, appropriate food reserves and assistance for increasing farm production in a range of countries.

Against this global backdrop, the EU has a role to play in a number of policy spheres including trade, development assistance and technical transfer. Besides this, Europe is a major producer of food with some arable land in reserve, notably in the new Member States. As a temperate region with reasonably robust soils in most areas, the EU may be able to withstand the negative effects of climate change more successfully than many other parts of

the world and thus it could become a more sustainable and competitive supplier of several commodities in the longer term. Europe should be ready to take up a larger role in food production later in the century if this is required. The challenge is to maintain this resilience and capacity to increase production if necessary over the longer term by pursuing good husbandry of national and human resources and investing in research and development (Swinnen 2009a) (LUPG 2009).

On the basis of this analysis it may be necessary to invest in the future resource base, to improve stock management and provide appropriate assistance to developing countries. However, there is no case for artificially inflating European output in the short term through dedicated policies. The need to retain capacity has implications for land use, suggesting that agricultural soils should be conserved and transfers to urban uses and forestry managed with care. Abandonment needs to be monitored and controlled. Land devoted to bioenergy crops also would reduce the area available for food crops and on a global scale these crops are likely to have a role in increasing commodity prices and lowering food security in some respects. Nonetheless, some increase in bioenergy supply will be needed at a European and global scale on current projections. In so far as this consists of dedicated agricultural crops, the factors of production are kept in use and can be switched back to food crops if necessary. Whether this would happen in practice is unclear however and their overall impact on food security looks negative.

If there is an increase in commodity prices in future this may occur more in relation to arable crops, including bioenergy crops, than with respect to sheep and cattle, the principal livestock utilising grasslands. For this reason the pressure on permanent grassland could increase over time with a danger of arable conversion on a significant scale. Higher prices as a whole will not necessarily translate into improved gross margins for farmers because of the upward movement in input prices, particularly for inorganic fertilisers. Consequently, whilst we may expect improvements to farm income on a buoyant price scenario this is not necessarily the case. Further structural change, with a falling number of commercial farmers, seems almost certain and may be accentuated by price volatility, the increasing level of regulation applied to farming and the demands of the powerful retail sector.

Perhaps more difficult to forecast than the supply side, are the changes in consumer demand that could be expected by 2020. Whilst some point to a likely deceleration in population growth towards the middle of this century due to increased wealth (Godfray *et al.* 2010), it is not clear how far the present trends towards eating prepared, processed and catered foods will evolve in future. However, since the less affluent countries in the EU have some way to catch up with the front runners within North West Europe, some extrapolation of present trends is not unreasonable. Similarly, a shift towards consumption of more sophisticated foodstuffs with greater added value can be expected if income growth resumes – with some benefits to farmers in the case of cheeses, organic food, speciality vegetables etc. The level of preference for local foods could also increase over time but at present this appears to co-exist with a trend for consumers to buy foods from a variety of global sources, with a more eclectic set of tastes emerging.

At present there is a growing concern about climate change and adding a new dimension to an older debate about whether people should eat less meat, particularly red meat, as a way of reducing their personal carbon footprint. At the moment it is likely that only a very small minority are changing their diet for this reason, but the number could well grow over time, particularly if health and nutrition benefits are perceived to align with climate change arguments (Cabinet Office 2008). Ironically there are significant environmental benefits from some forms of red meat production. In particular a substantial fraction of livestock is grass-fed (FAO 2006a) and where this is sourced from HNV agriculture, grazing animals can play a key role in maintaining and preventing the scrubbing over of pasture of biodiversity value. Furthermore in many of these areas, grazing livestock is the only feasible form of agricultural

production as the land is unsuitable for cropping (EEA 2009a). The risk of confusion amongst retailers and consumers about environmentally appropriate food choices seems very considerable.

The rather uncertain implications of changing consumer preferences in Europe need to be considered alongside the growing influence of retailers in shaping tastes and purchasing patterns and their capacity to impose production conditions as well as prices on farmers and growers. Greater transparency and accountability will be needed in the food chain accompanied by an active debate on the public benefit of different supply options as well as private preferences. At the same time European producers will be more exposed to global markets; the dynamics of consumer behaviour in China, India and other emerging economies may be more of an influence on their decisions than movements in demand within the EU.

In summary, production in Europe of several foods may increase over time, and consumers may demonstrate a preference for local products more than they do now. However, it is not clear that significant increases in food production are required before 2020 for the purpose of either protecting European consumers or reducing malnutrition in other countries. Equally, a substantial fall in output seems unlikely given current forecasts of market trends. There is a risk of possible global food shortages in the longer term, potentially exacerbated by climate change and this provides a reason for retaining and improving capacity in Europe through sustainable resource management as well as greater investment in research and development.

4.2. Reducing Agriculture's Environmental Footprint

There has been considerable progress in addressing the negative impacts of agriculture on the environment since the 1970s. Advances have included the withdrawal of some of the most toxic and persistent pesticides, better management of livestock manures, the improved protection of landscape features such as hedges and ditches and the introduction of incentives to maintain valued landscapes and organic farming systems. Nonetheless, a wide spectrum of environmental concerns remains. Agriculture is now the major source of water pollution in many catchments since emissions from industry and urban sewage have fallen. The EU will not meet its target of halting the decline of biodiversity by 2010 and agriculture has had a part to play in this failure given the dependence of many species on semi natural habitats under agricultural management. The population of a group of relatively common farmland bird species fell by 44 per cent in EU countries between 1980 and 2005 (Birdlife International 2009).

Agriculture contributes around 9 per cent of total greenhouse gas emissions in the EU, measured in terms of CO_2 equivalents and is a major emitter of methane and NO_X, both of which are powerful greenhouse gases. It is more difficult to establish the health and continued resilience of agricultural soils in Europe very precisely but considerable evidence of large scale concerns was identified in recent work led by the Joint Research Council (JRC 2009). About 45 per cent of agricultural soils are estimated to have low organic carbon content, and these are disproportionately concentrated in southern Europe (EEA 2005).

From an environmental perspective, the challenges for agricultural production remain considerable and can be summarised as:

i) maintaining and enhancing water supply and improving water quality
ii) maintaining and enhancing soil structure, composition and quality
iii) reducing contamination and pollution of soils and water due to poor nutrient and crop protection management

iv) making the best and safest use of substances diverted from landfill or other waste disposal routes
v) maintaining air quality and reducing greenhouse gas (GHG) emissions
vi) halting the continuing loss and enhancing the level of both farmland biodiversity and valued landscapes.
vii) improving resource efficiency and reducing wastes from agricultural production
viii) contributing to improved energy efficiency and the production of renewable bioenergy resources
ix) improving the level of carbon sequestration in agricultural soils and vegetation.
x) addressing a number of local issues, such as flood risk, the dangers of fire in some dry areas which can be addressed through appropriate grazing, noise and dust from more intensive livestock farms etc. The challenge is to both reduce damaging impacts and to improve and restore aspects of the environment where agricultural management is an important driver.

By 2020 the environmental expectations on farmers will have increased further rather than stayed constant. There are several reasons for this:

First there is still a gap between existing standards in agricultural production and those laid down in EU legislation. Implementation of environmental regulations has been less rapid than in the industrial sector because of the costs and difficulties of inspection, monitoring and controlling practices at farm level and limited political will. The European Commission is actively engaged in seeking better implementation of legislation in force, such as the Nitrates Directive for example. Several Member States have derogations of this Directive, which are generally time limited but will expire before 2020, triggering a need to change farm practice.

Some EU environmental legislation has been agreed already but the full provisions will come into force over an extended period of time, such as watershed management requirements under the Water Framework Directive and the forthcoming requirement to introduce Integrated Pest Management under EU pesticides legislation.

Third, there is further legislation or targets yet to be agreed but to be expected prior to 2020. These include a possible soils directive and measures to achieve reductions in greenhouse gas emissions from agriculture. If the latter reflected the targets agreed by the EU under the recent Copenhagen Accord, cuts of around 20 per cent in emissions could be expected. A new European strategy for conserving biodiversity for the period to 2020 is in the process of being drawn up and this is certain to have implications for agriculture, with new targets under discussion.

Outside the legislative sphere, standards are also imposed on farmers by their customers, who are becoming more demanding about sustainability, the presence of residues in produce, the carbon footprint of food and other issues. Many retailers are imposing standards on suppliers, often more demanding than those required under current legislation. Certification and assurance schemes, with environmental provisions, whilst voluntary, are becoming the norm in larger supply chains in parts of Europe and it may be difficult for producers who are unable to comply with these to gain access to key markets in future

More generally, the environmental agenda continues to enlarge, placing more emphasis on issues previously given relatively limited attention. Soil management is one example of this and carbon sequestration is likely to be another. In summary, there is still a shortfall in the environmental performance of agriculture, whether measured by current standards or those likely to be in place by 2020. Simply standing still is not a feasible option.

4.3. The Contribution from Technology

Whilst agricultural science and technological development have played a major role in increasing global agricultural output over the last 45 years, there is evidence that agricultural productivity in the EU has slowed over 2000-2006, in common with other developed economies (OECD-FAO 2009). This trend is expected to continue within the EU-15 although significantly greater increases in productivity are expected to occur in the new Member States (FAPRI 2009; European Commission 2007) and the gap in average yields between old and new Member States will close over time.

In considering the extent to which technology can assist in reconciling the twin challenges of production and environmental sustainability, it is important to recognise that farming systems vary in their uptake and use of technology. Thus intensive cropping and livestock farms may rely on large-scale mechanisation and automation to increase the efficiency of production, (Gebbers and Adamchuk 2010), but many extensive systems may be small-scale, low-input, family-based farms with little technological input (Cooper *et al.* 2009). However, even in these extensive systems the adoption of new approaches and technology, including information technology tools (mobile phones, portable computers) can make a significant difference to their ability to match their supply with consumer demand (Godfray *et al.* 2010; IAASTD 2008). This dichotomy suggests expanding the important role of technology transfer and farm advisory services to facilitate and enhance decision-making by land managers and farmers on the adoption of technology appropriate to their production requirements and particular circumstances.

Technology and sustainable crop production

For crop production in particular, technology has had a positive impact on the productivity (yield per unit area) of staple food crops over the past 50 years (IAASTD 2008, Royal Society 2009). Although the future global target set at the FAO World Summit on Food Security (FA0 2009a) indicates a need for increased global food production, the greater technological challenge for the EU is likely to come from maintaining sustainable forms of production in the context of environmental instability arising from global climate change (Tester and Langridge 2010). Over the period 2013-2020, this challenge is likely to become increasingly evident among the southernmost Member States (EEA 2010)

In considering an environmentally sustainable agenda for crop production within the EU, a number of important agronomic priorities emerge. These include the need to:

i) maintain and enhance agricultural productivity without increasing significantly the existing land area and other natural resources used for agricultural production
ii) enhance the nutrient value of crops both for animal feed and human consumption
iii) develop techniques to enable crops to withstand abiotic stresses such as drought, temperature extremes and toxicity
iv) improve nutrient use by plants, particularly of nitrogen
v) maintain and increase soil fertility
vi) increase crop resistance to pests and diseases (including organisms that increase in frequency as a result of ongoing climate change)
vii) enhance crop competitiveness against weed species

In crop production, the main foci of technological development are likely to be on:

- yield enhancement using biotechnology (Royal Society 2009)
- adaptation to abiotic stress (e.g. drought, salinity) *via* crop management regimes such as regulated deficit irrigation regimes (Davies et al. 2002) and improved crop protection methods (Ordidge et al. 2009) or genetic improvements of stress tolerance in crops (Royal Society 2009)
- management of biotic stresses (pests, weeds, diseases) through integrated pest management, biological control, genetic approaches to disease resistance (Royal Society 2009) and the development of 'precision-farming technologies targeting agro chemical and water inputs to a crop (Blandford & Hill 2006)
- soil conservation *via* the adoption of zero or reduced tillage techniques to reduce damage to soil structure and loss of groundwater (Royal Society 2009)

The uptake of these technological developments will tend to vary between the different arable, field crop and mixed farming systems. Intensive producers are likely to have the financial and technical resources to exploit new crop varieties and production technologies. Many of these producers are already using precision technologies (Table 1) to help them address problems of in-field environmental variability. Precision technologies enable the grower to accurately map the local environment and to apply a precise dosage of nutrient, water and crop protection treatments individually tailored to the needs of individual plants or localised areas of the crop (Gebbers and Adamchuk 2010). Such technologies have the advantage of optimising conditions for plant growth and reducing the amount of actual input of fertiliser and crop protection products, thus enhancing the sustainability of intensive crop production.

Table 1 Three Key technologies in crop production

Technology	Function and constraints on application	Timescale
Conventional breeding and use of F1 hybrids	Used to develop higher-yielding varieties. Hybrids are associated with increased vigour in the F1 generation and may display traits beyond the range of those of the parents in the F2 generation. Constraint on current use of hybrids is the need for repeated hybridisation in each round of seed production. This is expensive and can lead to problems regarding supply and Intellectual Property. Approaches are being explored to resolve the production issues in the long-term	>10 years
Transgenic (genetically-modified) varieties	Yield enhancing traits from other varieties or species inserted into the crop. Field potential may be constrained by local environmental conditions. Also significant political concerns within the EU about the use of GM varieties currently constrain their use.	>10 years
Precision technologies	Use of remote sensing, GIS & GPS technologies to map and monitor global and local variation in crop production, coupled with the use of precision and variable rate application machinery to tailor inputs of fertiliser, water, pesticides and seeds to local conditions. Constrained by technical know-how and cost	Available now

Some of these technologies may be beyond the financial resources of most extensive producers and in many cases, farm size is too small to make the adoption of precision technologies financially viable. In some cases, the problem can be circumvented by the use

of machinery rings or cooperative producer groups that facilitate the sharing of such technology. However, for many of these farms the use of a higher-yielding variety adapted to the specific farm environment (rather than one requiring substantial additional inputs which are likely to be both economically and environmentally unsustainable) might be seen as being more beneficial to the sustainable production agenda. For example, work on the cultivation of agricultural ryegrasses with high levels of soluble sugar which potentially can be used for bioethanol production, may offer an additional economic and environmentally sustainable option for pasture management for livestock farmers. Moreover since the grass can be grown on land that is unsuitable for other crops, its production need not conflict with requirements for food or some animal feed production (IBERS 2009).

There are a number of reasons for looking closely at the needs of lower yielding farms. Firstly, there are social and environmental benefits to supporting farmers on low-yielding lands. Secondly the development of varieties that can withstand environmental stresses such as drought, temperature fluctuation, salinity or toxicity that may occur in these areas is seen as a critical requirement for enhancing productivity under future global environmental change scenarios (Royal Society 2009). Indeed the importance of identifying varieties tolerant of abiotic stress is increased as it is anticipated that new high yielding crop varieties are likely to result in smaller increases in yield production, since the differential between these and existing modern varieties is relatively small as the latter already exhibit high-yielding traits (IAASTD 2008). Moreover some authors argue that the introduction of genetically-modified or transgenic plants may not deliver the expected yield increases due to the influence of environmental conditions on the expression of genetic traits (Sinclair *et al.* 2004, MacMillan *et al.* 2006 and Box below).

However, progress in breeding varieties for marginal environments has been slow (IAASTD 2008) due to the complex traits and low heritability associated with characteristics such as drought tolerance (IAASTD 2008). Better progress has been made for abiotic stresses linked to particular stages in the life cycle of the crop, for example tolerance to extremes of temperature during reproductive developments (Hall, 1992; Prasad *et al.* 2006).

Box 1 GM technologies and the sustainable production agenda

The introduction of genetically modified (GM) crops into agricultural production has been driven by economic rather than environmental concerns. Within the EU it has been highly controversial and is subject to strong regulation (IEEP 2010**)**.

At the present time, varieties of maize, oilseed, brassica and soybean are available that tolerate broad-spectrum herbicides and show resistance to vegetation chewing insect pests. Further disease and pest resistant cereal varieties are likely within 5-10 years with the emergence of environmental stress tolerant varieties likely within the next 10-20 years (Royal Society 2009). The emergence of these varieties offers the potential to enhance crop productivity although, within the next 5-10 years, it is likely that the greatest contribution will come from non-GM approaches (Tester and Langridge 2010).

The continued emergence of biofortified varieties (Mayer *et al.* 2008) such as 'golden rice' - a transgenic line of rice with enhanced levels of β-carotene (Paine *et al.* 2005), - and animal feed crops with a modified composition to enhance their conversion efficiency to meat and to lower methane emissions, will help to address concerns over the nutritional quality of human and animal feed and the emission of greenhouse gases from intensive livestock production (Godfray *et al.* 2010).

The speed at which genomes can now be sequenced and re-sequenced means that new varieties are likely to emerge more rapidly in the coming years. The extent to which they play a role in future European agriculture will depend on the willingness of the public within EU Member States to accept them as well as the outcome of more technical appraisals of their merits and environmental impact which will remain essential. The evidence concerning the contribution of GM crops to sustainability of production is mixed, with some showing potential for decreased insecticide use and others for increased herbicide use (IAASTD 2008). There have been considerable concerns about biodiversity impacts in the UK where there is an inverse correlation between agricultural yields and levels of biodiversity within fields (Johnson and Hope 2004). A number of environmental and food safety issues still need to be assessed. It is unclear whether greater public investment in biotechnology research will go some way to reduce the perception that biotechnology is driven purely by commercial interests (Godfray *et al.* 2010, Royal Society 2009). Ironically one consequence of the polarised debate surrounding the use of GM varieties is that non-GM jurisdictions lose out on current knowledge and opportunities to explore the sustainability of such technologies and whether or not their adoption can assist them in future food production and environmental sustainability goals (Tester and Langridge 2010).

Another area of technological advance of particular interest from a sustainability viewpoint is improved soil management. Soil degradation and erosion is largely a product of poor land and water management practices often combined with fragile soils. These conditions are likely to be exacerbated by ongoing climate change. Significant advances in the sustainable management of soils can be achieved by the application or modification of crop management practices such as intercropping, adjusting crop sowing date or planting of seed mixes to enhance the use and capture of water and minimise the exposure of soils to wind and water erosion. Such practices may require the capture of local producer knowledge (Herrero *et al*. 2010) and also help to buffer crops against abiotic stress, pest and disease outbreaks (Royal Society 2009). Many of these practices occur in organic farming, which is recognised as delivering benefits for the protection of soil, biodiversity and water quality (European Commission 2004). Advances that help to maintain or increase the productivity, sustainability and profitability of organic farming and other more ecologically inspired approaches such as agro-forestry are clearly beneficial and need to be pursued alongside the high tech pathways that attract so much of the research attention.

On larger, more intensive farms, the adoption of zero tillage farming (Table 2) can make a positive contribution to sustainable soil management. Zero tillage can increase organic matter content and carbon sequestration in soils (West and Post 2002), reduce erosion (Schuller *et al.* 2007), run-off and pollution of water courses where conditions are suited to the practice. However, there can be environmental and production penalties including increased use of herbicides for weed control, increased nitrous oxide emissions from fertilisers, particularly on waterlogged soils, and the emergence of a different suite of pests and diseases attacking crops (Tester and Langridge 2010).

Table 2 Technologies for enhancing soil management and/or the ability of crops to withstand abiotic stress

Technology	Function and constraints on application	Timescale
Zero tillage	Can successfully address soil damage in many conditions but requires appropriate skills, a new generation of affordable machinery. Greater herbicide use and reliance on often heavy machinery are of environmental concern	Available now
Biochar	Incorporation of biochar (charcoal) into soils can enhance carbon sequestration and may also reduce leaching of nutrients and enhance the slow release of nutrients to crops thus enhancing yield (Marris 2006).	Available now
Plant breeding and conversion of annual to perennial crops	Either replacing annual with perennial crops, or use of breeding programmes to develop perennial varieties of wheat, sorghum, sunflower etc. Latter varieties could be available with adequate support	Within 10 years
Intercropping	Growing two or more crops alongside each other to provide shade, enhance use and capture of water and nutrient resources and reduce incidence of pest and disease outbreaks.	Available now
Seed mixes	Plant mixtures of different species genotypes to buffer against abiotic stress	Available now
Modify sowing date	Sow to enable ground cover whilst water still available	Available now
Precision and deficit irrigation	Technologies to target and vary water inputs to the crop. Deficit irrigation may involving inducing low level water stress in the crop to encourage it to divert resources from vegetative growth to grain / seed production	Available now
Protective film covering	Modern coverings can alter levels of solar radiation & can be used in combination with other techniques to increase condensation and lower air temperature	Available now
Genetic modification	Many lines developed especially for severe drought & salinity resistance but more moderate drought conditions in field can result in very little change in yield. Performance of many GM lines still to be tested and proved in the field	>10 years

Livestock production and technological development

With respect to livestock production, the technological challenges include a need to:

i) enhance the productivity and performance of animals
ii) reduce the emissions of greenhouse gases and other potential pollutants arising from animals, manure and slurry
iii) enhance the nutrient value of animal feed whilst keeping minerals and other additives to the lowest optimum level
iv) maintain and enhance animal welfare standards

v) improve livestock management to minimise the negative impact of diseases and organisms migrating into Europe as a result of climate change

Use of conventional livestock breeding techniques has had a significant impact in enhancing nutrition, health and rural livelihoods particularly in developed countries (IAASTD 2008). The greatest gains in productivity have been in pigs and poultry and to a lesser extent in dairy cattle (IAASTD 2008). For outdoor grazers, productivity gains can be lost if the breed is not well matched to the environment. The matching of breeds to environmental context has been the subject of much discussion in the management of some semi-natural vegetation systems (*e.g.* maquis and upland grazing) particularly in the context of the development of agri-environment schemes.

Livestock production is a major contributor to greenhouse gas emissions (accounting for approximately 9 per cent of emissions within the EU). The levels vary markedly between production systems, thus for example the production of methane for intensive (housed) grain-fed dairy cattle in Europe has been measured at 117-128 kg of methane per animal per year, compared to 53-60 kg of methane per animal per year for grazed dairy and beef cattle (FAO 2006b). A recent study by Nguyen *et al.* (2010) suggests, however, that emissions of CO_2 for beef production from intensively reared dairy calves was lower than that from suckler herds (16.0 – 19.9 kg compared to 27.3 kg CO_2 per 1 kg of beef meat).

Key foci for technological development within the livestock sector are likely to remain: the genetic improvement of animals; improvements in the formulation of animal feed, for example to reduce methane emissions from cattle, and the phosphate content of pig and poultry manure (Shukla *et al.* 2009); and further automation of milking systems and pig and poultry units to enhance environmental conditions (Gebbers and Adamchuk 2010). A range of biotechnology techniques designed to improve stock performance or indeed to eliminate the need for livestock altogether by producing animal proteins from tissue cultures (Haagsman *et al.* 2009), is being developed; but questions of public acceptability and ethics arise in some cases, for example around the issue of animal cloning (EGE 2008). If such techniques are widely used they may contribute to falls in greenhouse gas emissions in various ways and lead to a smaller population of livestock with multiple secondary effects on the environment.

Conclusions

These developments are likely to underpin a trend towards agricultural intensification in both crop and livestock sectors but, by allowing more output per hectare, may reduce the need for conversion of additional land for agriculture within the EU or elsewhere. Use of animal feed with fewer polluting by-products and the development of fully housed dairy systems, for example, offers the potential for reduced greenhouse gas emissions from animal production (Land Use and Climate Change Group 2010). The further pursuit of zero-grazed intensive animal production for beef and dairy animals does, however, raise some potential conflicts with the requirement for grazing management to maintain pastoral landscapes and the biodiversity of species-rich grassland and other semi-natural habitats (Land Use and Climate Change Group 2010).

The emergence of new varieties and /or technologies for enhancing plant stress tolerance may lead to intensification on more marginal land – where this is economically and agronomically feasible – but is also likely to facilitate the maintenance of agricultural production in certain regions of Europe. The wider adoption of reduced tillage and precision technologies is expected to deliver environmental benefits, although in areas where this technology is introduced, the associated large machinery could encourage an increase in

field size and loss of landscape features, especially in localities where 'traditional' farming practices occur at present.

New technologies vary in their impact on sustainability, with some having positive impacts, such as integrated pest management, and other more mixed or negative consequences. Many anticipated advances relate to the use of inputs and the yields of crops and animals but some are primarily resource conserving, such as advanced irrigation techniques.

Although it is clear that a number of technologies have the potential to make a substantial contribution to sustainable production, it is not evident that all farming systems will benefit. The greatest uptake of new technology tends to be associated with intensive large-scale agricultural systems that have the know-how, capital and economies of scale in production, enabling them to capture the benefits of new technological developments. The extent to which extensive or small-scale farmers, who operate in more diverse ecosystems or challenging environments, can utilise these technologies is more uncertain, and suggests a need for effective technology transfer and advisory support to incentivise the adoption of the most beneficial advances and to identify those best-suited to particular farming systems.

4.4. The Land Use Equation

There is a declining area of land available to agriculture in Europe because of the progressive increase in urbanisation and the net transfer of land from agriculture to forestry. This decline is occurring slowly and there are areas in the new Member States where land could be brought back into agricultural production. Nevertheless, the trajectory is in a downward direction. With more competing uses for land, for example for recreation, there may be steeper losses than the average in some regions. At the same time there is a possibility that the level of crop production in Europe will rise over the next three decades as a result of changing levels of demand, increased competitiveness and the near certainty that bioenergy production will increase as a result of policy interventions, possibly reinforced by rising energy prices. A range of bioenergy projects become attractive if crude oil prices return to levels above $90 – 100 per barrel in real terms.

Establishing and maintaining environmentally as well as economically appropriate land uses in Europe over the next decade will be a significant challenge. A few but by no means all the elements in the equation are introduced here.

Bioenergy

Bioenergy feedstocks represent a sizeable new demand on Europe's limited area of rural land which is expected to expand over time as a direct response to EU policy, particularly the Renewable Energy Directive, which sets targets of a 20 per cent share of energy from renewable sources by 2020 (EC 2009) alongside those extant for biofuels. In effect these targets are a driver for further arable crop production as well as for more exploitation of woodland and raise questions about how much additional production can be accommodated within the farmed area without eliminating a substantial area of more extensive production, much of which is important from the perspective of biodiversity, landscape and other environmental public goods. However, there is a connection between this internal EU concern and the wider global picture. The EU is reliant on imports of both fossil fuels and bioenergy – the UK and Sweden both purchase wood chips on a growing scale for example. If a cautious approach to bioenergy production on European land results in a greater volume of imports then the environmental costs of this production need to be fully taken into account. The EU is now part of a global land use jigsaw with the interactions between the pieces becoming closer.

It is difficult to forecast the extent to which the new markets for bioenergy will be met from European rather than imported sources. This depends on a range of factors including price levels, the extent of tariffs on imports, the application of potentially demanding sustainability criteria under the rules of the Renewable Energy Directive, competing uses for the raw materials and the character of markets which can be defined by predominantly local factors, such as national legislation. For example, the German EEG (*Erneuerbar-Energie-Gesetz* – Renewable Energy Source Act) which in 2004 included significant incentives for electricity production through biogas, stimulated a 6-fold increase in biogas plants and the planting of a significant area (>560,000 ha) of agricultural land for biofuels – primarily maize. Since it is only economically viable to transport maize for this purpose up to a distance of 30 kilometres, the impact of biogas plants on local land use will have been significant in some areas.

At a European level the EEA has estimated that around 3.6 million hectares of agricultural land was directly devoted to biomass production for energy use in the EU-25 in 2005 (EEA 2006b). Of this, 83 per cent was devoted to oilseeds. This could increase several times if prices are high enough or incentives introduced by national governments specifically encourage local production.

The bioenergy debate also has implications for forestry. Countries where bioenergy already plays a significant role in total primary energy supply such as Sweden and Finland (15 and 19 percent, respectively) generally have a large pulp and paper industry, where the combustion of black liquor during the Kraft pulping process contributes to bioenergy production. In future, new technologies should lead to the expanded use of both agricultural residues (agrofuels) and forest feedstocks (woodfuels) for the production of cellulosic liquid biofuels for transport, and pilot-scale plants have already been in operation for several years (in Canada, Sweden, Spain, the US and other countries). GHG emissions associated with cellulosic liquid biofuel production and use are significantly lower than those obtained from fossil fuels and food-based liquid biofuels such as starch- or sugar-based bioethanol. In terms of bioenergy heat and electricity generation, the majority utilise woodfuels from forestry or forest product residues; few agrofuels such as energy crops are specifically grown for this application. In Sweden one result of increased bioenergy demand is the development of energy plantations of willow or poplar on agricultural land to supply biomass feedstocks. At present there is little competition for forest biomass between the energy sector and the traditional forest products sector, and it is unlikely that such competition will occur in the immediate future. However, recent price trends for wood have been increasing, and the expanding use of wood energy may support this (FAO, 2007).

The Commission estimates that reaching the target of a 20% renewable energy share could multiply total biomass demand from agriculture and forests by a factor 2 to 3, including a substantial increase in efficiency of biomass production and use. Projections made by the UN-ECE and FAO suggest a possible imbalance between supply and demand to meet existing material use and extrapolated renewable energy needs, if the importance of wood in the biomass component of the total renewable energy supply remains constant. Under this scenario it has been estimated that, due to steadily growing demand, the ratio of fellings over net annual increment could temporarily increase in some European countries to over 100 %, causing a decline in growing stock after 2020 and with other implications as well. A temporary high utilisation rate is not necessarily unsustainable, given the skewed forest age-class structure in many Member States, but it could turn EU forests from a carbon sink into a temporary source (European Commission 2010).

Forestry

Forests, as defined in European statistics, extend to 155 million hectares or about 37 per cent of the EU land area, compared with 41 per cent for agriculture, and are expanding slowly. They vary considerably in character, density and the type of management practised, if any (see Box 2 and Annex 1). Many forests are managed independently but in some countries there is a significant area of woodland located on farms, usually in relatively small blocks.

Forestry policy in Europe is based on the principle of Sustainable Forest Management (SFM), and forests have significant capacity to provide a wide range of public goods in the future as well as wood and other traditional products such as game, fruit and fungi. The importance of forest biodiversity has long been recognised - forest habitats constitute almost 20 % of the whole terrestrial Natura 2000 network, although only one third of these habitats are in a favourable conservation status. However, if well sited and managed, forests have the potential to provide a growing spectrum of environmental and social benefits and sources of renewable energy. Their part in future European land use, should be assessed against their role in protecting soil, regulating freshwater supplies and acting as sinks of carbon as well as conditional economic returns. At the same time there may be growth in output of more staple forest products driven by market opportunities in some regions (see Box 2).

Two leading questions for the coming decade concern the case for expanding the total area of forestry and the extent to which new forms of management will be required as both private and social objectives for woodland in different parts of Europe evolve.

Forests expand either because of deliberate planting, which has not been economic in most of Europe recently, but has been grant aided in some regions, or because of progressive land abandonment and natural succession. Data on the scale of natural succession tends not to be very reliable, so it is difficult to judge how far it is taking place. This form of expansion is unplanned and often arises from the demise of farm management. Some of it occurs on land of High Nature Value where abandonment can create fire hazards and is often subject to criticism both from foresters and environmental interests. On the other hand, natural regeneration can be a means of introducing more semi-natural vegetation into agricultural landscapes, buffering existing woodlands and fixing carbon at low cost. Its value depends on the precise local conditions and land use objectives. In the right location natural succession has a role in a future land use equation.

Planned afforestation is expected to continue. The Commission reports an afforestation target under all 2007-2013 Rural Development Plans (RDPs) of 650,000ha (0.4% of agricultural land in EU27) together with a further 240,000 ha of non-agricultural land. This may seem surprisingly high given the modest economic returns from most woodland. However, there are several different reasons for planning forest expansion, including a new emphasis on carbon sequestration and water quality in some Member States such as Denmark. In their post-Health Check revisions to RDPs many Member States have allocated additional funding to increasing supplies of renewable energy but it is not clear what proportion of this will be used to support the forest sector. The RDP targets may well not be reached.

Box 2 Forestry in Europe

Of the 155 million hectares classified as forest in the EU-27, 130 million ha are available for harvesting in the EU and a further 21 million ha covered by other wooded land (European Commission, 2010). About 60 % of the EU's forests are privately owned, and the majority of these are smaller than five hectares. As a result of afforestation programmes and natural regeneration on marginal land, forest cover has increased over the past few decades, and in most forests the annual growth increment has exceeded the volume removed. There are very significant differences between regimes in terms of the economic importance of forests, ownership, objectives of state intervention, integration with agriculture and environmental issues. Seven distinct regional forest types have been identified, of which the Nordic region (Finland and Sweden) dominates in terms of productivity, investment and harvesting of roundwood (see Annex 1):

The main forest products include sawn timber, wood-based panels, pulp for paper, and also firewood chips and bark for bioenergy, often produced by small and medium sized enterprises based in rural areas. The forest sector provides around 8 % of the total added value from manufacturing. Wood production for industry steadily increased from 1950 to 1990 in Western Europe and then levelled out until 2000; there was a similar trend in Eastern Europe with the levelling beginning around 1985. Now there is potential to further increase sustainable wood mobilisation within the EU, but balancing issues of the competitiveness of the forest based industries, economic viability, environment, fragmentation of ownership, organisation and motivation of forest owners poses considerable challenges (European Commission, 2010). The future competitiveness of the EU forest sector is determined mostly outside Europe by events on the world market. However, analysis suggests that the Nordic–Baltic and Central regions will remain centres of gravity in a globalised world, with potential for substantial future growth and perhaps the South-eastern European region through increased productivity and low costs. Responses to globalisation in the EU so far have been focused on competing in the price sensitive global raw material markets, but innovations in higher value-added wood products and non-timber products and services are considered underdeveloped. More innovative policies for future forestry and new markets seem scarce in Europe. Instead there is a focus on traditions, limited emphasis on the future, and avoidance of risks in the forest sector. (IIASA, 2007).

Carbon management objectives should come to have a larger role in guiding forestry policy. Forests sequester carbon in biomass and soil, but forest degradation or conversion to other land use can cause substantial GHG emissions due to fires, biomass decay and mineralisation of soil organic matter, leading to forests becoming a carbon source. Because EU forests are accumulating biomass they currently act as a net carbon sink removing about 0.5 Gt of CO2/year, compared to EU-27 industrial GHG emissions of 5 Gt CO2 equivalent/year. However, the combined effects of climate change (for example, more frequent very strong storms), the prevalence of older stands and possible unforeseen increases in timber harvesting may have an impact on this sink capacity (IIASA, 2007).

Despite the benefits of appropriate forest management for carbon sequestration, it seems unlikely that this will result in a large transfer of land into forestry unless there are decisive new incentives to do so or new woodland management systems (such as a resumption of traditional multi-cropping solutions) become attractive economically. This is an avenue to pursue since the use of trees within farming systems (for example by intercropping, wood pasture, agri-forestry, permaculture) has the potential to address climate change and deliver

a range of marketable products. When appropriately sited within farmland, trees can provide shade and shelter and contribute to the sustainable management of water quality and quantity.

Where active afforestation programmes are developed, environmental sustainability needs to be very carefully considered, including impacts on biodiversity, water demand and fire hazards. Since afforestation tends to occur on the least productive farmland, particular care is needed to ensure that valuable semi-natural habitats under agricultural management, such as many mountain pastures and species-rich meadows, are not affected adversely. Effective prior assessment procedures need to be built into incentives for afforestation, particularly in the selection of appropriate sites and tree species.

There are also questions about how far the management of existing woodland could alter by 2020 in the light of changing circumstances, such as new markets for fuel wood or requirements to increase grazing levels in certain areas to reduce the risks of wildfires. Economic motives may activate some of the management needed from an environmental perspective but the increasing spectrum of demands for carbon, biodiversity and fire and water management suggests that there will be a growing role for advice, information, training, demonstration projects and well targeted incentives. More strategic thinking about the balance between farmland and woodland and greater emphasis on integrated land management in the light of the climate debate would help to inform the sustainable production agenda in Europe.

New Patterns of Agricultural Production in Europe?

Over time there will be changes in the geographical pattern of agricultural production in Europe and these may be more widespread in the period to 2020 than they have been in the last decade. Within a single market the operation of the laws of comparative advantage will result in certain forms of production for example pigs, poultry, many fruit and vegetables and milk being concentrated geographically in those areas that are most competitive. These forms of production decline in less competitive regions, with a variety of consequences. This may reflect lower labour costs, as in central and eastern Europe, better soils, climate and natural conditions, as evidenced in changes to fruit production and closeness to the market, which can be a significant consideration in milk production, for example. Other factors influencing location include the availability of particular skills and management capacity and greater access to capital.

In the United States, a single market with fewer internal barriers than Europe, there has been larger scale relocation of some forms of production than seen in Europe. Dairy farming is no longer concentrated on the East Coast, as it once was, but is now found in areas with lower costs and larger scale units notably in Wisconsin, the mid West and the South. Most of this change comes about as a result of the establishment of new enterprises or enlargement of existing ones in the area of growth rather than the movement of farms from one location to another. This type of restructuring has been inhibited in Europe by the system of milk quotas, as well as the strength of national markets and a range of institutional factors. However, milk quotas are due to be abolished by 2015 and relocation of production can be expected, even if overall levels of output are little changed, as seems possible. The most competitive areas, such as the Netherlands, Denmark, Northern Italy and North West France may gain at the expense of higher cost regions. These might include areas with poorer conditions for fodder production, such as many Less Favoured Areas, or small structures, as in much of Poland or more difficult climatic conditions, such as parts of southern Europe. In those Member States where the national quota regimes have permitted relocation of production within the country, such as the UK, there has been evidence of more specialised

regions gaining market share, with East Anglia losing at the expense of western parts of England for example (Alliance Environnement 2008).

These dynamics are not easy to predict, however. There are barriers to regional relocation which are not always immediately evident. For example many central and eastern European countries have not increased their overall share of EU output of arable crops in the way that many would have predicted on the basis of their lower land and labour costs. Institutional and structural factors, some relating to land ownership, others to technological and advisory capacity, entrepreneurial skills and access to capital have slowed the pace of investment and rate of increase in yields (Swinnen 2009b). Since accession in 2004, the only major new Member State in which agricultural production has increased significantly is Poland – in some countries it has actually declined (Csaki 2009).

In the longer term some of the current barriers to greater regional concentration may be eroded. For example:

- Transitional problems in many new Member States in particular will diminish. Limited access to capital in Bulgaria and Romania for example is a barrier to investment at present that may be expected to decline over time.
- Policy barriers, such as sugar and milk quotas are being removed. The reform of the CAP sugar regime is already leading to relocation of production in Europe. The move from coupled to decoupled payments, occurring at different rates in different Member States, will in principle be a spur for relocation.
- The overall trend towards market liberalisation, both within the EU and potentially more globally through lower tariffs on a range of imports, will erode some of the power of local and national markets which have remained robust in many sectors up to now.
- These issues may be accentuated by the rise of large pan-European supermarkets, such as Carrefour, Aldi and Tesco, now present in a growing range of countries and able to source food products from an increasingly wide network of suppliers in different locations.

At the same time there will continue to be factors working against a more pronounced pattern of regional specialisation. In arable farming there may be some withdrawal of cropping from more remote and less favoured areas. As argued earlier in this paper, however, there are reasons to believe that the overall arable area is unlikely to decline and indeed may well expand, particularly if production of bioenergy and perhaps protein crops grows further in Europe. Amongst the potentially more mobile forms of production, such as vegetables, there are local loyalties and preferences, advantages to operating in familiar local markets and keeping transport costs low. The “eat local” movement reinforces this, especially where it is taken up by supermarkets and local hotels and restaurants. There are some niche products strongly identified with particular regions, such as many cheeses and fine wines, which generate good returns and have a strong competitive position. Efforts to reinforce the power of specialist labels may increase the range and market significance of these products over the next fifteen years.

Finally there are environmental constraints on increasing regional concentration of production. These can be significant in the intensive livestock sector where there have been problems of water pollution and waste management in recent years, notably in the Netherlands, Brittany and Flanders. Active efforts to reduce the concentration of these units and corresponding pollution loads in highly competitive areas have been made in the Netherlands, where it has also been necessary to transport slurry over considerable distances to disperse environmental pressures.

Similarly, in some regions which have developed a large scale intensive horticulture sector there have been problems of water pollution, excessive extraction of groundwater, salinisation and soil pollution. Such pressures are pronounced in parts of the coastal strip of southern Spain which has gained market share from other parts of Europe. Measures to address these concerns could lead to dispersal in production and the use of less intensive techniques.

Looking towards 2020 it is not unreasonable to expect more farm level and regional scale specialisation and to see the distribution of some production systems within Europe changing significantly. The fruit, vegetable, milk and livestock sectors are amongst those that seem most likely to be affected. On the whole these adjustments might be expected to favour those regions that already are highly competitive for structural reasons, such as Denmark and the Netherlands or regions able to overcome previous disadvantages – which potentially could include Romania, Bulgaria, Hungary and Poland. At the same time, new crops could become established and some more traditional ones, such as tobacco, could cease to be viable.

The land use implications of these issues need to be teased out systematically. At present it is not clear what happens on dairy farms that cease milk production, for example. Some may be abandoned or converted to forestry but it seems more probable that most will remain in some form of agricultural use, particularly where they have been occupying relatively productive pasture. In the UK many such farms seem to remain in grassland and are used for beef animals, sheep or recreation; others are converted to arable cropping. Data is poor however, and it is difficult to judge the consequences of such structural changes in Europe as a whole (IEEP 2009). This is a topic where further research would be worthwhile.

Production Intensity and Environment

From a sustainability perspective there is value in maintaining a mixture of both high yielding and more extensive forms of agriculture within Europe and to match this pattern to environmental and resource management needs as well as to economic drivers. High yielding systems are needed to maintain output and carbon efficiency while extensive systems provide the bulk of many environmental public goods such as biodiversity, landscape and cleaner water. Extensive systems, where suckler cows graze on semi-natural vegetation, may be the most efficient way to manage a resource that has relatively few other economic uses. At the same time there is a need to decrease the dependence of all systems on non-renewable inputs by increasing their environmental performance and raising the efficiency with which they use resources such as water and energy.

Some reductions in input use can be expected to occur as a result of the new technologies such as precision farming, the high costs of energy and inorganic fertilisers, policy pressures such as the implementation of the Water Framework Directive and phasing out of the coupled payments in the CAP as well as the demands of consumers, retailers and others in the supply chain. Carbon efficiency is likely to improve in response to the dynamics of the market as well as policy drivers.

However, long established trends towards intensification and abandonment also appear likely to continue, accompanying almost inevitable increases in the scale of farming, the retirement of an older generation, the continued incentives for mechanisation, the convergence of production systems in the new Member States with those in the EU-15 and other factors.

Whether arising from greater demand for bioenergy or for other reasons, periods of increased real prices for arable crops can be expected. These will raise the opportunity cost of environmental management, as has been occurring in the new Member States. There will be pressures to increase production on lower intensity land uses, including permanent grassland and the area of such systems will decline in the face of intensification in more competitive locations and on the other hand, reduced farm management on more marginal ground. Both pressures will need to be compensated for through appropriate policy interventions such as higher levels of payment for participating in voluntary agri-environment schemes. Measures to improve market returns from less intensive and environmentally sensitive forms of management will also be needed to maintain both producer and consumer confidence in these systems as well as avoid excessive dependence on public expenditure. Organic production is the clearest example of such an approach but there are many others too.

There is clearly a larger role for private sector funding in this domain especially where public and private interests can be brought into alignment, even if this is on a relatively modest scale in the next decade. An example of a private initiative to promote improved environmental management in water supply catchments is given in Box 3 below.

Box 3 An example of a private initiative to promote improved environmental management in water supply catchments

SCaMP is a sustainable catchment management programme involving United Utilities (UU) (a major water company), the Royal Society for the Protection of Birds (RSPB) and around 60 farms or land holdings in the North West region of England. Its objective is to deliver sustainable management of the upland moor, blanket bog and woodland habitats owned by UU in order to

- Maintain and enhance the biodiversity associated with these habitats
- Restore sites of scientific interest
- Reduce the costs of water treatment
- Deliver a viable living for tenant farmers

Land owned by United Utilities (57,500 ha) is the primary source of water for 6.7 million people in the North West of England. At present, the SCaMP project extends to 20,000 hectares of this total in the Trough of Bowland and the Peak District. An application is being prepared to enlarge the programme over a wider area in the next five years.

Even with more intensification in some regions, localised land abandonment is likely to continue to occur, particularly where there are major impediments to agriculture, for example on very steep slopes, on inaccessible land, exceptionally wet or dry soils, areas with very small holdings or those under intense pressures from urban uses. How far abandonment will take place on larger areas of land, for example when a generation of older farmers who have been tolerant of relatively harsh conditions on traditional farms begins to retire, is uncertain and will require further research. Some continued transfers of farmland to forestry certainly can be expected, as noted above. Further work on the environmental consequences of abandonment and the natural regeneration of scrub and woodland in different parts of Europe would also be valuable so that incentives for traditional forms of management can be concentrated more systematically on areas where abandonment is least desirable whilst changes of land use are accepted or encouraged where they would be most appropriate. A more strategic approach to land abandonment and forestry would be beneficial in all rural

development programmes. For example, these might seek to promote decisions whereby farm land of high biodiversity value could be managed as open habitat and new woodland could be actively managed to provide wood fuel, timber and deliver carbon storage.

The balance between intensive and extensive farming systems and the trade-offs between them will become more important as a policy question. Extensive systems are responsible for a significant share of public good provision, particularly for biodiversity and landscape and account for a large proportion of High Nature Value farming. Unfertilised semi-natural grasslands currently may be a net carbon sink as well as having botanical value. However extensive systems are not necessarily efficient in terms of mitigating climate change where more intensive systems of producing animal protein may also have a significant role. For example, a recent study suggested that beef production from suckler cows in Europe was responsible for average emissions of 27kg of CO_2 equivalent per kilogram of meat compared with around 18kg for beef produced from the more intensively managed dairy calves. The eutrophication and acidification potential from suckler cows was also considered to be higher (Nguyen et al 2010). Nonetheless, care must be taken not to eclipse the value of more extensive systems in the carbon debate. For example by managing grazed habitats they help to prevent invasion by scrub and coarse grasses with the attendant risk that damp soils will dry out, leading to enhanced oxidisation of carbon (Land Use and Climate Change Group 2010). Public incentives will need to ensure that the environmental and indeed socio-cultural benefits of extensive systems are maximised and to address trade-offs in an explicit way. Equally, it is important to avoid the introduction of policies that discourage sustainable extensive systems in the course of trying to improve the climate mitigation performance of agriculture.

In the light of this analysis, there will be a strong public interest in maintaining more extensive systems with marked environmental public good characteristics alongside more intensive systems which are likely to be sustained largely by the market. More targeted and differentiated CAP direct payments could help to underpin a spectrum of appropriate systems. The level at which these more extensive systems need to be sustained to meet environmental goals, the different forms of management required and questions of the distribution of land management priorities within Europe need further work. Some types of environmental provision, good soil management for example, need to be dispersed through the countryside. However, other forms of management need to be maintained or targeted mainly in specific locations such as sensitive catchments or valuable nature conservation sites where continuity of management or the restoration of damaged habitats may be the priority rather than concentrated in areas which arise simply from market forces. At the same time it will become more important to achieve multiple social and environmental as well as production benefits from agricultural land as it becomes an increasingly scarce resource. There will be advantages in combining production and public goods benefits where possible within the same space and region, especially as rural land itself becomes more scarce and increasingly subject to urban pressures.

In short, establishing a sustainable pattern of production with varying levels of intensity and land uses appropriate to complex environmental as well as socio-economic goals requires a delicate array of public interventions as well as appropriate initiatives by farmers, land managers and the supply chains in which they work. The role of the CAP in this field is touched on below.

5 IMPLICATIONS FOR THE CAP

As noted earlier, the sustainable production agenda applies at the local level and at all the tiers above this up to the European and global scale. For agriculture the European level is of great significance because so many of the policy levers are deployed by the EU, albeit with considerable national discretion available for Member States, and most of the budgetary resources for intervention are concentrated at this level too. For forestry the position is different but there are several European policy initiatives bearing on sustainability. Furthermore, the arguments for strengthening the linkages between agricultural and forestry policy to create a more holistic approach to European land use will grow over time.

At the European level the CAP is still a powerful driver of agriculture and land use. While the original objectives of the CAP, still enshrined in the present Treaty, on the Functioning of the European Union, do not refer to sustainability at all, the often overlooked EU Sustainable Development Strategy does clearly apply to agricultural policy in Europe. The absence of new Treaty objectives for agriculture, however desirable they might be, should not inhibit the further evolution of the policy in this direction. The challenge is to harness a re-focused CAP, addressing the post 2013 agenda in an effective way, to a set of new EU policy measures concerned with the environment, energy and climate, research, trade and economic development. The aim is to create a matrix of policies that support one another in shifting the trajectory of the agricultural and forestry sectors over time.

Given the current debate about food security and Europe's role in feeding the world, it is important to be clear about overall production goals. From a sustainability standpoint the need is to retain the resources and capacity to increase the levels of food, fibre and bioenergy production in Europe in the longer term, should this be required, but not to seek a general increase in output levels in the immediate future since priority actions to achieve greater food security in present circumstances lie elsewhere. For a few specific crops such as soya, where there is a very high level of import dependency and questions of sustainability in some supply countries, different arguments apply and there is an important issue to debate.

In any case, most policy interventions within the CAP are significantly decoupled and influence the level and composition of production only to a certain degree for example, in sectors such as beef production, bioethanol and tobacco where the level of support internally or through tariffs is relatively high. There is a need however to increase the focus on better resource management. Within this bracket should be included the safeguarding and improvement of European soils and rural water resources, biodiversity and carbon stocks as well as appropriate farming skills, technologies research capacity and production infrastructure essential for the future.

This is a more complex set of goals than the traditional sectoral production objectives for agriculture and cannot be achieved by the CAP in isolation. The CAP needs to be more interlinked both horizontally to other sectoral and rural policies and vertically to both global and more local concerns. Greater attention to sustainability implies the more precise setting of objectives and targets, the integrated planning and deployment of different policy measures, the regular review of programmes and their effectiveness and enhanced monitoring and evaluation. These are approaches associated with the Pillar 2 rather than Pillar 1 model of the CAP and, even if the present distinctions between the two Pillars diminish or disappear, would need to be embedded in a significant portion of a new policy oriented towards sustainable production.

It would also be helpful to increase the flexibility of the CAP and the funding mechanisms within it so as to be more responsive if necessary to significant and sustained changes in

the principal commodity prices as well as the greater price volatility which so many expect. Judgements about the level of incentives required to secure particular forms of management and indeed the extent to which farmers can absorb the costs of new regulations are dependent to some degree on the current and expected future profitability of agriculture. If world prices were to rise substantially for those commodities that potentially could be produced on a larger scale in Europe there would be a response from farmers. Output would rise and the case for income support of the more productive sectors would fall. In this situation there is a danger of more intensive production patterns at the expense of the environment and the provision of environmental goods becomes more costly, creating a larger role for incentives under the CAP. This in turn would increase the level of funding required if adequate incentives are to be provided through the CAP. However, a more profitable agriculture sector could more easily absorb the costs of complying with regulation and potentially needs less assistance in making investments required for more sustainable management. If on the other hand commodity prices are substantially lower, less investment would occur, farm amalgamations could well accelerate, labour costs would be cut back and land abandonment is likely to become more widespread. Regulation becomes less attractive in political and economic terms, if returns are low over a sustained period, especially if there is a greater emphasis on maintaining the competitiveness of European producers on the international market. In these circumstances environmental incentives generally need to focus less on reducing inputs and more on sustaining economically marginal management systems of environmental value. The economic viability of farming becomes a more important concern if prices remain low and there needs to be sufficient flexibility to adjust sustainability policies accordingly. Some of these issues and related questions of transition within the CAP are addressed in the first paper within this series (Hart et al 2010).

On any price scenario the challenge is to maintain a healthy and vigorous agriculture and related forestry sector and to intervene principally where market failures occur. This suggests a range of policy interventions working together such as:

- The development of appropriate standards and encouragement of good practice, using advice, demonstration farms, regulatory and cross compliance approaches, incentives and other methods. As well as developing standards within Europe there is a need to develop a stronger international framework for environmental standards, not least to avoid displacing problems to third countries via imports.
- Adjustment to the level and pattern of those policy measures that influence production patterns, e.g. coupled payments such as Article 68 measures in the CAP, cross compliance and afforestation assistance
- Appropriate structural measures such as encouraging more co-operation between farms – sharing expensive technologies etc
- Improved governance, including more effective monitoring of impacts, better enforcement of legislation, more proactive engagements with key sectors of the farming community
- Improved planning and coordination of policies at the European and national levels
- Increased training and education for land managers and those delivering policy and advice
- Longer term investment in science and technology
- Greater use of technology transfer and advisory services to speed uptake of best practice
- The targeting of support measures, such as direct payments to specific objectivesThe selective use of fiscal measures, such as charges and taxes.

Within this spectrum of policy measures some are clearly best suited to the national level or to domains mainly outside agricultural policy altogether, such as education. Nonetheless, a stronger European dimension to some of these policies might help a structural shift towards sustainability, for example in relation to research and development, increasing technology transfer and better advice and information for land managers. They could be included in a "Road Map" of policies intended to guide European farming and forestry to a more sustainable pattern by 2020. Within such a Road Map both innovation and the pursuit of environmentally sensitive forms of management would be more prominent than at present. Nonetheless incentives for both investment and appropriate land management alongside accompanying regulations would probably remain key forms of intervention at a European level, particularly within the CAP.

There is certainly a role for EU regulation, both in the form of binding measures and cross compliance. As noted above this is particularly suited to pollution control, the prohibition of entirely unsustainable products and practices, setting standards for the character and performance of inputs and machinery , controlling the use of labelling and helping to drive technological development so as to support a sustainability agenda.

Incentives for land managers can be applied in the form of one off aid for investments and transitional costs or as ongoing management payments to sustain forms of activity which otherwise would be commercially unattractive for farmers. This is a domain where the CAP already plays an important role and one that is likely to increase in the future if the environmental challenges described in this paper are given political priority over the period to 2020. In particular, payments are needed where farms are facing additional costs and loss of income from pursuing an environmentally preferable form of management. In more marginal areas of farmland, where abandonment may be economically attractive, the calculation of costs may need to take account of a significant proportion of fixed costs as well as variable costs if incentives are to be high enough to maintain agricultural management.

Beyond this is the question of the economic viability of farming in Europe and the level of farm incomes required in order to sustain both sufficient competitiveness and a farming structure of the kind that is compatible with the European landscape and rural culture. This is a difficult judgement to make, particularly with uncertainties over future market returns but there are clearly scenarios in which appropriate direct payments could play an important role in preventing large scale structural change.

With regard to research, the adoption of a sustainable production agenda as a central goal of agricultural and forestry policy in Europe would entail a series of adjustments for both practitioners and policy makers. This would need to be informed by appropriate data and a sustained research effort, addressing a spectrum of issues from practical field management to more theoretical considerations. Establishing a clearer outline of the research required would itself be a useful step towards sustainability, particularly if it embraced technical, socio-economic, environmental and policy issues. Some key areas of research are suggested in the Box below:

Box 4 Some research priorities

One element of the research required is an investment in agro-environmental data in Europe so that there is a stronger baseline of information with regard to issues such as the sustainability of soil management and the fate of biodiversity on farmland. More reliable information is required to set appropriate targets and then to monitor them. This requires investment in the capacity to measure carbon management in the rural environment, establishing baselines and monitoring variations over time. New information is required about aspects of agriculture, such as the impacts of new technology, best practice in soil management and the presence of semi-natural vegetation on farms. Systems to collect this need to be put in place – which in some cases seems possible within the framework of existing surveys. The requirements of environmental legislation, such as the Water Framework Directive, are leading to the assembly of new information in some areas but the process needs to be taken further if a more systematic approach to sustainability is to be adopted.

As part of this investment, it would be valuable to have more information about management practices and land use change in Europe so that this scarce resource can be managed as effectively as possible. Certain aspects of land use where research could be helpful are referred to in this paper. They include information about the dynamics and implications of changes in primary production patterns (such as the re-distribution of milk production), the drivers of abandonment and their environmental consequences for the environment, the longer term prospects for different kinds of forestry and forest management and the trade offs between management practices from a sustainability perspective. Policy makers and land managers need support both in identifying the most appropriate practices and systems in different conditions and the types of intervention required to encourage or sustain them. From a policy perspective this includes an active programme of monitoring to identify not only the outcomes of specific practices in different locations but also the performance of the policies adopted.

Whilst a research effort would focus within Europe it should also have a wider international dimension. This would allow account to be taken of technologies, management practices and policies adopted elsewhere. Beyond this, however, there is a need for a clearer view of the dynamics of agricultural and forestry land use on a global scale. An appreciation of the environmental consequences of different levels of European imports of commodities such as soya or bioenergy crops, and equally of European exports needs to be fed into the policy equation, alongside information on other aspects of the EU footprint such as trade in energy and mineral fertilisers. Judgements about sustainability increasingly will need to be set in a global context and preparation for this cannot begin too soon.

The CAP could provide both a European framework and some of the considerable budgetary resources needed for a transition to greater sustainability to occur. So it would have a prominent role within a Road Map or equivalent plan. Many of the types of measures currently found in the Rural Development Regulation have the potential to contribute to the goals outlined here and they could be supplemented by measures targeting support in a simpler way to fairly broadly defined sustainable systems with relatively little administrative burden. Other new priorities, such as research and the development and diffusion of new technologies could be given more priority within the CAP, particularly Pillar 2, but would be driven mainly by other policy levers

An enlarged Pillar 2 could incorporate a greater commitment to long term sustainability by using a combination of new measures, greater emphasis on some existing measures and a stronger focus on capacity building. Further funding would be required to adequately meet these goals as well as existing ones so the scale of the CAP budget and its disposition would be an even more critical question. The framework for and measures within such an approach might include:

- Establishing more specific goals for sustainable soil and water management in agriculture developed at the national or regional level, in response to a framework set out in EU policy. These goals would be delivered by action programmes including both measures co-funded through the EAFRD and others which relied on alternative approaches, including enhanced advisory services, nationally funded measures and regulation. Progress would be monitored and reported at the European level as part of the RDP programming cycle, but in an accessible, publicly available online format. Funding for soil management for example would be increased but would require more leadership from national and local administrations and more active participation by farmers, not least in producing plans, seeking advice, trying new approaches to management and making the necessary investments.
- Similarly specific goals would be developed to maintain and enhance biodiversity, manage adaptation to climate change in rural areas and maintain important landscapes. Biodiversity plans may need to be elaborated in some detail to capture the needs of specific species and habitats and HNV farming systems in addition to the key Natura 2000 sites. A variety of measures inside and outside EAFRD could be deployed to meet these goals.
- With regard to the mitigation of climate change, strategies could be developed to set out the respective roles of agriculture, bioenergy crops and forestry in broad terms so that research and development, technical innovation, aid for forest establishment and management, support for processing etc could take place within a coherent forward looking framework and prioritised accordingly. More innovative approaches, such as an expanded role for EAFRD, could have higher priority.
- Investment aid is potentially a key measure in building up sustainability, at farm level and in the associated supply chains. There is scope for progressively focussing aid under EAFRD more on specified farm and forest investments which are clearly contributing towards defined criteria and phasing out other aid. Rules in this regard could be more restrictive in the EU-15 than in the newer Member States for a transitional period.
- Research and development costs will fall largely outside the CAP in frameworks established for the purpose. However, there is scope for investing more in applied research and practical application of technical advances within EAFRD by earmarking funding for pilot projects, innovation, extended field trials with detailed monitoring and enhanced focus on dissemination. Greater exchange between national authorities, research stations, advisory services and others could be achieved by funding networks, and supporting resources such as websites and databases at a European level. A proportion of EAFRD funds could be earmarked specifically for such activities. New articles within EAFRD might be required, for example to support pilot projects but provision also could be made through an enhanced use of technical assistance resources, which themselves could be enlarged.
- Increased emphasis on building up capacity to address longer term sustainability issues, with less institutional separation between those responsible for agriculture, forestry and renewable energy supplies. Trade offs and synergies between different goals need to be mapped and analysed more systematically and fed into the policy making process at different levels.

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ANNEX 1 FORESTS IN THE EU

Annex Table 1 EU forest types

Globalized Nordic–Baltic region	Globalized pulp in paper industry-oriented, raw material production oriented regions in Nordic countries, and related supply regions in the Baltic states
Wood production oriented in Central Europe	Raw material production-oriented regions in Central Europe supplying sawmilling in pulp and paper industry, and related supply regions
Plantation-oriented in (mainly) "Atlantic Rim" Western Europe	Regions based on plantations, mainly supplying to pulp in paper forest industry, for the most part in "Atlantic Rim" Western Europe
Broader, multifunctional forestry oriented regions in Western Europe	Broader, multifunctional forestry-oriented regions with industries mainly catering to domestic consumption in Western Europe
Urban society service influenced in Northwestern Europe	Regions with forestry dominated by in oriented toward serving urbanized societies and comparatively little raw material production-oriented forestry in North-western Europe
"Countries in transition" in Eastern Europe	Regions dominated by restitution issues, "countries in transition," weak, broken, private forestry tradition, weak infrastructure, and uncompetitive domestic forest industries in Eastern Europe
Low forest management intensity in Southern Europe	Regions dominated by low forest management intensity (if any), comparatively high importance of non-wood forest products, forest fires in southern Europe

Table ** EU Forest Types (IIASA, 2007)