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POLICY INSTRUMENTS TO SUPPORT GREEN GROWTH IN AGRICULTURE - MAIN REPORT

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POLICY INSTRUMENTS TO SUPPORT GREEN GROWTH IN AGRICULTURE – MAIN REPORT

EXECUTIVE SUMMARY

1. The purpose of this report is to ***synthesise*** the experience of OECD countries in developing and implementing policies, programmes and initiatives related to green growth in the agricultural sector.

- *The concept of green growth*

  - Green growth is defined as fostering economic growth and development, while sustaining the natural assets base that provide the resources and environmental services on which our well-being relies. Increasing concerns about the sustainability of current patterns of economic growth underpin the demand for a greener model of growth. A continuation of a "business-as-usual" approach to meeting the rising global demand for food, energy and infrastructure will result in using natural resources beyond their ecological carrying capacity.

  - Green growth implies policies that either incrementally reduce resource use per unit of value added (*relative decoupling*) or keep resource use and environmental impacts stable or declining while the economy is growing overall (*absolute decoupling*).

- *Agriculture policy initiatives and policy instruments*

  - While the term "green growth", is currently gaining wide recognition among policy makers, the vast majority of OECD countries do not have an overall green growth strategy for their agricultural sectors. Numerous individual national policies were identified as being consistent with the concept, but most countries indicated that, so far, there is no consensus within relevant ministries on a formal strategy to develop and implement policies and encourage private initiatives on "green growth" for the agricultural sector. Several countries utilise the terms "green growth" and "sustainable development" interchangeably, whereas official objectives and targets have only been set for the latter.

  - Only a small number of policy instruments and initiatives have been developed with aims consistent with those of the concept of achieving green growth in agriculture. Most of these policies were already in place before the publication of the OECD's Green Growth Strategy. For EU members, most of the green growth initiatives form part of the national Rural Development Programmes 2007-13.

  - The initiatives undertaken that support green growth in agriculture cover a wide spectrum of policy areas. In several countries, most of these policy initiatives are weighted more towards the "green" dimension rather than "growth". Most countries have focused on improving energy efficiency and achieving low carbon emissions in the agricultural sector.

  - Differences exist concerning the relative emphasis to be accorded different types of policies that support "green growth" (e.g. internalisation of environmental externalities, strengthening of

incentives to support green innovation and technologies, etc.), but most countries underscore that core elements are: production of renewable energy, improvements to energy and material efficiency, and attainment of a low-carbon agro-food sector.

- Both strategic objectives and targets that support green growth (i.e. quantifiable policy goals with a designated timeframe) vary substantially across countries.

- Strategic objectives highlighted by several countries include: supporting a competitive business sector (including in rural areas); using agri- and forestry raw materials to contribute to renewable energy generation; promoting an open and transparent global economy, using export opportunities.

- Specific, quantifiable and time-bound targets were mostly reported in the areas of reducing energy use, increasing the share of renewable energy in total energy use, improving energy efficiency, including that of buildings, extending the area of land under organic farming and, for a handful of countries, reducing the use of harmful pesticides.

- Most of these objectives and targets appear to be driven by international agreements or − for EU members − by EU requirements, particularly those pertaining to environmental policy and those already included in agricultural and rural development policy. More specifically, a majority of EU members report not only objectives for increasing energy efficiency, but also targets for absolute reductions in energy use, both of which are driven by EU energy policy.

- A wide range of instruments and a variety of "policy mixes" are applied across OECD countries. Policy instruments supporting green growth relate not only to traditional regulatory or "command and control" approaches, but to a much wider array of tools − such as economic, informational, co-operation and educational instruments. Caution is needed in making broad generalisations about the preferred approaches, as priorities and time paths vary across countries.

- The most common policies highlighted by countries include regulation, promotion of low-emission technologies, promotion of renewable energies, and improvement of energy efficiency. Also mentioned were support for the development of eco-industry and markets for green business, and eco-labelling.

- Very few countries have exploited the potential for green economy measures to create employment.

- There is a broad consensus that meeting the challenge of "sustainable intensification" – the "double Green Revolution" − will not be possible without considerable investment in agricultural research and development. The application of existing and new knowledge on the farms and in the food sectors can improve yield, sustainability and resource-use efficiency. Ongoing long-term investment in innovation and R&D is essential in order to improve productivity, reduce environmental impacts and increase competitiveness.

- Most OECD countries have directed greater attention towards improving their knowledge-bases relating to environmental issues in agriculture over the past two decades, through increased spending on agri-environmental research, often undertaken through public-private partnerships. The rise of the knowledge economy has been accompanied, *inter alia*, by the increased economic importance of the property rights attached to the production and commercialisation of new ideas.

- Some countries cited putting a price on pollution through economic policy instruments, such as emissions trading schemes, as one of the most effective ways of promoting a green growth.

- Although OECD countries have made a concerted effort to reduce the most environmentally harmful types of agricultural supports – those based on prices and output levels – such support still constitutes half of the total support accorded to agricultural producers. The potentially most environmentally harmful fell from 74% of the total support in 1995-97 to 50% in 2009-11, while the share of the potentially most environmentally beneficial support has risen from 5% to 8% of total support over the same period.

- A great variety of institutional settings and organisational arrangements are involved in the development and implementation of policies that support green growth. Typically, four types of ministries are involved — those addressing environment, energy, economy and agriculture. A few countries have established mechanisms to co-ordinate work, or "specialised agencies" or international research consortia to support policy development (e.g. Global Research Alliance on agricultural greenhouse gases). The involvement of regional and local-level administrations in policy making seems to be limited.

➢ *Monitoring progress*

- Four OECD countries (the Czech Republic, Korea, the Netherlands and the Slovak Republic) have applied the OECD framework for measuring progress towards green growth. Although the application of the OECD framework is largely consistent, the emphasis on agriculture and the selection of agricultural-related indicators differ.

I. INTRODUCTION

2. Green growth has been identified as an alternative global growth trajectory, and in many countries all economic sectors are being scrutinised for the extent to which they offer growth potential that is environmentally benign and socially beneficial (OECD, 2011a, 2011b; EC 2011a, 2011b; Hallegatte *et al.*, 2012). Green growth policies have emerged as a central element in the policy discourse relating to the recovery from the financial and economic crisis, reflecting the idea that environmental goals can be attained while stimulating a viable and competitive economy.

3. The need for green growth arises because a "business as usual" path does not fully account for environmental limits and social concerns. Green growth focuses on the interface between the environment and the economy, and new sources of economic growth that are consistent with resilient ecosystems. The OECD's Green Growth Strategy defines an economic development path that is consistent with long-run environmental protection, using natural resources within their carrying capacity, while providing acceptable living standards and poverty reduction in all countries.

4. Green growth aims at combining a cleaner economy with a stronger economy. It means fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which the well-being of societies relies. Thus, a green growth strategy would yield a "double dividend" effect – higher growth with lower environmental impact – by improving the efficiency of resource use and increasing investments in natural capital to drive economic growth. [1] In that context, several sources of green growth can be distinguished (**Box 1.1**).

5. Responding partly to the global economic downturn and partly in recognition of the increasingly apparent biophysical limits to growth, including energy costs, the green growth agenda represents a renewed focus on the fundamental drivers of growth, including the re-examination of the use of factors of production, environmental innovation, and the removal of policy distortions. In contrast to the previous environment-development rhetoric embodied, for example, in the "environmental Kuznets curve"[2] message of grow first and make environmental investments later, the green growth analytical framework suggests that going green can notably be compatible with growth, but also can be a source of growth (OECD, 2011a).

6. Essentially, green growth has two implications: the requirement that existing resources are used as productively as possible but without impairing their future productive potential or provoking further environmental degradation, and preferably in ways that are consistent with reducing existing negative environmental impacts. Green growth also requires that there should be, over time, a sustained increase in the productive potential of existing resources and where possible an expansion in the total resources available for satisfying human wants.

1. The double dividend effect does not apply a *priori* to all sectors and the effects depend on the nature of substitution between human capital and technology, and the stock of natural resources. For a discussion of the so-called "double dividend" or Porter Hypothesis see Xepapadeas and de Zeeuw (1999).

2. See, for example, Stern (2004).

7. Green growth implies policies that either incrementally reduce resource use per unit of value added (*relative decoupling*) or keep resource use and environmental impacts stable or declining while the economy is growing overall (*absolute decoupling*). Green growth has recently become an overarching policy objective in several countries.

Box 1.1. Sources of green growth

Green growth has the potential to address economic and environmental challenges and open up new sources of growth through the following channels:

- **Productivity.** Incentives for greater efficiency in the use of resources and natural assets: enhancing productivity, reducing waste and energy consumption and making resources available to highest value use.
- **Innovation.** Opportunities for innovation, spurred by policies and framework conditions that allow for new ways of addressing environmental problems.
- **New markets.** Creation of new markets by stimulating demand for green technologies, goods, and services; creating potential for new job opportunities.
- **Confidence.** Boosting investor confidence through greater predictability and stability around how governments are going to deal with major environmental issues.
- **Stability.** More balanced macroeconomic conditions, reduced resource price volatility and supporting fiscal consolidation through, for instance, reviewing the composition and efficiency of public spending and increasing revenues through the pricing of pollution.

It can also reduce risks of negative shocks to growth from:

- **Resource bottlenecks** which make investment more costly, such as the need for capital-intensive infrastructure when water supplies become scarce or their quality decreases (*e.g.* desalinisation equipment). In this regard, the loss of natural capital can exceed the gains generated by economic activity, undermining the ability to sustain future growth.
- **Imbalances** in natural systems also raise the risk of more profound, abrupt, highly damaging, and potentially irreversible, effects – as has happened to some fish stocks and as could happen with damage to biodiversity under unabated climate change. Attempts to identify potential thresholds suggest that in some cases – climate change, global nitrogen cycles and biodiversity loss – these have already been exceeded.

Source: OECD (2011*a*).

8. More specific to agriculture, an OECD report (OECD, 2011c) summarises similar elements of sector-specific green growth in terms of:

- Increased resource use efficiency − increasing production relative to inputs used.
- Well-functioning markets and provision of the right pricing signals.
- Establishment of well-functioning property rights.

9. The agricultural sector faces challenges in adapting to an economic environment oriented towards green growth. With projected demand expected to grow strongly, agriculture has to continue to increase productivity, economise on the use of increasingly scarce resources and adapt to climate change. At the same time, it needs to be able to contribute to improving environmental quality.

10. A green-growth strategy for the food and agriculture sector aims to ensure that enough food is provided, efficiently and sustainably, for growing population. This means increasing production, while managing efficiently scare natural resources, such as water; reducing the carbon intensity and adverse environmental impacts throughout the food chain; enhancing the provision of environmental services, such as carbon sequestration, flood and drought control; and conserving biodiversity (OECD, 2011c).

11. Governments have at their disposal a wide range of instruments for achieving green growth in agriculture (**Table 1.1**). In general, no one instrument or type of instrument can be singled out as more appropriate or efficient. The optimal mix of policy instrument depends on the objective to be achieved, and the environmental, economic, social and political context in which the instrument will operate.

12. Appropriate policies for moving agriculture closer to meeting the conditions for green growth need careful design and continuous monitoring. Policies across and within the different pillars of green growth can be either mutually enhancing (synergetic) or conflicting (trade-offs). For example, energy subsidies aimed at raising the adoption of irrigated agriculture and policies to increase charges for water use, with the aim of preventing aquifer depletion, work against each other in terms of producer incentives and result in neither policy objective being achieved. This complexity underlines the importance of policy coherence.

Table 1.1. Green growth toolkit for food and agriculture

	Green growth policies
Environmental regulations and standards	Enact and enforce controls on excessive use of agrochemicals and fertilisers in production Strengthen rules and standards for water, soil quality, and land management Improve enforcement of environmental regulations and standards and certification from the farm-gate to the retail sector
Support measures	Decouple farm support from commodity production levels and prices Remunerate provision of environmental public goods (such as biodiversity, carbon sequestration, and flood and drought control) beyond reference level and closely targeted to environmental outcomes[3] Target environmental outcomes where feasible, otherwise target production practices favourable to the environment Target public investments in green technologies
Economic instruments	Price inputs to reflect scarcity value of natural resources Impose charges/taxes on use of environmentally-damaging inputs Implement trading schemes for water rights and carbon emissions Address policy constraints (governance, etc.) in less developed economies
Trade measures	Lower tariff and non-tariff barriers on food and agriculture products bearing in mind the potential impact on environmental concerns such as biodiversity and sustainable resource use. Eliminate export subsidies and restrictions on agricultural products Support, well-functioning input and output markets
Research and development	Increase public research on sustainable food and agricultural systems Promote private agricultural R&D through grants and tax credits Undertake public/private partnerships for green agricultural research
Development assistance	Allocate more development aid for environmentally sustainable initiatives, in food and agriculture Raise profile of agriculture in Poverty Reduction Strategies Allocate more funding for agriculture in Aid for Trade projects
Information, education, training and advice	Increase public awareness for more sustainable patterns of consumption such as via eco-labelling and certification Incorporate sustainable approaches in training, education and advice programmes throughout the entire food chain

Source: OECD (2011c).

3. Reference levels define the minimum level of environmental quality that farmers are obliged to provide at their own expense and differ from country to country depending on property rights and legal systems (OECD 2010).

13. The objective of this report is to provide a ***synthesis*** of the various policy instruments used by OECD governments to achieve green growth objectives in agriculture, based primarily on material provided by governments in response to the following questions:

- *Is there a consensus among policy makers in your country on a strategy to develop and implement policies and encourage private initiatives on "Green Growth" (or similar term, such as "the Green Economy") for the agro-food sector?*
- *What are the principal green growth-type policies applied to the agro-food sector that are currently in place in your country (such as government expenditures on green infrastructure, incentives for private investment in green agro-food sectors, targeted subsidy reform, pricing of pollution and natural resources, public procurement, education and training, environmental footprint labelling and traceability of foods)?*
- *To what extent have these policies been implemented as part of a specific green growth (or similar) strategy with the establishment of policy targets and monitoring mechanisms (such as for improved resource-use efficiency, reduction in greenhouse gas emissions, job creation, share of renewable energy in total energy)?*

14. The report is structured as follows: Chapter II discusses the overall approach that countries are taking towards establishing a green growth strategy in agriculture, including strategic objectives (i.e. broad strategic policy goals that are neither quantifiable nor have a specific time-limit) and targets (i.e. quantifiable policy goals with a designated timeframe). It also discusses the implementation of the OECD framework for monitoring progress towards green growth in agriculture.

15. Chapters III and IV discuss the various policy instruments used. These instruments have been grouped along the lines of the framework used in the OECD report *A Green Growth Strategy for Food and Agriculture* OECD (2011b). It should be noted that various policy instruments often form part of a policy package and contribute to more than one aspect of green growth and they could therefore simultaneously be classified under different categories.

16. Chapter V offers some tentative conclusions that emerge from this discussion.

17. Finally, the Annex [COM/TAD/CA/ENV/EPOC(2032)ANN/FINAL] presents a compilation of country experiences of policies and initiatives designed to achieve green growth in agriculture.

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II. GREEN GROWTH STRATEGIES IN AGRICULTURE IN OECD COUNTRIES

2.1 Overall approach

18. Most OECD countries have some policies in place that relate to the concept of green growth, although the degree of ambition shows considerable variation (Table 2.1). Overarching green growth strategies in agriculture have been developed and implemented by only two OECD countries: ***Denmark*** and ***Korea***.

19. Launched in 2009, ***Denmark's*** *Green Growth Strategy* was designed to establish a green growth economy in which the agro-food sector can improve its innovative and competitive potential. The stated purpose of the Strategy is to bring about a modern and competitive agro-food sector that is compatible with a high level of environmental, nature and climate protection. Its central aspect is that it promotes coherence between the environment and production methods through technological innovation and revision of agricultural legislation. The Strategy, prepared with the collaboration of sectoral ministries and public agencies, and with expert input from working groups, is an ambitious and long-term plan for defining environment and nature policies and the conditions of growth for the agriculture sector until 2020. A total of DKK 13.5 billion (EUR 1.8 billion), to be financed in part by the EU Rural Development Programme 2007-14, is to be invested in green growth activities until 2015 − an increase of around 50% in investments compared to previous initiatives.

20. ***Korea*** is at the forefront of green growth initiatives. In 2008, the *Low Carbon, Green Growth Strategy* was launched, as part of a new national development paradigm adopted in response to the challenges posed by the country's excessive energy-dependency on imported fossil fuel and the doubling of its GHG emissions over the past 15 years.[4] The main emphasis of the green growth strategy is on energy efficiency. The role of technological progress and innovations as a source of new growth momentum is highlighted. The Strategy is targeted at increasing the adoption of green technology in order to reduce carbon emissions, and also aims at strengthening Korea's international competitiveness by greening existing industries and establishing new businesses as an engine for economic growth.

21. In the agricultural sector, the *Low Carbon, Green Growth Strategy* emphasises the following areas: i) improvement in the efficient use of resources; ii) reduction of GHG emissions; iii) creation of green jobs; and iv) increasing the use of renewable energy in total energy. Examples of green growth policies in the agricultural sector include: public expenditure on green infrastructure (e.g. the supply and national diffusion of green technology/equipment, and the creation of low-carbon green villages); incentives for private investment in greening agro-food sectors (e.g. green technology certification systems, adoption of renewable energies using geothermal heating system and biogas generation from livestock manure); GHG trading systems (as from 2015); green education programmes for farmers; carbon labelling systems (beginning in 2013); and a traceability system for agricultural products. It is estimated that implementation of green growth policies in the agro-food sector would reduce GHG emissions by 10%, and create 420 000 green jobs over three years (Kim et al., 2011).

4. Korea is one of the highest per capita energy-consuming countries in the world and imports 97% of its gross energy consumption.

22. An evaluation of the green growth policies for the agricultural sector was undertaken by the research project "Development of Strategies for Promoting Green Growth in Agriculture and Rural Districts", conducted over 2010-11 under the auspices of the Korea Council of Economic & Social Research Institutes (Kim et al., 2011). The report shows that, although green growth measures have been correctly formulated, the development of policy programmes capable of producing tangible results and success in achieving the widespread uptake of green technologies appears to be insufficient. With regard to policy tasks for green growth in rural districts, the study recommends appropriate policy objectives and targets for green growth in the agricultural sector, which take into account local conditions.

Table 2.1. Examples of green growth policies in agriculture in the OECD area

Country	Policy
Australia	Caring for our Country
	Carbon Farming Initiative
	National Enabling Technologies Strategy
Austria	The Resource Efficiency Action Plan
Belgium	Marshall Plan 2 - Green
Canada	Growing Forward Policy Frameworks
Denmark	Green Growth Startegy
European Union	Resource Efficiency Initiative
	European Innovation Partnership on Agricultural Productivity and Sustainability
France	Energy Performance Plan for Farms
	Grenelle de l'Environnement and the ECOPHYTO plan on pesticides
	Agro-ecological project
Ireland	Food Harvest 2020
	Origin Green Programme
Japan	Strategy for the Re-birth of Japan
	Biomass Industrialisation Strategy
Korea	Low-Carbon Green Growth Strategy
Mexico	Sustainability of Natural Resources Programme
New Zealand	Primary Growth Partnership
	Emissions Trading Scheme
	Pastoral Greenhouse Gas Research Consortium
Netherlands	Green Deals
	The Dutch Enterprise Policy : Top-sector Approach
Switzerland	Action Plan on the Green Economy
United Kigdom	The Green Food Project
	Advice and Incentives for Farmers Project
United States	Renewable energy policies related to agriculture (e.g. programmes to support production of second and third generation biofuels)
	Sustainable Agriculture Research and Education Program

23. In ***Australia***, there are numerous policies that could be labelled "green growth", although policies to encourage "green initiatives" do not single out farmers, but target landholders generally. Funding for such initiatives is primarily provided through the *Caring for our Country* scheme in accordance with the objectives set down by its business plans. A range of different funding mechanisms are used, complementing those established under the *Landcare* scheme. The "growth" aspect of this is perhaps that landholders (and not solely farmers) can access a separate revenue stream that is closely targeted towards

positive environmental outcomes. In the area of R&D, policy instruments used to support green growth in agriculture aim to: increase public research on sustainable food and agricultural systems; promote private agricultural R&D through grants and tax credits; and undertake public-private partnerships for green agricultural research. In particular a unique form of collaboration exists between the Australian government and industry through Research and Development Corporations, which work to increase resource use efficiency and productivity in the agricultural sector.

24. In ***Belgium*** there is no specific "green growth" policy, either for the economy as a whole or for the agro-food sector, but the greening of the agro-food sector is part of the overall approach to sustainable development. In the *Flemish* region, the Government is committed to a policy aimed at the application of sustainable business processes in the Flemish economy, including a sustainable consumption pattern of agricultural and fisheries production. In the *Walloon* region, one of the six priority areas of the *Priority Action Plan for the Future of Wallonia* is on competitiveness clusters and business networks, including agribusiness. In the *Brussels* region, there is an overall policy to create green jobs and to boost the green economy in the Brussels Capital Region (*Green Jobs Pact*). The first economic sector to be focused on was the construction sector, while the agro-food sector was addressed in the second half of 2012, with the main objectives being: the creation of new, sustainable, green jobs and stimulation of the demand for sustainable food. Given the situation of the region (almost no production, but large food consumption), the demand-side constitutes an essential lever for transition to the green economy. The strategy focuses primarily on the area of "collective" consumption (e.g. school canteens and restaurants).

25. In ***Canada***, while Agriculture and Agri-Food Canada (AAFC) has no explicit department-wide "green growth" policies, it is committed to policies that support environmental sustainability actions in a manner that encourages innovation and productivity growth, increases economic returns and shares knowledge among sector participants. Emphasis is placed on improving input use efficiency, reducing environmental impacts and increasing outputs through genetic improvements. Continued investments in R&D and technology transfer are key policy activities.

26. The vision of the current policy framework Growing Forward (GF), which was developed jointly by federal and provincial/territorial governments, is for a profitable, innovative, competitive, market-oriented agriculture and agri-food industry. GF came into force in 2008 and is expired on 31 March 2013. The next policy framework focuses on two broad outcomes: competitiveness in domestic and international markets, and adaptability and sustainability of the sector. These outcomes are supported by policies that include innovation,, market development and adaptation activities, many of which support environmental knowledge and improvements, and include environmental outcomes. AAFC also has a Departmental Sustainable Development Strategy (DSDS), which commits AAFC to supporting an economically, socially and environmentally sustainable agriculture, agri-food and agri-based products sector that ensures proper management of available natural resources and adaptability to changing environmental conditions.

27. No official document dealing with green growth policies in the ***Czech Republic*** has, as yet, been published, but the Ministry of Agriculture is currently preparing a *Strategy of Agriculture* and the Rural Development Programme for the period 2014-20. The latter places emphasis on: renewable resources (i.e. solar, biogas, etc.); farming, under both organic and integrated regimes; special targeted farming on high-nature value (HNV) biotopes; and land consolidation (decide land ownership and enable the development of measures to protect natural resources).

28. In ***Estonia*** there is no specific green growth strategy for the agricultural sector. The country's interest in green growth is mainly reflected through various government programmes concerning either renewable energies or bio-economy.

29. In the ***European Union*** (EU), while the key EU strategy of "Europe 2020" does not formally include the term "green growth strategy", it does share many of the features of a green growth strategy, and seeks "green" outcomes, citing "green growth" as an object of attention. A number of green growth-related initiatives have been undertaken in order to address, *inter alia*, issues, such as resource efficiency (including resources, such as energy, raw materials, food, water, biodiversity and land), sustainable use of natural resources, low carbon economy, building resilience to climate change, and sustainable consumption and production patterns. The two main initiatives are: mainstreaming resource efficiency into EU legislation; and the European Innovation Partnership *Agricultural Productivity and Sustainability*. The "CAP towards 2020 Communication" COM(2010)672, of 18 November 2010, also deals with the application of the "smart, sustainable and inclusive growth" of the "Europe 2020" strategy for agriculture and acknowledges that "green growth in the agricultural sector and the rural economy is a way to enhance well being by pursuing economic growth while preventing environmental degradation". The linkages between the CAP and the "Resource Efficiency" flagship of the Europe 2020 strategy indicate that a "green growth" type approach to the challenges of the future has been recognised in the EU policy process.

30. In ***France***, while many policies incorporate the objectives of "green growth", this concept is only used by a few French public actors, who instead prefer sustainable development. This mainly reflects the fact that long-term decisions on environment and sustainable development need to be made because of the consensus reached in 2007 on the occasion of the *Grenelle de l'Environnement* − a discussion based on multiparty co-operation among public authorities and different stakeholders and actors in the society. Five groups are represented: the state, local communities, NGOs, employers and employees. A debate was organised through six working groups, each containing 40 members. Each group then worked in "workshops", and summaries and reports were made available to the public. Following this, local meetings in the regions and public consultation on Internet took place. Finally, a general report was unveiled at the "round table" of the *Grenelle*, held on 24 and 25 October 2007. The 2009 *Loi Grenelle* legislation includes several policies relevant to green growth in agriculture, such as organic agriculture and the reduction in the use of pesticides. In 2012, targets for the Ecology and Energy Transition (*Transition Environnementale et Energétique*) were adopted during the Environmental Conference. In line with this, the Agro-ecological project for France (*Projet Agro-Ecologique pour la France*) was launched in December 2012. It aims to reconcile economic and environmental performances by deeply reorienting public incentives and legislation, research, training and council in the field of agronomy and agriculture.

31. In ***Greece***, the EU Rural Development Programme of Greece 2007-13 is the main vehicle which encourages the promotion of green growth in the agricultural sector. The most relevant measures in this area include: support to promote the use of renewable energy; support to increase the value-added of agricultural products (e.g. processing); support to promote environmentally-friendly production practices (e.g. organic agriculture, stock-farming extensification, rotation of fields previously used to grow tobacco with non-irrigated crops); and agri-environmental actions to protect water resources (e.g. protection of areas vulnerable to nitrates, and the adoption of integrated management systems in tobacco and sugar beet production).

32. Green growth in agriculture in ***Japan*** is primarily reflected through the following government initiatives: i) the *New Growth Strategy* of 2010 which aims to ensure the sustainability of the environment and the economy; ii) *The Strategy for the Rebirth of Japan* of 2011, to aid the recovery from the Great East Japan Earthquake, utilising rural area resources for producing energy;[5] and iii) "promotion of the greening

5. Strategy for the Rebirth of Japan (English) http://www.npu.go.jp/policy/pdf/20120127/20120127_en1.pdf

economy and society, and green innovation" has also been addressed recently in the 4th Basic Environment Plan (Cabinet decision, 27 April 2012)[6], which is the principal Japanese environmental policy.

33. ***Hungary*** does not have a specific green growth strategy. The country's commitment to the green growth of the agro-food sector is primarily reflected through: i) the EU's Rural Development programme of Hungary 2007-13 (i.e. building a more competitive low-carbon economy; protecting the environment and preventing biodiversity loss; developing new green technologies; introducing efficient smart electricity grids; harnessing EU-scale business networks; improving the business environment, particularly for SMEs; and helping consumers to make well-informed choices); ii) the *National Environmental Technology Innovation Strategy* (NETIS), in force between 2011-20, which puts emphasis on the aspect of innovation in environmental green growth technologies; iii) the *National Rural Strategy*, adopted in 2012, following a broad social debate, and which will remain in effect until 2020; and iii) the Ignác Darányi Plan, a programme set up within the framework of the National Rural Strategy, which covers every area of agriculture and rural development.

34. In ***Ireland***, the 2012 Government Policy Statement on Growth and Employment in the Green Economy affirms the Government's commitment to developing the green economy www.djei.ie/publications/enterprise/.../Delivering_Our_Green_Potential.pdf). The Statement identifies the opportunities in the Green Economy for sustainable economic growth and job creation, sets out how the Government is supporting the green economy and outlines new implementation structures to oversee the development of the sector. It also reaffirms the interdependencies that exist between the green economy and the Government's Sustainable Development Framework.

35. For agriculture, *Food Harvest 2020* provides the strategic vision for the development of the agri-food, fisheries and forestry sector for the period up to 2020. The strategy envisages a sector that can reap considerable rewards if it works and acts "smartly" so as to make the most productive use of the country's rich natural "green" resources in a way that is both economically viable and sustainable in the future. Research, development and innovation have a central role to play in the growth of the sector. Examples of elements of the strategy include: the *Agricultural Catchments Programme* (ACP) and the *Dairy Efficiency Programme & Beef Technology Adoption Programme*.' Another initiative is the *Origin Green* programme − a voluntary sustainability programme launched by Bord Bia (the Irish Food Board) in 2012 on behalf of the Irish food and drinks industry. Participating organisations are asked to demonstrate their commitment to operating sustainably by focusing on a number of key areas including: greenhouse gas emissions, water management, energy conservation, waste management and recycling, animal welfare and biodiversity.

36. In ***Mexico***, the main policy instrument to promote green growth in the agri-food sector is the *Programme for the Sustainability of Natural Resources*, which was implemented by the Mexican Ministry of Agriculture (SAGARPA) during the 2012 fiscal year. SAGARPA's policies are also part of a general framework whose cornerstone is the *National Strategy for Climate Change*, which was introduced in 2007. The Special Program for Climate Change (SPCC) 2009-12 is the main legal instrument outlining Mexican strategy, actions, and goals to meet the challenges of climate change. It contains the main mitigation and adaptation actions, including those applying to the agricultural sector.

37. In the ***Netherlands***, there is no specific programme to promote green growth at the national level, and the terms "green growth strategy" or "green economy" are not used in national policy documents. However, there is a wide variety of policy programmes which address issues related to green growth. Most of the examples of policies associated with green growth relate to already existing policies under the

6. The Fourth Basic Environment Plan (English Summary): http://www.env.go.jp/policy/kihon_keikaku/plan/plan_4/attach/pamph_en-1.pdf; http://www.env.go.jp/policy/kihon_keikaku/plan/plan_4/attach/pamph_en-2.pdf

heading of sustainable development. Long-term multi-year agreements and partnerships of government with the private sector, citizens and civil society are the main policy approaches used to encourage innovation and to improve sustainable productivity in the agro-food sector, including the horticulture sector. Much emphasis is placed on energy efficiency, renewable energy use and production and reduction of GHGs.

38. In ***New Zealand***, there is no formal document that outlines a strategy to apply to "green growth" as such, but there are a number of relevant policy developments. In January 2011 the government appointed a Green Growth Advisory Group (GGAG) to evaluate and advise on opportunities for green growth to contribute to an increased rate of economic growth for New Zealand. The GGAG reported to government in December 2011. The government is responding to many aspects of the GGAG's recommendations through its Business Growth Agenda (BGA). The BGA focuses on six key "ingredients" businesses need to grow: export markets, innovation, infrastructure, skilled and safe workplaces, natural resources, and capital. Each of these has its own programme of work. "Greening Growth" is specifically presented as a cross-cutting theme spanning the BGA. Furthermore, additional actions in the natural resources, innovation and export markets reports have implications for greening growth.

39. Green growth in the agricultural sector in ***Norway*** is primarily reflected through the country's sustainability goals for agriculture, with the current agricultural policy, with border control measures, agricultural support and targeted environmental measures being considered essential. Research to improve agricultural productivity is also important.

40. The ***Slovak Republic*** does not currently have a dedicated strategy or action plan on green growth or on improving resource efficiency for the agro-food sector, but these issues are addressed primarily through: i) the national targets for the *Strategy Europe 2020*; the *Biomass Action Plan* 2008–13. The *Biomass Action Plan for 2008–13* also includes targets for biomass energy utilisation in the Slovak Republic.

41. ***Sweden*** has not drawn up a specific national green economy strategy. Instead, work on the transition to a green, sustainable economy is reflected, for example, through legislative proposals in a number of different areas, such as transport/infrastructure, energy, forestry and agriculture, climate, and the national environmental objectives. An inter-ministerial working group exists to discuss and provide input on issues concerning the green economy.

42. Agricultural policy in ***Switzerland*** comprises many of the elements of a green growth policy for food and agriculture, although in official domestic policy documents its elements are not explicitly labelled as policies contributing to "green growth" or a "green economy". The Government's *Action Plan on the Green Economy* at national level, which was adopted by the Swiss Federal Council in March 2013, entails 27 measures (including food waste reduction) and mandated the Federal Department of the Environment, Transport, Energy and Communications to prepare a parliamentary amendment of the Environmental Protection Act (EPA). The salient points of the planned revision of the EPA include, *inter alia,* the following: definition of targets for the efficient use of natural resources; the measurement of resource use; provision of information and raising of public awareness; improvement of the resource efficiency of consumption and production; enforcing the recycling management (e.g. recovery of phosphorous out of sewage sludge for agricultural use); and strengthening of Switzerland's international commitment to the green economy.

43. In ***Turkey***, the *National Climate Change Action Plan* (NCCAP) (2010-20), published in July 2011, is the main policy framework to promote green growth. The NCCAP includes strategic objectives and goals on GHG emission control and adaptation to climate change over 2011-23. The overall aim of the NCCAP is to address climate change by identifying national actions for limiting GHG emissions

and building resilience through managing impacts, thereby encouraging mitigation and adaptation to climate change in Turkey. The NCCAP addresses measures in priority sectors (energy, industry, waste, buildings, forestry, transportation and agriculture), specifically focusing on long term co-operation, technology development and transfer, and national and international financing mechanisms.

44. In the ***United Kingdom***, green growth is mainly reflected in the *Natural Environment White Paper* (NEWP) presented in 2011 (the first White Paper on the natural environment in 20 years), which outlines the Government's vision for the natural environment over the next 50 years. Sustainability is a key objective for economic growth for the UK (*e.g.* GHG reduction targets; carbon budgets; and waste and recycling targets). The NEWP covers the following areas: climate change, biodiversity, water, air quality and soils. Two specific projects of the NEWP relate to agriculture: i) the *Green Food Project*; and ii) *Advice and Incentives for Farmers*.

45. The ***United States*** does not have a specific green growth strategy for agriculture, but it does have policies which aim to increase productivity in a sustainable way, including programmes to support production of second and third generation biofuels.

2.2 Strategic objectives and targets

46. The majority of countries appear to have strategic objectives covering a wide range of subjects related to green growth. Most of the reported strategic objectives are fairly general in nature and tend to express guiding principles rather than require any concrete commitments. Typical examples of these areas include ensuring sustainable agriculture; climate change; resource conservation; ensuring energy security; and reducing energy use; promoting sustainable consumption and production in the food chain; reducing fossil fuels; promoting green public procurement; and waste and recycling (**Box 2.1**).

Box 2.1. Selected examples of strategic objectives related to green growth in agriculture

Denmark

- Become independent of fossil fuels by 2050.
- Make significant increase in its resource efficiency.

European Union

- Reverse the recent trend of diminishing productivity gains by 2020.
- Secure soil functionality in Europe at a satisfactory level by 2020.

Finland

- Create a thriving bio-economy, generating high value-added.

France

- Adopt a new model of sustainable development that respects the environment, combined with lower consumption of energy, water and other natural resources.

Germany

- Achieve an important increase in its energy-related use of biomass.

Ireland

- Encourage efficient and environmentally sustainable production in the agro-food sector; boost the green credentials of agro-food firms

Korea

- Reduce its heavy dependence on imported energy and decrease production of GHG emissions.

The Netherlands

- Meet the need for food and shelter for 9 billion people globally by 2050, while at the same time reducing the environmental impact of food production throughout the whole food chain.

Slovakia

- Encourage utilisation of biomass energy.

Slovenia

- Encourage utilisation of biomass energy.

Sweden

- Recover food waste using biological treatment.

Switzerland

- Reduce the consumption of resources to environmentally sustainable levels (Cleantech Masterplan).
- Improve consumer awareness, by providing information on goods that indicates the effects of their production on the environment.

Turkey

- Reduction of GHG emissions and building of resilience by encouraging mitigation and adaptation to climate change

United Kingdom

- Improve the production and productivity of the agro-food sector, while at the same time increasing the environmental performance of the whole supply chain.
- Reduce food waste.

47. The most commonly mentioned strategic objectives refer to energy (increasing the share of renewable energy; improving energy efficiency; reducing energy use) and to GHG emissions. In these two areas, several countries report absolute reductions in energy use and GHG emissions. It is worth noting that these objectives are driven primarily by international agreements (e.g. the Kyoto protocol), or regional-wide strategic goals (e.g. EU energy policy).

48. Although water scarcity is a priority issue for many countries, surprisingly only a couple of countries reported targets for improving their efficiency of water use (**Box 2.2**).

Box 2.2. Selected examples of targets related to green growth in agriculture

Material use

- France: In animal husbandry, reduce dependence on imported raw materials used for making animal feed.
- Ireland: Achieve 75% of food and drink exports from members of the Green Origin Scheme by 2014.
- Switzerland: Reduce the consumption of fossil fuel oil by 20% by 2029.

Energy use and energy efficiency

- France: Achieve a minimum of 30% low-energy farms by 2013.
- Netherlands: By 2020, reduce CO_2 emissions by at least 3.5Mt; produce 200 PJ per year of renewable energy from biomass; and produce about 12 PJ from wind energy on land (the Agro Covenant).

Renewable energy

- Denmark: Increase use of animal manure for green energy to 50% of total by 2020.

- Korea: Increase supply of bio-energy from 66% in 2007 to 88% of total in 2013.
- Slovakia**:** Achieve a 5.75% share of biofuels on total energy consumption of fuels in 2010, and a 10% share in 2020.

Organic farming and certification

- Austria**:** Achieve a 20% increase in the share of organically farmed areas in the total agricultural area by 2010.
- Denmark: Double the area under organic farming by 2020.
- France: Have 6% of the total agricultural area under organic farming by 2012, and 20% by 2020.
- France**:** Have 50% of farms applying for environmental certification.

GHG emissions

- Denmark: Reduce agricultural GHG emissions by 800 000 tonnes in 2015 and achieve a further reduction in 2020.

Waste

- Japan**:** Recycle more than 80% of biomass waste (which includes livestock manure) and utilise more than 25% of unused biomass by 2010.
- Sweden: Recover at least 60% of phosphorus compounds present in wastewater for use on productive land by 2015. At least half of this amount is to be returned to arable land.

Water (pollution and efficiency)

- Canada: The target of a value between 81-100 on each of the Water and Soil Quality Agri-environmental Performance Indices to be achieved by 31 March 2030 is set for the water quality objective of the Federal Sustainable Development Strategy.
- Denmark**:** Reduce the release of nitrogen from agriculture by 19 000 tonnes by 2015, and reduce it further by 2020; reduce the release of phosphorus from agriculture by 210 000 tonnes by 2015; reduce the release of ammonia.
- Portugal: Attain, over ten years: 80% efficiency in water consumption in the urban sector; 65% of efficiency in agriculture; and 85% efficiency in the industrial sector.

Pesticides

- Denmark: Reduce the impact from pesticides from 2.1 to 1.4 by the end of 2013, corresponding to a frequency in use of pesticides of 1.7.
- France: Reduce consumption of pesticides by 50% within 10 years.

Green public procurement

- Denmark**:** Commit to the 50% target for green public procurement in 2010, covering 10 product groups.
- Finland: Organic, vegetable-based or seasonal food to be available in government kitchens and also provided by food services at least twice a week by 2015.
- France: By the end of 2012, reach the target of 20% of products used in hospitals, schools, canteens, etc. being of organic origin.
- The Netherlands: Achieve sustainable public procurement for: cocoa (100% in 2025); timber (50% in 2011); and soy palm oil (100% in 2015).

49. It is of interest that some countries have objectives relating to promoting sustainable production and consumption, which indicates that such countries consider green growth to be a holistic challenge encompassing the whole agro-food chain − and not just the primary sector. Only a very few countries have

reported strategic objectives aimed at creating more green jobs in the agricultural sector, although several mentioned the promotion of eco-efficient technologies as a strategic objective.

50. Regarding consumption areas associated with high environmental impacts, several countries reported having objectives or targets specifically in the fields of livestock buildings and greenhouses (typically for energy efficiency in buildings), transport (typically for increased use of biofuels in transport and fuel efficiency standards for tractors) and food production (typically the increasing land area under organic farming). However, in most cases objectives or targets are set for efficiency improvements in technology and production rather than addressing consumption by managing demand. Two exceptions are ***Finland*** and ***France***, which have established targets for the public sector to increase consumption of organic food (e.g. in schools and hospitals).

51. In ***Denmark***, the *Green Growth Strategy* considers organic farming to be an important driver of green growth. It is planned to increase the area used for organic production from 6% in 2007 to 15% in 2020 through a massive effort, representing an outlay of almost DKK 350 million a year.

52. In ***Korea***, the Five-Year Plan outlines government actions for implementation of the *Low Carbon, Green Growth Strategy*, and details tasks for ministries and local governing entities, as well as specific budgets. Under the Plan, the government will spend approximately 2% of annual GDP on green growth programmes and projects. Investments will initially be geared towards infrastructure systems in order to boost the economy. In line with this, Korea has passed a USD 30.7 billion stimulus package in 2008 aimed at supporting its green objectives. This includes renewable energy resources, energy-efficient buildings, expansion of railway systems and improvement to waste management systems. Over time, the government aims for Korea to become a leading exporter in green research and technology. The strategy sets the following policy targets: reduction of GHG emissions from their 2007 level (18.39 million tonnes); bioenergy supply: an increase from 66% in 2007, to 88% in 2013; environmentally friendly agricultural production: a rise from 3% in 2007 to 10% in 2013, and to 15% in 2020.

53. In ***Canada***, AAFC has set time-bound, quantitative targets for achieving environmental outcomes that reduce the risks to soil, water and biodiversity. These targets are reported in annual federal government *Reports on Plans and Priorities*, such as "Fresh Water Quality: Achieve a value between 81-100 on each of the Water Quality and Soil Quality Agri-Environmental Performance Indices by 31 March 2030 (www.tbs-sct.gc.ca/rpp/2012-2013/inst/agr/agr02-eng.asp#s2.1.1)..

54. In ***France***, implementation of the EU Rural Development Programme 2007-13 contributes to the green growth of French agriculture. For example, the *Plan de modernisation des Bâtiments d'Elevage et le Plan Végétal pour l'environnement*, that encourage and subsidise modern and environmentally friendly investments. Regarding the agro-food industries, the following programmes can be mentioned: i) the "energy and industry" chapter from the *Plan national d'adaptation au changement climatique* (PNACC), released in July 2001, which defines the priority actions for the agro-food sector, such as the use of more efficient cooling equipment or of renewable energy; ii) the *Plans régionaux de l'agriculture durable (PRAD),* created by the law for the modernisation of agriculture and fisheries (LMAP), which set the broad regional guidelines of agricultural, agro-food and agro-industrial policy. The PRAD offer a reflection on the vision of sustainable agriculture, combining economic efficiency and environmental performance, shared by all partners and, in particular, by the processing industry for agricultural products.

55. Nevertheless, the main current devices and programmes related to the environment are those originating from the discussions held during the *Grenelle* of the environment on sustainable agriculture: i) the *Environmental Certification of Farms*, which is a voluntary process accessible to all sectors, and builds around the themes of biodiversity, fertiliser management and management of water resources; ii) The *Plan for Energy Performance of Farms* (*La plan de performance énergétique des exploitations agricoles*),

which aims at improving the overall energy efficiency of farms. The latter is based on a broad development of the diagnosis of the energy and greenhouse gas emissions from farms. It seeks to identify potential improvements in terms of energy saving, changes in agricultural practices, and the appropriate production of renewable energy. The practices that make possible reductions of direct energy consumption (tractor settings, efficient driving, etc.) and also indirect energy consumption (e.g. changes in fertilisation methods, for feed, etc.) are encouraged. Equipment that uses less energy is promoted (especially in livestock buildings and greenhouses), as is some equipment which allows the production of renewable energy. iii) The *ECOPHYTO plan 2018 on pesticides* aims to reduce the use of pesticides by 50% by 2018 if possible, while maintaining a high level of production and preserving the quality of agricultural products. It is led by the Ministry of Agriculture, Agro-food and Forestry, together with the participation of the major actors concerned – farmers, technical institutes and researchers. iv) *The Plan Agribio 2012* which has as an objective, an increase in the share of organically farmed area in total agricultural area from 2% to 6%.

56. In ***Hungary***, the National Rural Strategy, which considers organic production as a high priority, has set the following targets: the area for organic production to be increased from 133 000 ha in 2012 to 350 000 ha in 2020 (a 163% increase).

57. In the ***Netherlands***, targets are set for various agro-food sectors in order to achieve the goals set by the EU for 2020, concerning energy efficiency and renewable energy across the whole food chain. For example, 20% of livestock farms are to be 100% reliant on electricity from sustainable sources by 2020.

2.3 Monitoring progress towards green growth in agriculture

58. Governments in several OECD countries are increasingly aware of the importance of monitoring and evaluating their agricultural policies and are devoting considerable efforts to strengthening their monitoring and evaluation approaches. For example, evaluation of the EU's rural development programmes, which also include agro-environmental programmes − is required by legislation within an established framework which also comprises quantitative indicators. Less formal approaches are used by other member countries, which also use quantitative indicators (OECD, 2009). Also, in their responses to the questionnaire, several countries pointed out that they regularly monitor environmental outcomes in compliance with established environmental targets (e.g. reduction of CO_2 emissions). In the EU, for example, as part of its Resource Efficiency Strategy, is developing indicators for monitoring progress on the path to the 2050 resource efficiency vision (ec.europa.eu/environment/resource_efficiency/news/up-to-date_news/12122012_en.htm).

59. As part of its *Green Growth Strategy*, the OECD has developed a conceptual framework and a set of indicators to help governments monitor progress towards green growth.[7] The framework draws on four interrelated-groups of indicators which capture major aspects of green growth. Particular attention is paid to efficiency and productivity issues. The focus is on the environmental performance of production and consumption, and on drivers of green growth, such as policy instruments and innovation activity.

60. The ***Netherlands*** was the first country to publish a green growth indicator report based on the OECD framework (Statistics Netherlands, 2011), followed by the ***Czech Republic***, ***Korea*** and the **Slovak Republic**[8] (Czech Statistical Office, 2011; Statistics Korea, 2012).[9] Although these three reports are

7. The measurement framework is described in detail in the 2011 Green Growth indicator report: *Towards Green Growth: Monitoring Progress: OECD Indicators.*

8. For creation of the green growth indicators follows conclusions of a national workshop on Green Growth held in 2011, the recommendations of the *OECD Environmental Performance Review: Slovak Republic* (2011), as well as the recommendations of the *OECD Economic Survey of Slovak Republic* (2012). In 2012, the working group on green growth indicators was established by the Slovak Environmental Agency and Ministry of Environment (www1.enviroportal.sk/indikatory/schema.php?schema=124).

largely consistent, there are differences when it comes to indicator selection, as indicators were selected to best reflect national circumstances and data availability. For example, indicators of the natural asset base were focused on coal and water for the ***Czech Republic***, and on natural gas and fish for the ***Netherlands***). Indicators of policy responses and economic opportunities emphasise expenditure on R&D in the ***Czech Republic*** and ***Korea,*** while in the ***Netherlands*** the issue of carbon emission trading is highlighted).

61. The emphasis on agriculture and the selection of agricultural-related indicators also differ (**Table 2.2**): the ***Czech Republic***'s report includes three agricultural-related indicators (nutrient balances, structure of land cover change; farmland birds); the ***Korean*** report, which selected and analysed 23 green growth indicators applicable to Korea, includes two agricultural-related indicators (consumption of chemical fertilisers and annual rainfall per capita); whereas the ***Dutch*** report, which studied 35 indicators, only five were related to agriculture (domestic biomass consumption, nutrient surpluses, farm bird index, land cover conversion to built-up land and nitrate concentration in groundwater).[10] For the **Slovakia Republic**, three out of the 33 indicators included individual refer to agriculture.

62. In the next phase of the work on green growth, the implement the OECD green growth measurement framework will be developed for the agricultural sector and applied to selected OECD countries.[11]

9. In **Germany** a set of green growth indicators following the OECD framework was also published by the Statistical office (in German only): *Test des OECD-indikatorensets green growth in deutschland*, https://www.destatis.de/DE/Publikationen/Thematisch/UmweltoekonomischeGesamtrechnungen/Umweltindikatoren/IndikatorensetsOECD5850015129004.pdf?__blob=publicationFile

10. The list of indicators for the Netherlands was revised in 2012 and the 35 indicators selected were based on the following criteria: relevance to the Dutch situation, coverage (all themes of green growth must be covered), interpretability, data quality; and consistency with other sets of indicators.

11. A similar exercise was performed jointly by the OECD and the International Energy Agency for the energy sector, where a set of indicators was proposed (OECD, 2012).

Table 2.2. Agricultural-related indicators used by the Czech Republic, Korea and the Netherlands

	Environmental and resource productivity	Natural resource base	Environmental quality of life	Economic opportunities and policy responses
Czech Republic	Nutrient balances: i) nitrogen ii) phosphorus	Land cover change: i) agricultural land, pastures and meadows ii) urban areas and infrastructure iii) semi-natural habitats Farmland birds		
Korea	Consumption of chemical fertilisers	Annual rainfall per capita.		
Netherlands	Energy efficiency: i) agriculture and fisheries ii) manufacturing iii) transport iv) other services Share of renewable energy in total: i) biomass ii) wind iii) other Nutrient balances: i) nitrogen ii) phosphorus	Land conversion into built-up land: i) agriculture ii) nature iii) forest iv) built-up		
Slovak Republic	Nutrient balances	i) Land use ii) Agricultural land area affected by water and wind erosion, by class of erosion.		

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IIII. POLICIES FOR IMPROVING PRODUCTIVITY AND RESOURCE EFFICIENCY IN THE CONTEXT OF GREEN GROWTH

3.1 R&D, technology and innovation

63. The capacity of the agricultural sector to produce adequate supplies of food, feed, and non-food uses in an environmentally sound manner is closely linked to the level of technological development and innovation. Production improvements have been brought about mainly through R&D in the areas of biology (e.g. crop and plant varieties, and animal breeds), mechanics (e.g. farm equipment) and management (e.g. integrated pest management). On the consumption side, the diffusion of scientific information concerning food safety, nutrition and environmental quality is important to consumers.

64. The strong growth in agricultural productivity experienced since the post-war period has been driven largely by technological advances and the rapid adoption and diffusion of new technologies. Scientific developments in agriculture brought about rapidly rising productivity growth, the development of new crop varieties, and increased yields in many countries through the "Green Revolution".[12]

65. Innovation plays a key role in fostering greening growth. One of the main messages of the OECD Green Growth Strategy is that innovation, together with market-based incentives and appropriate regulation and taxation, can accelerate the transition to greener growth and help decouple environmental degradation from economic growth. OECD analysis shows that significant innovation, such as the creation of new products, processes and technologies, as well as their diffusion and application will be required to achieve the decoupling of growth from environmental pressures in the most efficient manner.

66. Fostering greener growth through R&D and innovation has received greater attention from governments in recent years across the OECD area. For example, the ***European Union***'s Growth Strategy for 2020 and ***Korea's*** National Strategy and five-year plan for green growth, consider green innovation to be the crucial impetus to build competitive and sustainable economies.

67. Technological innovation through advances in information and communication technologies, engineering and biotechnology can improve the economic and environmental performance of farming systems and can provide an important impetus to green growth across the OECD area. New technologies realised through R&D can contribute to improving environmental performance and achieving green growth targets by replacing resource-intensive and polluting activities, or by making them more eco-efficient. They have the potential to reduce the load of known toxins in agricultural production, substitute safer alternatives, protect ground or surface waters, conserve natural habitats, reduce nutrient loads in soils, lower gaseous nitrogen loss and reduce the amount of non-renewable energy used in the cropping cycle.

68. Adopting these innovations will entail changes to current farming practices and the implementation of new technologies to enhance resource productivity and eco-efficiency. Green growth can provide a new paradigm for agricultural research, placing the emphasis simultaneously on

12. Fuglie (2010) found that raising real R&D spending by 1% per year would increase US agricultural output by 83% by 2050.

environmental and economic requirements, with the aim of enhancing productivity without compromising the natural resource capital.

69. But adopting technologies for fostering green growth farming systems involves uncertainty and tradeoffs. Technologies that can contribute to an economically efficient farm sector and provide financial viability for farmers, while at the same time improving environmental performance in a way that is acceptable to society, will provide "triple dividends" to green growth. Moreover, the aims are "moving targets" which must address new issues and changing priorities. Technological developments are rapidly evolving and information on the costs and benefits of adopting technologies in agriculture is often imperfect. Thus, the choice of technology adoption is made in a climate of uncertainty, with a large element of "trial and error" in its application, and the speed and extent of adoption varies considerably among farmers.

70. In addition, there may well be substantial challenges, both technical and social, in promoting innovation and adoption of new technologies in the food system. One particularly contentious area is the role of new technologies, including biotechnology and nanotechnology, in addressing future food needs (**Box 3.1**).

Box 3.1. Technological breakthroughs contributing to green innovation in the agro-food sector – The case of nanotechnologies

Nanotechnology, which involves the manipulation of material measuring between 1–100 nanometers in at least one dimension, is leading to the development of potentially revolutionary technologies in a variety of industries, including agriculture and food. By increasing productivity and resource use, reducing postharvest loss, improving product quality, increasing the competitiveness of agricultural producers, advances in nanotechnology may present new opportunities to foster green growth, if the multiple challenges to their use can be overcome. Investment in several OECD countries (e.g. Australia, Canada, Chile, European Union, Japan, Korea, New Zealand, Mexico, Switzerland and the United States) has been growing and a wide range of nanotechnology applications are currently being developed and commercialised, with goals ranging from improved food safety to reduced agricultural inputs, improved processing and nutrition, and enhanced packaging.

Agricultural nanotechnology applications include: sensors in many applications (bacteria in food, plant health monitoring, soil quality and pollution identification), filtration/purification for air/water applications, energy storage and photovoltaic, fibre production, soil stabilisation, slow-release nanofertilisers and encapsulated pesticides. In agriculture, nanotechnology R&D has mostly focused on improving input use and delivery, from water to nutrients, nano-pesticides and nano-herbicides. Interesting applications include the use of nanoporous zeolites to slow the release and increase the efficiency of fertilisers; nanosensors to measure soil quality; smart delivery mechanisms for herbicides. There has also been significant R&D on food and water safety, with the development of nanosilver or nanoclay products to improve water flitration, and nanosensors to detect and help track food pathogens. The most important area of development, however, has been in the field of nutritional supplements and packaging and storage.

Nanotechnology can potentially benefit the agro-food sector in several key areas, including sustainable production, plant and animal health, food processing and packaging, as well as in reducing the environmental impact of agricultural operations. For example, nanotechnology can contribute to enhancing agricultural productivity in a sustainable manner, using agricultural inputs more effectively, and reducing by-products that can harm the environment or human health. Nanotechnology-based biosensors deployed in crop fields and in plants to monitor soil conditions, growth and disease vectors, can expand the concept of precision farming in which productivity can be optimised, while providing inputs (i.e. fertiliser, pesticide, irrigation, etc.) and conditions (i.e. temperature, solar radiation) in the precise levels necessary. Similarly to nano-medicine applications, pesticides and herbicides can be formulated with nano-particles to enhance the effectiveness of active ingredients and allow targeted delivery and release, thereby requiring less dosage per application and minimising runoff of excess chemicals. Nanotechnology can help in the diagnosis, treatment and monitoring of crop and livestock diseases, and ensure timely intervention. Moreover, developments in nano-bioprocessing have the potential to convert agricultural waste into energy and other useful by-products, thereby transforming waste that can adversely impact the environment into a valuable resource.

A major challenge facing the sector is how to maintain growth and move towards commercialisation. Sustained funding can be difficult to obtain because of the length of the time required to establish the results of research, the high cost of equipment and the uncertainty of the findings. Another major challenge relates to health and environmental

risks.[13] Various issues and concerns have been raised, concerning, in particular, the lack of full understanding of the impact of nanomaterials on health and the environment, as well as the inadequacy of current regulations to cope with rapid advances in nanotechnology. In the context of green growth, these policy challenges highlight the importance of assessing the impact of nanotechnology from a life-cycle perspective that considers the full range of economic, environmental and societal implications.

Source: Gruère (2012); Gruère, Narrod and Abbot (2011).

3.1.1 The "enabling" environment for the development and uptake of green technology and innovation

71. The rationale for policy actions to foster green innovation rests on several well-known market failures and is what is usually referred to as the "double externality" problem (OECD, 2011a). The first concerns the under-investment in the production of new knowledge by the private sector due to knowledge externalities and the disincentives provided by free riding. The second argument stems from the negative externalities associated with the environment − such as climate change − and has implications for both the creation and diffusion of technologies. For example, because GHG emissions are not priced by the market, incentives to reduce them through technology development are limited. Similarly, there is less diffusion and adaptation (once green technologies are available) if market signals regarding the environmental benefits of such technologies are weak.

72. In addition, other market failures and barriers, such as institutional failures, dominant patterns in energy and transport markets − which can create entry barriers for new technologies and competitors due to, for example, the high fixed costs of developing new infrastructures − uncertainty about future success, long timescales for infrastructure replacement and development, and a lack of options for product differentiation may be unique to, or more prevalent in, markets for green innovation (UK Committee on Climate Change, 2010).

73. Unleashing green innovation will require a comprehensive strategy that considers the full spectrum of policies to create, diffuse and apply knowledge, covering both supply and demand-side policies as postulated in the OECD's 2010 Innovation Strategy and re-stated in its study on fostering innovation for green growth (OECD, 2011b). A policy environment based on core "framework conditions" – sound macroeconomic policy, competition, openness to international trade and investment, tax and financial systems – is a fundamental building block of green growth strategies and allows innovation to thrive.

74. In addition to the above overarching policy framework for green innovation, the "enabling environment" for fostering innovation for green growth in agriculture encompasses several agriculture-specific factors. R&D efforts in the sector; adequate levels of education and training among farmers; access to advice and credit (especially those that require a larger scale of operations and where the initial investment costs required are high); quicker and cheaper means of disseminating and sharing information, and pressures from the civil society are all contributing towards facilitating the adoption of farm technologies which are benign to green growth. Moreover, policies should also be conducive to non-technological innovations, including those pertaining to organisational and behavioural changes because such innovations play an important role in fostering green (OECD, 2011a).

13. Nanotechnologies could, in themselves, constitute a specific source of pollution, which may be more difficult to treat than conventional ones. A study by Zhang et al., (2012) study on nano-pesticides used in the treatment of pears found that they entered the fruits more easily than standard pesticides.

75. Farmers will invest in and implement green technologies and farm practices if they expect the investment will be profitable, if they have the appropriate skills, information and motivation, and if government policies provide appropriate incentives, or at least avoid creating dis-incentives. Where the environmental benefits from employing sustainable technologies are not expected to accrue to farmers, but to people outside agriculture, and where there are no markets for the benefits, levels of adoption could be sub-optimal from a societal perspective. Equally, where the costs of the environmental effects caused by current farming activities are paid by other sectors, farmers will have no incentive to adopt environmentally sustainable technologies.

76. Agricultural policies can also be particularly important for agricultural innovation as they can alter the prices facing farmers for their inputs and outputs, which in turn will influence their decisions on investment. Some measures may also influence farmers' choice of product and farming practices.

77. Agricultural policies are frequently giving conflicting signals which hinder the uptake of technology. For example, some agricultural policies encourage the expansion of agriculture on environmentally fragile land, leading to the overexploitation of natural resources, and make no requirement to farmers to take into account environmental spill-overs into other sectors. Moreover, many agricultural support policies get capitalised into the value of land, encouraging a greater intensity of production and influencing the kind of technologies that are adopted.

78. The combination of the many different economic, structural, behavioural and policy factors in a wide range of different situations means that there is no simple or unique explanation as to what leads farmers to adopt new technologies and that there is no single factor or policy that will drive green innovation. A comprehensive strategy for boosting green innovation will require policy actions on several fronts, including clear and stable market signals (e.g. carbon pricing or other market instruments that address the externalities associated with environmental challenges). Such signals will enhance the incentives for farmers to adopt green innovations, and would also indicate a clear policy commitment on the part of governments to move towards greener growth.

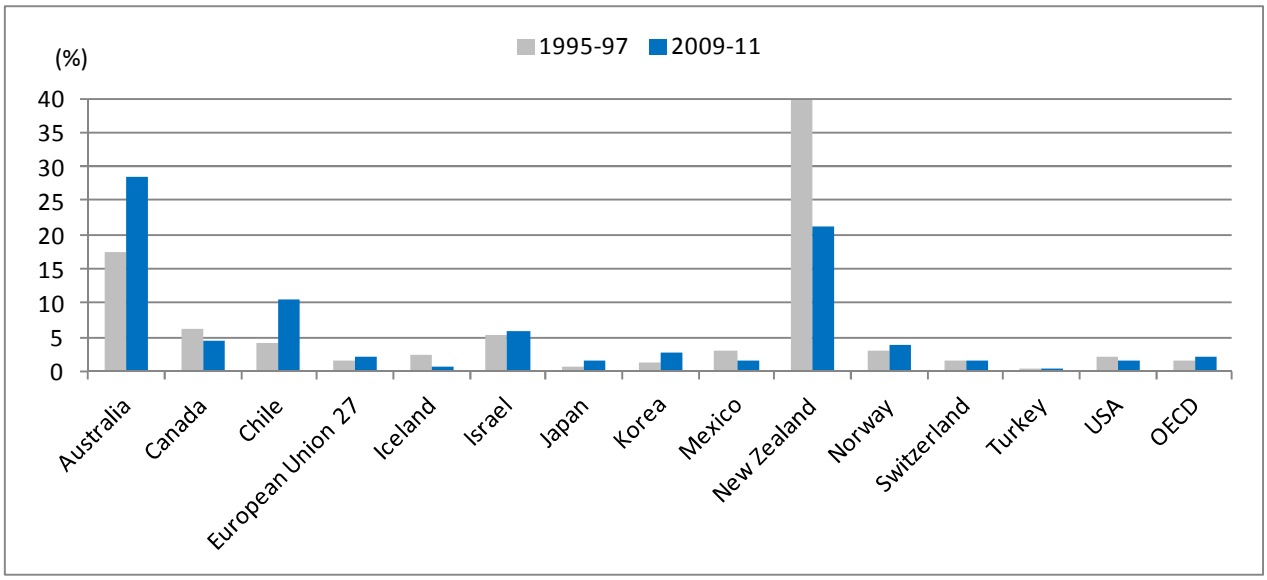
79. If green growth is to be achieved in the agricultural sector, the overall policy framework needs to be consistent and coherent, particularly in the context of agricultural policy reform, trade liberalisation and multilateral environmental agreements. This will require a more integrated approach in terms of setting objectives for green growth in agriculture, defining research and development priorities, and targeting and implementing policy measures at the appropriate level. Improving the innovative capacity of the farm sector would involve identifying obstacles to innovation; revisiting policies that hamper innovation, structural change and the functioning of output and input markets; and implementing measures to foster innovation and competitiveness (OECD, 2013a). However, in practice it is a considerable challenge to achieve policy coherence across a range of government, ministries and other institutions.

3.1.2 Fostering innovation for green growth - Research and Development (R&D)

80. While technology can continue to be a key driver for productivity and yield increases in OECD agriculture, maintaining this level of performance will largely depend on research and technologies to enhance the ability of the agricultural sector to increase eco-efficiency, improve sustainable resource use, and respond to climate change. The productivity of agricultural production can be enhanced through appropriate technology and management techniques for farms, resources and land which do not harm the environment.

81. Estimates of the rates of return to agricultural R&D suggest a very high social value of agricultural R&D, indicating considerable under-investment in agricultural research systems.[14] Yet, and despite the importance of the agricultural sector to food security, about only 4% of public and private R&D spending in OECD countries is oriented towards agriculture. Moreover, even though government funding for R&D is permitted under international trade agreements, it accounts for just a small share of total support to agriculture − around 2% in the OECD area in 2009-11 (**Figure 3.1**). Public spending on agricultural research as a proportion of total support to agriculture is very high in ***Australia*** and ***New Zealand*** only (28% and 21% in 2009-11, respectively).[15]

Figure 3.1. Share of government expenditures on agricultural R&D in total support to agriculture



Source: OECD, PSE/CSE database, 2012.

82. Public investment in basic and long-term research plays an important role in innovation. Such research has a public-goods character and is therefore unlikely to be undertaken by the private sector. It helps address fundamental scientific challenges and fosters technologies that are considered too risky, uncertain or long-gestating for the private sector.

83. In the context of green growth, public research will need to cover many areas, including, for example, both mitigation and adaptation technologies to climate change and water management; it will need to be well designed, and able to complement private investment in research; it should be neutral with respect to specific technologies, as innovations may emerge from a wide range of fields; and it should be targeted to areas in which social returns and spill-over effects are potentially the greatest.

84. Because of the high costs involved, the management of research systems will assume increasing importance. One of the conclusions of the 2012 OECD conference on improving Agricultural Knowledge

14. Annual internal rates of return of investments on agricultural R&D estimated in the literature range between 20% and 80% (Alston, 2010).

15. It should be noted that these figures do not include private agricultural research, which in some countries is significant (e.g. in the United States, private agricultural research accounts for more than 60%). While government focuses mainly on public-goods research (as the results benefit society as a whole), the private sector focuses mainly on R&D related to marketable goods (e.g. research in biology, microbiology and computing).

and Innovation Systems (AKS) was that the budget austerity currently facing many countries is heightening the need to improve the effectiveness of these systems and to reinforce multidisciplinary co-operation at national and global level (OECD, 2012a).

85. Moreover, because of the long lead time in research activities, the timely identification of future research problems carries a substantial premium. In the context of green growth, for example, one area which warrants increased attention is research into lower-input farming systems geared to developing economically viable methods of cultivation and husbandry, while also producing beneficial effects for the environment (e.g. lower agro-chemical input per unit of output) and on the use of land (extensive methods).

86. Governments can encourage R&D using a variety of financial and non-financial incentives (**Box 3.2)**. They can promote business R&D investments in agriculture through targeted supports, tax credits and public/private partnerships, which have a multiplier effect on public research funding. As one way of trying to increase resource efficiency, some governments have increased the use of contracts or competitive research grants, but further analysis of the factors which determine the efficiency of research systems is required.

Box 3.2. Types of incentives to promote R&D

Financial incentives

- *Direct financing*: The government can directly finance R&D undertaken at public scientific bodies such as universities, government research institutes and science parks.
- *Grants*: The government can directly fund private R&D initiatives through awarding financial grants (both for-profit and not-for-profit). Grants allow the government to target the projects with high social returns.
- *Tax incentives*: Tax incentives represent an indirect form of support to private R&D efforts by providing tax relief that lowers costs. This measure gives more autonomy to the private sector, but makes it difficult to target projects.
- *Removing subsidies*: The government can also remove subsidies for environmentally harmful products (e.g. fossil fuels) in order to create a level playing field for R&D on resource-efficient technologies.
- *Long-term investments:* The government can provide R&D for resource-efficient technologies with long-term, low-rate investment in companies, or loans by venture capital and other financial organisations.

Non-financial incentives

- *Protection of intellectual property rights:* The creation of a legal environment that protects patents and relaxes anti-trust activities can increase the likelihood of generating an acceptable return from R&D investment.
- *Demonstration projects:* It is essential that trials are conducted to prove the technical viability at a commercial scale of those new technologies that do not readily attract private sector financing. Demonstration projects are also needed to tailor developed technologies to fit specific contexts.
- *Human resources development:* The availability of university graduates influences the potential number of research scientists and engineers. Education policies lead to a match with the requirements of industry.
- *Industrial standards:* The provision of standardisation in products and processes can not only reduce the costs of production by providing clearly specified requirements, but also speed up competition for upgrading of products.

- *Co-ordination bodies:* The creation of co-ordinating agencies or advisory councils can improve the flow of information between government departments, research organisations and industry, fostering learning processes, indigenous innovation and technological diffusion.
- *International collaboration:* The government can facilitate the formation of international joint ventures and other international collaborative efforts to encourage resource-efficient technology transfer and innovation.

Source: de Serres *et al.* (2010)

87. Success of R&D policy depends on a variety of factors including: i) balanced protection of intellectual property rights (i.e. enabling "reasonable' returns so as to encourage private investment while simultaneously enabling widespread diffusion of benefits); ii) define performance (e.g. the development of resource-efficient technologies would be encouraged by setting clear goals that specify efficiency and emission characteristics of technologies); iii) clearly define the role of each partner in public-private partnerships (de Serres *et al*., 2010).

88. At least 21 OECD countries stimulate private sector research through the provision of R&D tax credits which provide firms with tax benefits that are related to the costs of undertaking specific innovation activities (Stevens, 2011). ***Canada***, for example, offers a broad-based R&D tax credit of up to 35% of total expenses for experimental development, basic and applied research, and related supporting activities. The ***United States*** is now proposing to simplify, increase and permanently extend its R&D tax credit.

89. In ***Australia***, through the R&D Tax Incentive, which was introduced in July 2011, the government is encouraging investment in rural R&D across the economy through tax credits. In particular, the R&D Tax Incentive is a targeted tax offset designed to encourage more national companies to engage in R&D. It aims to: boost competitiveness and improve productivity across the economy; encourage industry to conduct R&D activities that may not otherwise have been conducted; provide business with more predictable, less complex support; and improve the incentive for smaller firms to engage in R&D. The R&D Tax Incentive is open to firms of all sizes in all sectors who are conducting eligible R&D activities. There are two components to the incentive, a 45% refundable tax offset for entities with a turnover less than AUD 20 million, and a non-refundable 40% tax offset for the rest.

90. Accelerated depreciation schemes for research-related capital expenditures and reduced labour taxes on scientists and researchers provide incentives to expand research and innovation. Some countries lower the corporate tax rate for innovation-related profits, such as those resulting from royalties or the sale of patents. Other countries target the tax credit to specific sectors and outcomes, including environmental research. For example, as stipulated by the *Framework Act on Low Carbon Green Growth*, the ***Korean*** Government revised the Restriction of Special Taxation Act in order to provide tax breaks for green finance as from January 2010. Skilfully harnessing the tax system offers a means for increasing R&D expenditures to advance Green Growth in agriculture and other sectors.

91. Regulations affect innovation in several ways. Although regulation can encourage green innovation, its impact is not straightforward and varies across sectors, industries and technologies. The design of regulations is also important: they should be sufficiently stringent to encourage innovation; stable enough to provide investors confidence; flexible enough to foster genuinely novel solutions; closely targeted on the policy goal; and provide incentives for innovation (OECD, 2011a). Poorly designed regulations, in terms of stringency, stability; flexibility and closely targeted on the policy goal may impede innovation.

92. A number of regulatory issues are of particular importance for agricultural innovations, including property rights protection (**Box 3.3**), environmental regulations (see section 4.2), health and food safety regulations, and bio-based regulations. In the ***European Union***, smarter regulations aim to simplify existing EU legislation to spur innovation and reduce the administrative burden for operators. Independent evaluations have been commissioned on several legislative areas, including Genetically Modified Organisms (GMOs), animal health, plant health and seeds. Furthermore, impact assessment is now required for any regulatory proposals, including those involving contributions to sustainable development and innovation. In terms of innovation, impact assessment takes into consideration, *inter alia*, whether the proposal: hinders or stimulates R&D; promotes greater productivity or resource efficiency; and affects intellectual property rights.

Box 3.3. What are property rights?

Property rights define the rules determining who may control or benefit from designated assets. These assets may be tangible (physical) or intangible (virtual, or conceptual). Hence, property rights can be assigned in relation to a wide range of assets: natural resources found on, above or below ground on specified tracts of land; buildings and land; industrial processes; property existing only in digital form; physical works of art; intangible artistic creations (such as music, literature and design) and so on. Property rights are legally enforceable and may be vested in individuals or groups of individuals, or in legal entities (e.g. corporations).

Property rights usually confer a bundle of specific benefits and privileges that regulate the relationship between the rights-owner and the asset. Rights do not necessarily imply full ownership nor the sole authority to use and dispose of a resource; different individuals, families, groups, or even the state often hold overlapping use and decision making rights. To be secure, rights should be of sufficient duration to allow one to reap the rewards of investment and should be backed by an effective, socially sanctioned enforcement institution. This institution might be the government, local communities or other institutions (Bromley, 1991).

The composition and precise form of the bundle of rights can vary depending on the type of asset. In general, the property rights bundle can be broken down into user rights (including the exclusive claim to the income derived from the use of the asset), transfer rights (control over the sale, gift or bequest of the asset) and transformation rights (unconstrained modification or destruction of the asset).

Not all these rights are relevant for every type of asset. Moreover, the legal definition and attribution of property rights in particular cases may explicitly limit or withhold one or more of these components of the bundle, or some of potential rights may be ruled out by over-riding general legislation. Furthermore, different elements of the bundle may be allocated to different beneficiaries. For example, landownership may confer user rights and transfer rights to landowners, although user rights may be constrained by general environmental and safety legislation and access rights to parts of the land may reside with the general public.

Property rights are not absolute or unchanging (Bromley, 1991). Three particular factors which can trigger change include: technological change (which can make access to resources feasible for the first time; reduced costs of obtaining or processing information or reduce the cost of defining and enforcing rights); new markets (due to technology, reduced trade protection, political shifts); changes in relative factor scarcity; and state intervention to define and enforce property rights in exchange for revenue (Furubotn and Pejovich, 1972).

3.1.3 Fostering innovation for green growth: property rights to knowledge-based capital

93. Naturally occurring resources are in finite physical supply and so their expansion cannot be a strong driver of growth over the long term.[16] However, their productivity can be enhanced by combining

16. It could be argued that finding ways of accessing or exploiting natural resources that were previously not used (e.g. shale gas reserves) amounts to an expansion of the natural resource base, and a demonstration that it should not be considered as finite. However, by definition these resources are not renewable and over the medium to long term they will in principle be exhausted.

them with new inputs, with other (renewable) inputs whose productive potential is continuously being upgraded (e.g. a better educated workforce), with more productive man-made capital or with existing inputs but in new ways. This kind of productivity-enhancing innovation is essentially limited only by human ingenuity. Thus, it is expansion of the non-physical productive resources (knowledge, know-how, "intellectual capital") that is expected to be the main driver of green growth in the longer term. It follows that the question of how the property rights relating to these resources are specified and in whom they are vested is potentially of major importance in the green growth context. Lack of an adequate system of property rights that would enable those responsible for developing new intellectual capital to fully appropriate a commercially-based economic return for it could be seen as a major constraint on research and innovation processes.

94. The OECD (2011c) study on tools for delivering on green growth identifies low appropriability of returns to innovation and investment as one of the factors holding back green growth, although the diagnosis can be applied more generally to any kind of growth-oriented innovation and investment. A causal factor in this low appropriability is ascribed in part to an incomplete system of property rights, which is categorised as an aspect of government failure.

95. A number of other government and market failures are also responsible for low appropriability of returns. For example, other barriers to innovation may emerge from systematic failures that hinder the flow of knowledge and technology, such as: i) capability failure (e.g. lack of managerial capacity); ii) institutional failure (e.g. universities, research institutions); iii) network failures (e,g. weak links between actors of innovation systems); and iv) framework failures (e.g. deficiency in regulatory frameworks, cultural and social values) (OECD, 2011a).

96. The traditional means for protecting new intellectual property in productive processes has been the patent system (OECD, 2011a). Patents have emerged as the central institution for asserting intellectual property rights in many crucial fields of science and technology, including agriculture.[17] The rapid progress of modern agricultural biotechnology has led to an increased awareness of the patenting of agricultural plants, and the number of plant biotechnology patents granted by governments (e.g. the United States) has grown exponentially over the last two decades. This period coincided with fundamental revolutions in the ways in which agricultural technologies were developed. As agricultural technology has become more science-based, patents on platform and enabling biotechnologies, transformation and gene-transfer techniques and methods for genomics research have strongly influenced the development of new technologies.

97. Patents have helped private enterprise develop new technologies and disseminate knowledge. Without patent protection, private companies might not be able to recover development costs of new technologies that improve the performance of tractors, irrigation equipment, pesticides, storage facilities and other inputs. By endowing discoverers with property rights over the results of their efforts, patents affect the incentive to innovate and are likely to lead to an increase in the flow of innovations. Patents can also help to improve the dissemination of knowledge, technology transfer and commercialisation.

17. Of particular importance for agricultural productivity, the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) provides that patents shall be available – with a few exceptions – in all fields of technology for inventions that are new, non-obvious and useful. An exception concerns plant varieties, which may be excluded and protected via a *sui generis* system such as the one provided under the convention of the International Union for the Protection of New Varieties of Plants, or by any combination of those two options. In addition, in some cases, national law and regional or international accords afford IPR protection beyond the TRIPS minimum standards (e.g. availability of protection for new plant cultivars via patents and plant variety protection laws).

98. However, intellectual property licensing is a challenging topic for policy makers. Notwithstanding the aforementioned beneficial effects, licensing agreements can also have the effect of cartelizing an industry, or of increasing the market power of a single licensor. The challenge for policy makers is to determine whether a particular agreement is likely to facilitate or hurt competition. In other words, the system of patents and licensing should provide incentives for private investment in innovation, without compromising the sharing of knowledge and further spread of innovation **(Box 3.4)**.

Box 3.4. Main economic arguments for and against patents

In academic literature the usual argument in favour of intellectual property protection - as it appears in the seminal works of Arrow (1962), Nordhaus (1969) and Romer (1990) - is that innovation amounts to knowledge production, and as knowledge is inherently non-rival there is a market failure and insufficient incentives to innovate. The non-rival character of knowledge implies that once an invention is known, everyone can use it with no additional R&D cost. Patents provide incentives to R&D and to disclose information, but at the social costs of reducing the invention's use during the validity of the patent.

More recent academic research has called into question this conventional view and, consequently, the effectiveness of patents as a tool for stimulating innovation (Hall and Harhoff, 2012; Jaffe and Lerner, 2011; Langinier and Moschini, 2002). In situations where imitating is as costly as inventing, or where firms have the economic and technical means for protecting their inventions, there is no need for further legal protection. Under these circumstances, patents may simply become a source of market distortion and facilitate rent-seeking or strategic behaviour by patent holders. The theoretical literature shows that when research is sequential and builds upon previous discoveries, stronger patents increase the costs of subsequent innovators, especially when innovators need to combine inventions from several different sources. In this case, the enhanced ability to enforce patents may *impede* rather than *promote* innovation, contrary to conventional belief. Finally, transaction costs and contracting problems associated with proliferation of patents may also adversely impact on innovation (Mueller et al., 2013)

99. The effectiveness of the IPR regime relies on effective institutions. IPRs should be well protected and appropriately enforced to provide strong incentives for innovation but also lead to the public benefits that flow from dissemination of knowledge in the marketplace. Competition authorities play an important role in ensuring that patents are not used anti-competitively. A number of OECD governments have made efforts to encourage firms to learn about the patent system and apply for green patents. These include expedited examination of patent applications relating to green technologies. ***United Kingdom***: The UK Intellectual Property Office has developed a strategy specifically to facilitate the protection, management and appropriate exploitation of intellectual property connected with low-carbon technologies.

100. A commonly held view is that basic research, which may feed into a variety of new applications and products, is best undertaken in the public sphere, or at least financed from public funds, and should be made available to all as a common resource. By contrast, near-market research and development of specific techniques, which may draw on the common pool of basic research, but which can be marketed to end-users, is best left to the private sector, since the private sector is better placed to foresee specific market demands and is able to fund its development activities out of market returns. However, with the increasing importance of PPPs and other forms of collaborative research, the distinction between public versus private funds is blurred. Under US law, basic research per se cannot be patented.[18] Likewise, in Europe, it is not straightforward for basic research to qualify as patentable.[19]

18. An interpretation confirmed by the recent ruling in the case *Ariad Pharmaceuticals, Inc. v. Eli Lilly and Co*., No. 08-1248, slip op. at 2 (Fed. Cir. Mar. 22, 2010) (en banc).

19. The European Patents Convention lists four requirements to be met by a patentable invention: there must be an invention; if there is an invention, it must satisfy the criteria of novelty, of being an "inventive step", and of having industrial applicability (WIPO).

101. This situation raises questions as to the destination of the rent from the basic research. When much basic research is so complex and esoteric that only large corporations have the resources to understand and exploit it for an end-use, in what sense can it be said that this knowledge belongs to society as a whole, and to what extent if any is society able to capture the benefits of ownership if it becomes available only when embodied in products and services marketed by private sector companies? If universities and public research organisations were able to recoup more of the market returns from their basic research, this would allow a larger share of self-funding of new basic research and would help guarantee the continuity of basic research programmes in times of budget stringency.[20]

102. The trend towards funding of on-campus research laboratories and programmes by large companies does not necessarily solve the problem. Even if it is correct to interpret this trend as a recycling of some of the market returns from basic research back to the institutions that generated the basic research, it is not necessarily a perfect substitute for income that is directly appropriable by universities. Indeed, corporate funding of university research arouses mild concern in some quarters about potential loss of scientific independence and research autonomy in these public institutions.

103. Finally, since the benefits to research and innovation with respect to environmental conservation and enhancement do not − for the most part − pass via markets and are essentially 'non-appropriable', it can be expected that this kind of knowledge creation to fall to the public sector, although much of it will not qualify as "basic research" at all. In fact, the coupling of "green" and "growth" has increased total demands and expectations directed towards the research establishment, and this has to be borne in mind by governments that might be tempted to reduce research funding due to over-stretched budgetary resources.

3.1.4 Fostering innovation for green growth: public-private partnerships

104. Public-Private Partnerships − that is joint agreements with agro-food industry or other stakeholders (e.g. producer organisations, universities, environmental groups, etc.) − are gaining importance in several OECD countries. For example, ***Australia*** and ***New Zealand*** have created special research institutes jointly funded by government and industry, with a focus on specialised agricultural research. Similar co-operative research programmes are in place in ***Canada***, ***Denmark***, the ***Netherlands***, the ***United Kingdom*** and the ***United States***.

105. In its Green Growth Strategy, one of the aims of the ***Danish*** Government is the efficient organisation of agricultural R&D, to be brought about through a green development and demonstration programme, aimed at increasing the co-ordination between research, innovation and demonstration in the agro- and aquaculture and food sectors.

106. In ***Korea***'s green-certified firms are given prioritised access to public funding for R&D programmes, including eco-friendly agriculture and food, renewable energy. The criteria for the award of certificates are the ability to demonstrate that the technology adopted has reached 70% of the most advanced level in the same line of technologies. The list of candidates is renewed every year to reflect related technological advancement and social change.

107. In ***Australia***, the national rural R&D priorities aim to foster innovation and guide R&D effort in the face of continuing economic, environmental and social change. There are collectively five national rural R&D priorities: productivity and adding value, supply chain and markets, natural resource management, climate variability and climate change and bio-security. Through the rural Research and Development Corporations (RDCs) model, the *National Enabling Technologies Strategy*, Australia has

20. This case is argued strongly in Arai (2000).

increased public research on sustainable food and agricultural systems and undertakes public/private partnerships for green agricultural research.

108. The RDC model is a key contributor to increases in public research on sustainable food and agricultural systems. It is estimated that in 2012-13 the Australian Government will match industry levies on production of about AUD 235.9 million. RDCs are a public/private partnership between the Australian Government and industry, which includes "green agricultural research". Through the RDCs, the Government and industry share the funding and strategic direction setting for primary industry R&D. The RDCs account for a significant proportion of Australian's rural R&D. Of the 15 RDCs, six are statutory authorities funding only R&D, and nine are industry-owned companies that fund industry service provision, including R&D and marketing. As evidenced by its productivity performance, whereas rural productivity is increasing at more than twice the rate of other industries in the economy in recent decades, the rural RDC model has been successful.

109. The *National Enabling Technologies Strategy* provides a framework to support the responsible development of enabling technologies, such as nanotechnology, biotechnology and other emerging technologies. With funding of AUD 38.2 million over four years, it aims to help industries capitalise on growth opportunities and ensure that the country benefits from enabling technologies, while ensuring that processes are in place to identify, monitor and mitigate any associated risks. The Strategy also provides a central point for policy co-ordination and community engagement at the Federal, State and territorial level.

110. More specifically, the expected outcomes from the Strategy are: timely and accurate information that informs policy makers' decisions on the impacts, opportunities and challenges of enabling technologies; increased competitiveness through uptake of nanotechnology-based products, processes and services; effective regulatory frameworks to manage the impacts of enabling technologies on public health, safety and the environment, but which do not unreasonably inhibit or prohibit their uptake; and an understanding amongst government, researchers and industry of public interests with regard to enabling technologies.

111. In ***France***, one of the actions of the ECOPHYTO plan on pesticides is to encourage innovation in the design and development of low pesticide input practices and cropping systems. The research and development effort within the *Ecophyto* plan seeks to develop new Integrated Pest Management solutions that can contribute to sustainable agriculture while preserving the competitiveness of French agriculture. Toward this end, the Ministries of Agriculture and Environment have requested that the *Institut National de la Recherche Agronomique (INRA)* launch the research which is mobilising a hundred experts from over 30 organisations and is focusing on four main crop sub-sectors: arable crops, fruit arboriculture; viticulture; and vegetable crops. For each of these sub-sectors different strategies for limiting the use of pesticides are being analysed.

112. In ***New Zealand***, the *Primary Growth Partnership (PGP)* provides investment in research and innovation to boost productivity, economic growth and sustainability across New Zealand's primary, forestry and food sectors. PGP funding must be matched by co-investors from industry. A key programme under the PGP is the establishment of the Centre for Agricultural Greenhouse Gas Research. The *Sustainable Farming Fund* (SFF) supports rural communities to undertake applied research and extension projects to tackle a shared problem or to develop a new opportunity. SFF projects are led by rural landowners and managers, often with the support of industry organisations, agribusiness, researchers or consultants. The *Pastoral Greenhouse Gas Research Consortium* (PGGRC), is a partnership, formed in 2002, between the Government and the dairy and fertiliser industries, to provide livestock farmers with the information and means to mitigate their GHG emissions. The scope of the programme is broad, and includes research into improvement of the production efficiency of ruminant animals. The PGGRC target

is to decrease emissions by 10% per unit of output by 2013 over business as usual benchmark, relative to 2005 (estimated to be 4 million tonnes).

113. Launched in 2007 and administered by the Ministry of Agriculture and Forestry (MAF), the *Sustainable Land Management and Climate Change Plan of Action* (SLMACC), is a five-year programme for the land-based sectors, running in partnership with the land management sectors, local government and Maori. Key work streams include: the impacts of climate change and adapting to climate change; reducing New Zealand's GHG emissions and enhancing carbon sinks; research; and a technology transfer programme. Priority research topic areas and funding are identified through consultation with stakeholders. Research programmes have been carried out in the following areas: farm-level GHG reporting using the Overseer nutrient budget model; bioenergy and biochar R&D; national nitrification inhibitor research; national agriculture and forestry inventory development; and life-cycle analysis for a number of industry sectors and products.

114. In the *Building Innovation* theme of the *Business Growth Agenda* a number of actions are envisaged: strengthening research institutions (where there are several actions to reposition public education and research institutions to develop more effective links between the business sector and CRIs and universities); public science investment (where the action to develop the Statement of Science Investment Priorities will consider the potential for green research); international knowledge transfer (where the work to establish mutually beneficial science investment opportunities with Singapore and the actions on science that are part of the New Zealand strategies will support the transfer, adaptation and adoption of existing and new technologies).

115. The *Enterprise Policy - Top Sector Approach* government initiative in the ***Netherlands*** aims to boost growth and innovation in nine sectors: agro-food; horticulture and propagating stock; high tech; energy; logistics; creative industries; life sciences; chemicals; and water. The core of the top sector approach is collaboration among researchers, entrepreneurs and government (the "golden triangle"). *Top-sector Agro-Food* focuses on further sustainable food supply chains where there is a continuous challenge of improving resource efficiency.

116. In the ***United Kingdom***, the *Green Food Project* is a is a joint initiative between government and stakeholders (industry and environmental partners) to reconcile the competing demands of producing more food and improving the environmental performance of the whole supply chain (e.g. lowering GHGs, reducing levels of waste and water use, and improving biodiversity and soil quality). Among the questions to be addressed will be how competing pressures on land use and on natural resources can be managed, how new technologies should be embraced, the implications of changing consumer behaviour, the potential to innovate. In particular, it will examine how production and consumption could change in the future in five different sectors – wheat, dairy, bread, curry, and geographical areas. The initial conclusions of the project, which were published in July 2012, address a range of topics, primarily R&D, knowledge exchange, future workforce in the food industry, investment, building effective structures, valuing ecosystem services, land management, consumption and waste.

117. In the ***United States***, the 2008 Farm Bill, which contains the major provisions dealing with federally supported and United States Department of Agriculture (USDA)-administered agricultural research, education and extension services, authorised the creation of several new research activities related to specialty crops, organic agriculture, bio-energy, nutrition and pollinators. An increasing emphasis is placed on competitive grant funding. The 2008 Farm Bill also raised funding authorisation for "1890 institutions" and broadened eligibility for federal grants for agricultural research, education and extension, particularly for Hispanic-serving institutions.

3.1.5 Fostering innovation for green growth - international co-operation

118. Although much of the policy emphasis on achieving green growth objectives is inevitably domestic in nature, there is also an important role for international collaboration in several areas. In particular, the sharing of the results of R&D and new knowledge that contributes to the greening of agriculture is important. There is considerable potential for taking advantage of spillovers at the international level from the development of new production methods in agriculture.

The Global Research Alliance

119. The *Global Research Alliance* (GRA) on Agricultural Greenhouse Gases, which was launched in December 2009 and now has more than 30 member countries from all regions of the world, is a voluntary network set up to increase international co-operation, collaboration and investment in agricultural GHG research.[21] The focus of the GRA is on R&D and the extension of technologies and practices that will help deliver ways to grow more food (and produce more climate-resilient food systems) without increasing GHG emissions at a global level. It aims to deepen and broaden existing mitigation research efforts across the agricultural sub-sectors of paddy rice, cropping and livestock. This includes the cross-cutting themes of soil carbon and nitrogen cycle and inventories and measurement issues.

120. A key initial task includes conducting a stocktaking of research activities to guide the development of research activities. The Alliance promotes an active exchange of data, people and research to help improve the ways in which agricultural greenhouse gas research is conducted and to enhance the scientific capability of participating countries. For example, the New Zealand Government sponsors the Global Research Alliance Senior Scientist Award, which provides support to scientists from New Zealand and other Alliance countries who undertake exchanges on research projects on agricultural GHG mitigation. Likewise, the United States, through the 2012 United States Department of Agriculture Global Research Alliance Fellowships, will support scientists from Columbia, Ghana, Indonesia, Malaysia, Mexico, Peru, the Philippines and Vietnam to work side-by-side with US scientists on climate change mitigation research.

121. As of March 2012, an Alliance Council and five scientific groups have been formed: the Paddy Rice Research Group; the Livestock Group; the Croplands Group; the Soil Carbon and Nitrogen Cycling Cross-Cutting Group; and the Inventory and Measurement Cross-Cutting Group. These Groups have developed work plans that bring countries and other partners together to collaborate in research, as well as to share knowledge and best practices, build capacity and capability amongst scientists and other practitioners, and work towards breakthrough solutions to addressing agricultural GHG emissions.

122. The Paddy Rice Research Group (co-chaired by Japan and Uruguay) is focused on emissions from paddy rice cultivation systems. The Group is working to find ways to reduce the emissions intensity of paddy rice cultivation systems, while improving its overall production efficiency. Trade-offs with emissions of nitrous oxide and changes of the quantity of carbon stored in paddy soils are also being considered. The Group's work will help improve countries' national inventories of greenhouse gas emissions from paddy rice cultivation systems. It will also provide knowledge of source and sink extents and mitigation options to paddy rice farmers, land managers and policy makers, by looking at the impacts of water management, organic matter and fertilisers and cultivar selection.

21. As of April 2012, there were 33 member countries: Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Costa Rica, Denmark, Finland, France, Germany, Ghana, Indonesia, Italy, Ireland, Japan, Malaysia, Mexico, the Netherlands, New Zealand, Norway, Peru, the Philippines, the Republic of Korea, Spain, Sweden, Switzerland, Thailand, the United Kingdom, the United States, Uruguay and Vietnam.

123. Specifically, the Paddy Rice Research Group is working on the standardisation of measurement techniques, identifying good practice and gaps in current knowledge, and developing improved country-specific emission factors and mitigation options. Relevant literature is being pulled together into a database. Over time, the Group will look at how to scale up results across countries and extrapolate solutions to the long term.

124. The Livestock Group (co-chaired by New Zealand and the Netherlands) is looking at emissions from ruminant and non-ruminant livestock systems. Key emissions covered are methane from enteric fermentation and waste management, nitrous oxide from animal wastes and fertilisers, and soil carbon. The Group's work will help catalogue available mitigation options and improve understanding of the ways of managing livestock emissions and improving efficiency of production. Immediate goals for the Livestock Group include:

- Collecting, collating and analysing information in livestock emissions research.
- Developing best practice guidance and standardised methodologies for measuring emissions from livestock production and making training and development opportunities available.
- Establishing networks and databases on key areas of activity, e.g. microbial genetics, manure management, etc.
- Fostering research collaboration between member countries and with key partner organisations (e.g. the CGIAR Climate Change Agriculture and Food Security programme, the EU Joint Programming Initiative, the International Livestock Research Institute).

125. The Croplands Group (co-chaired by the US and Brazil) is focused on reducing GHG intensity and improving overall production efficiency of cropland systems. The Group is looking at ways to limit the losses of carbon and nitrogen from crops and soils to the atmosphere, and transferring that knowledge and technologies to croplands farmers, land managers and policy makers around the world.

126. The main GHG emissions studied by the Group are nitrous oxide and soil carbon. Different techniques are being applied to understand the croplands production pathway: from soil condition, to tillage or no-till systems, climatic effects and crop varieties for low GHG emitting production. There is also a strong emphasis on working with farmers to apply new technologies and management practices in the field. The Croplands Group has been set the specific goals of:

- Taking stock of key scientific projects and personnel involved in GHG emissions and soil carbon sequestration of cropping systems.
- Developing a searchable literature database relevant to croplands emissions and soil carbon sequestration.
- Assembling protocols, guidelines, and methods for determining soil carbon, GHG fluxes, and assessing temporal and spatial variations among measurements.
- Developing sub-groups looking specifically at GHG emissions and changes in soil carbon in agricultural peatlands and wetlands; using simple and complex models to evaluate carbon and nitrogen emissions; and assessing net GHG emissions and soil carbon sequestration with cropland management practices.
- Identifying funding opportunities for cross-national research collaboration.
- Cataloguing best management options and recommendations for different croplands environments.

- Over time, and adopting a consistent international approach, the Croplands Group aims to build a global network of GHG emission and soil carbon sequestration data from specific management approaches (for example, the GRACEnet approach used by the USDA Agricultural Research Service).

127. The Soil Carbon and Nitrogen Cycling Cross-Cutting Group (co-chaired by Australia and France) aims to improve models and methodologies related to soil carbon and nitrogen, and related mitigation opportunities as they affect the production systems covered by GRA (livestock, croplands and paddy rice). It focuses on three major research areas: i) technical workshops; ii) identifying models; iii) testing and comparison of models. The Group, which has twenty seven countries participate in its work, has developed a work plan around the following issues:

- The identification of available data sets (on soil carbon, GHG emissions, soil-plant-atmosphere balance for nitrogen or carbon) and models.

- The definition of criteria for model applicability, particularly for mitigation options.

- Options to fill data gaps, particularly for some climatic/agricultural areas, through collaboration.

- Selecting key models and core datasets for (i) inter-comparison, benchmarking and (iii) improvement of models for coverage, predictive capability and reliability, especially for mitigation options.

128. The Inventories and Measurement Cross-cutting Group (co-chaired by Canada and the Netherlands) focuses on two major research areas: i) improved GHG quantification methodologies. It deals with all inventories including formal country submissions. ii) Guidance for GHG measurements, such as validation of models and identification of existing mitigation opportunities. Seventeen countries participate in the work of the Group,

International Knowledge-Based Bio-Economy Forum

129. The International Knowledge-Based Bio-Economy (KBBE) Forum is a partnership between the ***EC***, ***Australia***, ***Canada*** and ***New Zealand*** launched in September 2010. It aims to share knowledge on policy strategies and actions, create new knowledge to address societal challenges related to the bio-economy, and to foster collaboration and joint activities that will promote innovation in bio-economy sectors. It promotes co-operation in the bio-economy through policy dialogue and scientific co-operation between the partners. The Forum also acts as a think-tank for identifying future trends and challenges in the bio-economy.

130. Four themes were identified for KBBE focus:

- Bio-based Materials (led by Canada in 2010-11);

- Food & Health (led by Australia in 2010-11);

- Fisheries & Aquaculture (led by the EC in 2010-11); and

- Sustainable Agriculture (led by New Zealand in 2010-11)

3.2 Energy efficiency- renewable energy

131. Across the OECD area energy use is a critical component in the ability of the agricultural sector to achieve competitiveness and sustainability. Agriculture plays a double role in relation to energy, being both a consumer and producer. Energy is consumed at a variety of points in the food chain and accounts for as much as 20% of total energy use in some OECD countries. Moreover, agriculture has the potential to be an important source of clean, renewable energy.

132. Many policy makers view the development of agriculture-based biofuels as both a catalyst for rural economic development and as a response to the problem of countries' growing dependence on imported energy: a range of policy measures have been put in place in order to promote biofuel production and use, the principal ones being subsidies of various types and production or consumption mandates.

133. However, the use of agricultural crops for biofuel production is a controversial issue. Concerns have been raised about the implications for food prices and resource use in agriculture – particularly in countries where land previously used by wildlife or forest is to be used for the production of biofuel feedstocks, and where the magnitude of the net contribution of first-generation biofuels to reducing GHG emissions is a subject of current debate. A number of studies suggest that biofuels policies provide significant subsidies to agricultural producers, which can create trade distortions.[22] The OECD's own work in this area suggests that biofuel policies lead to higher and more volatile world prices for crops, such as maize and oilseeds, which provide first-generation feedstocks (OECD, 2008).

134. In terms of green growth, increasing the yield of existing crops and introducing the use of new agricultural crops (e.g. jatropha) in order to promote biofuel production will pose certain challenges. The combination of the consequent demand that would be placed on available land and the pressure likely to be exerted on other inputs may make it difficult to improve environmental quality in agriculture.

135. The development of second-generation feedstocks such as woody biomass may also place additional demands on land and other natural resources and have detrimental effects on the environment, unless appropriate steps are taken. However, other potential benefits of the increased use of biofuels, such as reduced reliance on fossil fuels, need to be taken into consideration when evaluating the future direction of biofuels policy.

136. Apart from the use of biofuels, there exists a range of interventions designed to reduce energy use, involving the more efficient use of machinery and heating in order to reduce direct energy demand at all stages of the supply chain (including household appliances). At the farm-gate, indirect demand can be reduced by changing production systems (e.g. switching crop types and expanding organic farming); a more targeted use of inputs; and better management of animal health. Some interventions are win-win, offering the potential to lower the costs associated with energy use and to reduce the greenhouse gas emissions associated with inputs. Overcoming information failures and behavioural barriers is the key to realising these changes.

137. Although technological developments, changes in crop management and renewable energy use are of critical importance in increasing the energy efficiency of agriculture, due consideration should also be given to the relative cost-effectiveness and challenges of changing production behaviour, versus that of inducing changes on the consumption side.

138. In 2007, the ***European Union*** set the ambitious goal of achieving a 20% share of renewable energy (and a 10% share of renewable energy in transport) by 2020. The renewable energy goal is a

22. See, for example, Moschini, Cui and Lapan (2012) for an overview of the literature.

headline target of the Europe 2020 strategy for smart, sustainable and inclusive growth. To achieve the 20% target, the *Renewable Energy Directive* has introduced a legislative framework laying down individual mandatory targets for each member state's share of renewable energy in final energy consumption (member states are to make independent decisions on the most cost-efficient technology path and support schemes necessary for achieving those targets). On 17 October 2012, the European Commission published a proposal to limit global land conversion for biofuel production and raise the climate change benefits of biofuels used in the EU. The use of food-based biofuels to meet the 10% renewable energey target of the *Renewable Energy Directive* will be limited to 5%.The European Commission is also proposing to enhance the incentives for the best performing biofuels, thereby improve the GHG savings of the overall biofuel mix used in the EU by 2020 compared to fossil fuels as well as to reduce the impact on the potential increase in food prices.

139. In ***Austria***, the *2007 Energy Efficiency Action Plan* covers energy efficiency measures in private households and public and private services, as well as the agricultural and transport sectors. It also includes cross-sectoral measures. The action plan includes a number of detailed initiatives.

140. In ***Canada***, the 2006 Government's renewable fuels strategy has four key objectives and corresponding sets of policy instruments aimed at supporting the development of a domestic biofuels industry in Canada: i) reducing GHG emissions resulting from fuel use by increasing the retail availability of renewable fuels through regulation; ii) supporting the expansion of production of renewable fuels through incentives to production to biofuel producers; iii) helping farmers capture new opportunities in this sector through the provision of capital incentives for the construction or expansion of biofuels facilities that include new equity investment from farmers of at least 5% of eligible project costs; and iv) Accelerating the commercialization of new technologies through support for the construction of large scale demonstration facilities for the production of next-generation renewable fuels, such as cellulosic ethanol made from agricultural residues and waste products.

141. In ***Denmark***, a central element in the country's *Green Growth Strategy* is the emphasis placed on the development of renewable energy in the agricultural sector. In particular, the role of the agricultural sector as a supplier of green energy is to be strengthened, with up to 15% of arable land to be used for energy crops − which represents a 16-fold increase in energy production coming from agriculture − and the share of farm animal manure to be used for green energy is to be increased from 5% to 50% by 2020.[23] Policy initiatives to help in reaching these targets include annual financial support for starting investments in biogas and a grant scheme for planting perennial crops. The grant scheme for perennial crops will be assessed in 2012.

142. In ***Finland***, within the scope of the country's energy-related targets, agricultural investment support is granted to on-farm boiler houses and biogas plants using renewable energy sources. The purpose of the investment support is to promote the increased use of renewable energy sources, the more efficient use of energy (and energy saving), the adoption of new energy technologies and the reduction of environmental damage from energy production and use. Production and use of biogas are promoted through investment and support to research and training and communications projects to assist in the establishment of bio-energy production plants, as well as through pilot projects applying new research data and technologies. A particular objective of the support is to promote the construction of biogas plants in areas with large farm animal populations and consequent environmental impacts.

143. In ***France***, promotion of renewable energies is mainly through the *Energy Performance Plan* (*PPE) for Farms, 2009-13* programme, which aims to increase awareness of energy consumption on farms

23. According to the Danish Energy Agency, in order to meet this requirement, 130 biogas plants would have to be constructed by 2020.

through: reducing energy consumption; enhancing energy efficiency in agriculture; producing renewable energies; and improving farmers' competitiveness. It includes a number of actions to be conducted at the farm level, with particular emphasis on "energy diagnosis". In addition, a new plan targeting "Methane Energy and Nitrogen Autonomy" has been launched in March 2013 as part of the Agro-ecological Project. The plan has a dual aim: i) to develop renewable energy in the framework of French energy transition; and ii) to support the substitution of mineral nitrogen by nitrogen from livestock manure.

144. In ***Japan***, the *Basic Promotion Plan for Biomass Utilisation*, endorsed by the Cabinet in 2010, promotes the utilisation of biomass as an alternative energy source. It aims to support the creation of an autonomous, distributed system of energy supply in local regions through the use of biomass.. The Basic Plan established targets to be achieved by 2020, and set out guidelines and a technical "road map" for achieving these targets. The "Biomass Industrialisation Strategy" was announced in September 2012. Several ministries participated in formulating the strategy, including the Ministry of Agriculture, Forestry and Fisheries, the Ministry of the Environment and the Ministry of Economy, Trade and Industry.

145. In ***Greece***, the Ministry of Environment, Energy and Climate Change implemented a law in May 2010 which permits farmers to construct solar photovoltaic installations on their land, in order to produce electricity, either for personal use or for sale to the Public Enterprise of Electricity, thus offering farmers a potential source of additional income. According to the legislation, the area of farmland used for such photovoltaic installations cannot exceed 1% of the total farmland in each prefecture. This measure has as a goal the promotion of renewable energy systems and, in the long term, the mitigation of climate change. These measures serve not only as a tool for "greening" agricultural growth by implementing environmentally friendly policies, but also aim to create "green" jobs.

146. The agricultural sector is a large energy user in the ***Netherlands***, mainly because of the use of heated greenhouses in its large horticulture sector. The *Clean and Efficient Agro Sectors* programme (launched in 2008) is a public-private partnership with the government that sets out how the agro-food sector can help achieve the national targets for GHG emissions to which the country has committed internationally and in the European framework.

147. For the greenhouse horticulture sector, the government, through the "*Glasshouses as Energy Providers"* innovation programme, is working, in public-private partnership with the industry and knowledge institutes, to ensure that new greenhouses become independent of fossil energy by 2020. Improvement in energy efficiency is mainly sought through more efficient methods of cultivation and investments in energy-saving technologies. The national government and the greenhouse horticulture sector have also agreed to set up a CO_2 emissions trading scheme in return for lower energy taxes in greenhouses horticulture.

148. Multi-year agreements are also being made with other agricultural sectors, such as livestock farming, open cultivation, bulb cultivation and the forestry and timber sector, with a view to achieving energy efficiency improvements averaging 2% per year in the period up to 2020, and to introduce the production of renewable energy in 2020.

149. For the livestock sector, the development of manure policy is recognised to be closely linked to the achievement of targets in the field of sustainable energy and, in particular, reducing other GHGs. By 2020 energy-intensive livestock farming (poultry, pigs and calves) aims for a complete switch-over on 20% of holdings to the use of sustainable electricity (e.g. biomass, solar water heaters for heat and/or small windmills and solar panels for their own electricity consumption). By the same date, the dairy sector aims to achieve the lowest emissions of GHGs per litre of milk in the EU; the dairy and pig sectors aim to separate 25% of their manure, reducing the need for artificial fertiliser and achieving a reduction (of 15%) in methane emissions from manure storage; and the poultry sector aims to incinerate 2/3 of its manure.

150. A number of programmes are also in place to realise the EU's 2020 goals of renewable energy across the whole food chain. For example, within the *Sustainable Logistics Innovation Programme*, industry and government shall work together to reduce energy consumption in the logistics chain.

151. The ***Netherlands*** also considers that research in the field of genetics (both Genetically Modified Organisms − GMOs − and ordinary genetics) is necessary in order to give higher energy value to energy crops and to adapt them to demanding growing conditions. In addition, government involvement may be necessary in GMO approvals for the non-food sector. The Dutch Government, together with Wageningen University and Research Centre and the European Association for Bio-industry (EuropaBio), is preparing to carry out an initial analysis of the current situation.

152. In the ***United States***, interest in renewable energy has developed rapidly, due in large part to a strong rise in domestic and international petroleum prices and a dramatic acceleration in the production of domestic biofuels (primarily maize-based ethanol).[24] A number of programmes are in place, focusing on: energy efficiency and conservation of domestic resources; research programmes that target the development of renewable sources of energy; and the creation of new industries and new jobs. These programmes are aimed at a variety of beneficiaries, including farmers, the private sector and academia.

153. Although many of the programmes have their roots in the 1970s, several major energy laws have been enacted since 2005: the Energy Policy Act of 2005; the Energy Independence and Security Act of 2007; the Energy Improvement and Extension Act; and the American Reinvestment and Recovery Act. Each of these laws established, expanded, or modified energy efficiency and renewable energy research, development, demonstration and deployment programmes.

154. Until recently, ethanol and biodiesel − the two most widely used biofuels − received significant government support under federal law in the form of mandated fuel use, tax incentives, loan and grant programmes, and certain regulatory requirements. While the mandate remains in place, several key biofuel programmes expired at the end of 2011 (e.g. a tariff on ethanol imported from most countries, as well as tax credits for ethanol).

155. The *Renewable Fuel Standard* (RFS) mandate requires that the nation's fuel supply contain a specified amount of blended biofuel. The RFS sets a minimum of the biofuel to be used in the United States and it also mandates maximum lifecycle GHG emissions from each type of biofuel contributing to the mandate. The mandate is enforced by a credit-trading scheme that ties together biofuel producers with refiners, exporters and blenders of oil-based gasoline (EPA, 2010). With the termination of tax incentives and import duty on ethanol, and the more ambitious targets being mandated, the RFS mandate has become the main policy instrument in the US for promoting the use of biofuels.

156. Moreover, with the more ambitious targets being mandated, the RFS could, in future, become binding (OECD, 2011). Current technological developments seem to suggest that the targets of the cellulosic biofuel mandate, as currently regulated by the EPA, are unlikely to be met by 2022. Binding mandates mean more consumption of biofuel than would otherwise occur, leading to higher domestic production or imports. The EPA has the authority to waive the total volume of renewable fuel mandated by the RFS, as well as the specific requirements for cellulosic biofuel and biomass-based diesel fuel, should domestic supply be inadequate to meet the mandate, or were the implementation of the requirements deemed to have severe economic or environmental effects. The *OECD/FAO Agricultural Outlook 2012-21*

24. US biofuel production is dominated by ethanol, 98% of which is produced from maize; biodiesel comes primarily from soybean oil (around 60%). About one-third of US maize production is devoted to ethanol production.

provides a detailed analysis of uncertainties surrounding the implementation of the mandate and the impacts of three alternative options (OECD/FAO, 2012b).

157. Federal support for the development of agriculture-based systems of renewable energy production is also provided in the form of loans, grants and loan guarantees; research, development and demonstration assistance; educational programme assistance; and procurement preferences. Also, several states have already established their own incentives, regulations and programmes to support renewable fuel research, production and consumption, that supplement (or exceed) federal incentives.

158. Most of the federal programmes are administered by five separate agencies and departments (the Environmental Protection Agency, the U.S. Department of Agriculture (USDA), the Department of Energy, the Internal Revenue Service and Customs and Border Protection).[25] However, as renewable energy production has been considered primarily a concern of energy, tax and environmental policy (rather than agricultural policy) most of the federal programmes that support renewable energy production in general, and agriculture-based energy production in particular, are outside the domain of the Farm Acts.

159. The USDA – and in particular the Rural Business and Co-operative Programmes − operate a wide array of programmes aimed at achieving the goal of 80% of America's electricity coming from clean sources (including wind, solar, nuclear, clean coal and natural gas) by 2035, and ensuring America's energy independence from imports.[26] These programmes provide grants, guaranteed loans and payments for a wide range of purposes, including: support for rural energy efficiency and self-sufficiency; research, development, deployment and production of advanced biofuels (especially cellulosic); realisation of energy efficiency improvements (e.g. providing aid for conversion of older heating sources to cleaner technologies); installation of renewable energy systems (e.g. installation of flexible fuel pumps, solar panels and building bio-refineries); completion of energy audits and feasibility studies; encouragement of federal procurement of bio-based products; and creation of educational programmes to increase understanding of biodiesel and promote its use.

160. The 2002 Farm Act was the first omnibus Farm Act to explicitly include energy. Under the 2008 Farm Act (The Food, Conservation, and Energy Act of 2008), renewable energy policy built on the programmes initiated under the 2002 Farm Act, by amending or establishing various biofuels incentives, including lowering the value of the ethanol excise tax credit, establishing a tax credit for cellulosic biofuel production, extending import duties on fuel ethanol, and introducing several new grant and loan programmes (all of which are set to expire at the end of FY2012) (OECD, 2011b).

161. The 2008 Farm Act authorised USD 1.1 billion in mandatory funding for FY2008 through to FY2012, compared with USD 800 million under the 2002 Farm Act (FY2002-07), with most of the increase mandated for the Biorefinery Assistance Program, which aims at promoting the development of advanced biofuel refining capacity.

162. US policy to expand the production of agriculture-based renewable energy − especially biofuels and wind power – has significant implications for agriculture and resource use. The production of maize-based ethanol – and, consequently the overall production of maize − has expanded dramatically over the

25. The Department of Energy operates the greatest number of efficiency and renewable energy incentive federal programmes; the Department of the Treasury and the Department of Agriculture operate several programmes; a few programmes are also conducted by the Departments of Transportation, Labor, and Housing and Urban Development. For more details discussion, see Yacobucci (2012) and OECD (2011).

26. In addition to these programmes, there are several conservation programmes which significantly reduce fuel and other energy-related costs, such as the Conservation Security Program, the Environmental Quality Incentive Program, Conservation Technical Assistance, etc.

past several years. The effect on agricultural commodity markets has been national, but commodity production adjustments and the resulting environmental outcome, vary across regions (Malcolm, Aillery and Weinberg, 2009). Changes in the crop sector have also affected the cost of feed for livestock producers. Most notably, since 2006 the escalating demand for maize as a component of feed in ethanol production was one of the factors contributed to the sharp increases in driven grain and oilseed prices. As commodity price inflation has accelerated both in the US and globally, the "food versus fuel" debate has come to the fore of the policy agenda.

3.3 Waste[27]

163. A considerable amount of "waste" can be generated by the food and agriculture sector system, which not only adds to pressure on the land and water resources used by the system, but also represents an untapped resource. As noted earlier, the food and agricultural system has become increasingly energy intensive. The growth in the production of "convenience" foods and changes in the presentation of foods to consumers (e.g. vegetables that have been washed and packaged rather than sold in their relatively unprocessed state) not only increases energy usage, but also generates a higher waste stream in the form of excess packaging.

164. The standards set by retailers (e.g. requirements on the size and appearance of fruit and vegetables) can also add to the amount of material entering the waste stream, as products that do not meet those requirements are unable to find a market.

165. Green growth in agriculture and the food system will require participants in the system to examine product life-cycles and governments will need to evaluate what they can do to help reduce energy usage and product waste. This is already beginning to happen. For example, food retailers in some OECD countries are beginning to reduce the amount of plastic packaging they use and various initiatives are being taken to promote the recycling of packaging materials.

166. Many of the supply-side initiatives involve the creation of networks, platforms or partnerships with participation from industry and other stakeholders. Governments can assist through the use of conventional measures, such as funding research, education and demonstrations of green technologies. They can also promote greater efficiency in the use of energy and of food and raw material production in the sector by modifying existing regulations (e.g. those relating to product standards, or the use of waste products in feeding livestock.

167. In 2010, the ***European Union*** adopted a communication on bio-waste and the topic of waste is receiving increasing attention in the European policy agenda. A strategy for food waste reduction is being developed, as indicated in the road map on *Resource Efficiency*.

168. In the ***United Kingdom***, there are initiatives to reducing waste in food chains. The *Waste Resources and Action Programme* (WRAP) initiative entails government collaboration with businesses, individuals and communities to reduce food waste. Household food and drink waste represents GBP 12 billion in lost value and 20 million tonnes of CO_2-equivalent in emissions each year. Research by WRAP focuses on ways to cut down the amount of food thrown away by consumers and covers consumer habits, attitudes and behaviour patterns, appropriate ways of communicating to priority audiences and retail innovation. In partnership with WRAP, the grocery sector has instigated changes to make it easier for consumers to buy the right amount of food, and to optimise freshness and value, as well as to implement

27. The market and trade effects of reducing food waste will be examined in a separate study during the 2013-14 PWB of the Committee of Agriculture.

large-scale consumer campaigns. As a result, 670 000 tonnes of food waste have been diverted from landfills, saving GBP 600 million a year.

169. In ***Austria***, the *Waste Prevention Programme* was set up in mid-2011 by the Ministry of Environment, as part of the Federal Waste Management Plan 2011. It targets: the construction sector; industry and households in general; the food sectors (notably the food industry, retail and large-scale catering establishments); and the re-use sector (including repair networks).

3.4 Water

170. New OECD work is analysing trends and patterns of innovation in water and conservation technologies.[28] As shown in **Figure 3.2,** innovations (as measured by patents) in water-related agricultural technologies, such as drip irrigation, drought-resistant crops and controlled watering have grown steadily over the last decades.[29] Drought-resistant crop technologies experienced the highest rate of growth, with very high growth at the end of the 1990s and the beginning of the 2000s, before flattening towards the end of the period. There was a peak in this field at the end of the 1990s, when inventions were filed in 6 patent different offices.

171. Innovation in water-related technologies appears to be concentrated in a handful of countries. World-wide, the ***United States*** is by far the front runner in innovations in agricultural water technologies, while certain countries have achieved strong positions in specific fields (**Table 3.1**). For example, ***Italy*** is the third-most innovative country in the world for control of watering; ***China*** is the third-most innovative country in the development of drought-resistant crops; and ***Israel*** is the second-most inventor country in the area of drip irrigation. The top 20 inventor countries in each agricultural water-related technology are presented in **Table 3.1**).

172. Interestingly, the development of more than half of inventions in the development of drought-resistant crop technologies has been through international collaboration. On the other hand, the rate of international co-invented patents for drip irrigation and control of watering inventions is rather small, amounting to only 5%.

173. Concerning policy approaches, it should be noted that, as water issues are mainstreamed in the activities of the Organisation, the present document includes only those countries which have provided information on their water policies.

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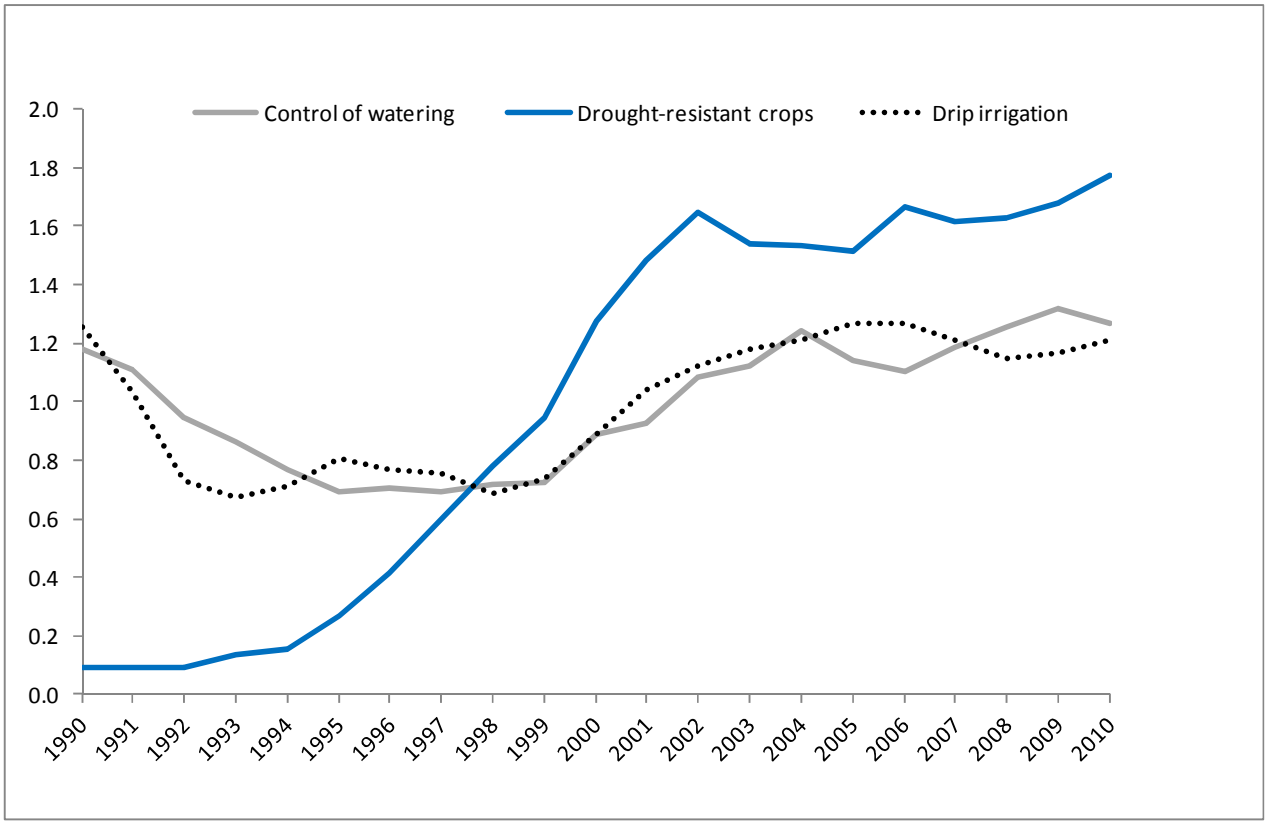
28. This OECD work provides the first descriptive analysis of innovation in water-related adaptation technologies and of their international diffusion at the global level (Dechezleprêtre, Haščič and Johnstone, 2013). The analysis is based on a unique data set comprised of over 50 000 patents filed in 83 patent offices, between 1990 and 2010, and covers a wide range of technologies that may either increase the supply of water in drought conditions (e.g. rainwater collection, groundwater collection, water storage, desalination, etc., or decrease water consumption (e.g. water control in agriculture, drought-resistant crops, drip irrigation, water efficiency technologies in power production, domestic water recycling, efficient water distribution systems, etc.).

29. These three water-related technologies are defined as follows: *Drought-resistant crops*: mutation or genetic engineering; DNA or RNA concerning genetic engineering, vectors (e.g. plasmids, or their isolation, preparation or purification for drought, cold, or salt resistance). *Drip irrigation*: watering arrangements located above the soil which make use of perforated pipe-lines or pipe-lines with dispensing fittings; and *Controlled watering*: watering arrangements making use of perforated pipe-lines located under soil level.

Figure 3.2. Trends of water-related innovations in agriculture



Note: To make the series comparable they have been normalised by their own average.

Source: Dechezleprêtre, Haščič and Johnstone (2013),.

174. Only a few countries reported policies aimed at improving efficiency of water use in agriculture.[30] In ***Australia***, the *National Water Market* provides incentives for the efficient use of water resources. It is composed of several separate water markets, differentiated by water systems or administrative boundaries. The scale of Australia's water markets varies greatly, from small, unconnected water markets to extensive connected systems such as the Murray-Darling Basin, the largest water-trading area in Australia. Water trading provides opportunities for water resources to be allocated between competing uses. Each state and territory maintains responsibility for the legislative and administrative arrangements for water rights and water trading. The water market has a number of participants, including: users and owners (e.g. irrigators, farmers, rural water utilities, irrigation infrastructure operators, industry, urban water utilities and environmental groups); intermediaries (e.g. brokers, solicitors, banks); researchers (e.g. environmentalists, scientists, economists and hydrologists); government (e.g. the Australian Government, state and local government and trade approval authorities; and public (e.g. investors, community groups and the general public).

30. The OECD series on water provides policy analysis and guidance on the economics, financial and governance aspects of water management. The OECD (2012c) report examines the linkages between agriculture and water quality, including recent policy experiences in OECD countries in addressing water quality issues in agriculture.

Table 3.1. Top-20 inventor countries by technology in water efficiency and conservation technologies for agriculture (2000-10)

	Controlled watering		Drought-resistant crops		Drip irrigation	
Rank	Country	Share of world's high-value inventions (%)	Country	Share of world's high-value inventions (%)	Country	Share of world's high-value inventions (%)
1	USA	40.3	USA	44.7	USA	29.2
2	Germany	7.6	Japan	9.0	Israel	10.9
3	Italy	7.1	China	6.7	Japan	7.6
4	Australia	5.9	S Korea	4.5	Germany	7.4
5	Canada	4.4	Germany	4.4	S Korea	5.9
6	Israel	4.2	Canada	3.8	China	5.9
7	Taiwan	4.2	Spain	3.5	Switzerland	3.9
8	Japan	4.0	Israel	3.2	Taiwan	3.7
9	UK	3.8	India	3.2	Australia	3.5
10	Switzerland	3.0	France	2.8	UK	3.1
11	France	2.3	UK	2.6	Italy	3.1
12	Spain	2.3	Belgium	2.5	Spain	2.7
13	S Korea	1.5	Australia	2.4	Canada	2.7
14	China	1.2	Netherlands	1.2	France	1.8
15	New Zealand	1.2	Italy	0.8	Greece	1.7
16	Netherlands	1.2	Austria	0.7	Austria	1.2
17	Denmark	0.8	Switzerland	0.5	Sweden	0.8
18	Norway	0.8	Hungary	0.5	Mexico	0.8
19	Brazil	0.6	Taiwan	0.5	Brazil	0.6
20	Sweden	0.4	Hong Kong	0.4	Belgium	0.4

Source: Dechezleprêtre, Haščič and Johnstone (2013).

175. In ***Germany***, the 2007 amendment to the Fertiliser Act set: a minimum distance to be respected in between water bodies and sites where fertiliser application may be carried out; limited the application of animal-based fertilisers (to 170 kg of nitrogen/ha/year); set area-related upper limits for the application of nutrients from farm manure of animal origin; and set requirements on the application of fertilisers. The 2010 *Federal Water Act* specified further requirements for buffer zones for the use of pesticides and fertilisers near river banks.

176. In ***Greece***, according to the requirements of Directive 91/676/EEC (introduced into the national legislation with JMD 161890/1335/1997), eight vulnerable zones (with respect to nitrogen pollution from agricultural run-off) have been identified and suitable action programmes have been put in place. The adoption of sound agricultural practices, obligatory for all farmers operating in vulnerable zones, is a key element of these programmes.

177. In addition, a *National Plan of Action* has been developed in the context of implementing the 2009/128/EC Directive aiming to protect the human health and the environment (based on a joint ministerial decision). The newly developed legislative framework aims to protect the aquatic environment and freshwater from the impacts of pesticide use. For this purpose, a number of special areas have been set up, where the use of pesticides is either restricted or forbidden.

178. In March 2011, a joint ministerial degree (JMD) regulating waste water management was signed, that includes, among other things, the re-use of treated wastewater for irrigation purposes. This measure has been designed to save water resources and to promote the use of treated wastewater (i.e. minimising the use of freshwater in irrigation, industry, etc.). A JMD was passed in June 2011, requiring farmers and cattle breeders to declare their irrigation bores by the end of the year. This measure is aimed at monitoring the abstraction of ground water being used for irrigation reasons; controlling the unreasonable use of water resources; and defining the water rights of farming areas.

179. In ***Ireland***, the objective of the Rainwater Harvesting Scheme is to conserve water by maximising the use of rainfall run-off and thus reduce water costs on farms. Grant-aid support is provided for rainwater harvesting facilities and equipment. The scheme has been targeted initially at young trained dairy farmers.

180. In ***New Zealand***, the primary purpose of the *Irrigation Acceleration Fund* is to support: i) investments for regional-scale rural water infrastructure; ii) funding for strategic water management studies; and iii) funding for community irrigation schemes.

3.4.1 Water management and property rights

181. The OECD work on water management in agriculture points out that the shift in water resource policies, with a greater accent on demand rather than supply management, has brought reforms to the institutional and property right structures in many countries (OECD, 2010). But the progress and path of water policy reforms has been mixed across countries. Poorly defined property rights, including problems over separating land from water entitlements found to be one of the key impediments to water market formation and further strengthening of property rights and institutions for water management in agriculture is advocated.

182. In most OECD countries, water property rights − in terms of access − involve a complex set of rules, where water is often allocated in terms of *quantities* rather than *prices,* between users and for environmental needs. As pressures builds-up to reallocate water between different users and to meet environmental demands there is a need for water property rights to become more flexible, where these rights exist and for supporting institutions to be more robust to ensure an economically efficient and environmentally effective allocation of water.

183. Regimes for groundwater rights are generally less developed compared to surface water (see the OECD questionnaire at www.oecd.org/water). User right systems are also frequently unco-ordinated between groundwater and surface water. Typically the landowner (farmer) is given the exclusive right to extract from groundwater beneath his/her property, although most countries have introduced regulations to limit private extraction from commonly shared groundwater resources and landowners will normally require consent from a government agency prior to making extractions. Some states in **Australia** have more advanced water rights regimes for groundwater, involving water entitlement licences (which might only be issued for 5 to 10-year periods), annual allocations and trading in groundwater (see **Box 3.5**).

Box 3.5. Water policy reforms and property rights: The Australian experience

Australia has embraced the idea of competition and markets as a paradigm for water management. A nationally consistent water entitlement and trading system has been established to provide security to both water users and the environment. Water trading allows scarce water resources to be transferred to their most efficient and productive uses, and is being delivered through a range of State and National initiatives. The result has been the generation of significant opportunities to achieve sustainable and efficient water use. The development of water markets is seen as a key mechanism, along with planning and appropriate regulation, to address over allocation of water resources whilst optimising the economic, social and environmental outcomes in Australia. This integrated approach will also assist to adapt to changing water availability in the face of a climate change.

Underpinning the Australian experience is a suite of institutional and property right reforms that have made it easier to set up viable water markets. The general model is one that has involved development of a water entitlement regime that allows people to own the right to use water. State governments' legislation makes it clear that water is controlled by the State on behalf of the general public. Water users may only acquire or hold an entitlement to use water that is available according to a statutory water plan. Moreover, it is the role of governments rather than the courts to determine how much water is available for use. The result is a property right regime that is conducive to the development of efficient markets. In general the rights to use water is 'unbundled' into a three part structure:

- The ***entitlement*** is a proportionate share of water as specified in a water plan. This entitlement is separate from any land title and may be traded among any willing purchasers. These are referred to as permanent trades.

- Decisions on ***volumetric allocations*** are made on an ongoing basis throughout a water year. The allocation is made to an entitlement and recorded in the water account associated with the entitlement. Allocation trades, or temporary trades as they are called in Australia, can then be made by debiting one account and crediting another. Allocations are not linked to land titles. These annual allocations may be traded among willing purchasers.

- ***Use approvals*** then set out the rules for applying water to a nominated area of land and deducting the amount used from a water account associated with the use approval. Site use approvals are not generally tradable as the conditions relate specifically to a piece of land.

In the face of worsening climatic conditions in eastern and southern Australia and difficulties in rebalancing the amount of water in the environment pool versus the consumptive pool and addressing institutional weaknesses, the Federal Government announced Water for the Future in 2008. Water for the Future is a AUD 12.9 billion investment over 10 years with overarching objectives to take action on climate change, use water wisely, secure water supplies and support healthy rivers and waterways. Investment is being mainly used to purchase water entitlements for the environment and infrastructure upgrades and reconfiguration, with water savings being returned to the environment on a shared basis.

Source: Adapted from OECD (2010).

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IV. POLICIES ORIENTED TOWARDS IMPROVING THE ENVIRONMENT

184. One of the central issues in achieving green growth is to ensure that all the costs associated with economic activity are reflected in production and consumption decisions (i.e. that they are internalised either through prices or via some other mechanism). In terms of market-based instruments, two major approaches have long been identified – one based on the use of taxes and subsidies (Pigou, 1932) and the other based on the attribution of property rights (Coase, 1960). An alternative approach is the use of various non-market instruments, including regulations.

185. Market-based instruments aim at addressing market failures mainly through price signals. This category includes environmentally-related taxes, charges and fees, tradable permits, and subsidies for reducing pollution. Non-market approaches can be divided into separate categories – one covering direct environmental regulations, and the other covering voluntary approaches, including information-based instruments.

186. Each of these approaches has its own participation advantages and disadvantages and none is universally superior to the others. Efficacy and efficiency depend on a range of factors including the nature of the issue to be addressed, the institutional environment, and the technical limitations and constraints associated with the use of particular policy instruments.

187. The OECD *Green Growth Policy Toolkit* (**Table 1.1**) promotes a shift away from more environmentally harmful supports, towards environmentally beneficial payments and requirements. Adoption of these adjustments would enhance the productivity of environmental investments and make farm support measures a more effective vehicle for green growth. It would also increase the effectiveness of environmental regulations in agriculture due to a decrease in the negative ecological impacts of farm support. Such a shift in the composition of agricultural support would result in an overall reduction in the cost of achieving environmental objectives, and lead to increased eco-efficiency.

4.1 Market-based instruments

188. In several sectors, market-based instruments – primarily taxes and charges and tradable permit systems – are used as a means of discouraging practices that are damaging to the environment by raising the cost of these activities to producers. The role of these economic instruments in promoting Green Growth in agriculture is not, however, as significant as in other sectors (e.g. transport). Due to both the nature of property rights systems and difficulties in identifying sources of pollution, taxes are relatively ineffective for dealing with negative environmental externalities in agriculture, which tend to be location-specific and diffuse in nature. In many cases, regulations and payments have proved easier to implement than taxes in encouraging greener activities among agricultural producers.

4.1.1 Payments

189. Governments provide supports to farmers and agri-businesses to manage the supply of agricultural commodities, influence their cost, supplement producers' income and achieve other social and environmental aims. This support to farmers, which was estimated to total USD 248 billion (EUR 181 billion) in 2009-11 in terms of the OECD Producer Support Estimates (PSE) (or 20% of farm gross receipts), can be ranked according to its potential impacts on the environment (**Table 4.1**).

190. Market price support mechanisms and payments based on output are potentially the most harmful for the environment because of the production incentives they create, whereas payments based on cropped land, animal numbers, historical entitlements or overall farming income are likely to be more neutral in environmental terms, as they place limits on the level of production supported and constitute a form of decoupled support (**Box 4.1**).

Box 4.1. Relative *potential* impacts of support measures to producers on the environment

Since the mid-1980s, as part of its work on monitoring and evaluating agricultural policy developments, the OECD Secretariat has measured, on an annual basis, the level and composition of support (monetary transfers) associated with agricultural policies in OECD countries (and, to an increasing extent, also for non-OECD countries), using a standard methodology. The classification of support into different categories is based on how policies are actually implemented and not on the objectives or impacts of those policies. The categories of the support to producers, as measured by the Producer Support Estimate (PSE), reveal the transfer basis for support (based on commodity output, input, area/animal numbers/receipts/income or non-commodity output); whether the support is based on a current or historical (fixed) basis and whether production is required in order to receive support. Each policy measure is also labelled with supplementary implementation details, which for example, show whether the policy measure is provided with or without production limits; whether or not it involves constraints on input use or farming practices (i.e. specific requirements concerning farming practices related to the programme in terms of reduction, replacement or withdrawal, in the use of inputs, or a restriction of farming practices). Moreover, the payments that require input restrictions are further broken down into payments that are conditional on compliance with basic, mandatory requirements (e.g. cross compliance) and payments that require specific practices going beyond basic requirements and are voluntary. Payments requiring voluntary input constraints are further disaggregated into payments requiring practices related to: i) environmental issues (i.e. agri-environmental programmes); ii) animal welfare; and iii) other specified practices. OECD 2009, Box 2.2, discusses how agri-environmental payments are classified in the various PSE categories.

The PSE classification of categories of policy measures, although based on implementation criteria, has the potential to show the degree of flexibility in production choice that farmers have and, thus, how different policies could influence farmers' decisions to produce commodities and non-commodity outputs using farm resources. OECD work on monitoring and evaluation has demonstrated that, in general, the more a policy measure provides incentives to increase the production of specific agricultural commodities, the greater is the incentive towards monoculture, intensification (greater yields), or bringing marginal (environmentally sensitive) land into production, and the higher is the pressure on the environment. On the other hand, the more a policy measure can be targeted to a specific environmental goal, the greater is its potential effectiveness in achieving that goal (OECD, 2001a; 2001b; 2004; 2006; 2010).

Ranking agricultural policy measures according to their potential relative impacts on production shows that, all other things being equal, market price support, output payments (per output unit produced) and variable input subsidies (such as those that apply to fertilisers, pesticides, water and energy) provide the greatest potential incentive to increase commodity production, although this effect is weakened when constraints on output produced or inputs used are in place. Policy measures that are designed to deliver support based on current parameters, such as area or animal numbers and that require commodity production, have a potentially somewhat weaker influence on production incentives. Policy measures providing support based on historical parameters, such as the overall farm area or income of the farmer, have potentially far less influence on production incentives, while those that provide support based on non-commodity criteria (such as the provision of trees, stone walls and hedges), have potentially the least influence on production and can be targeted to specific environmental objectives.

It should be emphasised that neither the total PSE nor its composition in terms of different categories of policies can be interpreted as indicating the actual impact of policy on production and markets. Clearly, the actual impacts (ex post) will depend on the many factors that determine the aggregate degree of responsiveness of farmers to policy changes – including any constraints on production. For example, while it is true that market price support mechanisms and payments based on output are potentially the most harmful for the environment, whether they actually are harmful depends on a host of other factors, including whether production quotas are attached to them and whether they incorporate strong cross-compliance requirements, or are constrained by agri-environmental regulations independent of the support payments. Similarly, payments based on area, animal numbers, farm receipts or income, and historical entitlements are only potentially neutral in their effects on the environment, but may be harmful − or even beneficial − depending on specific programme designs and other regulations.

Notes: Annex Box 1 of the OECD (2005) study provides a more detailed discussion on the potential impacts of the various PSE categories on the environment; while the OECD (2009b) study provides an extensive discussion of the potential impacts of PSE categories on different types of farmland management.

Source: OECD (2005; 2009).

191. Payments based on non-commodity criteria and payments for input use linked to constraints on resource use are generally beneficial because they are usually designed to help reduce agricultural pressures on the environment. These include supports given to farming systems and practices that preserve environmentally sensitive land and biodiversity; maintain flood, drought or soil erosion control; and provide sinks for greenhouse gases and carbon storage. However, the level of green supports to farming are far outweighed by variable input- and production-linked support policies that have damaging environmental effects.

Table 4.1. Share of PSE supports in the OECD area by category, ranked by potential environmental impact (%)

Potential environmental impact	Type of support measure	1995-97	2009-11
Potentially most harmful	Market price support	67	43
	Payments based on commodity output, without imposing environmental constraints on farming practices	3	2
	Payments based on variable input use, without imposing environmental constraints on farming practices	4	5
	Total	*74*	*50*
Potentially less harmful	Payments based on current cropped area/number of animals/receipts or income, without imposing environmental constraints on farming practices	10	5
	Payments based on historical entitlements/receipts or income, without imposing environmental constraints on farming practices	1	2
	Payments based on fixed capital formation, without imposing environmental constraints on farming practices	3	3
	Payments based on on-farm services, without imposing environmental constraints on farming practices	2	3
	Total	*16*	*14*
Potentially more beneficial	Payments subject to environmental cross compliance(1)	*5*	*28*
Potentially most beneficial	Payments based on non-commodity criteria that impose environmental constraints on farming practices	1	2
	Payments based on fixed capital formation that impose environmental constraints on farming practices	1	1
	Payments based on on-farm services that impose environmental constraints on farming practices	0	0
	Payments based on variable input use that impose environmental constraints on farming practices	0	0
	Payments based on current cropped area/number of animals/receipts or income that impose environmental constraints on farming practices	3	4
	Payments based on historical entitlements/receipts or income that impose environmental constraints on farming practices	0	1
	Payments based on commodity output that impose environmental constraints on farming practices	0	0
	Total	*5*	*8*

Note 1: This includes payments from various PSE categories which are subject to environmental cross compliance.

Source: OECD Secretariat calculations based on OECD PSE/CSE database, 2012.

192. OECD countries have made a concerted effort to reduce the most environmentally harmful types of agricultural supports – those based on prices and output levels – and have achieved a decrease from over 74% of the total in 1995-97 to 50% in 2009-11. About 96% of payments in this category take the form of market price support. Price support for agricultural commodities masks market signals to producers and encourages intensification of production, entailing higher levels of fertiliser and pesticide use and subsequent adverse effects on the environment, soil quality and biodiversity. While some countries have taken clear steps to decouple support from output and price levels, other countries have not yet begun to address the problem.

193. Payments based on levels of input use have increased as a share of PSE in this time period (from 1995/97-2009/11) from 10% to 13% of PSE. There are three main targets of supports for input use: 1) support for the (unconstrained) use of variable inputs such as credit, fertilisers, fuel or water; 2) support for fixed capital formation or on-farm investments; and 3) support for on-farm services including pest and

disease control and seed and soil testing. The first category has by far the most negative environmental impacts. Support to input use in OECD countries is evenly divided across these three approaches, although there are wide variations among countries.

194. Domestic price supports have been largely replaced in this decade by direct payments based on past entitlement levels or farm income, and which may or may not require production. Payments that do not require production and are based on factors other than output (*e.g.* area, animals, receipts or income) now account for over a third of total support to producers in the OECD area. These supports are mostly aimed at increasing farm income, with less production-distorting and potentially less environmentally damaging effects than those requiring commodity production.

195. Payments based on non-commodity criteria (i.e. mainly agri-environmental schemes) continue to increase their share of total PSE, but still account for only 2% of agricultural support in OECD countries. Payments are made to agricultural producers to adopt specific farming practices, such as retiring environmentally fragile land from production, planting trees, or changing tillage practices in a way that can contribute to alleviating climate change or flood risk. Payments are also made to farmers to provide public goods such as landscape elements, biodiversity preservation and wetland conservation.

196. In some countries, it is possible to make supports conditional on producers following specified production practices in pursuit of broader environmental objectives. Environmental cross compliance may be required, with the policy acting as compensation or incentivise to meet regulatory requirements. Payments subject to environmental cross-compliance requirements have increased to apply to 28% of total PSE in the period 2000-11 (as compared to 5% in 1995-97). Among OECD countries, the ***European Union***, ***Switzerland*** and the ***United States*** provide more than 50% of their agricultural supports with some constraints linked to environmental protection and other objectives (OECD, 2010; Claassen, 2012). In the EU, environmental cross-compliance is applied to over 95% of commercial farms.

197. Other things being equal, with respect to furthering environmental objectives, targeted measures are likely to be more efficient and cost effective in achieving specific environmental aims than cross-compliance approaches. Under cross-compliance, the distribution of income support payments is unlikely to correspond to the distribution of environmental costs or benefits of agricultural production. Income support payments are typically linked to current or historical production, whereas it is often the case that the volume of production from farms in areas of high environmental value is relatively low. In that case, high levels of payments to farms in relatively productive areas under cross-compliance conditions are likely to generate relatively modest environmental returns per unit of expenditure.[31]

198. That being said, cross-compliance is clearly preferable to price support measures that provide an income transfer to farmers without any environmental conditions. More generally, however, price and income support that is directly linked to current output is likely to intensify production, which may work against the aim of reducing the stress that farming places on the environment. Given the likelihood that public funds will be increasingly scarce in the future, there is a strong argument for shifting expenditure from relatively untargeted measures for improving environmental quality to more targeted measures, such as those under environmental programmes.

199. In reality, many environmental programmes are composed of a mixture of measures – such as implicit taxes imposed by rules and regulations and subsidies – designed to reduce negative externalities (e.g. such as water pollution), and measures designed to increase positive externalities (e.g. such as an

31. The econometric study by Bokusheva, Kumbhakar and Lehmann (2010) found that in Switzerland environmental cross compliance increased the productivity of single inputs in milk farms, but decreased it in crop farms.

increase in wildlife populations). The advantage of such programmes is that, if designed appropriately, they can address environmental issues at a much finer geographical scale than other programmes, can be targeted to achieving specific environmental outcomes, and can achieve these outcomes at lower cost than untargeted measures.

200. Finally, the use of payments to achieve environmental aims can confront problems of conflicting objectives. For example, in order to maintain a particular wildlife ecosystem (*e.g.,* one created by the grazing of hill land by ruminants) there may be a trade-off in terms of providing an incentive for the maintenance of particular production systems. Grazing animals may increase the nutrient loading in water supplies and add to GHG emissions at the same time as protecting wildlife habitat. A choice may have to be made between ecosystem preservation and other environmental objectives in such situations.

4.1.2 Environmental taxes

201. Only a few countries have levied taxes and charges on farm inputs as a way of addressing environmental issues in agriculture. These have mostly been applied to environmentally-damaging chemicals, such as those associated with fertiliser and pesticide use.

202. In ***Denmark***, the law on the restructured pesticide tax, which was due to be submitted in the autumn of 2009, came into force in January 2012. A key element of the tax is that smaller or specialised crops, such as potatoes and lettuce, should not be so heavily taxed that their production would be outsourced. In addition to the new tax, a new national target was set for the use of pesticides based on environmental impact, and several measures were passed to support the greater use of Integrated Pest Management (IPM), according to EU Directive 2009/128/EC. One of the objectives is to provide subsidised advice in the clearance of IPM.

203. Carbon taxes in agriculture have not been seriously considered even though farming can be a very-energy intensive sector. Farmers use carbon-based fuels directly in vehicles and machinery and indirectly in the form of carbon-based fertilisers and pesticides and fuel-intensive inputs. While a tax could be introduced in order to encourage use if more energy-efficient systems of production, proponents of carbon taxes have generally sought to exclude the agricultural sector, since emitters are not easily identifiable and it is often difficult to monitor the amount of emissions.[32]

204. Moreover, the application of taxes designed to reduce GHG emissions in agriculture could conflict with other environmental objectives. For example, there may be a desire to maintain grazing animals in order to preserve certain types of landscapes and grazing-dependent ecosystems. If the effect of a GHG tax were to cause farmers to reduce stocking rates or to abandon livestock farming this could have a negative impact on such ecosystems. There could also be a conflict with other types of policies − for example, the provision of subsidies under agri-environmental programmes to encourage certain types of land-use systems.

205. More generally, taxes are difficult to apply when non-point-source pollution is involved and this tends to be the case throughout much of the agricultural sector. In the water quality area, for example, it can often be difficult to determine the source of the pollution of water bodies – and, specifically how much a particular farm contributes to the problem. Where the amount of nutrients generated can be monitored –

32. Levying such taxes on agricultural output has the disadvantage that there is no incentive for farmers to reduce the level of emissions in the production process. For example, were a tax to be applied per head of livestock, there would be an incentive to maximise the sales weight of the animal in order to lower the rate of tax per kilo. The higher use of feed that this would involve could weaken the effectiveness of the tax in reducing emissions.

for example, in concentrated feeding operations – it is somewhat easier to monitor the externality and to address it.

206. There may be wider scope for the application of taxes and charges to promote the internalisation of environmental costs in agricultural production decisions, but this would require clearer definitions of property rights. In the agricultural sector, different types of rights – access and use rights, control rights and transfer rights – co-exist and are attached to various types of land ownership (FAO, 2011).

4.1.3 Tradable rights

207. As with taxes, tradable rights based on environmental quotas, permits and restrictions do not yet appear to play a significant role in agri-environmental policy, despite the growing use of such measures for environmental policy design in other sectors. Tradable rights have been used mainly in the area of water management (*e.g.* ***Australia*** and the ***United States***) and agricultural nutrients (*e.g.* Ontario in ***Canada***, the ***Netherlands*** and the ***United States***).

208. ***Australia*** and ***New Zealand*** designed tradable permits to address the concern of GHGs from agriculture. ***Australia's*** *Carbon Farming Initiative* (CFI), which is the world's first national scheme aimed at reducing carbon emissions from farming and forestry, was enacted in August 2011 and is part of a suite of land sector measures under the wider *Clean Energy Future* package, which is the Government's climate change initiative for primary industries. Potential participants in the CFI include farmers, landholders, foresters, community groups, businesses and local governments.

209. In ***New Zealand***, the *Emissions Trading Scheme* (ETS), a price-based mechanism for GHGs, is a key policy instrument and represents one of the Government's efforts to meet its international commitments on climate change and move towards a low carbon economy: it will fully cover agriculture as of 2015. However − with some exemptions − the emissions trading system sets the point of obligation for agriculture emissions at processor level (i.e. meat and dairy processors, and fertiliser companies), rather than at farm-level, in order to reduce regulatory and transactions costs.

4.2 Non-market (regulatory) instruments

210. A Green Growth strategy in agriculture entails strengthened regulations and standards to ensure that agricultural producers internalise environmental costs to a greater extent. For example, the discharge of dangerous substances into agricultural land, groundwater and waterways could be better controlled and/or prohibited. Reductions in GHG emissions from agriculture could be achieved through regulations covering land, soil and nutrient management aimed at lowering emissions from soil decomposition. Livestock management regulations have been shown to be effective in greatly reducing methane emissions. Stricter health and safety standards for food commodities could reduce problems arising from the use of polluting agro-chemicals (*e.g.* nitrogen and phosphorus loading). Fines and penalties for breaching environmental laws in agriculture are the usual means of enforcement, although they are not always adequately applied.

211. Regulatory requirements have long been applied in the agricultural sector to prevent negative impacts on the environment from agricultural activities and all OECD countries impose a complex set of regulations. Regulatory measures can meet agri-environmental objectives in a variety of different ways, imposing differing degrees of restrictiveness on landowners. These regulatory requirements range from outright prohibitions, to very prescriptive details about farm management practices and resource-use requirements. Most of the regulations in force in OECD countries are related to the use (storage, handling, plant and animal application) of agricultural inputs (pesticides, industrial fertilisers, manure) which have the potential to cause negative environmental effects (in terms of soil, water and air pollution) (**Table 4.3**).

Table 4.3. Matrix of environmental regulations in agriculture

Regulation	Purpose	Form
Water quality	Maintain chemical, physical and biological integrity of water by addressing point and non-point sources of pollution	Groundwater controls Pollutant discharge permits Animal feeding restrictions Irrigation rules
Air quality	Maintain and improve the quality of air to protect human health and the environment by controlling emissions	Emission standards for air pollutants (e.g. nitrous oxide) Standards for particulate matter Air quality permits
Land use	Preserve the quality of land through limiting production intensity and the over-use of chemicals	Chemical use permits Limits on waste disposal Soil removal and placement rules
Pesticides	Control use of chemicals which may pose a risk to human health and the environment	Pesticide registration and labelling Pesticide use restrictions Food and feed residue limits
Natural habitats	Maintain or restore the natural habitats and populations of species of wild fauna and flora	Land development restrictions Protection of endangered species Agricultural habitat rules
Machinery & equipment	Maintain farm machinery and equipment in good working order and prevent environmental damage	Emission controls Noise limitations Diesel fuel restrictions
Food safety & quality	Safeguard the health and well-being of consumers	Animal welfare provisions Storage and handling regulations Food labelling requirements

212. There are also requirements concerning the use of land (including buffer strips and green coverage requirements) and the maintenance of water quality (including controls on groundwater, irrigation, silage and slurry operations) and protection of valuable wildlife and habitats. Stricter regulations tend to be applied in areas with higher environmental or resource conservation values. Some of these requirements are specific only to agriculture, while others are part of broader national environmental legislation affecting many sectors, including agriculture. Over time, OECD regulatory requirements for agricultural production have broadened in scope and have become increasingly stringent.

213. Some countries provide financial assistance to farmers (generally in the form of investment subsidies) to comply with stricter environmental regulations where this is consistent with the allocation of property rights between farmers and society. An increasing number of regulatory requirements also derive from state, provincial, regional or local measures under the framework of over-arching national regulatory policy and law, in order to accommodate the local nature of many environmental concerns.

4.3 Voluntary agreements

214. In a number of countries, farmers and landowners (often grouped in local initiatives) are involved in voluntary agreements to facilitate group activities aiming to improve the productivity and environmental sustainability of the agricultural sector.

215. Voluntary agreements range from initiatives under which participating parties set their own targets (and often conduct their own monitoring and reporting), to initiatives where a contract is made between a private party and a public body, or stakeholder groups such as local communities and/or non-governmental or environmental groups. By making public such commitments, voluntary agreements are expected to improve the resource efficiency and environmental performance of the sector concerned beyond the level required by the existing environmental legislation and regulations.

216. Voluntary agreements provide greater flexibility than regulations and can offer more ambitious goals, while lowering administrative and enforcement costs and enabling faster implementation. Moreover, they improve dialogue and trust between industry and stakeholders. However, voluntary agreements are difficult to apply in areas in which the sector does not have a business interest in voluntarily changing its behaviour; they are unable to incite all companies to invest in environmental protection; and they cannot, on their own, deal with negligent or consistently poor performers (existence of "free riders") (OECD, 2003).

217. Despite their voluntary nature, the level of enforcement of such agreements can be diverse and the targets set in the agreements can be either general, qualitative goals (e.g. continuous improvement) or specific quantitative targets relative to previous performance (e.g. reduction of material usage) or absolute targets (e.g. zero emissions).

218. Voluntary agreements also include instruments such as eco-labelling standards that seek to improve consumer awareness about the environmental impact of products and/or practices. In particular, in order to enable customers to distinguish products grown without chemical fertilisers or pesticides from conventionally produced agricultural products, a number of OECD countries have established standards for "eco-labels" and have set up bodies to certify their authenticity, particularly in relation to organic or integrated agricultural production processes, which influence production practices at farm level. As such, they could be an important instrument in stimulating the environmental dialogue aiming to achieve sustainable consumption and production.

219. One example is the *Environmental Certification for Farms* scheme of the 2010 "*Grenelle 2*" environmental law in ***France*** that enshrined environmental certification in the French code of rural law. It also created a new value statement for products, both processed and unprocessed, from farms certified as having "high environmental value". The scheme was designed by all of the partners in the *Grenelle* consultation process (i.e. the farming industry, environmental organisations, consumer bodies, representatives from downstream industries and relevant official bodies), it is voluntary and open to all sectors of the industry. It is built around four themes: biodiversity, plant protection strategy, management of fertiliser use and management of water.

220. It also includes so-called voluntary agreements, which are negotiated agreements between the government and particular agricultural sector(s) to address a specific environmental concern. For example, in the ***Netherlands***, *Green Deals*, launched by the government in 2011, aims to promote and accelerate the transition to a green economy by encouraging the private sector, NGOs and citizens to develop and implement projects for achieving a more sustainable economy. Through partnerships and the exchange of information, they work to remove harmful regulations and to make *Green Deals* effective. For example, the government has set targets for the Dutch Dairy Organisation and the Dutch Agricultural and

Horticultural organisation to achieve zero-carbon emissions in dairy chains by 2020. By removing harmful regulations, *Green Deals* aim to strengthen private initiatives.

221. Voluntary agreements can also be concluded with local communities. They involve government support to community-based groups implementing collective projects to improve environmental quality in agriculture. Since the 1980s, a number of countries, including ***Australia***, ***Canada***, and ***New Zealand*** place emphasis on the use of community-based approaches to resource management in rural regions, through collective action to address environmental issues. Much emphasis is placed on improving the flow of information and using peer pressure to attain results (OECD, 2009).

222. In ***Australia***, *Landcare* is a uniquely Australian partnership between the government, the community and business to address environmental issues in local communities. Landcare Australia Limited (LAL) was formed by the Commonwealth Government in 1989 as a private non-profit company with the aim of encouraging community groups to develop a self-help attitude and capacity in planning, promoting and using sustainable land, water and vegetation management practices. Its role is to raise awareness about *Landcare* in the broader community and to raise funds for *Landcare* and Coastcare projects on the ground. LAL works with its business partners to help deliver triple-bottom line results for each corporate sponsor. Its aim is to assist partners in improving their own economic, environmental and social outcomes. LAL receives funds from governments, corporate organisations and private donations.

223. In **Ireland**, Bord Bia (the Irish Food Board) launched the *Origin Green* programme in 2012. This voluntary sustainability development programme involves manufacturers setting targets in areas such as energy, waste, water, biodiversity, thereby minimising their overall carbon footprint and lessening their impact on the environment. The programme is also expected to result in increasing the industry's overall efficiency and competitiveness. The objective is to have 75% of Irish food and drink exports sourced from Origin Green members by the end of 2014, and to increase membership levels in the future. The ultimate aim is the creation of a significant point of differentiation for the Irish food and drinks industry around the area of sustainability. Full membership requires each participant to propose a plan containing specific actions to achieve to achieve quantifiable targets of improved sustainability performance.

224. In ***New Zealand***, a number of farmer-based *Landcare* groups, some of which receive administrative or financial support from regional authorities, have also formed over the past decade to address issues connected with sustainable agriculture. In addition, the *Sustainable Management Fund*, which was launched in 1994, provides cost-share support for community-oriented projects promoting environmental management, while the *Sustainable Farming Fund*, launched in 2000, provides funding on a similar basis towards projects aimed at improving the financial and environmental performance of the land-based sectors. These programmes encourage the transfer of information and technology from technical experts to communities, including farmers.

225. In the ***United Kingdom***, there are initiatives to improve the environmental footprint of food systems through the mobilisation of public-private partnerships. The Climate Change Act of 2008 commits the United Kingdom to an 80% economy-wide reduction in GHG emissions from 1990 levels by 2050. The agriculture industry's ambitious Greenhouse Gas Action Plan (GHGAP) aims to reduce annual emissions by 3 million tonnes CO_2 equivalent by 2018-22 through strategic delivery of messages, technical advice and information to agricultural producers in all farming systems. GHGAP builds on existing initiatives (for example, the Dairy Roadmap) and brings together whole supply chains, to encourage the adoption of farm practices that are more efficient and to reduce GHG emissions while enabling cost savings per unit of production and enhancing landscapes and biodiversity.

4.4 Technical assistance and institutional measures

226. Advisory and institutional measures include collective projects to address environmental issues and measures to improve information flows to promote environmental objectives. This information can be provided to both producers, in the form of technical assistance and extension, and to consumers, via labelling.

227. As noted earlier, greater emphasis has also generally been placed on communicating information to farmers on environmental issues via technical assistance and extension, in order to induce voluntary changes in farming practices and improved environmental outcomes. Such measures feature an increasingly comprehensive array of information, and now employ a wide range of communication tools, such as the Internet.

228. Demand-side measures, such as green public procurement are also receiving increasing attention, as governments acknowledge that insufficiently developed markets are often the key constraint for eco-innovation. Many governments are substantial purchasers of food – for the military, for the prison population, and for food assistance programmes. Such purchases can be used to promote the greening of the agricultural sector.

229. The ***Danish*** Green Growth Strategy also introduced changes to modernise legislation and harness structural development in order to provide farmers with better opportunities for growth, improve their the financial viability and increase the competitiveness of the agricultural sector. The limit on the number of animals on a farm and the requirement that a farmer must have a certain amount of land in relation to the number of animals on his/her farm has been removed.

230. The legislative changes introduced permit farmers, for the first time, to form shareholding corporations for the ownership of land for farming purposes. The previous legislation required individual ownership and management, and a maximum of four farms owned per farmer, or a maximum of 400 ha. The stated motivation for these changes was to avoid the closure of one-quarter of Denmark's 13 000 farms that had been forecast to take place within 5 years.

231. In the ***United Kingdom***, focus of the *Advice and Incentives for Farmers Project*, which is still at the development stage, is on the provision of targeted advice to farmers. The aim of the project is to better integrate advice for environmental outcomes and economic performance.

232. The performance of these "soft" agri-environmental measures will be examined in a separate project during the 2013-14 PWB. In particular, it is envisaged to assess the extent to which such measures contribute towards: i) improving: the economic viability of a farm, skills, employment creation and productivity improvement (including on-farm innovation and technology transfer); ii) the adoption of environmentally benign farming practices; and iii) the extent to which such measures are coherent with other support measures.

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V. CONCLUSIONS

233. An essential element of green growth is the adoption of policies that will foster economic development, while protecting environmental sustainability over time. Green growth implies policies that either incrementally reduce resource use per unit of value added (*relative decoupling*) or keep resource use and environmental impacts stable (or declining) while the economy is growing overall (*absolute decoupling*). A green growth strategy would yield a "double dividend" effect – higher growth with lower environmental impact – by improving the efficiency of resource use and increasing investments in natural capital to drive economic growth.

234. In several OECD countries, green growth has recently become an over-arching policy objective and all economic sectors are being scrutinised as to the extent to which they offer growth potential that is environmentally benign and socially beneficial.

235. The synthesis of the experience of OECD countries in developing and implementing policies to support green growth in the agricultural sector shows, that although most countries have some policies in place that relate to the concept of green growth, the degree of ambition shows considerable variation. A wide range of instruments and a variety of "policy mixes" are currently applied across OECD countries, with the majority of countries appearing to have strategic objectives covering a wide range of subjects related to green growth, particularly in the area of improving energy efficiency and reducing the carbon footprint of agriculture.

236. Policy instruments supporting green growth relate not only to traditional regulatory or "command and control" approaches, but to a much wider array of tools, including public-private partnerships and international co-operation in R&D to foster innovation for green growth in the sector. Caution is needed in making broad generalisations about the preferred approaches, as priorities and time paths vary across countries.

237. Innovation plays a key role in fostering green growth. Green growth can provide a new paradigm for agricultural research, placing the emphasis simultaneously on environmental and economic requirements, with the aim of enhancing productivity without compromising the natural resource capital. Improving the innovative capacity of the agricultural sector will involve identifying the obstacles to innovation; revisiting policies that hamper innovation, structural change and the functioning of output and input markets; and implementing measures to foster innovation and competitiveness. However, in practice it is a considerable challenge to achieve policy coherence across a range of government, ministries and other institutions.

238. One of the central issues in achieving green growth in agriculture is to ensure that all the costs associated with economic activity are reflected in production and consumption decisions. In contrast to other sectors, the use of market-based instruments in promoting green growth in agriculture is not significant, due to the nature of property rights systems and the fact that the agricultural sector is composed by a series of non-point sources of pollution.

239. Defining and enforcing property rights over scarce natural resources offers numerous potential advantages: incentives would be created to encourage efficient methods of exploitation and more responsible management practices; maintenance would be undertaken, and the future value of resources

would be enhanced. The more complete the set of property rights, the more tightly meshed are the private and social net benefits resulting from the use of the resources − which eliminates externalities. The licensing of intellectual property benefits the competitive process by diffusing innovation and by helping innovators to capture their rewards. But licensing of intellectual property has become a challenging topic for policy makers as licensing agreements could increase the market power of a single licensor. The challenge for policy makers is to determine whether a particular agreement is likely to facilitate or hurt competition.

240. A coherent overall policy framework, which has clear objectives, sets R&D priorities, and policy measures that are targeted and implemented at the appropriate levels is essential for establishing a comprehensive strategy for green growth in agriculture. Appropriate policies for moving agriculture closer to meeting the conditions for green growth need careful design and continuous monitoring. Governments in several OECD countries are becoming increasingly aware of the importance of monitoring and evaluating their agricultural policies and are devoting considerable efforts to making progress in this area. The next phase of the work on green growth will develop and implement the OECD green growth measurement framework for the agricultural sector and to apply it to selected OECD countries.