# Agriculture and Green Growth

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## INTRODUCTION: THE GREEN GROWTH PARADIGM

The OECD will deliver a Green Growth Strategy Synthesis Report to the 2011 Ministerial Council Meeting which will also provide the basis for an OECD contribution in 2012 to Rio+20, an international conference on sustainable development. The OECD Green Growth Strategy will elaborate tools and recommendations to aid governments in identifying the policies that can help achieve the most efficient shift to environmentally-sound growth. This report on *Agriculture and Green Growth* explains the significance of greener growth for the agricultural sector, elaborates a policy toolkit for Green Growth in agriculture, and discusses important considerations in addressing specific environmental challenges in agriculture.

The emergence of the concept of Green Growth marks a shift in the paradigm for economic progress to an approach which emphasizes environmentally sustainable development (**Table 1**). Traditional economic models have tended to treat environmental protection as an economic burden which detracts from or slows growth. The Green Growth model recognizes that steps to protect and conserve environmental resources can be a driver for national and global economic progress. Future economic growth will itself be put at risk if the Green Growth paradigm is not put in place. The principle obstacle to Green Growth is not an inherent tension between economic and natural systems, but the political economy of change and the need to address the environmental consequences of current economic development patterns.

**Table 1: Traditional Economic vs. Green Growth Policy Paradigm**

| | **Traditional Economic Paradigm** | **Green Growth Paradigm** |
|---|---|---|
| **Economic-environment links** | Environmental protection viewed as detracting from economic growth | Environmental protection viewed as a driver of economic growth |
| **Planning perspective** | Short- to medium-term perspective | Long-term perspective |
| **Policy perspective** | Government policy interventions to correct overt market failures | Government policy interventions to promote structural changes and facilitate adjustment |
| **Scope of environmental responsibility** | Government agencies and private sector units responsible for environmental management | All government agencies, corporate departments and wider society |
| **Environmental policy interventions** | Improvements to existing modalities of consumption and production | Changes to patterns of economic activity to reduce environmental pressures |
| **Economic policy interventions** | Taxes and charges on environmental externalities | Supports and fiscal incentives to green innovation, activities, businesses and jobs |
| **Economic indicators** | Measure rate and level of economic growth, *e.g*. GDP, productivity | Measure qualitative aspects of growth or well-being including environmental quality |
| **Environmental indicators** | Measure resource use and output of pollutants | Measure linkages between economic activity and output of environmental goods and services |

The realization of Green Growth depends on policies which spur economic development and job creation which devise value-added from the environment. This requires longer-term policy perspectives rather than the current stress on short and medium-term results as well as adjustment strategies to manage the successful transition to low-carbon, resource-efficient economies. Green Growth also demands policy coherence across economic, environmental and sector interventions. A broad range of government and corporate departments should be involved in implementing Green Growth policies and approaches rather than stand-alone environmental agencies or business units.

A primary conceptual change in the Green Growth policy paradigm is the need to transform production and consumption patterns from resource intensive processes to eco-efficient and low-carbon trajectories. Current OECD environmental policies have been relatively successful in addressing pollution, including through end-of-pipe and more integrated processes, and encouraging the adoption of life-cycle perspectives. However, more efforts are needed to alter fundamental patterns of economic activity in order to decouple growth from environmental degradation and to support the expansion of commercial eco-industries and eco-services. In developing countries, realizing significant gains in material living standards without imposing excessive burdens on environmental carrying capacity is the primary goal.

Green Growth is a concept that brings together a suite of policies to promote a transformation of consumption behavior, industry structures and technologies. This involves regulatory and fiscal measures to reduce the energy and carbon intensity as well as the land and water intensity of production and consumption in all sectors. Green Growth policies also seek to stimulate investments and steer spending towards clean technologies, renewable energy, water services, green transportation and infrastructure, waste management, and bio-based businesses.

In the Green Growth paradigm, traditional economic and environmental measures of progress are replaced by indicators of the linkages between the use of environmental goods and services and economic growth. Green Growth calls for a focus on qualitative growth rather than measuring success based on traditional economic indicators such as gross domestic product (GDP) or economic productivity. Interrelated indicators of economic progress, environmental sustainability and social welfare are needed. In agriculture and other sectors, progress on Green Growth is measured by the ability to contribute to social well-being by providing sufficient goods and services in ways that are economically efficient and environmentally beneficial.

## THE IMPLICATIONS OF GREEN GROWTH FOR AGRICULTURE

Moving towards greener growth in the agricultural sector will involve both synergies and trade-offs which will change over time. The implications of Green Growth for agriculture and the contributions of agriculture to Green Growth can be reciprocal or incongruent. **Table 2** gives a broad view of the possible synergistic and conflicting effects of Green Growth on agriculture across and within the different pillars of sustainability: economic, environmental and social. In the cells on the main diagonal, the two perspectives are mutually reinforcing as indicated in the positive sign. Policy pairs below the main diagonal may work against each other particularly in the short-term (negative sign), while paired interventions above the main diagonal are mutually enhancing (positive sign).

In the short-term, Green Growth policies which place a premium on environmental protection may constrain agricultural output, reduce global food security and entail adjustments in the use of human, financial and natural resources. The implications of Green Growth for agriculture in the longer-term are mutually-reinforcing in terms of environmental sustainability, economic growth and social well-being. The complementarities and differences between Green Growth and agriculture are reviewed in more detail below in terms of traditional economic factors (i.e. productivity, farm incomes, employment) and environmental factors (i.e. natural resource use, pollution, biodiversity) as well as broader social factors (*i.e*. food security, poverty reduction, rural development). While this report discusses Green Growth with a focus on primary agriculture, there is a much longer agro-food supply chain including processing and distribution which has Green Growth implications. The end results will depend on the policy instruments adopted and the structural adjustment measures which are put in place to ease the transition to a greener agricultural sector.

**Table 2: Agriculture and Green Growth: Complementarities (+) and Differences (-)**

| | **Economic Contribution of Agriculture to Green Growth** | **Environmental Contribution of Agriculture to Green Growth** | **Social Contribution of Agriculture to Green Growth** |
|---|---|---|---|
| **Economic Contribution of Green Growth to Agriculture** | Agriculture is the basis of economic development while Green Growth can improve agricultural performance **(+)** | Green labels and eco-services can contribute to economic returns in agriculture **(+)** | Green jobs and activities can diversify and contribute to rural development **(+)** |
| **Environmental Contribution of Green Growth to Agriculture** | Environmental measures may slow agricultural growth in the short-term **(-)** | Green Growth will yield environmental co-benefits in agriculture through resource conservation and carbon sequestration **(+)** | Reform of supports to relieve environmental stress can promote more equitable farm incomes **(+)** |
| **Social Contribution of Green Growth to Agriculture** | Green Growth may detract from efforts to improve food security in the short-term **(-)** | Green Growth will necessitate structural adjustment measures in transition periods **(-)** | Food security, poverty reduction, and rural development will be enhanced through Green Growth **(+)** |

**Agricultural contributions to Green Growth**

***Economic contributions --*** Green Growth will be at risk if the agricultural sector fails to provide sufficient food, feed and fiber for the increasing global population. Although agriculture accounts for less than 2% of GDP and less than 6% of employment in OECD countries, it is essential to supplying domestic and foreign food demand. In many developing countries, agriculture plays a central economic role in accounting for 30% of GDP and two-thirds of employment. Since it is forecast that global food production will need to be increased by 70% to feed the expected world population in 2050, greater economic efficiency and productivity in agriculture is essential.

Green Growth depends on investments in the agricultural sector and the viability of farms in OECD and non-OECD countries to ensure future food production. A 50% increase in private investment in primary agriculture and downstream services is needed to raise output in developing countries as well as public investments required in roads, irrigation, electricity and education. Advances in agricultural technology should yield productivity increases in most countries, but new technologies must be affordable, adaptable to alternative farming systems and geared to environmental protection.

***Environmental contributions --*** Agriculture provides a range of environmental and ecosystem services which are essential to Green Growth, including mitigation of greenhouse gases through carbon sequestration. Although direct greenhouse gas emissions from agriculture account for about 10%-12% of the total, the agricultural sector has the potential to offset emissions from other sectors. It is estimated that increasing the removal of atmospheric $CO_2$ through carbon sequestration in soil and vegetation sinks in agriculture has the potential to offset up to 20% of global fossil fuel emissions. However, this depends on enhanced soil management and cultivation as carbon sequestered in soils can be released back to the atmosphere through inappropriate farming practices.

Because agriculture accounts for 37% of total land use (68% if the use of land for forests is included), the sector plays a key role in the preservation of ecosystems which provide the basis for Green Growth. Agriculture affects the natural environment in providing for management of land and water resources, habitat protection, flood control, biodiversity maintenance, and shaping and protecting landscapes. Agricultural land management has been a positive force for the development of plant varieties, animal habitats, woodlands and wetlands. Attempts to place a monetary value on the environmental services provided by agriculture underline its rising importance in ecological and economic terms.

***Social contributions --*** Green Growth cannot be realized without global food security in terms of adequate supplies of food and agricultural commodities to nourish growing populations. World population is expected to grow by 2.3 billion people between 2010 and 2050 mostly in developing countries. While the incidence of undernourishment is projected to fall from 17% of the population of developing countries at present to 11% in 2015 in line with poverty reduction, progress in reducing the total number of undernourished people is far slower and depends on improved agricultural productivity and more equal access to food supplies.

Agriculture also provides the basis for the well-being of rural populations in OECD countries and poverty reduction in developing countries. About 75% of the world's poor live in rural areas and are dependent

on the agricultural sector for their livelihoods. Agricultural growth, through its leverage effects on the rest of the economy, can enable poor countries, poor regions and poor households to raise employment and incomes. In narrowing the rural-urban income gap and reducing rural poverty, agriculture can connect rural populations to broader economic development by providing a key link to Green Growth.

**Green Growth contributions to agriculture**

***Economic contributions*** **--** Green growth approaches which improve the internalization of environmental externalities in agricultural production can increase economic returns to farmers through more efficient input use and enhanced resource management. Although environmental measures may slow agricultural output in the short-term, eco-efficiency gains should yield long-term economic benefits. Green tools and techniques can reduce overconsumption and save expenditures on energy, water and agrochemicals. Ecologically-sound land management improves soil quality, nutrient content and moisture holding capacity. Agricultural outcomes are also enhanced through reducing losses from pesticide resistance, soil erosion and water pollution. For example, efforts to increase carbon sequestration in soil organic matter have yielded substantial benefits in many areas in terms of agricultural output and farm productivity.

Investing in the environment can lead to new sources of economic growth in agriculture based on environmental goods (*e.g*. organic products, renewable energy) and services (*e.g*. eco-tourism, resource conservation) which contribute to green jobs and farm incomes. Certification and eco-labeling of products based on organic and ecological production processes can add substantially to marketing premiums from environmental and health conscious consumers. Organic price premiums are estimated at 20%-40% in OECD markets depending on the food product. Agricultural biodiversity generates significant option values in conserving genetic resources that can be the basis for the development of new crop varieties and animal breeds. Eco-tourism on farms and in rural areas is a profitable emerging industry in many OECD countries, while production of biomass energy is raising farm incomes and revitalizing rural communities.

***Environmental contributions*** **--** The long-term performance of the agricultural sector is inextricably linked to the sound management of its natural resource base. Overall agricultural indicators have improved in recent years across the OECD due to environmental investments by farmers and agro-businesses. Agricultural nutrient balances have recovered and soil erosion has stabilized since the early 1990s. Better water management – involving irrigation water conservation, rainfall retention and waste water reuse – has yielded payoffs to public and private investments in agriculture. Agricultural yields have been raised through integrated pest management techniques which exploit natural biological processes. Conserving agricultural biodiversity also increases productivity through improved soil nutritional levels, crop pollination and hydrological functions.

Less pressure on scarce environmental resources from Green Growth also reduces environmental risks and expenditures. Risk management in agriculture has shifted from a focus on market volatility to managing environmental risks, including from diseases, weather conditions and climate change. OECD governments have largely stabilized price and market risks, but farmers face considerable production

risks from the unpredictable nature of the weather and the uncertain performance of crops and livestock. Reinforcing the ecology-agriculture link through Green Growth enhances stability in managing these risks. Losses to stock, crops and other assets can be limited by more environmental management of pests and land, soil and water resources. The need for drought risk insurance has been reduced through better irrigation techniques, water saving and improved pasture management. Steps to adapt agriculture to potential climate change risks through seed selection and altered cropping also acts to lower crop and farm insurance premiums.

***Social contributions*** **--** Sound management of agricultural resources based on Green Growth will increase the viability of rural economies and enhance social welfare for farm families. Reform of government supports to agriculture, which have traditionally been based on output levels and input use, is rectifying inequities in farm income distribution while relieving environmental stress. In the past, farm support measures failed to improve equity in farm incomes as they tended to benefit larger—and often more prosperous—operations. As farm payments are decoupled from production and targeted more on the basis of farm revenue, they will help meet the needs of poorer farm households.

Environmental measures contribute to poverty reduction in rural areas through enhanced provision of essential services such as food and water supply and sanitation. The increasing production of farm-based environmental goods and services is creating green jobs and contributing to rural diversification and development. Organic farming and the production of biomass for energy and related industries now underlies growth in farm employment and incomes in the OECD. Small and medium-scale farms, which make up a large share of commercial farming operations, depend on off-farm income to supplement their livelihoods. Ecotourism, which is growing at three times the rate of the overall tourism sector, is a promising avenue for farmers and local communities.

## POLICY TOOLKIT FOR GREEN GROWTH IN AGRICULTURE

The OECD Green Growth Strategy aims to deliver on environmentally-sound economic growth by advancing a comprehensive policy toolkit which is flexible enough to be tailored to differing national circumstances and stages of development. In agriculture, the government policy toolkit for Green Growth will consist primarily of a mix of regulations, supports and research and development (R&D) directed to enhancing environmentally-sound agricultural output (**Table 3**). The optimal choice of policy instrument depends on the economic, environmental and social objectives to be achieved, the agricultural system to be addressed, and the political economy context in which the instrument will operate.

**Table 3: Agriculture Green Growth Policy Toolkit**

| INSTRUMENT | GREEN GROWTH POLICY PRIORITIES |
|---|---|
| **Regulations and standards** | Enact controls on excessive use of agrochemicals in production<br>Strengthen rules and standards for water quality and land management<br>Improve enforcement of environmental regulations in agriculture |
| **Support measures** | Decouple farm supports from production levels and prices<br>Increase supports for environmental practices<br>Extend environmental cross-compliance measures |
| **Economic instruments** | Clarify property and user rights in the agricultural sector<br>Impose charges on excess use of environmentally-damaging inputs<br>Implement trading schemes for water rights |
| **Trade measures** | Lower tariff and non-tariff barriers to agricultural trade<br>Reduce export subsidies to agricultural products<br>Conclude Doha Development Round of trade negotiations |
| **Research and development** | Increase public research on green agricultural technologies<br>Promote private agricultural R&D through grants and tax credits<br>Undertake public/private partnerships for green agricultural research |
| **Development assistance** | Increase development aid to green growth initiatives in agriculture<br>Raise profile of agriculture in Poverty Reduction Strategies (PRS)<br>Augment funding for agriculture in Aid for Trade projects |

**Regulations and standards**

Regulation is one of the key levers governments can use to promote Green Growth in agriculture, including rules governing land and water use, chemical inputs, food safety and quality, and animal welfare. Most government policies, including in the environmental realm, are premised on the need to correct the failures of markets to take into account public, rather than just private, welfare. Regulations are the most common public policy instrument for getting markets and producers to pay for the public costs of harmful "externalities" such as pollution and natural resource degradation in agriculture and other sectors. A few OECD countries rely mostly on regulatory requirements to address environmental issues in agriculture.

All OECD countries impose a complex set of regulations to prevent negative impacts on the environment from agricultural activities (**Table 4**). These include limits on the intensity of production, the application of chemicals and pesticides, and the generation of pollution and waste. 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 and silage and slurry operations. Stricter regulations tend to be applied in areas with higher environmental or resource conservation values. Over time, OECD regulatory requirements for agricultural production have broadened in scope and have become more stringent.

Standards for agricultural products are a related tool to prompt producers to change production and handling methods and to remove less sustainable products from the market. Government standards for food products to ensure that they are not harmful to human health may require reduced inputs of fertilizers, pesticides and other chemicals. Other standards address storing and handling food products, ensuring animal welfare, and product labeling. In the interest of human health, governments may also require that food contain certain nutrients through the enrichment and fortification of products.

Environmental regulations and standards may require increased investments to comply with production and processing rules, raising farmers' costs and affecting competitiveness in the short-term. The impact of regulatory costs on farmers can be reduced by improved management approaches and technology. An increasing number of regulatory requirements derive from state, provincial, regional or local measures. Regulations generally need to be tailored to specific farming systems and the local nature of environmental concerns as a one-size-fits-all requirement may be neither environmentally effective nor economically efficient.

Regulations have a broad positive impact on the environment and society in terms of cleaner air and water and safer food products. In the longer-term, environmental regulations and standards raise farm welfare by improving productivity and eco-efficiency through cleaner production processes and enhanced resource management techniques. Food labeling regulations benefit farmers by helping to internalize environmental values in commodity prices. Where labeled and certified as eco-friendly, farm products receive marketing premiums contributing to farm incomes.

However, public mandates on agricultural producers to reduce emissions and to conserve water and natural resources may be inadequate to respond to growing environmental concerns. A Green Growth

strategy in agriculture involves strengthened regulations and standards to ensure that agricultural producers internalize 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 greenhouse gas emissions from agriculture can be achieved through rules for land, soil and nutrient management to lower emissions from soil decomposition. Livestock management regulations have been shown to greatly reduce methane emissions. Stricter health and safety standards for food commodities can reduce the use of polluting agrochemicals, *e.g*. nitrogen and phosphorous loading. Fines and penalties for breaching environmental laws in agriculture are the usual means of enforcement although they are not always adequately applied.

**Table 4: 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<br>Pollutant discharge permits<br>Animal feeding restrictions<br>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<br>Standards for particulate matter<br>Air quality permits |
| **Land use** | Preserve quality of land through limiting production intensity and overuse of chemicals | Chemical use permits<br>Limits on waste disposal<br>Soil removal and placement rules |
| **Pesticides** | Control use of chemicals which may pose a risk to human health and the environment | Pesticide registration and labeling<br>Pesticide use restrictions<br>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<br>Endangered species protections<br>Agricultural habitat rules |
| **Machinery & equipment** | Maintain farm machinery and equipment in good working order and prevent environmental damage | Emissions controls<br>Noise limitations<br>Diesel fuel restrictions |
| **Food safety & quality** | Safeguard the health and well-being of consumers | Animal welfare provisions<br>Storage and handling rules<br>Food labeling requirements |

**Support measures**

Governments provide supports or subsidies to farmers and agribusinesses to manage the supply of agricultural commodities, influence their cost, supplement the income of producers and achieve other social and environmental aims. These payments, which were estimated to total EUR 182 billion in 2009 in OECD countries in terms of Producer Support Estimates (PSE), can be ranked according to their impacts on the environment (**Table 5**). Market price support mechanisms and payments based on output are the most harmful for the environment. Payments based on cropped surface, animal numbers, historical entitlements or overall farming income are more neutral in environmental terms since they place limits on production and constitute a form of decoupled support.

Payments based on input and resource constraints are generally beneficial because they 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, green supports to farming are far outweighed and offset by the damaging environmental effects of input-linked and production-linked support policies. In the Green Growth Policy Toolkit, direct supports for commodity production and unconstrained input use should be reduced or redirected to achieve ecological aims.

**Table 5: Ranking of PSE supports by Environmental Impact**

| Environmental impact | Type of support measure | % OECD PSE 2001 | % OECD PSE 2009 |
|---|---|---|---|
| Most harmful | Market price support<br>Payments based on output | 69 | 48 |
| | Payments based on input use | 9 | 13 |
| More neutral | Payments based on cropped area / number of animals | 13 | 12 |
| | Payments based on historical entitlements / overall farming income | 7 | 23 |
| Beneficial | Payments based on input/resource constraints | 2 | 4 |

OECD countries have made a concerted effort to reduce the most environmentally harmful types of agricultural supports – those based on prices and output levels – which have declined from almost 70% of the total in 2001 to 48% in 2009. About 90% of payments in this category are market price supports. Price support for agricultural commodities masks market signals to producers and encourages intensification of production through higher levels of fertilizer and pesticide inputs with 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 seriously lag behind.

Payments based on levels of input use have increased in this time period from 9% to 13% of total PSE. There are three main targets of supports for input use: 1) support for the (unconstrained) use of variable inputs such as credit, fertilizers, 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.

Domestic price supports have been largely replaced in this decade by direct payments based on past entitlement levels or farm income 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 moderate production distorting and environmentally damaging effects.

Environmental supports or those based on non-commodity outputs continue to increase their share of total PSE and now account for about 4% of agricultural supports in OECD countries. Payments are made to agricultural producers to adopt specific farming practices such as 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. Countries such as the United States are now considering tax credits for projects protecting or restoring forests or shifting to carbon-storing farming methods.

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 incentive to meet regulatory requirements, or may be part of voluntary programs. Environmental cross-compliance schemes have increased to apply to 33% of total PSE in the period 2007-09. Among OECD countries, the European Union, the United States and Switzerland provide around 50% of their agricultural supports with some constraints linked to environmental protection and other objectives.

The Green Growth Policy Toolkit promotes a shift away from more environmentally harmful supports towards environmentally beneficial payments and requirements. 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. A shift in the composition of agricultural subsidies would generally reduce the cost of achieving environmental objectives and increase eco-efficiency.

**Economic instruments**

Economic instruments – primarily taxes and charges and tradable permit systems – are used to discourage practices that are damaging to the environment by raising the cost of these activities to producers. However, these economic instruments do not play a significant role in promoting Green

Growth in agriculture compared to the use of such measures for environmental objectives in other sectors. 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. Regulations and supports have proved easier to implement than taxes in encouraging greener activities among agricultural producers.

There may be wider scope for the application of taxes and charges to promote the internalization of environmental costs in agricultural production decisions, but this depends on 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 (**Table 6**). In many countries, farmers have retained broad implicit or customary rights to the use of land, water and other natural resources. These embedded rights plus the fact that agriculture is a non-point source of pollution make it difficult to implement taxes and charges on agricultural inputs and practices. Defining property rights, uses and misuses would help governments determine where farmers should be held liable at their own cost for environmental damage and also facilitate payments for environmental services.

**Table 6: Types of Property Rights in Agriculture**

| Owner | Type | Statutory or customary laws |
|---|---|---|
| **Public** (held by the state) | Access and use rights to land and natural resources | Statutory law (*i.e.* the written and codified law of a country including both national and local legislation) |
| **Private** (held by an individual or entity) | Control rights to make decisions on how the land and its natural resources should be used | Statutory law (*i.e*. ownership, informal holdings)<br><br>Customary law (*i.e.* traditional rules, norms and customs) |
| **Communal** (held by each member of a community) | Transfer rights to sell, convey, mortgage, reallocate access, use and control rights and transmit these to heirs | Statutory and Customary law |

Source: FAO, 2010

Taxes and charges on farm inputs have been levied in a few countries to address environmental issues in agriculture. These have mostly been applied to environmentally-damaging chemicals; Denmark, France, Italy, Norway, Sweden and individual states in the United States are among those which have taxed fertilizer and pesticide use. Carbon taxes in agriculture have not been seriously considered even though farming can be very energy intensive. Farmers use carbon-based fuels directly in vehicles and machinery (about 30%) and indirectly in the form of carbon-based fertilizers and pesticides and fuel-intensive inputs (70%). While a tax could move farmers to shift to more energy-efficient systems of production, proponents of carbon taxes have generally sought to exclude the agricultural sector since emitters are not easily identifiable.

Nor do tradable rights based on environmental quotas, permits and restrictions play a significant role in agricultural policy. Trading systems have been implemented on a limited basis for agricultural nutrients in Canada (Ontario), the Netherlands and the United States. Tradable rights – as well as higher tariffs in some cases -- have been used to improve agricultural water management. Trading of water entitlements can provide a scarcity market price and lead to the highest value use of water resources; these have been granted in the United States for the development of wetlands and for water extraction in Australia. Some OECD countries are exploring the use of trading systems to curb carbon emissions in agriculture. However, in New Zealand, a proposed emissions trading system sets the point of obligation for agriculture emissions at processor level, meaning meat and dairy processors and fertilizer companies, rather than at farm-level in order to reduce regulatory and transactions costs.

**Trade measures**

The removal of tariff and non-tariff barriers to agricultural trade can improve the functioning of global food markets, reduce unsustainable agricultural practices, and further the dissemination of technical knowledge in the interest of Green Growth. Domestic supports to agricultural production delivered by OECD countries have been economically feasible due to high levels of border protection to limit imports as well as subsidies for exports when surpluses emerged on the domestic market. Reform of agricultural trade is aimed at a more efficient allocation of food production across countries according to their comparative advantage and a more level playing field in world markets. This would improve predictability and security for food importing and exporting countries alike with environmental co-benefits.

By imposing tariffs and non-tariff barriers on agricultural imports, both OECD and non-OECD countries have created significant market distortions with negative environmental impacts. Within countries, trade barriers can affect the environment in altering the scale and structure of agricultural production, the mix of inputs and outputs, and production technologies. The ecological impacts tend to be indirect, including groundwater and surface-water pollution from fertilizer and pesticide run-offs and changes in land use that affect landscape appearance, flood protection, soil quality and biodiversity.

Protectionism also has international impacts on agricultural production patterns and environmental values including trans-boundary spillovers such as greenhouse gas emissions and biodiversity losses. Lower trade barriers should cause production to decrease in countries with historically high levels of fertilizer and pesticide application, thereby relieving environmental stresses in these areas. At the same time, output is likely to increase in countries that can accommodate an increased use of agro-chemicals owing to current low levels of chemical inputs. Developing countries, as well as global consumers, will benefit from the removal of trade barriers for products in which they have a comparative advantage (such as sugar, fruits and vegetables) and from reduced tariffs for processed agricultural commodities.

Since the late 1980s, the degree of border protection in OECD countries has been significantly reduced through international trade negotiations. Starting with the Uruguay Round Agreement on Agriculture, negotiated in 1986-1994 and phased in over five years, trade-distorting agricultural subsidies and tariffs have been subject to multilateral rules. However, bound tariffs (*i.e*. those at a globally-agreed maximum

level) on agricultural products remain high in comparison with other sectors, averaging 35%-50% of product value. Applied tariffs (*i.e.* those set by individual countries) are much lower averaging 17% for bulk agricultural commodities and 20% for processed foods.

Ongoing multilateral trade negotiations on agriculture in the World Trade Organization (WTO), which are part of the Doha Development Agenda launched in 2001, have not yet yielded agreement although talks continue on further reducing tariff and non-tariff barriers and export subsidies. It has been agreed that higher tariffs on agricultural products will be reduced more than lower ones and that final bound tariffs will be lowered using an agreed formula. The average cut on final bound tariffs on agricultural products for OECD countries must be at least 54%.

Agricultural export subsidies, which would not have been allowed for industrial products, have also been reduced significantly. The Agreement on Agriculture prohibits export subsidies for agricultural products unless they are specified in a member's lists of commitments and these must be reduced in terms of the monetary level and the quantities of exports that receive subsidies. Negotiations are now aiming to eliminate export subsidies by 2013, including those contained in export credits, guarantees and insurance, international food aid and exporting state trading enterprises.

Restrictions on agricultural imports by non-tariff measures have been largely replaced by "tariffication" or conversion to quantitative tariffs which are more transparent. Among the prohibited non-tariff measures are quantitative import restrictions, variable import levies, discretionary import licensing procedures, voluntary export restraint agreements, minimum import prices and non-tariff measures maintained through state-trading enterprises. The Agreement on Agriculture does not prevent the use of non-tariff import restrictions consistent with other WTO agreements such as those maintained under the Agreement on the Application of Sanitary and Phytosanitary Measures (health and safety regulations) and the Agreement on Technical Barriers to Trade (technical regulations and product standards including rules of origin). These measures, which can prove problematic for developing country producers, are also being negotiated.

More open agricultural markets will facilitate the sharing of technologies and innovations supportive of Green Growth. Barriers to trade in environmental goods and services are still important obstacles to the diffusion of cleaner technologies in agriculture and other sectors. Trade in environmentally-friendly technologies faces different rates of applied tariffs in OECD and non-OECD countries. In addition, non-tariff measures, such as quantitative import restrictions, customs procedures and foreign investment controls, act as barriers to technology trade and transfer. A balanced and comprehensive conclusion of the Doha Development Agenda would greatly contribute to reducing environmental distortions in agriculture.

**Research and development (R&D)**

The capacity of the global agricultural system to provide adequate supplies for food, feed, and non-food uses in an environmentally sound manner depends in large part on technology and innovation. New technologies can contribute to improving environmental performance and achieving Green Growth targets by replacing resource-intensive and polluting activities or making existing ones more eco-

efficient. Green Growth can provide a new paradigm for agricultural research with an emphasis on environmental requirements in the interest of both food security and enhanced productivity.

Technological innovation can improve the environmental performance of farming systems through innovations in engineering, information technology and biotechnology. Newer technologies can 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. These innovations imply changing current farm practices and using different technologies to enhance resource productivity and eco-efficiency.

Historically, the focus of agricultural research and development (R&D) has been to increase production, productivity and profits. The 1950s and 1960s saw science increasingly applied to agriculture with rapidly rising productivity growth, the development of new crop varieties, and increased yields in many countries through the "Green Revolution." Agricultural research has contributed enormously to humanity, enabling the supply of food to grow faster than demand despite rapidly increasing populations and shrinking natural resources. Maintaining this performance now depends 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.

There is waning public support for agricultural R&D and a diversion of research resources towards other agendas resulting in early warning signs of a slowdown in agricultural productivity growth. Recent studies find very high economic rates of return to agricultural R&D indicating it would have been profitable to invest more in research. But growth rates in public investment in agricultural research have decreased since the 1980s with the ratio of public R&D spending relative to agricultural GDP remaining relatively flat. Despite the importance of the agricultural sector to food security and Green Growth, only about 4% of public and private R&D spending by OECD countries is oriented towards agriculture. The world continues to collectively under-invest in agricultural R&D because of domestic and international market failures associated with appropriability problems.

Governments should increase agricultural R&D funding including for basic research in public laboratories and through advanced technology programs. For example, although biotechnology can play an important role in tackling Green Growth issues in agriculture, over 80% of public research investments in biotechnology go to health rather than to agricultural applications. New agricultural biotechnologies could be applied in plant and animal breeding and diagnostics, resulting in improved varieties of major food and feed crops with higher yield, pest resistance and stress tolerance. Biotechnology advances could facilitate the enhancement of the major staple crops of developing countries with vitamins and trace nutrients, and genetic traits and diseases of livestock and fish could be more easily identified.

Private sector spending on agricultural research has slowed along with the growth of public spending in recent years. Governments 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. Government research subsidies can push private research and innovation to address major

environmental and social challenges in agriculture and other sectors. Even though government subsidies for R&D are permitted under international trade agreements, they have accounted for a very small share of public supports to agriculture.

At least 21 OECD countries stimulate private sector research through R&D tax credits which provide tax benefits to firms related to the costs of undertaking specific innovation activities. Canada, for example, offers a broad-based R&D tax credit of up to 35% for expenses towards 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. Accelerated depreciation schemes for research-related capital expenditures and reduced labor taxes on scientists and researchers provide incentives to research and innovation. Some countries lower the corporate tax rate for innovation-related profits, such as from royalties or the sale of patents. Other countries target the tax credit to specific sectors and outcomes, including environmental research. Skillfully harnessing the tax system offers a means for increasing R&D expenditures to advance Green Growth in agriculture and other sectors.

**Development assistance**

Global action is needed not only to cut distorting subsidies and open markets to agricultural products, but also to increase the level and effectiveness of development assistance to promoting Green Growth in agriculture. Donors can support sound natural resource management and sustainable farming practices in developing countries through financial aid which targets resource conservation programs and low-carbon growth.

This generally requires greater emphasis in bilateral and multilateral aid flows on the agricultural sector, which now accounts for less than 4% of total development assistance. Despite the fact that 75% of the world's poor live in rural areas and are dependent on the agricultural sector, aid to agriculture continues to decline as a share of the total. The largest decrease has been in agricultural aid from bilateral donors which is now less than 3% of official development assistance (ODA). Assistance to agriculture from multilateral organizations such as the World Bank has also declined to 5-6% of multilateral aid.

While economic growth is an important contributor to poverty reduction, the sector mix matters with growth in agricultural incomes especially important in developing countries. In agriculture-based countries, for example in Sub-Saharan Africa, the sector employs up to two-thirds of the labor force and generates over 30% of GDP. For the poorest people, GDP growth originating in agriculture is four times more effective in raising incomes than that deriving from other sectors. In other countries, enhanced agricultural performance would narrow the rural-urban income gap and reduce rural poverty. It is agricultural growth, through its leverage effects on the rest of the economy that typically enables poor countries, poor regions and poor households to take the first steps toward economic transformation.

In the Green Growth Polity Toolkit, development assistance to agriculture focuses on natural resource management and adaptation to climate change. Agricultural productivity could be raised through basic resource management practices such as rainfall retention, irrigation water conservation, waste water reuse, dry-land cultivation, and controlling pests and weeds by exploiting natural biological processes.

Water management, particularly small-scale water control, in conjunction with technology diffusion and improved rural infrastructures, offers high payoffs to public and private sector investment and to Green Growth. Development assistance to the agricultural sector must also prioritize climate change adaptation. Agriculture and water resources, which are the most vulnerable to the adverse impacts of climate change, need to be climate proofed. In addition to funding, climate adaptation requires technical assistance and capacity building in poorer countries.

Poverty reduction strategies (PRSs), which are the vehicle for implementing the aid agenda, have tended to neglect the agricultural sector and also the environment. These strategies should recognize the importance of agriculture in poverty reduction and the role of natural resources as inputs into other productive sectors. Poor populations can raise incomes from selling environmental goods and services both in formal and informal markets such as wildlife products, timber, charcoal and eco-tourism. Strategies should also take into account that economic objectives will be vulnerable to environment-related shocks such as flooding, drought and climate change as they impact the agricultural sector, clean water and food security.

Aid for Trade, which helps countries improve their capacity to participate in the global trading system, could be directed to environmental enhancements in the agricultural sector. Aid for Trade priorities for agriculture should include transferring green technologies, developing water management infrastructure and fostering green enterprises. Agricultural products, mostly unprocessed, will continue to have a considerable weight in the export profile of developing countries. Development of green agro-enterprises holds potential as the cornerstone of a trade-based growth and poverty reduction strategy. This would enhance the ability of economies which rely on a narrow range of primary commodity exports (*e.g*. African cotton producers) to benefit from the changing global trade regime in agricultural products.

## ADDRESSING ENVIRONMENTAL CHALLENGES IN AGRICULTURE

Agriculture is unique in its ability to both detract from and contribute to Green Growth in significant ways. Agricultural production affects both the availability of natural resources -- especially land and landscapes, soil and water -- and the environmental quality of these resources through depletion, pollution and biodiversity loss. The implications of certain environmental challenges – particularly climate change, water and land management, biodiversity issues and growing demand for biomass – present specific problems and opportunities for the agricultural sector entailing complex policy considerations. The challenge is to enhance the ability of agriculture to further Green Growth objectives rather than impede them.

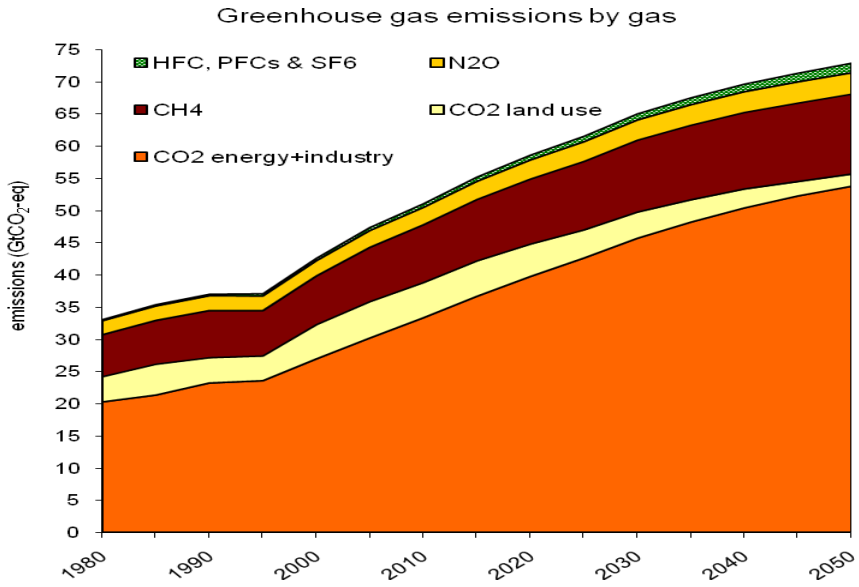
### Climate change

Climate change presents challenges for the agricultural sector in mitigating greenhouse gas emissions as well as adapting to climate impacts which are expected to have pronounced implications for farming. Climate change also offers opportunities in the agricultural capacity for carbon sequestration and the ability to offset emissions from other sectors. Complex synergies and trade-offs present themselves as agricultural producers attempt to reduce their carbon footprints while remaining competitive.

Agriculture accounts for 10-12% of global greenhouse gas emissions, primarily nitrous oxide and methane (**Figure 1**). Nitrous oxide, produced naturally in soil but also from fertilizers, is released by farming activity and accounts for 60% of total agricultural emissions. Rice cultivation and livestock breeding both emit large quantities of methane accounting for 30% of emissions from the sector. Modern farming is also very energy intensive and the use of fossil fuels accounts for 10% of agricultural emissions in the form of carbon dioxide. Developing country agriculture is estimated to account for about 74% of total greenhouse gases from the sector. Not included here is deforestation mainly for conversion to agricultural uses which accounts for a further 17% of global greenhouse gas emissions.

The climate footprint of agriculture is increasing as farming expands to produce more food for a growing world population. Policies aimed at reducing agricultural emissions may be more cost-efficient than some industrial and transport options. Improved cropland and grazing land management, changes in tillage methods, reduced fertilizer use and restoration of degraded lands will reduce nitrous oxide emissions. Methane emissions from livestock production can be lowered through genetics and improved nutrition and manure management. Steps can be taken to reduce agriculture's carbon emissions by switching to low-energy technologies and on-farm generation of renewable energy. Energy efficiencies can also be achieved in the processing, transport and distribution of food products throughout the supply chain.

**Figure 1: Global Greenhouse Gas Emissions by Gas**




Source: OECD, 2008c

Agricultural adaptation to the effects of climate change is also crucial. Severe climate change will have impacts in the agricultural sector due to increases in global mean temperatures and weather variability, including precipitation. Alterations in the seasonal timing of rainfall and snow pack melt can lead to the higher incidence and severity of floods and droughts. Less-resilient agricultural production areas will suffer in particular as temperatures rise in semitropical and tropical latitudes and as already dry regions face even drier conditions. Production variability and uncertainty of agricultural supplies are expected to rise and, in more extreme cases, production zones might shift affecting global patterns of food, feed and fiber output.

Government climate adaptation strategies in agriculture are needed. Farmers can shift sowing and harvesting dates, adopt different varieties or species, modify field operations such as tillage methods and fertilizer applications, and change grain drying and storing methods. Climate change will require greater attention to water saving practices both in terms of on-farm distribution and irrigation systems and larger infrastructure systems delivering water to farms. In developed as well as developing countries, adaptation also involves extending risk management approaches to include climate variability, increasing crop and disaster insurance, extending training and education, and strengthening extension and communication systems.

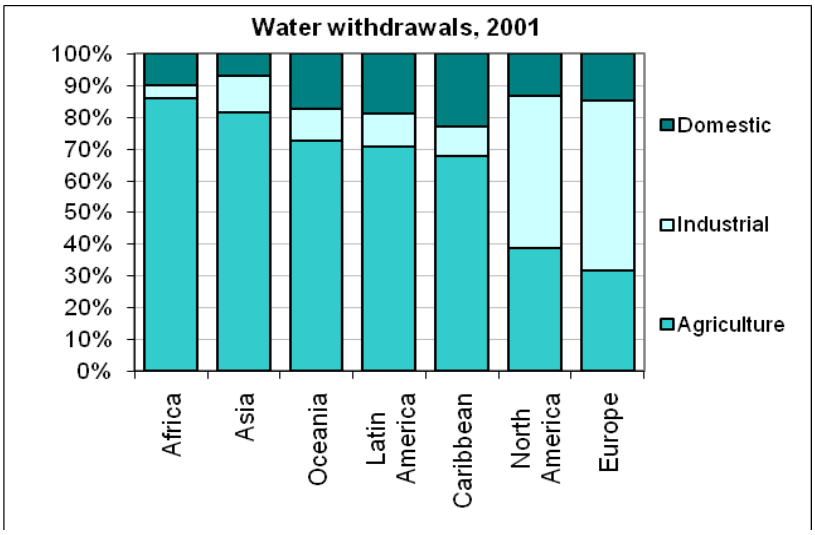
Agriculture can help mitigate greenhouse gases through carbon sequestration as soil can capture and absorb carbon and offset emissions from farming and other sectors. For example, greenhouse gas emissions associated with livestock could be offset by capturing the carbon in pastureland. Although it is estimated that carbon capture and storage in soil could offset as much as 20% of global greenhouse gas emissions, advanced techniques to increase soil carbon content are experimental as well as expensive. Global funding arrangements, like the Clean Development Mechanism (CDM) under the Kyoto Protocol,

could offer incentives to farmers for climate change mitigation including carbon sequestration projects as well as small-scale wind power generators and reforestation. A range of land-based activities, such as reduced deforestation and degradation, agricultural land restoration and soil carbon sequestration, could be added to post-2012 climate mitigation and adaptation mechanisms.

**Water management**

The agricultural sector faces the challenge of increasing food production using less water due to pressures from climate change as well as from urbanization and industrialization. Agriculture is the major user of water in most countries accounting for 30%-40% of freshwater withdrawals in the OECD area and 70% globally (**Figure 2**). With demand for food and water both rising, farmers need to use water more efficiently and improve agricultural water management. A combination of policy instruments -- market-based instruments, water use quotas and other incentives -- is needed.

**Figure 2: Global Water Withdrawals (OECD)**




Source: OECD, 2008c

Detrimental environmental effects from water are largely due to irrigation, which accounts for 70% of global agricultural water requirements. Inefficient use of water to increase farm output not only contributes to water shortages but can lead to flooding and off-farm pollution. Groundwater depletion and soil degradation due to excessive water use can exacerbate flood damage. The challenge is to ensure the optimal allocation of water resources to competing uses while preventing their degradation by pollution or over-depletion and respecting the ecosystems in which they are embedded. Farmland can also provide environmental services in acting as a flood sink and preserving aquatic ecosystems.

Government supports to agricultural production linked to levels of outputs and inputs have exacerbated problems of water mismanagement and scarcity. Many OECD countries have succeeded in lowering farm support levels and in decoupling support from production volumes and input levels. The result has been more efficient water use, better adaptation to water scarcity and lower off-farm water pollution.

Regulations and licenses are the main policy tool for ensuring sustainable management of on-farm water resources, mainly groundwater. However, poor enforcement of these rules often leads to illegal groundwater pumping and degradation. To reduce water stress, enforcement of existing regulatory measures and development of mechanisms for volumetric management and charging are essential. Farmers need to deploy best-practice efficiency improvements for irrigation and other end-uses, along with more sustainable water harvesting. Tools are being developed to enable better water oversight including the computerized linking of soil moisture monitors to drip irrigation systems.

Economic instruments, particularly appropriate water pricing and trading systems, could give incentives for agricultural water use efficiency. In OECD countries, most of the agricultural sector is connected to a water infrastructure network based on water tariffs. Although water charges should in principle reflect the supply and environmental costs of water, few countries practice full cost recovery due to potential negative effects on consumers and households. Current charges tend to reflect the operation and maintenance costs of water and do not include agriculture's share of capital costs for water supply infrastructure, the environmental costs and benefits, or levels of water scarcity. These charges could be increased in stages to cover full operation and maintenance costs, capital costs and depreciation of assets, new investment, environmental externalities and the opportunity costs of water resources.

Assigning property rights and responsibilities attached to water use and provision is a necessary condition for implementing market-based measures such as trading systems. Trading of water entitlements or buying and selling water access rights can provide a scarcity market price and encourage more efficient use of water resources. Formal water markets have emerged in some OECD countries, including the United States, Chile and Australia, where water resources are scarce. Under Australia's National Water Initiative, water rights can be transferred between different parties, such as irrigators, environmental water managers, and water infrastructure operators. In Chile, the 1981 Water Code declares that water rights are private property, separate from land, and can be freely traded. These trading approaches can be an efficient way of addressing water shortages, but raise questions about potential monopolization of water rights by richer users.

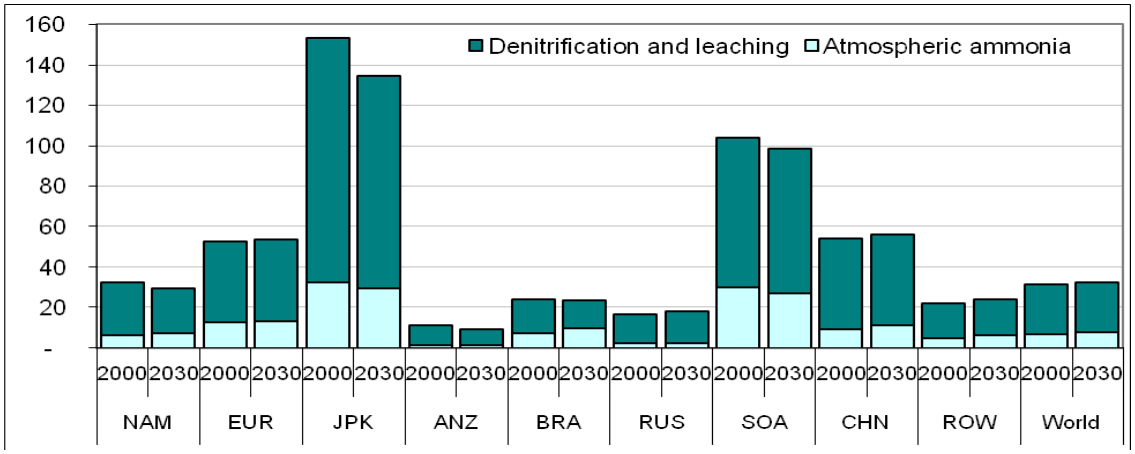
**Land management**

Because agriculture accounts for 37% of total land use (68% if the use of land for forest is included), it plays a key role in the management of land and soil resources, habitat protection, flood control, biodiversity maintenance, and shaping and protecting landscapes. With appropriate land management approaches, agriculture can make significant contributions to protecting ecosystems and habitats and providing other land-based eco-services. However, the increasing conversion of land area to farming and pastures can have detrimental impacts on environmental resources and ecosystems.

Rising populations and incomes are driving the demand for more land for agriculture, pasturing, and food production. In recent decades, the conversion of land to crops and pastures has had major detrimental impacts on natural forests, animal habitats, and other important ecosystems, particularly in developing countries. In the case of forest land, a failure to align economic with environmental objectives leads to continued loss and degradation of land. With increasing demand for food, soil

resources are coming under pressure to maintain or raise agricultural productivity. This has led to long-term soil degradation due to erosion, pollution, and physical and chemical deterioration. High levels of soil nitrogen content and nitrous oxide emissions are due to higher fertilizer inputs and animal stocking densities (**Figure 3**).

**Figure 3: Surface Agricultural Nitrogen Losses (2000 and 2030)**




Source: OECD, 2008c

Understanding the central role played by soil is key to management of land-based resources and to agricultural production. Soil itself provides a habitat and gene reserve for many micro-organisms, which can contribute to both soil productivity and biodiversity above ground. Soil stores nutrients and water, regulates and filters the flow of rainfall to plants and groundwater, and absorbs and releases atmospheric gases. Maintaining and enhancing soil quality is a high priority area for realizing Green Growth in the agricultural sector. This depends on integrated land management approaches which include appropriate cultivation, crop rotations, fewer chemical inputs, and careful selection of seed varieties. Techniques that improve soil fertility can yield economic benefits by increasing agricultural productivity and environmental benefits by enhancing biodiversity.

However, land management approaches must be matched to particular areas and ecosystems. For example, soil conservation practices on heavy soils in temperate climates will not be suitable for soils in warm wet equatorial zones. Even within a particular region, there will be considerable variation between the agricultural potential and environmental vulnerability of different sub-areas. Integrated land use planning aims to identify areas where a particular technology can provide multiple benefits for farming, ecosystems and communities. Effective implementation of land management strategies also depends on the full co-operation of the land users and local communities.

**Biodiversity loss**

Increasing rates of global biodiversity loss as evidenced in the decreasing array of plant and animal species are driven by a number of interrelated factors. These include conversion of land to agricultural uses, unsustainable management of natural resources, pollution, invasive alien species, and climate change. Healthy ecosystems provide vital and valuable resources and services to economies and societies, although these services are usually not monetized. For those who place inherent worth on the vitality of the natural world, preserving biodiversity is also an ethical concern. The agricultural sector can both contribute to and prevent loss of biodiversity.

Farm activities can have adverse impacts on biodiversity in terms of: a) the genetic diversity of crops and livestock, b) the diversity of wild species which may use habitats affected by farming activity, and c) the diversity of ecosystems which suffer the impacts of land conversion and certain agricultural practices. The diversity of genes in domesticated plants and livestock is decreasing due to commercial mono-plantations of single species and homogenization of agricultural production systems, the use of invasive alien species in plantations, and reductions in types of dairy and other stock. In terms of animal habitats, the increasing demand for food products is expected to lead to 10% more land use for agriculture worldwide, mainly in developing regions with high levels of biodiversity. In addition, agricultural activities such as tillage, drainage, rotation, grazing and extensive usage of pesticides and fertilizers have undesirable impacts on habitats, wild species of flora and fauna, and ecosystems.

However, agriculture can also help preserve and enhance biodiversity through greener approaches to management of land and other natural resources. Habitats and ecosystems can be set aside and maintained through appropriate techniques. Soil management practices can significantly enhance soil life and below ground biodiversity. Higher levels of agricultural biodiversity also increase productivity in agriculture through reduced pest incidence, improved soil nutritional levels, crop pollination, and hydrological functions. Agricultural biodiversity generates significant option values in conserving genetic resources that can be the basis for the development of new crop varieties and animal breeds.

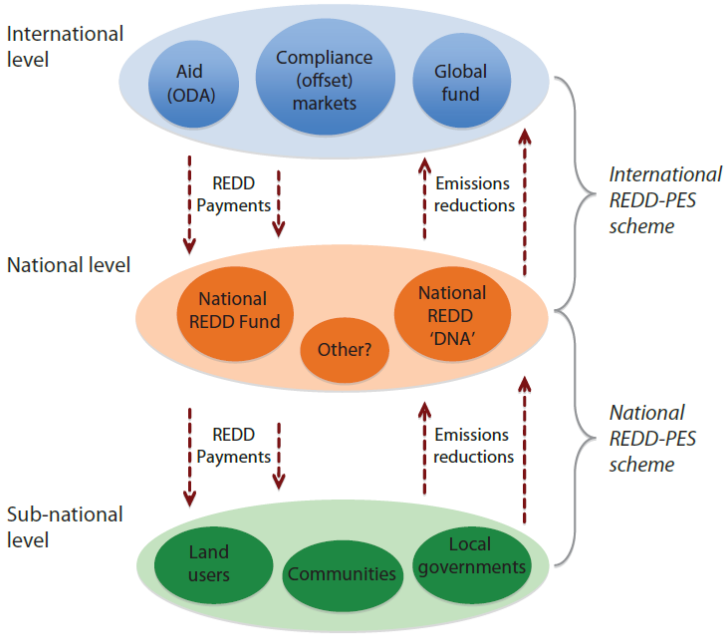
Preserving agricultural biodiversity depends on fuller recognition of the importance and economic value of natural resources including soils and forests and the ecosystem services they provide. Valuable approaches for promoting agricultural practices which promote biodiversity conservation are Payments for Ecosystem Services (PES). PES provide financial transfers to landowners, farmers and communities whose land use decisions may affect biodiversity values and create incentives for conservation of plant and animal species.

Four types of environmental services provided by agriculture and which could qualify for PES payments have been identified: i) supporting services (*e.g.* biodiversity, photosynthesis, soil formation); ii) provisioning services (*e.g*. food, water, wood, fiber and fuel); iii) regulating services (*e.g.* climate regulation, flood regulation, drought control); and iv) cultural services (*e.g*. recreation, aesthetics). Most existing PES schemes in agriculture give payments to avoid soil erosion, contamination of water supplies, and landscape degradation.

Several OECD and non-OECD countries have implemented PES schemes. The German government charges water utilities groundwater extraction fees, part of which are used to pay farmers to protect groundwater by reducing use of nitrogen-based fertilizers and pesticides. In countries such as Costa Rica and Argentina, laws have been enacted to provide the regulatory basis to contract landowners for the climate and biodiversity services provided by their land. There are also several private schemes which pay for ecosystem services in agriculture. For example, the Vittel (Nestlé Waters) program in France aims to maintain high water quality by paying farmers in the watershed to adopt low-impact practices in dairy farming.

Innovative financial mechanisms that can be used to promote biodiversity conservation are also being explored at the international level. The Convention on Biological Diversity (CBD) has supported about 30 PES schemes to compensate resource managers for off-site ecological benefits. The Reduction of Emissions from Deforestation and Forest Degradation (REDD) program has been proposed under the United Nations Framework Convention on Climate Change (UNFCCC) to help internalize the carbon-related ecosystem services provided by forests. REDD+ programs include agriculture and wetlands and could offer substantial biodiversity co-benefits. International finance delivered to achieve carbon emission reductions in areas that have both high carbon and high biodiversity benefits could help mitigate both climate change and biodiversity loss. These would be multi-level initiatives extending from international agreements through national legal structures to the sub-national level of land owners and communities (**Figure 4**).

**Figure 4: Model of Payment for Environmental Services (PES) Scheme**




Source: FAO, 2010

**Biomass production**

The economic and environmental effects of biomass production on the agricultural sector are diverse and location-specific. Biomass is used as a fuel (*e.g.* firewood, bio-diesel, bio-kerosene, and ethanol) and as a raw material for the pulp and paper, lumber, furniture, and construction industries. However, the use of agricultural resources for biomass production, particularly bio-fuels, competes with their use for food output and can negatively affect land use patterns, food supply and food prices.

Governments are promoting the production of bio-fuels for their contributions to developing low-carbon sources of energy and reducing greenhouse gas emissions as well as enhancing energy security. Bio-fuel production also creates new market outlets for sugar, cereals and oilseed helping to boost farm incomes and rural development. But higher demand can result in agricultural land use changes, including deforestation, as farmers shift large tracts of cropland and forests to produce inputs for bio-fuels. At the same time, questions have been raised about the effectiveness of bio-fuels in reducing net greenhouse gas emissions and the increased competition with food resources which raises food prices.

Bio-fuels are becoming a more significant element in the energy mix due partly to trends in prices for fossil fuels. Higher oil prices lead to increased investments in bio-fuel production seen as an alternative to carbon-intensive energy sources. Increased demand for energy, decline in low-cost sources of petroleum and restrictions on carbon emissions are expected to raise the cost of fossil fuels and create a growing market for biomass, including non-food crops such as grasses and trees, as a feedstock for bio-fuels, chemicals and plastics. However, this is resulted in a doubling or tripling of prices for grain and other agricultural inputs to bio-fuel production.

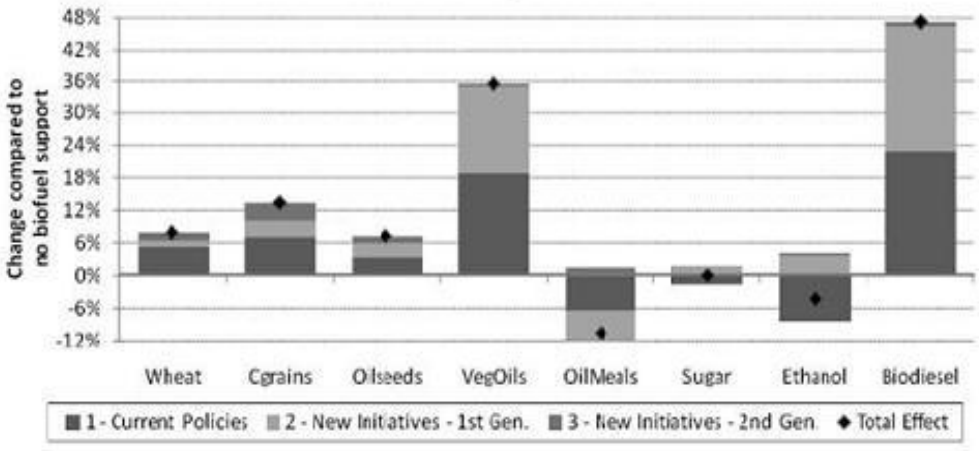
Increases in bio-fuel production are driven by policy incentives – renewable energy mandates and tax concessions – as well as economics. Governments in many OECD and non-OECD countries actively promote the production and use of alternative transport fuels made from agricultural commodities. The Renewable Fuels Standard (RFS2) in the United States and the Renewable Energy Directive (RED) in the European Union mandate levels of renewable energy in the overall mix acting to stimulate investment in and production of bio-fuels from agricultural commodities. Brazil, the United States, and the European Union account for 80%-90% of global bio-fuel output at present.

While bio-fuel production can be economically and environmentally viable in countries such as Brazil which produce ethanol from sugar cane, this is not the case in many OECD countries. Crops used for OECD bio-fuel production -- wheat, sugar beets and vegetable oils – do not result in comparative savings on greenhouse gas emissions. Whereas ethanol based on sugar cane generally reduces emissions by 80% relative to fossil fuels, ethanol feedstock in OECD countries obtains emission reductions of between 30%-60% not taking into account the negative effects of land use conversion. Nor does bio-fuel production contribute to energy security since significant levels of fossil fuels continue to be used.

Supports and mandates stimulating bio-fuel output in OECD countries have had negative impacts on food supply and crop prices (**Figure 5**). With global production of ethanol and bio-diesel projected to increase by 14% and 60% on average, respectively, due to government supports, the use of feedstock commodities would be substantially higher. Bio-fuel support measures are projected to increase average

wheat, maize and vegetable oil prices by about 5%, 7% and 19%, respectively, in the medium term. New bio-fuel support initiatives and mandates will put further upward pressure on commodity prices in the future.

**Figure 5: Impact of Bio-fuel Supports on World Crop Prices (2013-2017 average)**




Source: OECD, 2008a

OECD policies in support of biomass production should be reviewed for their cost-effectiveness and agricultural and environmental impacts. Bio-fuel production should target marginal and idle land and not compete with food-producing land, while emission reduction projections for bio-fuels should take into account land use changes. The policy mix to promote green use of biomass should include general efforts to reduce energy demand and greenhouse gas emissions and to open markets to freer trade in bio-fuels. Other forms of bio-energy-- such as bio-heat, bio-power and biogas which are mostly generated with non-agricultural feed stocks and agricultural wastes -- could represent economically more viable and environmentally more efficient ways to reduce carbon emissions for OECD countries.

## POLICY CONSIDERATIONS: USING THE GREEN GROWTH POLICY TOOLKIT EFFECTIVELY

The Green Growth Strategy seeks to augment ongoing OECD work to realize more sustainable growth and development through the elaboration of a policy framework integrating economic efficiency, environmental integrity and social equity objectives. With rising food demand and complex ecological challenges in agriculture, the diverse linkages between social welfare, agricultural economics and the environment must be taken into account in implementing the Green Growth Policy Toolkit.

While policies should seek to internalize agricultural externalities (positive or negative) to the extent possible, Green Growth approaches must be tailored to the unique nature of the agricultural sector. More so than in other sectors, the choice, design and implementation of policies will differ across countries depending on local environmental and agricultural conditions and political economy factors. For primarily social motives, a greater emphasis is placed on government supports – rather than on market-based instruments – to increase environmental practices in agriculture, augment targeted R&D and facilitate structural adjustment. A set of broad policy approaches – including impact assessments, environmental cross-compliance mechanisms, structural adjustment measures and alternative farming solutions – will assist in balancing economic, environmental and social considerations to effectively implement the Green Growth Policy Toolkit in agriculture (**Table 7**).

**Table 7: Using the Green Growth Policy Toolkit Effectively**

| | Economic tools | Environmental tools | Social tools | Science and technology tools |
|---|---|---|---|---|
| **Economic effects** | **Impact assessments** | Environmental regulations to internalize costs | Green poverty reduction strategies (PRS) in agriculture | Public research to promote eco-efficient agriculture |
| **Environment effects** | Payments for environmental services (PES) | **Environmental cross-compliance mechanisms** | Provision of social infrastructure in rural areas | Development of agricultural biotechnology |
| **Social effects** | Supports oriented to farm incomes | Production of environmental goods and services | **Structural adjustment measures** | Skills training in green agricultural practices |
| **Technical effects** | R&D tax credits for agricultural research | Water charges and trading systems | Rural green extension programs | **Solutions for alternative farm systems** |

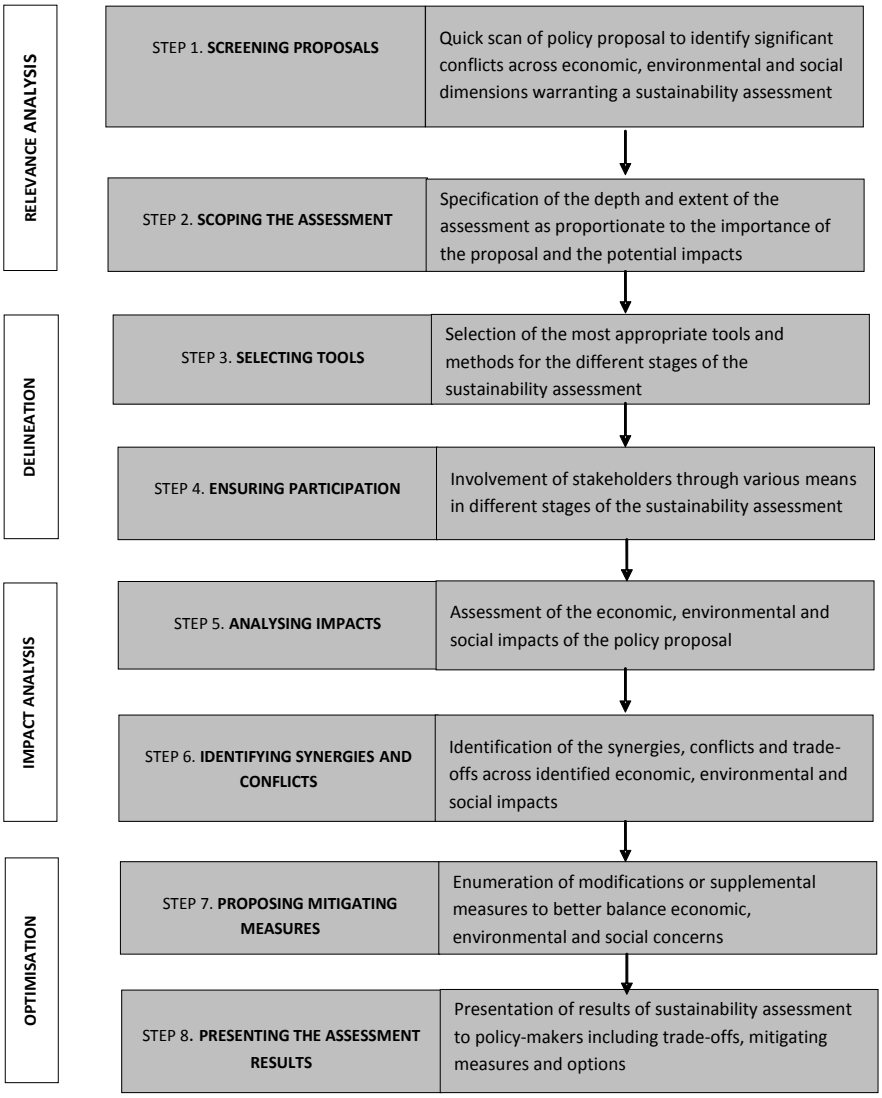
### Impact assessments

Prior to their implementation, agricultural policy measures in the Green Growth Policy Toolkit would benefit from impact assessments to evaluate the potential economic, environmental and social effects and their interrelations. Impact assessments can take into account national priorities and policy frameworks, local environmental and agricultural conditions, and alternative farm systems. Evaluation

criteria can be selected in advance and in most cases sufficient data is available to provide the basis for assessment. Impact assessment methodologies do not have to be complex, expensive or time-consuming.

Sustainability impact assessments (SIA) incorporate elements of OECD methodologies for regulatory impact assessments (RIA), environmental impact assessments (EIA) and strategic environmental assessments (SEA) (**Figure 6**). SIA are characterized by their interdisciplinary nature in evaluating economic, environmental and social impacts; their focus on highlighting short-term and long-term synergies and trade-offs; and their inclusive processes open to stakeholders. In this, sustainability assessments help governments frame problems, identify political sensitivities and scope solutions which will gain widespread acceptance.

**Figure 6: Sequence of Steps in Sustainability Impact Assessments**




Source: OECD, 2008b

SIA involve eight basic steps. *Screening* and s*coping* determine whether a sustainability assessment is actually needed and establish the extent and depth of the evaluation to be conducted. *Selecting tools* and methods for the assessment is followed by i*dentifying participants* to determine which authorities, experts and stakeholders will be involved, to what extent, and at what points in the process. At the core of the assessment is *impact analysis* of potential economic, environmental and social effects which can employ a range of techniques including cost-benefit analysis.

An important contribution of SIA is *highlighting synergies and conflicts* across the economic, environmental and social dimensions, including those between material and quality-of-life aspects of wellbeing. *Mitigating measures* are identified to reduce potential negative impacts and maximize sustainable outcomes. *Presenting the results* includes the delineation of alternative paths to reach Green Growth objectives so that decision-makers can clearly see and understand the costs and benefits of different policy options.

SIA could assess how farm support policies may exacerbate or alleviate environmental problems, inadvertently encourage environmentally-harmful activities, and contribute to or detract from Green Growth. SIA can help evaluate how policies might stimulate innovation and the diffusion of green technologies so that emissions reduction and resource management costs can be lowered in the future. Identifying externalities involving trade-offs between current and future well-being can highlight issues of inter-generational equity and longer-term productivity challenges. The value of SIA is in predicting diverse and interrelated outcomes and helping to devise mutually reinforcing policies across the various dimensions of agricultural Green Growth.

**Environmental cross–compliance mechanisms**

Environmental cross-compliance is one means by which governments can influence farmers to give greater weight to environmental values in their production decisions. Environmental cross-compliance mechanisms require farmers to adopt good environmental practices or resource management programs in order to receive government supports. Linking payments to the fulfillment of environmental requirements, which is significant in the European Union, the United States and Switzerland, now applies to about one-third of the aggregate Producer Support Estimate (PSE) in the OECD area.

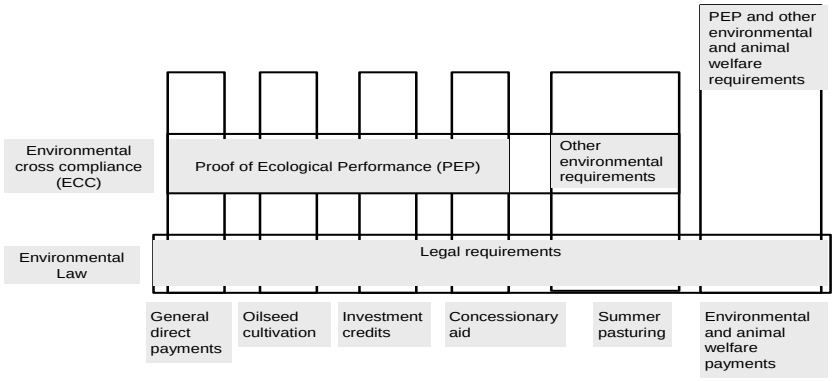
Among the rationales for environmental cross-compliance in OECD agriculture is leveraging income support payments to better ensure compliance with environmental requirements, making government payments to farmers more acceptable to society, and reducing policy-related transactions costs. Cross compliance can economize on administrative and other costs relative to separate implementation of agricultural income supports, environmental regulations, and payments for environmental quality. Other benefits of environmental cross compliance schemes include the wider application of the Polluter Pays Principle in agriculture, the inclusion of a broader range of farmers and producers in environmental programs, and greater synergies between agricultural and environmental policies.

Different environmental cross compliance approaches have been adopted. The European Union (EU) establishes a link between agricultural support payments and the respect of environmental regulations for ensuring the Good Agricultural and Environmental Condition (GAEC) of land and landscapes. Support

payments can be reduced or withdrawn for non-respect of these rules which define the reference level of environmental quality higher than that imposed by regulations. In the case of the United States and Switzerland, cross compliance support payments are conditional on meeting specific environmental practice or performance objectives. The United States uses these approaches principally in an effort to control soil erosion in agriculture.

The Swiss approach subjects all forms of agricultural support payments to environmental requirements (**Figure 7**). Eligibility for supports depends on adherence to environmental legislation specific to agriculture as defined in the laws on water protection, pollution control, nature conservation and protection of rural landscape. In addition, there are several supplementary requirements including that at least 7% of farmland must be used as "ecological compensation areas"; an appropriate nutrient balance must be maintained; crops must be regularly rotated and the soil protected; and appropriate animal welfare measures must be adopted.

**Figure 7: Swiss Cross-Compliance Requirements**




Source: OECD, 2010d

Environmental cross compliance mechanisms are not an option in all countries as they only apply where support payments exist and where environmental problems need to be addressed. In order to implement these schemes, there must be a system of income support payments to farmers in place that can be leveraged and also explicit or implicit "reference levels" which define the respective responsibilities of farmers and society for environmental protection. In countries where only economy-wide income and environmental instruments are implemented in agriculture, ecological objectives are obtained through legal obligations to comply with environmental regulations.

There are other limitations to cross-compliance. In broadly based schemes, cross compliance payments may not necessarily be received by those farming the most environmentally sensitive land. Major differences in the costs of compliance on different farms mean that the level of production disincentive needed to achieve the chosen environmental standards will vary. Identifying these differences in compliance costs can involve major administrative and monitoring efforts. There are also problems in

setting appropriate standards as the basis of compliance since it is easier to monitor variables such as pollution levels than others such as land values and biodiversity maintenance.

**Structural adjustment measures**

Approaches are needed to manage the structural changes associated with the transition to a greener agricultural sector. At the macro-level, greener economic growth could prompt a shift in financial and labor resources from agriculture to other sectors, particularly services. At the micro-level, the implementation of the Green Growth Policy Toolkit will likely induce changes in traditional farming practices and entail employment and distributional effects. The development of new green services, technologies and industries offers opportunities to the agricultural sector but also requires careful management of the potential decline and job losses in more environmentally-damaging activities. Structural adjustment measures to facilitate the transition to Green Growth include supports, rural diversification programs, and training in green job skills.

A major component of the Green Growth Policy Toolkit is reforming and decoupling agricultural supports from output and input levels to mitigate negative environmental impacts. Successful subsidy reform will depend on packaging and timing as well as possible compensation and assistance for those that are adversely affected. Under the WTO Agreement on Agriculture which aims at reducing trade-distorting supports in the Blue and Amber boxes, payments are permitted under the Green Box which promote structural adjustment and farm restructuring (**Table 8**). No limitation is placed on the duration or size of payments for producer retirement, which ensures the permanent exit of farmers from commercial production, or resource retirement, which facilitates taking land out of production and liquidating livestock herds.

**Table 8: Categories of WTO Agricultural Supports**

| Category | Type and trade impacts | Includes |
|---|---|---|
| **Amber Box** | Market support – significant distortion | All supports except that in blue and green boxes |
| **Blue Box** | Production related support – moderate distortion | Supports based on fixed acreages of arable land and fixed numbers of livestock |
| **Green Box** | Decoupled support – minimal distortion | Environmental protection<br>Research and development<br>Regional development<br>Structural adjustment<br>i. producer retirement<br>ii. resource retirement<br>iii. investment aids |

A third type of payment is designed to promote structural adjustment through investment aids which assist the financial or physical restructuring of farm operations in response to demonstrated structural disadvantages. Investment aids have proved the most popular of the three types of structural adjustment payments particularly in the European Union and the United States. They are used to

promote rationalization and restructuring of farming and livestock operations and to support the processing and marketing of agricultural products. However, investment aids are limited in both amount and time and must not be linked to the type or volume of agricultural production.

As part of the transition to Green Growth, governments can actively promote rural development based on environmental services and products. This includes converting land and resources to the production of organic and green products and the provision of eco-services. Grants and supports can be extended for the diversification of farming activities from commodity production to the processing of agricultural and forest products, eco-tourism and craft-related enterprises. Where environmentally and economically viable, land can be converted to biomass production including for bio-fuels.

The engagement of farm households in the broader rural economy should be increased, including the share of farms with eco-tourism activities. Rural economic diversification can be promoted through micro-credit and business development schemes. Gender-based programs are useful as it is often women in farm households who initiate and engage in economic activities as an alternative to production agriculture. First, regulatory barriers to diversification should be dismantled including land use regulations that prevent a change of use of existing buildings or new construction, labor regulations which narrowly define agricultural work, and tax provisions which limit allowable income from non-agricultural activities.

In agriculture as in other sectors, active labor market policies including skills training are essential for helping workers make structural transitions. The adaptive capacity of labor markets in agriculture may be more limited than in other sectors owing to the narrower focus of farming and also location-specific factors. Employment protection, unemployment insurance, and safety nets for farmers and farm workers should be in place. Public initiatives to train rural workers in green skills such as retro-fitting buildings, landscape and habitat preservation, and renewable energy production are needed. Farmers will generally benefit from vocational training and gaining basic business skills in human resource management, networking and market development.

**Solutions for alternative farm systems**

The Green Growth Policy Toolkit should promote the sustainability of alternative farming systems, including intensive and extensive, conventional and organic, large-scale and small-scale. Green growth will most likely be achieved by a mosaic of approaches to satisfy competing production, environmental and aesthetic needs and involve a mix of conventional, organic and integrated techniques. The Green Growth paradigm in agriculture offers a menu of approaches for maintaining the sustainability of diverse farming systems from the economic and environmental perspectives (**Table 9**).

**Table 9: Characteristics of Alternative Farm Systems**

| | Conventional Agriculture | New Agriculture |
|---|---|---|
| **Driving forces** | Population growth & food demand<br>Economies of scale<br>Productivity increases | Market liberalization<br>Environmental protection<br>Consumer preferences |
| **Products** | Food<br>Feed<br>Fiber | Renewable energy<br>Eco-services<br>High value-added chemicals |
| **Organization** | Intensive<br>Large-scale<br>Labor-saving<br>Yield-enhancing | Extensive<br>Smaller-scale<br>Labor-intensive<br>Quality orientation |
| **Practices** | Land tillage<br>Chemical inputs<br>Animal hormones | Organic farming<br>Nutrient balancing<br>Precision farming |
| **Technologies** | Mechanization<br>Agrochemicals<br>Enhanced seeds and breeds | Biotechnology<br>Information technology<br>Integrated technologies |

Whereas the evolution of agricultural practices over time has been largely in response to population growth and increasing demand for food, agriculture must now react to a more diverse range of drivers including global market competition, environmental concerns, and consumer preferences. Market liberalization has resulted in a wider range and number of producers, greater price variability and increased competition in most commodity markets. Food and feed production must be balanced with the conservation of natural resources, a reduction in environmental pressures and greater attention to rural viability and animal welfare. At the same time, consumers are demanding low-cost food of higher quality produced through organic methods with more variety, consistency and year-round availability. The agricultural sector is also being called upon to produce a wider range of products, including biomass and renewable energy, high-value added chemicals and eco-services.

In order to fulfill these competing demands, different types of farming systems have emerged with varying requirements for environmental sustainability. Conventional farming systems -- which tend to be intensive, larger-scale and more specialized -- supply the major share of the world's food. Their environmental quality depends on avoiding inappropriate cultivation and irrigation techniques or overuse of chemical inputs. While intensive production in smaller areas can increase local pollution, it has the advantage of leaving a wider area available for nature conservation and biodiversity maintenance. Conversely, single-species and mono-plantations can reduce biodiversity but have greater carbon accumulation abilities.

Extensive farming systems -- which are based on more land and labor inputs and fewer chemicals -- are unlikely to make a significant contribution to global food supply due to their smaller production scale and higher costs. Environmental concerns focus on biodiversity loss due to the expansion of agricultural lands and the depletion of the natural resource base from increased pressure on land. Explicit protection

of environmentally sensitive land can mitigate the negative effects of extensive agriculture, whose ecological benefits derive from reduced inputs of pesticides and fertilizers and greater use of organic farming methods.

Due to new driving forces, conventional agricultural practices are now supplemented by a wider range of approaches including organic production, nutrient balancing and precision farming. Organic farming, which is regulated and legally enforced through certification and labeling in many countries, relies on techniques such as biological pest control, green manure, composting and crop rotation to maintain soil productivity and control pests. Nutrient accounting records inputs of nutrients, such as nitrates and phosphates from fertilizers, and outputs of emissions for better management of nutrient use. Precision farming is based on information technologies such as global positioning systems and sensors to evaluate optimum sowing density, estimate fertilizer and other input needs, and predict crop yields.

Many farms use a combination of conventional and newer techniques as optimal approaches differ by the type and scale of the farm system and its location. The challenge is to identify which technologies work best in specific circumstances to both enhance factor productivity and conserve the resource base. As a result, newer biological, chemical, information and mechanical technologies must be assessed from the perspective of the economic viability and sustainability of the farming system. For example, integrated pest management uses a range of biological and natural practices to encourage pest predators and reduce the incidence of diseases but may also employ chemical controls to keep pests at an acceptable level.

All types of OECD farming systems now require a high level of skills and management capabilities to operate. Greater emphasis is being placed on green job skills, *e.g.* those that help to protect ecosystems and biodiversity, reduce chemical and water consumption, and minimize waste and pollution. Access to such knowledge can be enhanced through farmer training, education and extension. There is a need to translate the detailed understanding of alternative farming systems and technologies into a set of general best farming practices and to transfer this knowledge to farmers in different countries. This can be accomplished through exchanges of national and local experiences in designing and implementing greener farms and coping with competing interests.

## MEASURING PROGRESS ON GREEN GROWTH IN AGRICULTURE

The OECD Green Growth Strategy will present measurement tools to help policy makers evaluate the efficiency of their policies and measure the extent to which they are shifting economic activity onto a greener path. The aim is to broaden the range of existing economic indicators to allow for more comprehensive comparative analyses and benchmarking of countries on Green Growth. The OECD will provide: i) a framework and principles for thinking about what needs to be measured and how; ii) a summary of existing measures and possible gaps; and iii) a small number of key headline indicators for measuring progress on Green Growth.

A companion set of indicators is needed to assess progress toward Green Growth in agriculture which could provide input to monitoring exercises and policy development. *First*, an attempt should be made to quantify policy measures contained in the Green Growth Policy Toolkit on the basis of which countries may be surveyed on their applicability and implementation. *Second*, existing economic, environmental and social indicators may need to be supplemented to assess the relative economic efficiency, environmental impacts and general welfare aspects of OECD agriculture.

*Third*, indicators are needed to assess whether the Green Growth paradigm is improving economic outcomes in agriculture, delivering reduced pressures on the environment and enhancing quality-of-life aspects. Techniques for comparing bio-physical and socio-economic data could help evaluate the impact of Green Growth policies on agricultural performance over time. Given the site specificity of many environmental issues and the complexity of measuring environmental outcomes in agriculture, this is likely to be a complex process. In addition, optimal agricultural policy approaches will vary widely by country depending on relative preferences for regulations, supports and/or cross-compliance to achieve Green Growth objectives.

A set of key headline indicators for assessing the progress of Green Growth in the agricultural sector are proposed in **Table 10**. A far greater range of policy and performance areas and indicators are available, but a first task is to determine those measures would be most useful in assessing green advances in agriculture and for which data may be collected on a broad basis. Data for the indicators listed here are generally available at the national level.

In the *first* row, the indicators of Green Growth policies refer to: i) the environmental dimensions (positive and negative) of public supports to agriculture, ii) the use of economic instruments as proxied by water charges, iii) the level of trade barriers as seen in bound and applied tariffs on agricultural products, and iv) agricultural research and development (R&D) expenditures -- assumed to be increasingly directed to enhancing environmental values – as a share of total R&D spending.

In the *second* row, indicators of economic performance in agriculture include standard measures of agricultural output, productivity, employment and income. A measure of income derived from the production of agriculture-based environmental goods and services is added to gauge the value-added from Green Growth investments.

**Table 10: Headline Indicators for Measuring Progress on Green Growth in Agriculture**

| Indicators of: | Type | Proposed indicators |
|---|---|---|
| **Green policies** | Negative supports<br>Positive supports<br>Economic instruments<br>Trade barriers<br>R&D funding | Most environmentally harmful PSE as share of total<br>PSE for environmental practices and services as share of total<br>Share of full costs covered by water tariffs<br>Average level of bound and applied tariffs on agricultural products<br>Public & private R&D spending on agriculture as share of total |
| **Economic performance** | Output<br>Productivity<br>Employment<br>Income<br>Environmental output | Indices of crop and livestock production<br>Crop yield per land area<br>Number employed in primary agriculture<br>Income per capita in agriculture<br>Value of agriculture-based environmental goods and services |
| **Environmental performance** | Water quality<br>Land quality<br>Soil erosion<br>Air emissions<br>Biodiversity | Share of surface & groundwater with excessive nitrates & phosphorus<br>Share of agricultural land with excessive nitrates & phosphorus<br>Share of agricultural land affected by water and wind erosion<br>Agricultural greenhouse gas emissions as share of total GHG<br>Area of semi-natural habitats in total agricultural land area |
| **Social performance** | Rural development<br>Rural employment<br>Human capital<br>Social capital<br>Income distribution | Share of non-farm rural income<br>Share of non-farm rural employment<br>Average education levels in rural areas<br>Changes in population levels in rural areas<br>Distribution of rural household income |

In the *third* row, measures of environmental performance are based on existing OECD agri-environmental indicators, including those of the quality of water and land as measured by excessive nitrate and phosphorus content. Soil quality is indicated by the share of agricultural land affected by water and wind erosion. Levels of greenhouse gas emissions and habitat area are used to measure climate and biodiversity impacts from agricultural production.

In the *fourth* row, social performance in the agricultural sector is indicated by measures of rural development including diversification of economic activities in addition to primary production as seen in non-farm shares of rural income and employment. This can be further broken down to measure income and employment from environmental goods and businesses resulting from Green Growth investments in rural areas. Other social values are measured in terms of education levels (human capital), maintenance of rural populations (social capital), and income distribution (social equity).

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