Executive Summary

Improving the environmental performance of agriculture is a high policy priority in OECD countries. But determining the environmental impact of agricultural policies is complicated because specific policy measures do not take place in isolation, but within a broad and evolving socio-economic and technological context. Quantitative analysis using models is not designed to exactly replicate the real world but can provide guidance on the expected environmental outcomes, which could be particularly useful in assessing the relative impacts of different policies. This can assist policy makers to better understand the linkages between policy instruments and environmental impacts, and the trade-offs or synergies involved, and therefore aid policy makers in the design and implementation of cost-effective policies.

The key policy question is to identify the change in farmers' actions that are due to specific policy interventions, and then to determine the extent to which those actions affect environmental quality. While the conceptual relationships are relatively well-established, quantitative modelling is complicated for at least four reasons:

- Biophysical processes are complex and the relationship between a given practice and its environmental outcomes is not always clear.
- Many of the environmental effects are site-specific, reflecting heterogeneous agricultural and environmental conditions, and thus some impacts cannot be extrapolated to the aggregate level through generalised policy-response coefficients.
- There are in practice a mix of policy instruments applied and multiple environmental impacts which make modelling particularly difficult.
- Many of the environmental impacts are not measured (or measurable) in monetary terms. The same agricultural production practices may produce very different bundles of commodity outputs and environmental externalities in different areas.

The conceptual and quantitative linkages between agricultural policies and environmental impacts have been analysed using the Stylised Agri-environmental Policy Impact Model (SAPIM). Developed by the OECD Secretariat, the SAPIM framework has been applied to Finland, Japan, Switzerland and the United States. SAPIM uses a combination of economic and biophysical models of representative farms (or production units) in the case studies in the countries concerned.

The SAPIM approach is pragmatic – a farmer's decision-making is analysed at the field parcel level, because this level of detail is necessary to capture the complex economic and biophysical interactions that are site-specific. SAPIM is specifically designed to capture the environmental effects of different agricultural policies through their impacts at the *intensive* margin (input-use intensity and production practices), the *extensive* margin (land-use allocation between different agricultural activities) and the *entry-exit* margin (land entering or leaving agriculture) under heterogeneous conditions.

A number of standard policy instruments are explicitly modelled: nitrogen taxes, nitrogen application standards, buffer strips, area payments and conservation auctions.

The ***Finnish study*** investigated how environmental regulations, environmental taxes and voluntary agri-environmental payments perform in the case of crop production with varying land productivity that implies different input-use intensities and adoption costs with regard to agri-environmental measures. The effects of alternative policy instruments on nutrient runoff and biodiversity were taken into account through their impact on input-use and land-allocation choices. Conservation auctions – in which farmers bid for a limited amount of conservation contracts – were also analysed.

The ***Swiss study*** examined a mixed dairy/crop farm, focusing on ammonia emissions, greenhouse gases (GHGs) and nitrogen and phosphorus surpluses. Many of the standard policy instruments on chemical fertilizer also have an impact on the amount of manure applied on crops and therefore the amount of excess manure that is then exported outside of the farm. Because nitrogen can be applied either as chemical fertilizer or as manure, the nitrogen surplus needs to be addressed by policies that influence both sources of nitrogen input.

The ***United States study*** focused on the economic and environmental performance of conservation auctions compared to the more conventional agri-environmental policy measures. Three alternative land-use types were analysed in this application – land retirement for environmental purposes (riparian buffers) and two alternative tillage methods to produce cultivated crops (no-till and conventional tillage). No-till and conventional tillage represent important cropping management choices under the working lands agri-environmental programmes. In this application the sources of heterogeneity include both differential land productivity and environmental sensitivity of the land, involving differing propensity for erosion and thus nutrient and sediment runoff.

In addition to the standard policy instruments, conservation auctions were analysed. The application of a uniform pricing auction reveals farmers' adoption costs and thus their information rent is reduced and budgetary cost-effectiveness is increased. On the other hand, a discriminatory payment gives farmers an incentive to place their bids above their adoption costs: low adoption cost farmers have a greater incentive to do so than high adoption cost farmers.

The ***Japanese study*** investigated the optimal land-use allocation and nitrogen application under a representative Japanese farm that consists of rice paddies, upland fields and land abandonment. This case study integrated paddy rice production with an upland field crop (wheat) in the same analytical framework. In general, paddy fields can provide either positive or negative environmental effects, depending on farm management practices. Consequently, the incentives provided to farmers that encourage environmentally friendly paddy rice production practices have a significant impact on the environmental effects.

In each of the four case studies, the importance of the specific policy environment was emphasised. In particular, the "policy package" is crucial as it defines the context and therefore the assumptions that must be applied in order to have a realistic representation of the impact of policies. Each of the case studies highlights different production systems, environmental issues and policy contexts. The common thread underlying all of the case studies is the impact of various policies under heterogeneous conditions. Specifically, all of the case studies have an important crop production component, in which the impact of fertilizer application is assessed in terms of crop yield and nutrient runoff. Social benefit

analysis is adopted only in the Finnish and Japanese case studies, requiring monetary valuation of environmental effects (although detailed methodological discussion on monetary valuation is not conducted in this context).

In each case the analysis modelled alternative scenarios of policy options to determine the production choices and environmental outcomes that would be optimum from the perspective of producers and society (only in the Finnish and Japanese case studies). The results highlight the well-established observation that when positive or negative environmental externalities are not factored into farmers' decisions then the production choices and environmental outcomes will reflect the weighing-up of private costs and revenues by farmers. Policy intervention can potentially raise social welfare through bringing those externalities into the equation.

The analysis thus highlights the trade-offs involved – among production choices, policy instruments, economic and environmental outcomes. The value of the SAPIM approach is that a flexible framework has been developed that has the potential to be used by the policy and research communities to analyse their specific interests.

The SAPIM approach, like any other modelling approach, is subject to limitations with respect to the data, the model parameters, the economic and biophysical relationships represented. In particular, the site-specificity of agri-environmental relationships means that results cannot be readily generalised or attributed to more aggregate levels. A key source of uncertainty is arguably related to the valuation estimates of social benefits in the case studies. Nevertheless, the quantitative results in this study arising from the various scenarios modelled can be viewed and interpreted as illustrative.

The general policy lessons that can be drawn from the analysis are as follows:

- The heterogeneity of agricultural and environmental conditions makes it difficult to generalise a particular policy response to beyond where it was modelled.
- Un-regulated polluting activities should be included in policy design.
- It is important to take into consideration the existing policy environment when evaluating new policies.
- Environmental co-benefits and trade-offs should be recognised.

There has often been a lack of robust and quantitative analysis of the linkages between policy drivers and environmental outcomes in the agricultural sector. Decisions have been taken that have relied heavily on "trial and error" approaches to establish "which policies work". The approach described here is intended to redress the balance so that observed changes – for example, in nutrient runoff, or greenhouse gas emissions, or biodiversity associated with farming – can be better explained as to their cause and, in particular, their link to policy. The SAPIM approach has the potential to provide policy makers with a valuable tool to help them in designing and implementing effective and efficient policies.