Interim Report
September 2007

Annex 31-UK

Generalised Assessment of Agro-economics [Deliverable 5.3]

LIFE05 ENV/D/000182

Water Resources Management in Cooperation with Agriculture

GENERALISED ASSESSMENT OF AGRO-ECONOMICS

ADAS has developed a tool to allow a basic assessment of the cost-effectiveness of collections of mitigation methods.

Previous 'Cost-Curve' projects have separately identified mitigation methods and their likely effectiveness in controlling nitrate (Scholefield, 2005), phosphorus (Haygarth, 2004) and faecal indicator organism (FIO) (Haygarth, 2005) losses from agricultural land. From these projects, a list of 44 methods with potential to decrease losses of at least one of the three chosen pollutants had previously been identified: this formed the basis of the toolbox of measures used in the WAgriCo project.

To move towards a quantitative assessment of the effectiveness of mitigation methods, two separate activities were undertaken:

Definition of mitigation methods and implementation costs

Mitigation methods were defined in sufficient detail such that land managers or advisers would understand what was meant, for example, by 'establish a cover crop before spring sown crops'. The cost of each mitigation method was then assessed. A Senior Farm Economics Consultant calculated the costs of implementation of each mitigation method. Costs of field operations were generally based on current contractor rates. Costs were originally calculated per hectare of arable or grassland or per head of livestock and quantity of handled manure. These coefficients were scaled in proportion to the total land area, livestock number and quantity of handled manure on each of the model farm systems to derive the annual total implementation cost. Costs were based on clearly defined 'representative' farm types (see later). The costs represent those to the farmer of implementing the mitigation method.

Effectiveness of mitigation methods

The efficacy of each mitigation method in reducing losses of nitrate, phosphorus and FIOs was estimated. This was done using quantitative data collected from model runs during the series of previous Cost-Curve projects (as described above), and was supplemented by literature review data where methods had not previously been modelled. Method effects were expressed as absolute reductions in pollutant loss, and did not consider any interactions between methods. To prevent over-estimation of the effectiveness of multiple methods, the loss reductions were re-expressed as a percentage of the loss due to specific sources, namely external (fertilisers), internal (soil) and recycled (manure and excreta) sources. The net efficacy of multiple methods could then be calculated using a multiplicative model as:

$$\text{Net Efficiency:} = 1 - (1\text{-}E_1)\times(1\text{-}E_2)\times(1\text{-}E_n)$$

where E_n is the proportional efficacy of an individual method. The source apportionment draws upon a conceptual Cost-Cube model (Haygarth, 2005; Chadwick *et al*., 2006). However, as the approach does not explicitly represent the different modes of pollutant mobilisation and transport, it is still possible for the effectiveness of method combinations to be over-estimated.

Representative farms and baseline losses

Assessments were based on 'typical' farm systems. The model farm systems were defined to be representative of current UK practices and were characterised by an area of arable or grassland, a number of livestock, and associated inorganic fertiliser and managed organic manure inputs (Table 38-1). Pollutant losses from each model farm were calculated for combinations of soil texture (clay loam or sandy loam) and climate conditions (net soil drainage 170-620 mm) to represent the range of baseline pollutant losses across England and Wales.

Table 38-1. A summary of the representative farm types used to calculate costs and effectiveness of mitigation methods.

Farm System	Animal count	Excreta (t/year)	Managed manure (%)	Field area (ha)	Fertiliser (kg N/ha)
Grass (Dairy)	270	5040	60	150	190
Grass (Suckler Beef)	220	2288	60	100	60/100
Breeding Pigs (Indoor)	1330	2125	100	71	145
Broilers	150000	2500	100	437	145
Arable	-	-	-	300	165
Arable plus manure	-	2700	100	300	145

The baseline pollutant losses were calculated using a suite of 'tier-one' diffuse pollution tools for N, P and FIOs, dealing with losses from soil, from fertiliser or from manure. These baseline data, combined with assessments of the cost and effectiveness of each mitigation method were used to calculate the likely cost benefit of combinations of mitigation methods that could be invoked by a policy option (described below).

Method for assessing cost-effectiveness of combinations of mitigation methods

To calculate the effectiveness of combinations of mitigation methods in reducing pollutant losses, a tool was developed to calculate a Cost-Curve for the list of methods that were potentially applicable to a farm within the WAgriCo project.

A Cost-Curve is defined as the relationship between emission abatement and marginal cost. The function is continuous and has a positive gradient, i.e. the marginal cost always increases with increasing emission reduction, thereby satisfying the law of diminishing returns. Cost-curve optimisation is a numerically intensive calculation that scales exponentially with the number of potential methods. The optimal Cost-Curve can be determined only by simulating all possible orders of method implementation, as the marginal cost is dependent on the methods already implemented. For this work, we adopted a pragmatic approach in which the tool iteratively selects and implements the method with the least cost-benefit ratio at each cost step. At each step, each method from the pool of currently unimplemented methods is implemented separately and the cost-benefit of implementation is calculated. The method with the least ratio of additional cost and emission reduction is implemented. Mutually exclusive methods that have not yet been implemented will not be considered on subsequent steps.

The Cost-Curve calculation tool optimises simultaneously on the percentage reduction in phosphorus, nitrate and FIO losses. If preferred, options allow for a weighting to be given to methods that are effective against a specific pollutant. This would enable optimisation against, for example, differential costs of clean up per unit of pollutant loss. Additionally, the tool can be used to optimise on only cost or benefit, and to limit either the maximum spend or number of methods implemented. The maximum spend limit can be used to restrict method implementation to advisory policy options that either save money or are relatively low cost.

Application to WAgriCo PoMs

The methodology was used to provide an estimate of generalised farm costs and effectiveness for a range of different farm types within the WAgriCo project. Table 38-2 illustrates the cost to farmers undertaking the combination of 'Good Agricultural Practice' and 'Enhanced Good Agricultural Practice' primary measures for two soil types. The assessments represent the maximum likely benefit (in terms of reduced nitrate leaching) that could be achieved by implementing the combination of mitigation methods on these representative farms.

Table 38-2. Calculations of cost and effectiveness of WAgriCo PoMs applied to representative farms on two soil types: sandy loam (SL) and clay loam (CL).

Farm Type	Baseline Nitrate loss (kg N/ha)		Maximum Potential reduction (%)		Implementation Cost (€/ha)
	CL	SL	CL	SL	
Arable	47	51	20	21	47
Arable with Manure	51	57	28	28	47
Dairy	34	61	22	21	3
Beef	12	18	5	5	7

The model farms were defined to be representative of current practices, especially relating to the limits on the total nitrogen content of manure spread to land. Each was characterised by an area of arable or grassland, a number of livestock, and associated inputs of nutrients in fertiliser, excreta and managed manure.

The combination of primary mitigation measures ('Good Agricultural Practice' and 'Enhanced Good Agricultural Practice') were run for each of the 4 farm types on both sandy and clay soils in combination with medium climatic data. Table 38-2 shows the baseline results produced for the combined mitigation measures. The results suggest that the greatest percentage reduction would be seen on 'Arable with Manure' farms. This is due to the inclusion of mitigation measures that restricted the timing of manure application.

Under the combination of measures, both 'Arable' and 'Dairy' farm types would have a maximum potential reduction of around 20%. However, on the 'Dairy' farm type, this reduction would be achieved at a considerably lower cost of 3 €/ha. The implementation costs on both the 'Arable' and 'Arable with Manure' farm types would be higher due to the inclusion of 'establishing cover crops in the autumn', which within itself is approximately 25 €/ha.

Overall the results show potential for decreasing nitrate loss across individual farms. At the catchment scale, however, the average effect will be less than the largest reductions from individual farms as there is a range of farm types within the catchment that can not be captured by the 'average' or 'typical' idealised farms presented here. The results also assume that mitigation measures are also thoroughly and effectively implemented on the farm and, as a result probably reflect the maximum improvement in nitrate loading that could be attained.

This work will inform further agro-economic analysis undertaken in this project at farm, catchment and national levels.