The ETC/ACC framework for agricultural base-line scenario development in the context of integrated assessment for air pollution and climate change

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1 INTRODUCTION

The European Topic Centre on Air and Climate Change (ETC/ACC) is currently developing an Integrated Assessment (IA) framework. The three most immediate uses for the framework are:

- to provide a baseline scenario for the EEA State of the Environment 2004 report; this should cover all EEA member countries.
- to provide an EU wide projection for the EU monitoring mechanism, initially to 2010, and then to 2020
- to provide a baseline for the Clean Air for Europe (CAFÉ) programme for an enlarged EU i.e. EU 15, plus accession countries, plus Switzerland and Norway, for years 2010, 2015 and 2020

A full list of countries to be covered is given in Appendix 1. All projections will need to be made at the Country/Member State level. Priority for completing projections is firstly the EU countries, then the Accession countries and then other EEA countries. EEA candidate countries may be included at some future time.

The base year for the assessment will be 2000 (where available). Projections of emissions are required up to 2010, and, if possible, 2015, 2020 and 2030.

The ETC/ACC's Integrated Assessment (IA) framework contains, among others, modules to compute the main direct (i.e. non-energy related) air emissions from the agricultural sector (i.e. NH_3, CH_4, and N_2O). It is proposed that in 2003 these are modelled using the IIASA RAINS model for NH_3 emissions and the spreadsheet model developed by AEA Technology (AEAT) for the Sectoral Objectives Study for CH_4 and N_2O[1]. Both models could use output from the agricultural markets model CAPRI on agricultural activity levels (livestock numbers, crop areas, and fertiliser use etc) as source data. However CAPRI does not have the spatial and temporal coverage to meet all of the IA framework requirements. This note therefore:

- gives short descriptions of the three models, including the agricultural activity data which the RAINS and AEAT model require to make emissions projections;
- outlines the agricultural data that the CAPRI model can provide and input data used by CAPRI which would ideally be harmonised with other parts of the IA framework;
- reviews other agricultural models and forecasts to identify how missing data gaps could be filled;

[1] Starting from 2004 the RAINS model will also be able to compute emissions from greenhouse gasses. Whether this could replace the AEA technology approach needs to be evaluated

2 MODEL DESCRIPTIONS

The agricultural data required as inputs to the RAINS and AEAT model are listed in Table 1.

2.1 RAINS

The '**R**egional **A**ir Pollution **IN**formation and **S**imulation' (RAINS)-model has been developed by IIASA as a tool for the integrated assessment of alternative strategies to reduce acid deposition, eutrophication and ground-level ozone in Europe. The current version of the model describes the pathways of emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs) and ammonia (NH_3) and explores their impacts on acidification, eutrophication and ground-level ozone. It contains an emission-cost module (EMCO), with parts for emissions of each of these pollutants, an acid deposition and ecosystems impact module (DEP) and an optimisation module (OPT).

The NH_3 module of the EMCO model estimates current and future levels of emissions of ammonia based on national statistics and projections of agricultural activities, as well as data on other activities, including stationary combustion and transportation, taking into account implemented and possible emission control measures. The time horizon extends from the year 1990 up to the year 2010. Furthermore, EMCO also estimates costs for the reduction of emissions.

The data on current and historic agricultural activity in the RAINS NH_3 module were derived from the UN Food and Agricultural Organisation Statistical database (FAOSTAT) database and International Fertilizer Industry Association (IFA) for historical years. Additionally, assumptions about number of animals kept on solid and slurry systems were validated by data from questionnaires provided by MAFF (UK Ministry of Agriculture, Food and Fisheries), which had been prepared by Imperial College and distributed to many European countries.

A set of forecasts of future European agricultural activities were compiled by IIASA based on national information (Marttila, 1995; Nemi, 1995; Pippatti, 1996; Henriksson, 1996; Riseth, 1990; Menzi, 1995; Menzi et al., 1997; Davidson, 1996), on studies performed for DG-VI of the Commission of the European Communities (EC DG-VI, 1995a-k) for Eastern Europe, and on Egmond (1995), Stolwijk (1996), Folmer et al. (1995) for EU countries. The projection for the EU is based on the assumptions that

(i) until 2005 the Common Agricultural Policy will essentially consist of the type of the policies adopted under MacSharry, and

(ii) after 2005 the EU will gradually liberalize its agricultural policy (Stolwijk, 1996).

The projection of fertiliser consumption for EU-15, Switzerland and Norway is based on the "moderate grain price" scenario of the European Fertilizer Manufacturers Association (EFMA, 1996a,b). The basic assumptions of this projection are

(i) that there will be no change in the Common Agricultural Policy (CAP) until the year 2000; thereafter a more market oriented, less regulated CAP is expected; and

(ii) that by the year 2005/2006 the Central European Countries will have joined the EU.

Estimates on fertiliser consumption for the rest of Europe were derived from publications of the International Fertilizer Industry Association (Ginet, 1995). Since these forecasts do not always extend up to the year 2010, missing values were constructed based on a trend extrapolation.

Projections for the Republics of the Former Soviet Union were derived from an OECD study (OECD, 1995). The original forecasts of agricultural activities were subject to review during the preparation of scenarios for negotiations on the UNECE Gothenburg Protocol (signed in 1999), and were modified in response to comments from national experts.

Several abatement techniques are included in the RAINS NH_3 module:

- low nitrogen feed
- biofiltration (of air in mechanically ventilated pig and poultry houses)
- adaptation of animal housing
- covered outdoor storage of slurry (high and low efficiency)
- low ammonia application of slurry (high and medium-to-low efficiency)
- incorporation of solid waste (high and low efficiency)
- substitution of urea by ammonium nitrate
- end of pipe options in fertiliser production industry

An assessment of whether application of these techniques will affect N_2O and CH_4 emissions has been made previously (Brink et al, 2001). It is suggested that this methodology be used to ensure consistency between the application of any abatement techniques in the NH_3 projection and the CH_4 and N_2O projections.

2.2 AEAT MODEL

AEAT developed a spreadsheet model of agricultural N_2O and CH_4 emissions for the Sectoral Objectives Study (SOS) (Bates, 2001). It covered the EU 15 and provided estimates for 1990 and 2010. It calculates emissions using the IPCC emission inventory guidelines, based on national activity data. In general default emissions factors recommended by IPCC were used, except where country specific data was available. Total emissions estimates were scaled to give consistency with those reported by Member States for 1990.

The main data sources used for current agricultural activities and for projecting future activity for the SOS were:

- Current **livestock numbers** were obtained from **EUROSTAT**; future livestock numbers were derived from **DG AGRI Agricultural Prospects for Agricultural Markets 1999-2006**. Information on trends in agricultural products (milk and meat production) in the EU as a whole was extrapolated to 2010. These were converted to trends in livestock numbers by taking into account improvements in milk yield and productivity. Observed changes at the Member State level between 1990 and 1998 were used to apportion the change at the EU level between Member States. For animal types not covered by EUROSTAT or the DG AGRI projection, current and projection numbers were taken from the **RAINS database**.
- **Nitrogenous fertiliser use** - current use was taken from **FAOSTAT** database; forecasts of future use from the (1999) **European Fertiliser Manufacturer's Association** (EFMA) projection of changes in nitrogenous fertiliser consumption (1997/8 to 2007/8) (EFMA, 1999).
- **Crop production –** current production was taken from **FAOSTAT** database, forecasts were derived from **EFMA** (1999).

2.3 CAPRI MODEL

The first version of the CAPRI (Common Agricultural Policy Regional Impact) model was developed under the fourth EU framework program (1996-1999) to allow the analysis of the regional impacts of Common Agricultural Policy (CAP) on production, income, markets, and the environment. The CAPRI project was led by University Bonn and had a team of five main partners.

The underlying database of the model was originally completed for the years 1990-95 and is sourced mainly from Eurostat's SPEL and REGIO databases, with additional data from national and regional statistics. It has subsequently been updated to 1999 and 2001). It contains an activity based breakdown of regional agricultural production (about 50 activities) at NUTS II spatial level (200 region covering the whole EU 15), farm and market balances, unit value prices at national level (about 60 products, 35 inputs). It also includes policy variables at regional (premiums, set-aside, base areas etc) and EU-level (tariffs, administrative prices, trade quotas).

CAPRI is a comparative static equilibrium model, solved by iterating supply and market modules, building upon a three year average base (currently 1998). In each regional supply module, allocation is based on profit maximising behaviour under constraints (as availability of land, policy constraints as sales quotas and set-aside obligations, nutrient requirements of animals, young animal and fertiliser balances etc.), combining a primal technology description based on input/output coefficients with a dual cost function approach. The parameters of the cost functions are calibrated to exogeneous elasticities (animals) or econometrically estimated multi-product cost functions (annual crops). Perennial activity levels are projected based on time series model.

The current version of the market module (an aggregated version of the multi-commodity model 'WATSIM') is a non-spatial, net-trade, multi-commodity model; regionalised at Member State level (+Norway, Switzerland, and "Rest-of-the-world") with endogenous world market prices. Behavioural equations for supply and demand depend on prices at country (aggregate) level and equilibrate regional and international markets. Regional prices are linked via trade policy instruments as tariffs and export subsidies as well as transport and transaction costs to uniform world market prices. The model features a detailed description of the Commission market interventions (subsidised exports, intervention sales to stocks) including WTO commitments. Important driving forces in the market module are: population and income growth, changes in trade policy instruments and technical progress in agriculture. The supply functions for EU Member States are iteratively calibrated to the result of the regional supply modules. Both supply and demand data and model parameters for the rest of the world stem to a large extent from WATSIM, a world-wide modelling system for trade in agricultural products.

Equilibrium in the modelling system ensures cleared markets for final agricultural outputs – based on the market module - and intermediate outputs as young animals and manure and a match of animals' feeding and crops' nutrient requirements at regional level – based on the regional supply modules. Further on, the model simulates regional use of inputs according to the definition of Economic accounts. Whereas most inputs (as energy, plant protection etc.) are measured in constant prices, young animal and fertilisers are presented in physical units.

The model calculates nutrient balances and greenhouse gas emissions based on production system. Emissions and sources that are included are:

- CO_2, CH_4 and N_2O emissions from chemical fertiliser production
- CH_4 from livestock; these are based on German data for different types of production systems; the methodology is not consistent with IPCC methodology, but is currently being revised.
- NH_3 emissions during housing, grazing, storing of manure and application of fertiliser.

The CAPRI model includes all agricultural inputs and outputs according to the definition of national accounts, and break-down economic accounts, market and land balances consistently from EU to national and to regional level and even individual activities at regional level. Its activity based concept, describing agricultural production by the help of physical input and output coefficients was chosen to allow both for the modelling of typical agri-environmental policy measurements and to allow a link to environmental indicators.

Emissions that are currently not calculated in CAPRI are:

- N_2O emissions from application of fertiliser and manure, from nitrogen fixing by leguminous crops and background emissions from soils; the model features a detailed N balance (covering N fixing, atmospheric deposition and releases from soils) including NH_3 emissions, but currently does not break-down the N surplus into N_2O losses, nitrate leaching and N accumulation in soils.
- CO_2 emissions from on-farm energy use.

The CAPRI model is currently being improved under the CAP-STRAT project (3/2001-3/2004), which will also produce a reference run and analysis of several strategic scenarios (to be agreed with DG AGRI) of the future CAP. This is due to be completed in 2004. Including the mentioned emissions in the model is, however, not foreseen. Modelling of carbon sinks is currently being discussed as part of CAP-STRAT. One of the planned improvements in CAPRI is the disagreggation of the rest of the world (currently treated as one block) into 10/11 regional areas and the switch to a gross-trade representation. In addition to this the CAPRI team is completing a project for DG ENV, which includes improving the environmental indicators in the model, breaking down regional models to individual farm types and a trial application on a scenario developed in co-operation with DG ENV.

The model is typically applied to medium-term analysis (up to 10 years) so given current availability of statistical data, simulations are being run for 2008. Subsequent baselines for DG AGRI will use more up to date data and be based on improved versions of the model, but many underlying assumptions will be similar.

An initial discussion with CAPRI modellers, suggests that useful 'policy' scenarios to examine (i.e. those which would be likely to have a significant effect on greenhouse gas emissions) might be:

- Changing the way compensation payments are made to a cross-compliance model e.g. decoupling them from production and linking them to environmental externalities such as greenhouse gas production. Such scenarios are already being discussed with DG AGRI and DG ENV
- decrease in administrative payments
- promotion of organic/biological methods of production.

2.4 COMPARISON OF CAPRI OUTPUT AND RAINS AND AEAT MODELS' INPUT REQUIREMENTS.

Table 1 shows whether the data required by the RAINS and AEAT model is available from the CAPRI model. There are two pieces of activity data required by RAINS that CAPRI would not provide:

- number of fur animals – there are a significant number of fur animals in Finland and Denmark, and some in Spain, Sweden, Italy and Greece. However it should be possible to get data on current numbers and future trends from national experts in the relevant countries.
- proportion of inorganic nitrogenous fertiliser which is urea - this is important for modelling of ammonia emissions as the average N loss form urea is estimated to be significantly higher than for other fertilisers. Countries where a significant proportion of N fertiliser applications is urea include (based on 1995 data) Italy (40%), Hungary, Spain (30%), France, UK, Germany (10%), most of Eastern Europe (20%), and Albania (50%). It may be possible to get more recent information from EFMA, IFA (International Fertiliser Association) or FAO database.

The CAPRI model requires a number of exogenous variables, which are used to define the 'reference case' and would not be changed under the scenario runs. Variables in this category, which would also be key in other non-agricultural parts of the integrated assessment, are GDP growth and population growth. In CAPRI these are currently based on UN projections of population growth and World Bank projections of GDP growth, but ideally these should be harmonised with those being used in other parts of the IA framework (e.g. energy modelling). The values being used in the IA framework energy models (PRIMES) have been passed onto the CAPRI modelling team, who have agreed to incorporate them in the reference run.

Table 1 Comparison of AEAT and RAINS model data requirements and CAPRI data outputs

NH_3 (RAINS)	**CH_4 and N_2O (AEA)**	**Data available from CAPRI**
LIVESTOCK NUMBERS		
Dairy cows (all milking cows and cows in calf) (kept on slurry/solid waste system)	Dairy cows (+ proportion with particular waste management system, IPCC default factors can be used)	Available at NUTS II level (split-up in housing systems with factors at Member State level); regionalised milk yields
	Average milk yield, fat content and weight used to calculate emission factor for enteric fermentation for dairy cows	Emissions (N,P,K) depend on final weight/milk yields/number of piglets; Ammonia emission depend on housing/storage system (factors at Member State level)
Other cattle (all other cattle including bulls, beef cattle, young stock) (kept on slurry/solid waste system)	Other cattle (+ proportion using particular waste management system - IPCC default factors can be used)	Suckler cows, Male / Female Fattening, male / female raising (<1 year), calves fattening (male/female) at NUTS II level; different final weights at Member State level; split up in housing systems at Member state level
Pigs (kept on slurry/solid waste system)	Pigs (+ proportion using particular waste management system - IPCC default factors can be used)	Split up in number of fattened pigs and sows at NUTS II level, different final weights and gestation periods at Member State level, split-up in housing systems at Member State level
Laying hens	Laying hens	Laying hens (NUTS II)
Other poultry	Other poultry	Poultry fattened heads (NUTS II)
Sheep & Goats	Sheep and Goats	Sheep & Goat for milk; sheep & Goat for fattening
	Goats	
Horses	Horses	All other animals are aggregated (production value) at NUTS II level; number of horses available from REGIO
Fur animals		-

Table 1 (continued) Comparison of AEAT and RAINS model data requirements and CAPRI data outputs

NH_3 (RAINS)	**CH_4 and N_2O (AEA)**	**Data available from CAPRI**
FERTILISER USE		
Urea and other nitrogenous fertilisers	Total nitrogenous fertiliser	N,P,K use (split up in inorganic/organic) at NUTS II level in pure nutrient content; consistent with FAOSTAT data at Member state level in base year
CROPS		
	Rice production	7 cereals + rice, 5 oil seeds, pulses (N fixing), potatoes, sugar beet, textile crops, other industrial crops, tomatoes, other vegetables, apples/pear/peaches, citrus, other fruits, table grapes, table olives, table and other wine, nurseries, flowers, fodder maize, other fodder production on arable land, type types of grass land, other crops, set-aside, fallow land Data on N,P,K use for all crops per ha and region depending on yields Data on climatic condition and soil types are currently integrated in system
	Production of pulses (N fixing crops)	
	Tonnage of crops (and assumptions on % dry matter etc) to allow calculation of crop residues	

3 DATA GAPS AND POSSIBLE ADDITONAL DATA SOURCES

3.1 COVERAGE OF MODELS COMPARED TO IA FRAMEWORK REQUIREMENTS

The current version of the IIASA RAINS Europe model covers 31 of the required countries: Cyprus, Iceland, Liechtenstein Malta, and Turkey are not included. Projections are currently made to 2010, but can be extended to 2020 and beyond provided base activity data is available.

The AEAT spreadsheet model currently covers only the EU15 from 1990 to 2010 and would need to be expanded to cover the remaining countries. This is relatively straightforward provided that sources for all of the activity data can be provided.

The CAPRI model covers the EU 15 plus Norway. The base year is currently a three-year average 1997-1999 (but this will be updated to beyond 1999). The model is typically applied to medium-term analysis (up to 10 years), so given the current availability of statistical data, simulations are currently being run for 2008. There are currently no plans to extend the model to allow longer-term analysis or to include non-EU countries. An inclusion of Accession countries would require some intensive data mining to come up with complete and consistent data, including an activity based breakdown of inputs.

3.2 DATA GAPS AND POTENTIAL SOURCES OF ADDITIONAL DATA

While CAPRI is likely to provide the most detailed scenarios for the EU15 to 2010, it will not be able to provide any data for the period post 2010, or for the non-EU15 countries within the timescales required. Other potential sources for this data are listed below. In considering the suitability of other data sources, it will be important to ensure that underlying assumptions and the main policy trends assumed in the two sources are consistent, and ideally the CAPRI team should be involved in this assessment. Ideally, data should be available at a country level. If this is not possible then trends derived from regional data could be applied to relevant countries. The match between each of the most promising data sources and the data requirements of the AEAT and RAINS models is summarised in Table 2.

RAINS - The RAINS model does include projected livestock numbers and nitrogenous fertiliser consumption (to 2010) for most of the required countries, although for the accession countries these were made at differing times, with differing assumptions about economic growth, so form an inconsistent and outdated dataset. The data set for the EU is more consistent (e.g. for the EU-9 countries, it is based on the same model (Folmer et al, 1995)), but it is now relatively old.

DG AGRI – "Prospects for agricultural markets 2002-2009 (July 2002) contains a section on prospects for agricultural markets in the candidate countries for Central and Eastern Europe. This contains forecasts for cereals and oilseeds (area and yield), cows (number and yield), beef and veal, poultry meat, sheep and goat. This data could be extrapolated to 2010, and would provide much of the data needed for the RAINS and AEAT model. Data for current years should be available from EUROSTAT and the FAOSTAT database. Remaining missing data gaps would be laying hens, production of pulses and most importantly nitrogenous fertiliser use. General assumptions for the projection are increasing GDP leading to rising consumer incomes and demand for agricultural food products, and a stable population. Presumably as DG AGRI prepares the projection, key policy assumptions would be in line with those assumed in the CAPRI reference. Nitrogenous fertiliser use could be estimated using projection crop areas, fertiliser application rates and future changes in application rates, and for the RAINS model a split between urea and other types of nitrogenous fertiliser. Some data is available from FAO on application rates, although for many countries it is quite old (1990/91).

EFMA – The European Fertiliser Manufacturer's Association produces a ten-year projection of fertiliser consumption in the EU15 annually. The most recent is for 2001 to 2011 (EFMA, 2002), and also contains some estimates of future fertiliser consumption in the candidate accession countries based on a

comparison with past economic development of eastern German agriculture after reunification and based on recent consumption trends.

WATSIM –The WATSIM modelling system at the University of Bonn is a simulation model for agricultural market, currently updated, improved and applied for DG-AGRI. The WATSIM model integrates ex-post many data sources relating to market balances, production and agricultural policy (FAOSTAT, UDSA, OECD, World Bank, UNCTAD, WTO etc.). As a comparative simulation model, it is mainly not a forecasting tool, but builds its reference run by combining available information (model forecasts, publication, own trend analysis) in a plausible framework by the help of the modelling system. The model splits up the world into about 12 regions, with the EU as one aggregate. The team of WATSIM works closely together with the CAPRI network in order to streamline data sources, methodology and at least reference run results.

At the moment WATSIM is being used for medium term work for DG AGRI to produce forecasts to 2010, from a base year (for trade statistics etc) of 1997/8. However it has the capability and has been used in the past to make longer-term forecasts (to 2020). Updating the model would require a considerable amount of work in inputting basic market development data from other outlook groups (such as FAO, FAPRI etc), which the modelling team could not consider undertaking until mid 2003.

IDARA – Strategy for Integrated Development of Agriculture and Rural Areas in CEE Countries. The aim of this three year research project, funded by the EC's 5th FP and led by the University of Bonn is to identify key problems and discuss strategies for an integrated development of agriculture rural areas in the first group of CEEC acceding to the EU. One of the four main objectives is to develop a simulation model (I-Sim) for the CEEC that will allow a comprehensive analysis of the impact of alternative policy scenarios on production, consumption, net trade, income and budget and that ensure compatibility with the EU SPEL/MFSS. The University of Bonn is leading this modelling work; a model will be developed based on the CAP-SIM model. At present only Poland, Hungary and Czech Republic will be modelled; the base year is 1998, with a projection for 2006. The same data on activities, production and yields will be produced as in CAPRI. The project began in February 2000 and the projection is due to be completed by February 2003.

IAMO - The Institute of Agricultural Development in Central and Eastern Europe (based in Halle, Germany) has a Department of Agricultural Markets, Marketing and World Agricultural Trade which undertakes market analysis, market development and price formation for the Central and Eastern European Countries.

CAPMAT - CAPMAT (Common Agricultural Policy Modelling and Accounting Tool) is the successor to ECAM (European Community Agricultural Model) which is one of the inputs to the current RAINS agricultural data set. Developed by the Centre for World Food Studies of the Free university of Amsterdam (SOW-VU) together with Netherlands Bureau of Economic Policy Analysis, and the Agricultural Economics Research Institute, it is intended to be a ready-to-use tool to assess the impact of policy changes in the CAP. It has been used to analyse the impact of Agenda 2000, for the Dutch Parliament, for DG AGRI (DG AGRI, 2000) and for DG FIN.

CAPMAT has three components

- a dedicated database,
- an applied general equilibrium (AGE) model to simulate overall medium term effects,
- a simulation and accounting tool that uses outcomes from (1) and (2) to perform scenario calculations.

The main components of the database are (i) the FAO-Supply Utilisation Accounts (SUA), (ii) the SPEL data base, (iii) the EXMIS trade database, for extra-EU trade, (iv) the Economic Accounts of Agriculture from EUROSTAT, (v) the reports by the Court of Auditors (1977) and (vi) the EU-budget documents.

The basic analytic engine for the analysis is earlier ECAM model - a model of the applied general equilibrium (AGE) type that generates the basic developments with respect to supply, demand and cross-commodity substitution. ECAM distinguishes country modules and an aggregate EU module. Consumers maximise utility subject to a budget constraint, farmers maximise net revenues. They allocate crops to available land and livestock types to available buildings and equipment. The crop allocation module includes three forage activities that produce non-marketable green fodder. Budgetary rules reflect closely actual CAP regulations including the balance of the Community budget through adjustment of member contributions.

- The Simulation and Accounting Tool (SAT) is a GAMS program that performs a dynamic simulation to derive the implications of various price and compensation scenarios under assumed or calculated trends at detailed commodity level, applying selected growth factors from the ECAM model to the information extracted from the database.

The current base year for CAPMAT is 1999, with a projection horizon of 2013, although simulations up to 2020 have been completed. It currently covers only the EU15 and is unlikely to be expanded to the Accession countries in the short term. Outputs from the model include livestock numbers and productions, and crop production.

OECD (AGLINK) – The OECD has developed the AGLINK model in co-operation with its member countries. It is a recursive dynamic supply and demand model of world agriculture, which uses partial adjustment relationships used for analysis of the impacts of agricultural policies and for forecasting the medium term development in supply, demand and prices for the principal agricultural commodities produced, consumed and traded in member countries AGLINK is built around complete modules for 10 main OECD Member countries or regions (including EU, Hungary and Poland), and 3 non-OECD member countries and regions, while the countries not included are treated as exogenous to the model. The markets include 19 principal agricultural commodity markets for the OECD countries.

The OECD annually publishes a medium term outlook based on AGLINK results, so the current one is for 2002/2007 (OECD, 2002). This is complemented by a more detailed commodities outlook database. EEA countries for which data is available are EU 15, Czech Republic, Hungry, Norway, Poland, Slovak Republic, Switzerland, Turkey and for the New Independent States (as a group).

FAO - the FAO produces a medium term projection of world fertiliser trends (to 2005/06) which gives a regional projection of nitrogenous fertiliser consumption by region (West Europe, Central and Eastern Europe, Central Asia) (FAO, 2001). This data (extrapolated to 2010) was used by the USEPA to develop their forecasts of N_2O emissions from agriculture for developed countries (USEPA, 2001). FAO have also produced a long term projection (to 2015 and 2030) of **total** fertiliser use (i.e. NPK, not broken down by type) by region (West Europe, East Europe, Former Soviet Union) based on forecasts of crop production and assumptions about fertiliser efficiency. A final version of the FAO publication "Agriculture: Towards 2015/30" includes projections of supply and demand of agricultural products up to 2015 and 2030, for blocks of countries, including transition countries. Some information is already available from the Interim Technical Report. Projections are actually made by the FAO on a country by country basis, but only aggregated information is released.

FAPRI – the Food and Agricultural Policy Research Institute at Iowa State University (US) produces an annual US and World Agricultural Outlook (FAPRI, 2002) which contains forecasts to 2010/11 of some livestock (cattle, pigs) and crop types (typically those of interest to the US export market). Again this data was used by the USEPA to develop their forecasts of N_2O emissions from agriculture for developed countries (USEPA, 2001). The FAPRI forecasts are one of the sources used to develop the WATSIM reference run. Information on the countries and livestock and crops types covered by FAPRI is given in Appendix 2. Individual Accession Country forecasts that are available are for meat supply (all) dairy supply (all except Estonia, Latvia and Lithuania), wheat and coarse grain (Czech Republic, Hungary and Poland). Otherwise forecasts are available for 'Eastern European' Countries as a block.

IFPRI - The International Food Policy Research Institute (IFPRI) has developed the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) (Rosegrant et al, 2001 and 2002). IMPACT offers an integrated methodology for analysing alternative scenarios for global food demand, supply, and trade. IMPACT is a representation of a competitive agricultural market for crops and livestock. It consists of a set of country or regional submodels determining supply, demand, and prices for agricultural commodities. The country and regional agricultural sub-models are linked through trade, a specification that highlights the interdependence of countries and commodities in the global agricultural markets. The model uses a system of supply and demand elasticities incorporated into a series of linear and non-linear equations to approximate the underlying production and demand functions. World agricultural commodity prices are determined annually at levels that clear international markets. Demand is a function of prices, income, and population growth. Growth in crop production in each country is determined by crop prices and the rate of productivity growth. Future productivity growth is estimated by its component sources, including crop management research, conventional plant breeding, wide-crossing and hybridisation breeding, biotechnology and transgenic breeding.

A wide range of factors with potentially significant impacts on future developments in the world food situation can be modelled with IMPACT. It generates projections for crop area, yield, production, demand by food, feed and other uses, prices, and trade. For livestock numbers, IMPACT projects yield, production, demand, prices, and trade. A base-year of 1997 is used because this was the most recent data available at FAOSTAT database at the time of the 2001 update of the projections. Projections are made to the year 2020. Data is available at a regionalised level (EU 15, Eastern Europe, Central Asia and Rest of the Former Soviet Union)

IMAGE model – the Image 2.2 global model forecasts agricultural emissions for 17 world regions (including OECD Europe, Eastern Europe and Former USSR) to 2100. Emissions are calculated by the land use emissions model based on input from the agricultural economy model and land cover model. The agricultural economy model forecasts demand for food (animal and crop) and feed products, based on income per capita, and assumptions about food demand per capita, animal productivity, feed efficiency, and self sufficiency ratios which determine the amount of food trade between regions. Cropped areas are estimated using assumptions about crop productivity; fertiliser consumption is estimated based on assumptions about trends in fertiliser use industrialised regions are assumed to move linearly towards a target level for fertiliser application per ha of harvested land. Some of this data could potentially be used to help construct scenarios for post 2010.

Table 2 Comparison of Data Required by RAINS and AEAT Emissions Models and of Data supplied by Agricultural Models and

Model	**Spatial coverage**	**Base Year**	**Projection Year**	**When needed**	**Livestock numbers**	**Fertiliser consumption**	**Crop Production**	**Other issues**
RAINS (IIASA)	EEA	2000	2010 2015+20	Jan 03	Yes (inc fur animals and horses)	Total N, + propn urea, +production		
AEAT	EEA	2000	2010 2015+20	Results needed Sep 02 so data required Aug 02 Jan 03	Yes (inc fur animals and horses)	Total N	Crop production to calculate crop residues + n fixing crops	
Model	**Spatial coverage**	**Base Year**	**Projection Year**	**When available**	**Livestock numbers**	**Fertiliser consumption**	**Crop Production**	**Other issues**
CAPRI (Bonn Univ)	EU15, Nor, Ch	1998 (2001)	2008 (2011)	12/02 (4/04)	All except fur animals	Yes but no split into urea/other	Yes	Funded by DG AGRI and DG ENV
DG AGRI	EU15 (total only) 10 CEE Accession countries individually	2000	2009	Now	Derive from product and productivity figures	No	Partial	
EFMA	EU15 (in detail) Accession countries (based on trends)	2001 (based n 3year avg for 98/01)	2010/11	Now, but published data not very detailed		Yes, + production	Must be derived to estimate fertiliser consumption, but not clear if would be available	More detail on previous forecasts been made available to IIASA
WATSIM (Bonn Univ)	EU15, Rest of W Europe, Central Europe, Eastern Europe (all as regions)	1997/98	2010 2020	12.02 Would require funding for additional work – end 2003?	Could be derived from production	?	Yes	Not really a forecasting tool. Uses lot of exogenous data on that needs updating

Table 2 (continued) Comparison of Data Required by RAINS and AEAT Emissions Models and of Data supplied by Agricultural Models and

Model	Spatial coverage	Base Year	Projection Year	When available	Livestock numbers	Fertiliser consumption	Crop Production	Other issues
CAPMAT (Free University of Amsterdam and Central Planning Bureau, Netherlands)	EU15	1999	2013, but some unpublished runs to 2010	Reports still with DG AGRI	Yes or could be derived from production	No	Yes – most	Based on ECAM which was an input RAINS.
OECD/AgLink model	EU 15, some individual accession countries, others as a group,+ Switzerland, Turkey and Norway	2000	2007	now	Could be derived from production		Partial	
FAO	Industrialised countries Transition countries	1999-97	2015 and 2030	Summary report – 7/02 Detailed report – 12/02	Could be derived from production		Limited	
IFPRI	36 regions and countries	1997	2020	Now	could be derived from production	No	Partial	Based in Washington, US
FAPRI	EU15 (as total) some individual accession countries others as group	2000	2012	Now	Some, others could be derived from production		Partial	Iowa Univ, US

4 POSSIBLE WAYS FORWARD

At a meeting at RIVM in July 2002, representatives from AEA Technology, IIASA, and RIVM discussed the best way forward for integrated assessment in the agricultural sector. The relative merits of the various models identified above were reviewed, and it was agreed that:

- The most useful and appropriate model for the EU15 countries is the CAPRI model, and links with this modelling team should be strengthened if possible. The team should be encouraged to extend their model to the Accession countries as soon as possible. It was noted that this model is never likely to provide more than a 10-year projection. It therefore needs to be supplemented by models which can provide data post 2010, and at present by models/forecasts which provide results for the accession countries.

- As CAPRI results for the EU15 will not be available within the timescale required for modelling by AEAT, it will be necessary to use an interim set of results. It is proposed to use the DG AGRI forecasts, supplemented by data from the EFMA forecasts (as in the previous AEAT SOS forecasts). DG AGRI will be asked to supply a breakdown by Member State of the EU15 projection, but if this is not possible, then methodology used in the SOS study to disaggregate this projection will be applied. EFMA will be approached to provide more background information on their projection. Baseline data for the year 2000 will be obtained from Eurostat, with additional data from FAOSTAT, EFMA and IFA as necessary. Once the interim CAPRI results are available in 2003, these will be used; this should be in time for the RAINS modelling work.

- For the Accession countries to 2010, the DG AGRI projection provides much of the information needed on corps and livestock, but not fertiliser use. A methodology needs to be developed to derive this, possibly using DG AGRI crop forecasts and representative application rates, and comparison with trends identified in the short-term regional FAO fertiliser forecasts. An alternative would be to take the approach used by EFMA and extrapolate 1991-2001 trends for these countries.

- Post 2010, the FAO models will most likely to be the most appropriate, particularly if FAO can make data available at a country rather than regional level. FAO will be approached to identify this. The IFPRI model also provides forecasts to 2020, so could also be useful.

On the longer time horizon (i.e. 2004 and beyond) all this information could be integrated in the RAINS model as part of the extension of the model with greenhouse gasses. This needs to be further discussed.

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APPENDIX 1 COUNTRIES TO BE INCLUDED IN THE INTEGRATED ASSESSMENT

EU15	**EU Accession Countries**	**Other EEA Members**	**Candidate Countries for EEA membership**
Austria	Bulgaria	Iceland	Albania
Belgium	Cyprus	Liechtenstein	Bosnia-Herzegovina
Denmark	Czech Republic	Norway	Croatia
Finland	Estonia		FYR of Macedonia
France	Hungary		Switzerland
Germany	Latvia		
Great Britain	Lithuania		
Greece	Malta		
Ireland	Poland		
Italy	Romania		
Luxembourg	Slovak Republic		
Netherlands	Slovenia		
Portugal	Turkey		
Spain			
Sweden			

APPENDIX 2 COUNTRIES AND COMMODITIES IN FAPRI 2002

	Wheat	Rice	Coarse grain	Soybean	Rapeseed	Sunflower	Palm Oil	Meat supply	Dairy Supply
EU	*	*	*	*	*	*	*	*	*
Swiss									*
Other Western Europe	*								
Bulgaria								*	*
Czech Republic	*		*					*	*
Estonia								*	
Hungary	*		*					*	*
Latvia								*	
Lithuania								*	
Poland	*		*					*	*
Romania								*	*
Slovakia								*	*
Slovenia								*	*
Other Eastern Europe	*		*					*	
Eastern European				*	*	*			

Crop projections include area harvested, yield and production.

Meat supply contains information on million head of cattle and hogs and tonnes of beef, pork, broiler and turkey production.

Dairy supply forecasts contain information on number of milk cows and milk production per cow.