Commission modelling inventory and knowledge management system (MIDAS)
Report generation date 08/10/2020

MIDAS includes the descriptions of models in use by the Commission in support to the policy cycle. MIDAS is developed and managed by the **Competence Centre on Modelling** of the European Commission.

Find out more at https://ec.europa.eu/knowledge4policy/modelling_en
Contact: EU-MIDAS@ec.europa.eu

Factsheet

SWD/2018/301 final

Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy

Supporting model(s)

CAPRI, IFM-CAP, MAGNET, AGLINK-COSIMO, RUSLE2015, CENTURY

Impact assessment SWD/2018/301 final

Fact sheet on model contributions

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 08/10/2020

Overview

Title
Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy

Document ID
SWD/2018/301 final

Year of publication
2018

Led by
AGRI

Model(s) used
CAPRI, IFM-CAP, MAGNET, AGLINK-COSIMO, RUSLE2015, CENTURY

Additional information on model use for this Impact assessment

The **evaluation of existing policy** was supported by the study *An economic assessment of GHG mitigation policy options for EU agriculture (EcAMPA 2)* [1].

The EU **baseline** is composed of a combination of sources, to which modelling contributed. All details can be found in the Impact Assessment SWD/2018/301. Mentioned here are the DG AGRI *EU agricultural outlook 2016 and 2017* [2] and the study *Scenar 2030 - Pathways for the European agriculture and food sector beyond 2020* [3] outlining projections for EU agriculture in 2030.

For the **assessment of policy options**, the study *Scenar 2030* [3] plus the models CAPRI, IFM-CAP, MAGNET, AGLINK-COSIMO, RUSLE2015 and CENTURY are used, for details see SWD/2018/301.

References:

[1] Perez Dominguez I; Fellmann T; Weiss F; Witzke H; Barreiro Hurle J; Himics M; Jansson T; Salputra G; Leip A. An economic assessment of GHG mitigation policy options for EU agriculture (EcAMPA 2). EUR 27973 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2016. JRC101396

[2] EC 2016: EU AGRICULTURAL OUTLOOK Prospect for the EU agricultural markets and income 2016-2026, December 2016, see https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/agricultural-outlook-report-2016_en.pdf

[3] R. M'barek, J. Barreiro-Hurle, P. Boulanger, A. Caivano, P. Ciaian, H. Dudu, M. Espinosa, T. Fellmann, E. Ferrari, S. Gomez y Paloma, C. Gorrin Gonzalez, M. Himics, K. Louhichi, A. Perni, G.

Philippidis, G. Salputra, P. Witzke, G. Genovese; Scenar 2030 - Pathways for the European agriculture and food sector beyond 2020 (re-edition), EUR 28797 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-16663-4, doi:10.2760/43791, JRC108449.

CAPRI

Full title

Common Agricultural Policy Regional Impact Analysis

Run for this impact assessment by

European Commission

Contributed to

Evaluation of existing policy

Details of the contribution

The model helped to evaluate the existing policy, further detailed also in the impact assessment SWD/2018/301 itself.

Further details can be found in:

Perez Dominguez I; Fellmann T; Weiss F; Witzke H; Barreiro Hurle J; Himics M; Jansson T; Salputra G; Leip A. An economic assessment of GHG mitigation policy options for EU agriculture (EcAMPA 2). EUR 27973 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2016. JRC101396

CAPRI

Full title

Common Agricultural Policy Regional Impact Analysis

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

Impact area	*Impact category*	*Impact subcategory*
Economic impacts	Functioning of the internal market and competition	Competition
Economic impacts	Consumers and households	Prices, quality, availability or choice of consumer goods and services
Economic impacts	Specific regions or sectors	Significant effects on sectors
Economic impacts	Specific regions or sectors	Impact on regions
Economic impacts	Specific regions or sectors	Disproportionately affected region or sector
Economic impacts	Third countries and international relations	International legal commitments
Economic impacts	Third countries and international relations	Goods traded with developing countries
Environmental	Climate	Emission of greenhouse gases
Environmental	Climate	Ability to adapt to climate change
Environmental	Land use	Change in land use

IFM-CAP

Full title

Individual Farm Model for Common Agricultural Policy Analysis

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

Impact area	*Impact category*	*Impact subcategory*
Economic impacts	Operating costs and conduct of business	Adjustment, compliance or transaction costs
Economic impacts	Operating costs and conduct of business	Affects on individual Member States
Economic impacts	Specific regions or sectors	Significant effects on sectors
Economic impacts	Specific regions or sectors	Impact on regions
Social	Effects on income, distribution and social inclusion	Inequalities and the distribution of incomes and wealth
Environmental	Sustainable consumption and production	Sustainable production and consumption
Environmental	Land use	Change in land use

MAGNET

Full title

Modular Applied GeNeral Equilibrium Tool

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

Impact area	*Impact category*	*Impact subcategory*
Economic impacts	Operating costs and conduct of business	Affects on individual Member States
Economic impacts	Trade and investment flows	EU Exports & imports
Economic impacts	Trade and investment flows	Non-trade barriers
Economic impacts	Competitiveness (sectoral) of business	Cost of doing business
Economic impacts	Competitiveness (sectoral) of business	Market share & advantages in international context
Economic impacts	Innovation and research	Stimulation of research and development
Economic impacts	Consumers and households	Prices, quality, availability or choice of consumer goods and services
Economic impacts	Specific regions or sectors	Significant effects on sectors
Economic impacts	Specific regions or sectors	Disproportionately affected region or sector
Economic impacts	Third countries and international relations	International legal commitments
Economic impacts	Third countries and international relations	EU foreign policy and EU development policy
Economic impacts	Third countries and international relations	Impacts on third countries
Economic impacts	Third countries and international relations	Impacts on developing countries

Economic impacts	Third countries and international relations	Goods traded with developing countries
Social	Employment	Impact on jobs
Social	Employment	Impact on jobs in specific sectors, professions, regions or countries
Social	Employment	Indirect effects on employment levels
Social	Employment	Factors preventing or enhancing the potential to create jobs or prevent job losses
Social	Working Conditions	Wages, labour costs or wage setting mechanisms
Social	Effects on income, distribution and social inclusion	Households income and at risk of poverty rates
Social	Effects on income, distribution and social inclusion	Inequalities and the distribution of incomes and wealth
Environmental	Climate	Emission of greenhouse gases
Environmental	Waste production / generation / recycling	Waste production, treatment, disposal or recycling
Environmental	Sustainable consumption and production	Sustainable production and consumption
Environmental	International environmental impacts	Environment in third countries
Environmental	Land use	Change in land use

AGLINK-COSIMO

Full title

AGricultural LINKage - COmmodity SImulation Model

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

Impact area	*Impact category*	*Impact subcategory*
Economic impacts	Trade and investment flows	EU Exports & imports
Economic impacts	Competitiveness (sectoral) of business	Market share & advantages in international context
Economic impacts	Consumers and households	Prices, quality, availability or choice of consumer goods and services
Economic impacts	Third countries and international relations	Goods traded with developing countries
Environmental	Climate	Emission of greenhouse gases

RUSLE2015

Full title

Revised Universal Soil Loss Equation

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

Impact area	*Impact category*	*Impact subcategory*
Environmental	Climate	Ability to adapt to climate change
Environmental	Water quality and resources	Availability or quality of Fresh- or ground water
Environmental	Soil quality or resources	Acidification, contamination or salinity of soil, and soil erosion rates
Environmental	International environmental impacts	Environment in third countries

CENTURY

Full title

CENTURY agroecosystem dynamic model

Run for this impact assessment by

European Commission

Contributed to

Baseline and assessment of policy options

Helped to assess the following impacts

Impact area	*Impact category*	*Impact subcategory*
Environmental	Climate	Emission of greenhouse gases
Environmental	Climate	Ability to adapt to climate change
Environmental	Soil quality or resources	Acidification, contamination or salinity of soil, and soil erosion rates

CAPRI - Common Agricultural Policy Regional Impact Analysis

Fact sheet

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 08/10/2020

Overview

Acronym CAPRI
Full title Common Agricultural Policy Regional Impact Analysis

Main purpose:
A global agro-economic model used to assess impacts on agriculture of agricultural, trade and environmental policies. CAPRI provides results at a regional level and for economic and environmental variables.

Summary
The CAPRI modelling system is a global agro-economic model, initiated in 1999, designed for assessing economic and environmental impacts on agriculture at regional level.

CAPRI is a partial equilibrium model, which iteratively links a supply module, focusing on the EU, Norway, Turkey and Western Balkans, with a global multi-commodity market module. It consists of specific databases, a methodology, its software implementation and the researchers involved in their development, maintenance and applications. Specific modules ensure that the data used in CAPRI are mutually compatible and complete in time and space. They cover about 50 agricultural primary and processed products for the EU, from regional level to global scale including input and output coefficients.

The CAPRI model can be used for policy anticipation and formulation. It allows economic and environmental analysis of different policy scenarios regarding reforms of the Common Agricultural Policy (CAP). It is able to perform a regional level analysis of specific Common Market Organisations (e.g. sugar, dairies), trade of agricultural goods with the rest of the world (e.g. WTO proposals), environmental policies (e.g. greening, climate action and water) and different subsidy schemes in Europe (e.g. partial decoupling of agricultural subsidies). The model is frequently used in various Commission services (such as DG AGRI, DG ENV, DG CLIMA, Eurostat and the JRC) reporting on agricultural, environmental and climate policies at the regional dimension in the EU.

Keywords
partial equilibrium model , Environment , agriculture , CAP , impact analysis , climate change , greenhouse gas

Model category (thematic)
Agriculture

Model home page
http://www.capri-model.org/dokuwiki/doku.php?id=start

Ownership & license

Ownership
Joint copyright

Ownership details
The model code is open source

Licence type
Free software licence. The license grants freedom to run the programme for any purpose; freedom to run the program for any purpose; freedom to study (by accessing the source code) how the program works, and change it so it does enable computing; freedom to redistribute copies; and freedom to distribute copies of modified versions to others.

Details

CAPRI structure and approach

The economic model builds on a *philosophy of model templates* which are structurally identical so that instances for products and regions are generated by populating the template with specific parameter sets. This approach ensures comparability of results across products, activities and regions, allows for low cost system maintenance and enables its integration within large modelling networks. At the same time, the approach opens up the chance for complementary approaches at different levels, which may shed light on different aspects not covered by CAPRI or help to learn about possible aggregation errors in the model.

The CAPRI economic model, comparative-static in nature, is split into two major modules: the *supply module* and the *market module*.

The *supply module* consists of independent aggregate non-linear programming models representing activities of all farmers at regional or farm type level captured by the Economic Accounts for Agriculture (EAA). The programming models are a kind of hybrid approach, as they combine a Leontief-technology for variable costs covering a low and high yield variant for the different production activities with a non-linear cost function which captures the effects of labour and capital on farmers' decisions. The non-linear cost function allows for perfect calibration of the models and a smooth simulation response rooted in observed behaviour. The models capture in high detail the premiums paid under CAP, include NPK balances and a module with feeding activities covering nutrient requirements of animals. Main constraints outside the feed block are arable and grassland – which are treated as imperfect substitutes -, set-aside obligations and milk quotas. The complex sugar quota regime is captured by a component maximising expected utility from stochastic revenues. Prices are exogenous in the supply module and provided by the market module. Grass, silage and manure are assumed to be non-tradable and receive internal prices based on their substitution value and opportunity costs. A land supply curve let total area use shrink and expand depending on returns to land.

The *market module* consists in turn of two sub-modules. The sub-module *for marketable agricultural outputs is a spatial, non-stochastic global multi-commodity* model for about 50 primary and processed agricultural products, covering about 70 countries or country blocks in 40 trading blocks. Bi-lateral trade flows and attached prices are modelled based on the Armington assumptions (Armington, 1969). The behavioural functions for supply, feed, processing and human consumption apply flexible functional forms where calibration algorithms ensure full compliance with micro-economic theory including curvature. The parameters are synthetic, i.e. to a large extent taken from the literature and other modelling systems. Policy instruments cover (bi-lateral) tariffs, the Tariff Rate Quota (TRQ) mechanism and, for the EU, intervention stocks and subsidized exports. This sub-module delivers prices used in the supply module and allows for market analysis at global, EU and national scale, including a welfare analysis. A second sub-module deals with *prices for young animals*.

As the supply models are solved independently at fixed prices, *the link between the supply and market modules* is based on an iterative procedure. After each iteration, during which the supply module works with fixed prices, the constant terms of the behavioural functions for supply and feed demand are calibrated to the results of the regional aggregate programming models aggregated to Member State level. Solving the market modules then delivers new prices. A weighted average of the prices from past iterations then defines the prices used in the next iteration of the supply module. Equally, in between iterations, CAP premiums are re-calculated to ensure compliance with national ceilings.

Post-model analysis includes the calculation of different income indicators as variable costs, revenues, gross margins, etc., both for individual production activities as for regions, according to the methodology of the Economic Accounts for Agriculture (EAA). A welfare analysis at Member State level, or globally, at country or country block level, covers agricultural profits, tariff revenues, outlays for domestic supports and the money metric measure to capture welfare effects on consumers. Outlays under the first pillar of the CAP are modelled in very high detail. Environmental indicators cover NPK balances including nitrogen leaching, and carbon balances including carbon sequestration, and output of climate and air pollution relevant gases according the guidelines of the Intergovernmental Panel on Climate Change (IPCC) and the EEA/EMEP (European Monitoring and Evaluation Programme of the European Environment Agency) air pollutant emission inventory guidebook. Model results are presented as *interactive maps* and as thematic *interactive drill-down tables*. The CAPRI graphical user interface including the exploitation tools are documented in a separate user manual.

Furthermore, regional data are disaggregated to clusters of 1x1 km grid cells, covering crop shares, crop yields, animal stocking densities, and nitrogen balance term; these data are used to calculate other environmental indicators such as soil erosion.

Input and parametrization
The key inputs used for the model:

- prices
- agricultural land allocation
- supply and use balances of agro-food commodities
- productivity indicators (yields, processing ratios, slaughter weights, fat and protein content of milk)
- macroeconomic indicators (GDP, exchange rate, number of population)
- policy indicators (CAP and trade policy)

CAPRI constructs is own database (COCO – complete and consistent) at the global, national and regional level. The databases exploit wherever possible well-documented, official and harmonised data sources, especially data from EUROSTAT, EAA, FAOSTAT, OECD and extractions from the Farm Accounting Data Network (FADN). This allows for the possibility of annual updates. In case of gaps in the database, suitable algorithms were developed and applied to fill them. The database is constructed in a manner that assures consistency between the different data (i.e. closed market balances, perfect aggregations from lower to higher spatial levels, match of physical and monetary data).

Specific inputs from other sources or models are used as well (EDGAR, IMPACT, GLOBIOM, EBB, ...) to complete specific parts of the CAPRI database.

Main output

- agricultural production
- crop yields
- production areas
- agricultural commodity trade
- farmer's income
- prices and subsidies for commodities and regions
- Greenhouse gas and air pollutant emissions including carbon sequestration from land use change and land management change
- Nutrient and carbon balances including nitrogen leaching
- Water use by agricultural crop

The results generated from CAPRI are stored in a GDX format. A Java based graphical user interface allows the steering of different working steps (data base updates, baseline generation, model calibration, scenario runs).

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	CAPRI is a global model and covers 77 countries or 40 country blocks.
(Spatial) resolution	EU countries: national, NUTS2, farm types, HSU (cluster of 1x1 grid cells). Norway, Western Balkans and Turkey: national, NUTS2. Other countries: national or supra national (country blocks).
Temporal extent	Medium to long-term, typically 10-30 years (currently operational with runs to 2030 and 2050).

Temporal resolution	One specific simulation year, comparative static approach without any intermediate steps.

Quality & transparency

Quality

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	no	The model is deterministic. Uncertainties in parameters are covered by targeted sensitivity analysis on a few key parameters. The large model size does not permit full-fledged uncertainty analyses.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	When carrying out analysis key variables (i.e. yield trends, exchange rate, etc.) are changed to see the relative impact of assumptions on final results.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	There has been no formal evaluation of the model by an external panel, however the model has been extensively published in peer-reviewed journals and is widely regarded as the gold-standard for regional level analysis of agricultural and climate policy.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	no	Projections are not the main objective of the model, the model's strength lays in analysing deviations from the baseline (i.e. projections) due to external shocks (policy or other).

References related to external peer-review and publication in scientific journals:

- Himics, M., Fellmann, T., Barreiro Hurle, J., Witzke, H., Perez Dominguez, I., Jansson, T. and Weiss, F., Does the current trade liberalization agenda contribute to greenhouse gas emission mitigation in agriculture, FOOD POLICY, ISSN 0306-9192, 76, 2018, p. 120-129, JRC110846.

- Hasegawa, T., Fujimori, S., Havlik, P., Valin, H., Bodirsky, B., Doelman, J., Fellmann, T., Kyle, P., Koopman, J., Lotze-Campen, H., Mason-D`croz, D., Ochi, Y., Perez Dominguez, I., Stehfest, E., Sulser, T., Tabeau, A., Takahashi, K., Takakura, J., Van Meijl, H., Van Zeist, W., Wiebe, K. and Witzke, H., Risk of increased food insecurity under stringent global climate change mitigation policy, NATURE CLIMATE CHANGE, ISSN 1758-678X, 8, 2018, p. 699-703, JRC110841.

- Van Meijl, H., Havlik, P., Lotze-Campen, H., Stehfest, E., Witzke, H., Perez Dominguez, I., Bodirsky, B., Van Dijk, M., Doelman, J., Fellmann, T., Humpenoeder, F., Levin-Koopman, J., Müller, C., Popp, A., Tabeau, A., Valin, H. and Van Zeist, W., Comparing impacts of climate change and mitigation on global agriculture by 2050, ENVIRONMENTAL RESEARCH LETTERS, ISSN 1748-9326, 13, 2018, p. 060421, JRC110838.

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	The potential user has access to the full database (COCO) as part of the model files which are made available following the procedure described at www.capri-model.org
Can model outputs be made publicly available?	yes	Model results are available as a gdx file together with a graphic user interface available at www.capri-model.org. Some specific model runs might not be public if carried out by a partner for a specific client. Those undertaken (or funded) by the JRC can be made publicly available unless confidentiality requested by the partner DG (i.e. preliminary IA work). Another option to make model results publicly available is to use the Qlik-Sense interface of CAPRI, and by developing specific Dashboards for a selected set of results. Dashboards enable public users to exploit results interactively (maps, pivot tables, etc.), but creating Dashboards requires additional programming efforts and IT resources for hosting it on web servers.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	There is methodology and documentation section in the model's web site (www.carpi-model.org) where all modules are documented. Wiki format and a collection of pdf documents are both available.
Is the model source code publicly accessible or open for inspection?	yes	www.capri-model.org

References related to documentation:

- No references provided in MIDAS

The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Agriculture and rural development
- Climate action
- Environment
- Regional policy

The model is designed to contribute to the following phases of the policy cycle

- Anticipation
- Formulation

The model's potential

The CAPRI model is well suited to evaluate the impact of the Common Agricultural Policy, trade and environmental policies on agricultural production, income, markets, trade and the environment, on global and regional (NUTS2) scale.

The CAPRI model is often used to evaluate changes to the CAP and the potential impact of free trade agreements on the agricultural sector. It is also used to evaluate impacts on the agricultural sector of other sectoral policies such as environment and climate change.

Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

In the Year	CAPRI contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2018	Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy SWD/2018/301 final	AGRI	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Competition - Prices, quality, availability or choice of consumer goods and services - Significant effects on sectors - Impact on regions - Disproportionately affected region or sector - International legal commitments - Goods traded with developing countries - Emission of greenhouse gases - Ability to adapt to climate change - Change in land use
2018	Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy SWD/2018/301 final	AGRI	Evaluation of existing policy	*European Commission*	The model helped to evaluate the existing policy, further detailed also in the impact assessment SWD/2018/301 itself. Documented in: - DOI 10.2791/843461

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- *Feyen, L., Ciscar Martinez, J., Gosling, S., Ibarreta Ruiz, D., Soria Ramirez, A., Dosio, A., Naumann, G., Russo, S., Formetta, G., Forzieri, G., Girardello, M., Spinoni, J., Mentaschi, L., Bisselink, B., Bernhard, J., Gelati, E., Adamovic, M., Guenther, S., De Roo, A., Cammalleri, C., Dottori, F., Bianchi, A., Alfieri, L., Vousdoukas, M., Mongelli, I., Hinkel, J., Ward, P., Gomes Da Costa, H., De Rigo, D., Liberta`, G., Durrant, T., San-Miguel-Ayanz, J., Barredo Cano, J., Mauri, A., Caudullo, G., Ceccherini, G., Beck, P., Cescatti, A., Hristov, J., Toreti, A., Perez Dominguez, I., Dentener, F., Fellmann, T., Elleby, C., Ceglar, A., Fumagalli, D., Niemeyer, S., Cerrani, I., Panarello, L., Bratu, M., Després, J., Szewczyk, W., Matei, N., Mulholland, E. and Olariaga-Guardiola, M., Climate change impacts and adaptation in Europe, EUR 30180 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18123-1 (online), doi:10.2760/171121 (online), JRC119178.*

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- *Hasegawa, T., Fujimori, S., Havlik, P., Valin, H., Bodirsky, B., Doelman, J., Fellmann, T., Kyle, P., Koopman, J., Lotze-Campen, H., Mason-D`croz, D., Ochi, Y., Perez Dominguez, I., Stehfest, E., Sulser, T., Tabeau, A., Takahashi, K., Takakura, J., Van Meijl, H., Van Zeist, W., Wiebe, K. and Witzke, H., Risk of increased food insecurity under stringent global climate change mitigation policy, NATURE CLIMATE CHANGE, ISSN 1758-678X, 8, 2018, p. 699-703, JRC110841.*

- *Van Meijl, H., Havlik, P., Lotze-Campen, H., Stehfest, E., Witzke, H., Perez Dominguez, I., Bodirsky, B., Van Dijk, M., Doelman, J., Fellmann, T., Humpenoeder, F., Levin-Koopman, J., Müller, C., Popp, A., Tabeau, A., Valin, H. and Van Zeist, W., Comparing impacts of climate change and mitigation on global agriculture by 2050, ENVIRONMENTAL RESEARCH LETTERS, ISSN 1748-9326, 13, 2018, p. 060421, JRC110838.*

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IFM-CAP - Individual Farm Model for Common Agricultural Policy Analysis

Fact sheet

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 08/10/2020

Overview

Acronym IFM-CAP
Full title Individual Farm Model for Common Agricultural Policy Analysis

Main purpose
An EU-wide farm level model used to assess the economic and environmental impacts of the Common Agricultural Policy (CAP) by providing changes in land and input use, crop and animal production, farm income and CAP expenditures.

Summary
IFM-CAP is a micro model designed for the ex-ante economic and environmental assessment of the medium-term adaptation of individual farmers to policy and market changes. IFM-CAP was developed by JRC in close cooperation with DG AGRI starting from 2013 for the purpose to improve the quality of agricultural policy assessment upon existing aggregate (regional, farm-group, …) models and to assess distributional effects of policies over the EU farm population. Rather than providing forecasts or projections, the model aims to generate policy scenarios, or 'what if' analyses. It simulates how a given scenario, for example, a change in prices, farm resources or environmental and agricultural policy, might affect a set of performance indicators important to decision makers and stakeholders.

IFM-CAP is a comparative static positive mathematical programming model applied to each individual farm from the Farm Accountancy Data Network (FADN) to guarantee the highest possible representativeness of the EU agricultural sector. Farmers are assumed maximizing their expected utility at given yields, product prices and CAP subsidies, subject to resource endowments and policy constraints. The main strengths and capabilities of the model include the possibility to conduct a flexible assessment of a wide range of farm-specific policies and to capture the full heterogeneity of EU commercial farms in terms of policy representation and impacts (e.g. small versus big farms).

IFM-CAP can be applied for ex-ante economic and environmental impact assessment of agricultural and environmental policies at micro (farm) level. For example, IFM-CAP was applied to support the DG AGRI Impact Assessment accompanying the proposal for the CAP post 2020 (SWD/2018/301).

Keywords
optimisation model , agriculture , CAP , Farm Level Model , EU , microeconomic analysis

Model category (thematic)
Agriculture

Model home page
http://dx.doi.org/10.2791/14623

Ownership & license

Ownership
Sole copyright [European Union]

Ownership details
The JRC.D4 is the developer of the IFM-CAP code. The main model data (i.e. FADN) are subject to confidentiality agreement with DG AGRI.

Licence type
Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

Details

IFM-CAP structure and approach
IFM-CAP is a static positive mathematical programming model applied to each individual FADN (Farm Accountancy Data Network) farm (83 292 farms). It assumes that farmers maximise their expected utility at given yields, product prices and CAP subsidies, subject to resource endowments (arable land, grassland and feed) and policy constraints, such as CAP greening restrictions. Farmers' expected utility is defined following the mean-variance approach with a constant absolute risk aversion specification. Following this approach, expected utility is defined as expected income and the associated income variance. Effectively, it is assumed that farmers select a production plan that minimizes the variance in income caused by a set of stochastic variables for a given expected income level.

Farmer's expected income is defined as the sum of expected gross margins minus a non-linear (quadratic) activity-specific function. The gross margin is the total revenue including sales from agricultural products and direct payments (coupled and decoupled payments) minus the accounting variable costs of production activities. Total revenue is calculated using expected prices and yields assuming adaptive expectations (based on the previous three observations with declining weights). The accounting costs include the costs of seeds, fertilisers and soil improvers, crop protection, feeding and other specific costs. The quadratic activity-specific function is a behavioural function introduced to calibrate the farm model to an observed base-year situation, as usually done in positive programming models. This function intends to capture the effects of factors that are not explicitly included in the model, such as farmers' perceived costs of capital and labour, or model misspecifications.

Regarding income variance, most of the models in the literature incorporate uncertainty in the gross margin per unit of activity or in the revenues per unit of activity. The former models assume that prices, yields and costs are stochastic. The latter models either consider that costs are non-random because they are assumed to be known when decisions are made, or are less stochastic than revenues from the farmer's perspective. Thus, the variance in the gross margin can be approximated by the variance in revenues. In the IFM-CAP framework, the second approach is applied by considering uncertainty only in prices and yields (i.e. revenues) but without differentiating between sources of uncertainty.
IFM-CAP is calibrated for the base year 2012 using cross-sectional analysis (i.e. multiple observations) and Highest Posterior Density (HPD) approach with prior information on regional supply elasticities and dual values of resources (e.g. land rental prices). The calibration to the exogenous supply elasticities is performed in a non-myopic way by taking into account the effects of changing dual values on the simulation response.

The primary data source used to parameterize and calibrate IFM-CAP is individual farm-level data available from the Farm Accountancy Data Network (FADN) database complemented by other external EU-wide data sources such as Farm Structure Survey (FSS), CAPRI database and Eurostat. All farms represented in the FADN sample for the year 2012 (83 292 farms) are included in the model. However, to obtain expected income, past observations (2007–2012) on yields, prices and input costs for these farms are also used for model parameterisation and calibration.

One needs to be aware when applying IFM-CAP that the policy simulations obviously reflect the assumptions in the model. First, the current version of IFM-CAP assumes a fixed farms structure, implying that land can be reallocated only within farms in response to the simulated policy changes. A second potential caveat of the model is that market feedback effects (output price changes) are not taken into account. Third, certain crops are defined in the model as an aggregation of a set of individual crops (e.g. 'other cereals'). Fourth, FADN includes only commercial farms; small non-commercial farms are underrepresented in the database. A careful analysis of each of these limitations of the current version of IFM-CAP model is needed to be taken into account when analyzing the simulation results.

Input and parametrization

The following list includes the key data inputs used in the IFM-CAP model:

- Utilised Agricultural Area (FADN)
- Arable and grassland (FADN)
- Set of crop and livestock activities (FADN)
- Yields, Prices and Subsidies (FADN)
- Observed activity levels (hectares of crop area and number of livestock) (FADN)
- Farm level feed costs (FADN)
- Farm weighting factor (FADN)
- Land and milk quota rental prices (FADN)
- Prices and yields for fodder crops at MS level(FADN and CAPRI)
- Feed prices at MS level (CAPRI)
- Feed nutrient content (CAPRI)
- Nutrient requirement of animal activities (NRC , IPCC , LfL , CAPRI)
- Price and yield trends(CAPRI)
- Elasticities for feed demand at NUTS2 level (CAPRI)
- Supply elasticities for livestock activities (CAPRI)

- Supply elasticities for crops at NUTS2 level (Jansson and Heckelei, 2011)
- Carcass weights (Eurostat)
- Prices of live animals (Eurostat)
- Out-of quota prices for sugarbeet(Agrosynergie, 2011)
- MS sugarbeet in-quota production (DG-AGRI,2014)
- In- quota prices for sugar beet (Agrosynergie, 2011)
- Soil erosion cover-management factors (Panagos et al., 2015)

Main output
The main outputs/indicators generated by IFM-CAP for a specific policy scenario are the following:

Agronomic/structural indicators:

- Land allocation/crop area (ha)
- Herd size/animal number (heads)
- Livestock density (LU/ha)
- Share of arable land in Utilized Agricultural Area
- Share of grassland in Utilized Agricultural Area
- Land use change (ha)
- Agricultural production (Tons)
- Intermediate Input use (Tons)

Economic indicators:

- Agricultural output (€)
- CAP first pillar subsidies (€)
- CAP second pillar subsidies (€)
- Intermediate input costs (€)
- Variable costs (€)
- Total costs (€)

- Gross farm income (€)
- Net Farm Income (€)

Environmental indicators:

- Biodiversity index
- Soil erosion

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	EU-wide model covering the EU agricultural sector
(Spatial) resolution	Farm level model running in every single EU-FADN farms (around 83 292 farms)
Temporal extent	Used for medium-term comparative analyses. The time horizon (i.e. Baseline) for running simulation is 2025 and 2030 depending on the policy scenario.
Temporal resolution	Static model, simulations are done for a single time point (year), without any intermediate steps.

Quality, reliability & transparency

Quality and reliability

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	no	The model calibration is estimated based on observed farm data. The scenario simulations are usually done for one data point. The duration of model computational time is long which does not allow to run complex analysis of model uncertainties.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Sensitivity analysis of model responses to different production shocks. The duration of model computational time is long which does not allow to run complex sensitivity analysis.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	The model development was peer-reviewed by external experts in the field. Papers using the model were published in peer-review journals.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	no	The model calibration is estimated based on observed farm data. The model predictions were not confronted with observed data.

References related to external peer-review and publication in scientific journals:

- Louhichi, K., Ciaian, P., Espinosa, M., Colen, L., Perni, A., & Paloma, S. G. y. (2017). Does the crop diversification measure impact EU farmers' decisions? An assessment using an Individual Farm Model for CAP Analysis (IFM-CAP). Land Use Policy, 66, 250–264. doi:10.1016/j.landusepol.2017.04.010

- Arribas I., Louhichi K., Perni Á., Vila J., Gómez-y-Paloma S. (2017) Modelling Farmers' Behaviour Toward Risk in a Large Scale Positive Mathematical Programming (PMP) Model. In: Tsounis N., Vlachvei A. (eds) Advances in Applied Economic Research. Springer Proceedings in Business and Economics. Springer, Cham. doi: 10.1007/978-3-319-48454-9_42

- Elouhichi, K., Ciaian, P., Espinosa Goded, M., Perni Llorente, A. and Gomez Y Paloma, S., Economic Impacts of CAP greening: application of an EU-wide individual farm Model for CAP analysis (IFM-CAP), EUROPEAN REVIEW OF AGRICULTURAL ECONOMICS, ISSN 0165-1587, 45 (2), 2018, p. 205–238, JRC107039.

- Ciaian, P., Espinosa, M., Elouhichi, K. and Perni, A., Farm level impacts of trade liberalisation and CAP removal across EU: An assessment using the IFM-CAP model, GERMAN JOURNAL OF AGRICULTURAL ECONOMICS, ISSN 0002-1121 (online), 69 (2), 2020, p. 108-126, JRC118293.

- Espinosa, M., Louhichi, K., Perni, A., & Ciaian, P. (2019). EU-Wide Impacts of the 2013 CAP Direct Payments Reform: A Farm-Level Analysis. Applied Economic Perspectives and Policy. doi:10.1093/aepp/ppz021

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	no	The main model data (i.e. FADN) are confidential and are not publicly available. They are subject to confidentiality agreement with DG AGRI. They can be accessed by requesting them from DG AGRI and signing the confidentiality agreement.
Can model outputs be made publicly available?	yes	Only aggregated data respecting the conditions set in the confidentiality agreement. Individual farm data are not publically available.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	The references to model documentation are provided in Louhichi K. et al (2018).
Is the model source code publicly accessible or open for inspection?	no	The code of IFM-CAP is not subject to licence. The main model data (i.e. FADN) cannot be shared. DG AGRI is the owner of FADN data and any use require approval from DG AGRI. The source code is open if the confidentiality of the underlying core data is ensured and if user has agreement with DG AGRI for using the core data.

References related to documentation:

- Elouhichi K, Ciaian P, Espinosa Goded M, Colen L, Perni Llorente A, Gomez Y Paloma S. An EU-Wide Individual Farm Model for Common Agricultural Policy Analysis (IFM-CAP). EUR 26910. Luxembourg (Luxembourg): Publications Office of the European Union; 2015. JRC92574
- Elouhichi, K., Espinosa Goded, M., Ciaian, P., Perni Llorente, A., Vosough Ahmadi, B., Colen, L. and Gomez Y Paloma, S., The EU-Wide Individual Farm Model for Common Agricultural Policy Analysis (IFM-CAP v.1): Economic Impacts of CAP Greening, EUR 28829 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-74276-7 (online),978-92-79-86364-6 (ePub), doi:10.2760/218047 (online),10.2760/122560 (ePub), JRC108693.

The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Agriculture and rural development
- Environment

The model is designed to contribute to the following phases of the policy cycle

- Anticipation
- Formulation

The model's potential

The IFM-CAP model is designed to simulate EU-wide economic impacts of the Common Agricultural Policy and farm related policies targeted by the European Green Deal. The IFM-CAP can also be used to model environmental impacts of policies at farm level. The model provides detailed policy impacts at individual farm level on various economic and environmental indicators. More precisely, the IFM-CAP model allows a flexible assessment of a wide range of farm-specific policies; reflects the full heterogeneity of EU farms in terms of policy representation and impacts; covers all main agricultural production activities in the EU; provides a detailed analysis of different farming systems; and estimates the distributional impacts of policies across the farm population.

IFM-CAP was applied to support the following policy initiatives:

- DG AGRI assessment of CAP greening used in the Commission Staff Working Document (CSWD) 'Review of greening after one year' (see: European Commission (2016), Impact Assessment, SWD(2016) 218 final).

- Scenar 2030 - Pathways for the European agriculture and food sector beyond 2020 (see: M'barek, et al. (2017) Scenar 2030 - Pathways for the European agriculture and food sector beyond 2020, EUR 28797 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-16663-4, doi:10.2760/43791, JRC108449.

- Impact assessment of "CAP post 2020" (see: European Commission (2018), Impact Assessment, SWD(2018) 301 final)

Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

In the Year	IFM-CAP contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2018	Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy SWD/2018/301 final	AGRI	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Adjustment, compliance or transaction costs - Affects on individual Member States - Significant effects on sectors - Impact on regions - Inequalities and the distribution of incomes and wealth - Sustainable production and consumption - Change in land use

Bibliographic references

- *Ciaian, P., Espinosa, M., Elouhichi, K. and Perni, A., Farm level impacts of trade liberalisation and CAP removal across EU: An assessment using the IFM-CAP model, GERMAN JOURNAL OF AGRICULTURAL ECONOMICS, ISSN 0002-1121 (online), 69 (2), 2020, p. 108-126, JRC118293.*

- *Espinosa, M., Louhichi, K., Perni, A., & Ciaian, P. (2019). EU-Wide Impacts of the 2013 CAP Direct Payments Reform: A Farm-Level Analysis. Applied Economic Perspectives and Policy. doi:10.1093/aepp/ppz021*

- *Elouhichi, K., Espinosa Goded, M., Ciaian, P., Perni Llorente, A., Vosough Ahmadi, B., Colen, L. and Gomez Y Paloma, S., The EU-Wide Individual Farm Model for Common Agricultural Policy Analysis (IFM-CAP v.1): Economic Impacts of CAP Greening, EUR 28829 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-74276-7 (online),978-92-79-86364-6 (ePub), doi:10.2760/218047 (online),10.2760/122560 (ePub), JRC108693.*

- *Elouhichi, K., Ciaian, P., Espinosa Goded, M., Perni Llorente, A. and Gomez Y Paloma, S., Economic Impacts of CAP greening: application of an EU-wide individual farm Model for CAP analysis (IFM-CAP), EUROPEAN REVIEW OF AGRICULTURAL ECONOMICS, ISSN 0165-1587, 45 (2), 2018, p. 205–238, JRC107039.*

- *Louhichi, K., Ciaian, P., Espinosa, M., Colen, L., Perni, A., & Paloma, S. G. y. (2017). Does the crop diversification measure impact EU farmers' decisions? An assessment using an Individual Farm Model for CAP Analysis (IFM-CAP). Land Use Policy, 66, 250–264. doi:10.1016/j.landusepol.2017.04.010*

- *Arribas I., Louhichi K., Perni Á., Vila J., Gómez-y-Paloma S. (2017) Modelling Farmers' Behaviour Toward Risk in a Large Scale Positive Mathematical Programming (PMP) Model. In: Tsounis N., Vlachvei A. (eds) Advances in Applied Economic Research. Springer Proceedings in Business and Economics. Springer, Cham. doi: 10.1007/978-3-319-48454-9_42*

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MAGNET - Modular Applied GeNeral Equilibrium Tool

Fact sheet

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 08/10/2020

Overview

Acronym MAGNET
Full title Modular Applied GeNeral Equilibrium Tool

Main purpose
A global whole-economy model used to analyse policy scenarios on agricultural economics, bioeconomy, food security, climate change and international trade.

Summary
MAGNET is a recursive dynamic, multi-region, multi-sector Computable General Equilibrium model used to analyse policy scenarios on agricultural economics, bioeconomy, food security, climate change and international trade. It was developed by the Wageningen Economic Research (WECR) in cooperation with JRC and the Thunen Institute.

MAGNET is calibrated to the GTAP database and describes production, use and international trade flows of goods and services and primary factor use differentiated by sectors. The database distinguishes 141 countries or regions (including all EU member states), 65 sectors (plus several optional MAGNET-specific extensions) and 8 factors (e.g., labour, capital, land). A distinguishing feature of the model is its modular design which allows tailoring its structure to the research question. The GTAP model forms the MAGNET core while users choose among several extensions: different nesting structures or assumptions about factor markets, different agricultural-, trade- and biofuels-policy mechanisms and different assumptions relating to investment allocation. Other modules deal with the representation of the Common Agricultural Policies (including rural development), land and labour supply, production quotas, tariff rate quotas, biofuels directive, bioenergy policies, water in agriculture, GHG emmisions (marginal abatement curves) and tracking of Sustainable Development Goals (SDGs) to name a few.

MAGNET can be used in policy formulation through ex-ante policy analysis. The model assesses policy scenarios related to agriculture and agri-food trade while taking into account other fields directly connected with agri-food production such-as bioeconomy (bioenergy, biofuel, biobased chemicals, …), sustainable use of resources (land and water), food security and nutrition (developing and developed countries) and climate change, but also feedback with the wider (non-agricultural) economy. Policy scenarios are compared against a baseline including the most recent macroeconomic (GDP and population) and agricultural (yields, land productivity, EU agricultural mid-term outlook) exogenous drivers. Focusing on ex-ante policy analysis, the model can be used to support policy formulation or to provide valuable information to policy makers in front of exogenous shocks.

Keywords
trade policy , CAP , climate change , multi-commodity model , baseline , bioeconomy , agricultural economic model , Food Security , recursive-dynamic , Sustainable Development Goals (SDGs)

Model category (thematic)

Economy

Model home page

http://www.magnet-model.org/

Ownership & license

Ownership
Multiple copyright [Original code owned by 3rd party]

Ownership details
The MAGNET consortium, led by Wageningen Economic Research which is part of Wageningen University and Research, includes the Economics of Agriculture unit of the European Commission's Joint Research Centre (JRC.D4) and the Thünen-Institute (TI).

Licence type
Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

Details

MAGNET structure and approach

The Modular Agricultural GeNeral Equilibrium Tool (MAGNET) is a multi-region computable general equilibrium model which is a derivative of the well-known Global Trade Analysis Project (GTAP) model. It is developed and applied at Wageningen Economic Research (WECR) at Wageningen University and Research (WUR) and is also employed by the Thünen Institute (TI) and the Joint Research Centre (JRC/D).

MAGNET is calibrated to the latest version of the GTAP database which describes production, use and international trade flows of goods and services, as well as primary factor use differentiated by sectors. The GTAP database distinguishes 141 countries or regions (among them the 28 EU member states), 65 sectors and 8 factor endowments. It is based on country input-output tables and includes consistent bilateral trade flows, transport and protection data. Additional datasets are used for specific MAGNET modules, among them data coming from the International Energy Agency (IEA), the Food and Agriculture Organization of the United Nations (FAO), the United States Department of Agriculture (USDA), the Clearance Audit Trail System (CATS) database for CAP analysis. The choice of regions and sectors from the database can be flexibly aggregated to set-up specific model versions.

MAGNET consists of a system of three types of equations. Firstly, 'behavioural equations' employing 'convenient' mathematical functions represent, under conditions of constrained optimisation, the theoretical tenets of neoclassical economic demand and supply. Subject to a series of 'market clearing' (i.e., supply equals demand) and 'accounting' equations (i.e., income equals expenditure equals output; zero 'economic' profits) consistent with the underlying accounting conventions of the database, the model enforces 'equilibrium'. To solve the model, the number of equations and (endogenous) variables within the system must be the same (known as the model 'closure'). Additional variables under the direct control of the modeller (defined as 'exogenous'), which capture market imperfections (tax rates), factor endowments or technological change, can be manipulated or 'shocked', whereupon the model finds a new matrix of prices and quantities to arrive at a post-shock equilibrium subject to the aforementioned accounting and market clearing restrictions.

A key strength of the MAGNET model is that it allows the user to choose a la carte those sub-modules of relevance to a specific study. The user can (inter alia) choose between different nesting structures, apply different assumptions about the workings of the factor markets, include different agricultural-, trade- and biofuels-policy mechanisms and incorporate dynamic assumptions relating to investment allocation over time periods.

To characterise the peculiarities of agricultural markets, the model accounts for the heterogeneity of land usage by agricultural activity; a regional endogenous land supply function; the sluggish mobility of capital and labour transfer between agricultural and non-agricultural sectors with associated wage and rent differentials; the inclusion of explicit substitution possibilities between different feed inputs in the livestock sectors; and additional behavioural and accounting equations to characterise

EU agricultural policy mechanisms (e.g., production quotas, single farm payment, coupled payments, rural development measures). For the CAP module, additional coupled and decoupled policy variables are included to allow or a finer representation of CAP policy shocks. Furthermore, a detailed set of CAP policy payments, taken from the Clearance of Accounts Audit Trail System (CATS) database (DG AGRI) are used as a basis for calculating 'CAP reference scenario' shocks. In addition, an 'own-resources' module is included within the CAP budget accounting equations. Further modelling enhancements are incorporated including of 'first' and 'second' generation biofuels, GHG emission, water indicators. Other modules include treatment of waste, enhancement of labour market, fishery, inclusion of other climate policies and damage function and a specific module on Sustainable Development Goals (SDGs) indicators.

The results of the MAGNET model are typically presented in value terms or in price and quantity percentage changes. The MAGNET model compiles a large number of indicators, in particular related to production, trade flows, consumption, use of endowments, intermediate input use, income and price changes, land use, emissions, employment. As an additional tool of analysis, this study draws on the GEMPACK decomposition method. On running a complex scenario with an array of shocks (i.e., endowments, tariffs, technology change etc.), it is possible to calculate the part-worth of the resulting endogenous variable change that corresponds to a specific exogenous shock, or pre-specified group of exogenous shocks. Thus, when comparing each of the scenarios with the reference scenario, the comparative 'part-worth' importance of each of the policy indicators is evaluated in order to better understand the role that policy has to play (if any) in shaping bio-based market trends.

Input and parametrization
The key inputs used for the model:

- Value of Margins on international trade (GTAP database)
- Value of Bilateral imports and exports (GTAP database)
- Value of Intermediate and production factors use by industries (GTAP database)
- Value of commodity outputs (GTAP database)
- Value of Capital stock (GTAP database)
- Value of Tax revenues (GTAP database)
- Ad-valorem rate of several tax instruments (GTAP database)
- Income elasticities (GTAP database)
- Armington elasticities (GTAP database)
- Production elasticities (GTAP database)

- EU Agricultural Production and net trade (DG AGRI Agricultural Outlook)
- GHG emission for the (EU Reference Scenario 2016 on energy, transport and climate action; GECO)
- Land supply (FAOSTAT)
- CAP payments (CATS database)
- GDP and population projections (various sources)

The use of MAGNET requires, at a minimum, an understanding of the standard GTAP model and an ability to read GEMPACK code.

Main output

- Macroeconomic variables (GDP, welfare, value added, savings-investments, current account, world prices)
- Sectorial indicators (production, consumption, prices, bilateral trade)
- Production factors (employment, wage, land use and price, capital)
- Additional indicators tailored on the study (water, bioenergy, biofuel, …)
- Nutrition indicators
- Food security indicators (availability, access, utilisation)
- GHG indicators (CO2, Non-CO2)
- Sustainable Development Goals Indicators

MAGNET analyses the economy-wide and distributional impacts of policy and/or structural shocks, sectoral transmission of sector-specific policies for sectors, agents and regions. The output of MAGNET includes projections of input-output tables, GDP, employment, bilateral trade, capital flows and household consumption. The explicit formulation of representative households allows the derivation of welfare indicators.

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	Global

(Spatial) resolution	Country level
Temporal extent	Baseyear 2014, can run in time step up to 2100.
Temporal resolution	To be selected by the modellers, minimum 1 year.

Quality & transparency

Quality

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	yes	Partially. Uncertainty analyses are performed with regard to data, parametrs and exogneous assumptions to the aim of the specific research question. MAGNET is unique as it is able to perform sensitivity analyses with regard to model structure due it modular set up. Many scientific paper include uncertainty analyses directed at research question.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Partially. Not accounted for systematically, but most relevant ones tested via additional simulations. Sensitivity analyses are performed with regard to data, parametrs and exogneous assumptions to the aim of the specific research question. MAGNET is unique as it is able to perform sensitivity analyses with regard to model structure due to its modular set up. Many scientific papers include sensitivity analyses.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	Scenarios to account mainly sensitivity are usually added to main analyses. Results published on regular basis in (high impact) journals such as Nature, Nature Climate Change, Nature Communications, Environmental Research Letter, Agricultural Economics.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	no	There has been no formal evaluation of the model by an external panel, however the model has been extensively published in peer-reviewed journals and is widely regarded as state-of-the-art global Computable General Equilibrium of agricultural and bioeconomy analysis.

References related to external peer-review and publication in scientific journals:

- No references provided in MIDAS

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	no	The underlying database GTAP is not publicly available. Key database data relevant for papers are often provided within the paper or in supplementary information.
Can model outputs be made publicly available?	yes	Through publications in reports and journals, as well as in the data platform dataM.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	See model documentation, • Woltjer G., Kuiper M., Kavallari, A., van Meijl, H., Powell, J., Rutten, M., Shutes, L., Tabeau, A. (2014). The MAGNET model - Module description. Agricultural Economics Research Institute (LEI), LEI Report 14-057. The Hague, Netherlands.
Is the model source code publicly accessible or open for inspection?	no	The original code is owned by 3rd party and not publicly available. The GTAP standard model which is the core of the model is publically available. The MAGNET consortium, led by Wageningen Economic Research (WECR), includes JRC and the Thünen-Institute (TI).

References related to documentation:

- No references provided in MIDAS

The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Agriculture and rural development
- Economy, finance and the euro
- Energy
- Environment
- Regional policy

The model is designed to contribute to the following phases of the policy cycle

- Formulation

The model's potential

This economic simulation model, as a contribution to this impact assessment process, can provide insights into the effects of different policy scenarios on international trade and competitiveness.

The model is designed to conduct policy experiments, in which a reference scenario or baseline is first simulated over a future period and then, after changing one or more underlying assumptions (all kind of police instruments, tax, tariffs...), a new scenario incorporating these changes is run, also over the same time period. Comparison of the new scenario with the reference scenario at a given point in the simulation period, usually in terms of percentage differences, establishes the direction and relative magnitude of the impacts on all the endogenous variables of the change that is depicted in the hypothetical scenario at that point in time.

Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

In the Year	MAGNET contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2018	Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy SWD/2018/301 final	AGRI	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Affects on individual Member States - EU Exports & imports - Non-trade barriers - Cost of doing business - Market share & advantages in international context - Stimulation of research and development - Prices, quality, availability or choice of consumer goods and services - Significant effects on sectors - Disproportionately affected region or sector - International legal commitments - EU foreign policy and EU development policy - Impacts on third countries - Impacts on developing countries - Goods traded with developing countries - Impact on jobs - Impact on jobs in specific sectors, professions, regions or countries - Indirect effects on employment levels - Factors preventing or enhancing the potential to create jobs or prevent job losses - Wages, labour costs or wage setting mechanisms - Households income and at risk of poverty rates - Inequalities and the distribution of incomes and wealth - Emission of greenhouse gases - Waste production, treatment, disposal or recycling - Sustainable production and consumption - Environment in third countries - Change in land use

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AGLINK-COSIMO - AGricultural LINKage - COmmodity SImulation Model

Fact sheet

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 08/10/2020

Overview

Acronym AGLINK-COSIMO
Full title AGricultural LINKage - COmmodity SImulation Model

Main purpose
A global agricultural economic model used to simulate the medium-term development of annual supply, demand and prices for the main agricultural commodities produced, consumed and traded worldwide. It has been extended to simulate the economic impacts of market uncertainties and climate extremes.

Summary
AGLINK-COSIMO is a global simulation model developed jointly by the Organization for Economic Cooperation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO) Secretariats in collaboration with some OECD member countries. It is a partial-equilibrium, multi-commodity, recursive-dynamic model of global agricultural markets. It is used to simulate medium-term developments in annual supply, demand and prices of the main agricultural commodities produced, consumed and traded worldwide. Those projections are published annually in an extensive report (EC 2019) and also serve as a baseline reference for simulating counterfactual policy scenarios for in-house or scientific purposes, with this and other large-scale simulation models maintained in the European Commission. The 2020 version of the model has over 43,000 equations, covers more than 100 commodities (cereals, oilseeds, sugar, meats, dairy products, biofuels, cotton) in all OECD and FAO countries, and includes 43 domestic market-clearing prices that are linked with 36 international reference prices. The EU is treated as a single market.

At the EU level, the AGLINK-COSIMO model is used to produce the report 'EU Agricultural Outlook for Markets and Income' (EC 2019). The aim of this yearly exercise is to provide a detailed overview of EU agricultural markets over the next ten years ('medium term'). It incorporates information from policy makers and market experts in the European Commission, as well as from stakeholders, researchers and modellers, thus culminating into a consensus regarding the likely evolution of European agriculture and related markets. The resulting projections serve also as a baseline reference for simulating counterfactual scenarios of policy relevance with AGLINK-COSIMO or even other large-scale simulation models used in the European Commission. Apart from its standard deterministic version, the model has a stochastic component where market uncertainty stemming from variability in crop yields and macroeconomic factors is examined. Recent extensions pertain to post-model calculations regarding nutrition (calories, undernourishment, obesity) and agricultural greenhouse gas emissions as well as to the quantification of market outcomes due to concurrent and recurrent extreme-climate events.

Keywords
multi-commodity model , baseline , OECD , FAO , Simulation , agricultural markets

Model category (thematic)

Agriculture

Model home page
www.agri-outlook.org

Ownership & license

Ownership
Sole copyright [3rd party]

Ownership details
The OECD and the FAO are the sole owners of the model. The European Commission belongs to the users network and has a written agreement to use the model.

Licence type
Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

Details

AGLINK-COSIMO structure and approach

The overall design of the AGLINK-COSIMO model focuses on the potential influence of agricultural and trade policies on agricultural commodity markets in the medium-term, typically 10 years ahead. Development on the basis of the (agricultural) economics literature, existing country-level models, and formal bilateral reviews has resulted in a modelling system that reflects the views of participating countries. To remain tractable, the model specification imposes some degree of uniformity across country modules. Taking this constraint into account, agricultural markets are modelled to best capture relevant settings and policies that are country- and commodity-specific. In undertaking projection work with the AGLINK-COSIMO model, individual country modules are calibrated on baseline projections that participating countries submit annually to the OECD and FAO in the form of structured questionnaires.

Input and parametrization

Main inputs to the European Commission's version of the model are:

- The latest OECD-FAO Agricultural Outlook (issued every June), which is updated with
    - the short-term outlook for EU commodity balances: crops (wheat, maize, coarse grains, sugar beet, oilseeds etc.), meat (dairy cattle, suckler cows, sheep, pigs, poultry etc.), dairy, sugar production and biofuel production.
    - the latest macroeconomic and policy assumptions, and
    - new model developments in terms of equations and data to better represent EU agricultural markets and policies.

Variables in the model can be endogenous (i.e., determined within the system) or exogenous (i.e., determined outside the system and simply inserted). Most behavioural equations are "double-log" which are popular in the estimation of supply and demand functions. In those functions, explained variables (on the left-hand side) and explanatory variables (right-hand side) are expressed in logarithmic terms; that is Y experiences diminishing marginal returns with respect to increases in X:

$$\log(Y)= a + b*\log(X) + \log(r)$$

where *a* is the intercept, *b* is the Y-to-X elasticity (constant), and *r* is the residual (so-called 'r-factor'). Numerous variations of this general form exist to represent real-world movements, such as technological change and cobweb-like market adjustments. Intercepts, which are time-invariant, and r-factors, which are time-variant, are interdependent and equation-specific calibration terms. These terms are endogenous during model calibration but remain exogenous in simulation mode (e.g., for scenario analysis). Year-specific shocks are implemented by changing the corresponding r-factors of endogenous variables or the actual values of exogenous variables. Oil prices and macroeconomic factors, such as GDP growth, inflation, exchange rates, energy prices, and population are exogenous.

Main output

AGLINK-COSIMO generates projections on annual market balances for the next 10 years.

Key variables include production (e.g., crops, livestock), consumption (food, feed, biofuel, other industrial uses), trade (imports, exports), stocks (public, private), and prices (domestic producer, domestic consumer, domestic feed, global) of major agricultural commodities. The model covers over 100 commodities ranging from crops, such as wheat or maize, to processed goods and by-products, such as protein meals and distiller dried grains.

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	Markets may be single countries or groups of countries. The EU is treated as a single market. Country coverage in the 2020 version is as follows: North America: Canada, United States Latin America: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela (Bolivarian Republic of) Europe: Albania, Andorra, Belarus, Bosnia and Herzegovina, European Union, Faroe Islands, Iceland, Monaco, Montenegro, Norway, Republic of Moldova, Russian Federation, San Marino, Serbia, Serbia and Montenegro, Switzerland, Republic of North Macedonia, Ukraine, United Kingdom Africa (developed): South Africa Africa (developing): Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra-Leone, Somalia, South Sudan, Sudan, Togo, Tunisia, Uganda, United Republic of Tanzania, Western Sahara, Zambia, Zimbabwe Asia (developed): Armenia, Azerbaijan, Georgia, Israel, Japan, Kazakhstan,

	Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan Asia (developing): Afghanistan, Bahrain, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, Hong Kong China, Macao China, The People's Republic of China, Democratic People's Republic of Korea, India, Indonesia, Iran (Islamic Republic of), Iraq, Jordan, Kuwait, Lao People's Democratic Republic, Lebanon, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Occupied Palestinian Territory, Oman, Pakistan, Philippines, Qatar, Korea, Saudi Arabia, Singapore, Sri Lanka, Syrian Arab Republic, Chinese Taipei, Thailand, Timor-Leste, Turkey, United Arab Emirates, Viet Nam, Yemen Oceania (developed): Australia, New Zealand Oceania (developing): American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall-Islands, Micronesia (Federated States of), Nauru, New Caledonia, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna Islands LDC's (subgroup): Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Eritrea, Gambia, Guinea, Guinea-Bissau, Lao People's Democratic Republic, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Timor-Leste, Togo, Uganda, United Republic of Tanzania, Zambia BRICS (subgroup): Brazil, The People's Republic of China, India, Russian Federation, South Africa
(Spatial) resolution	Country/world regional level for domestic markets; world for global trade
Temporal extent	10 years ahead (medium term)
Temporal resolution	Annual (market year for crops, calendar year for processed products and meats)

Quality, reliability & transparency

Quality and reliability

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	yes	Uncertainties in input data and simulations are quantified every year with the partial stochastics module (Araujo-Enciso et al. 2017). Uncertainties in parameters are dealt with on a case-by-case basis using deterministic shocks.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Sensitivity analysis is performed every year with the partial stochastics module (Araujo-Enciso et al. 2017).
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	Done formally by the OECD in 2009-10
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	Informally, on a case-by-case basis. An ex-post exercise can be found online under https://doi.org/10.1787/19991142 (2013 version, Box 1.1).

References related to external peer-review and publication in scientific journals:

- Araujo Enciso, S., Pieralli, S. and Perez Dominguez, I., Partial Stochastic Analysis with the Aglink-Cosimo Model: A Methodological Overview , EUR 28863 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-76019-8 (print),978-92-79-76018-1 (pdf), doi:10.2760/450029 (print),10.2760/680976 (online), JRC108837.

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	no	Property of the model consortium
Can model outputs be made publicly available?	yes	Updated annually under https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/markets/outlook/medium-term_en (EU version) and http://www.agri-outlook.org/ (OECD-FAO version).
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	Documentation available online (Araujo-Enciso et al. 2015; 2017). Several other links can also be found under http://www.agri-outlook.org/about/.
Is the model source code publicly accessible or open for inspection?	no	Source code is only available to the users group and collaborators.

References related to documentation:

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The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Agriculture and rural development

The model is designed to contribute to the following phases of the policy cycle

- Formulation

The model's potential

The AGLINK-COSIMO model provides a yearly updated medium-term baseline to other market models used in the Commission, such as CAPRI, MAGNET and AGMEMOD. It is therefore used indirectly for ex-ante impact assessment (e.g., biofuels, climate negotiations, CAP reform, trade agreements). The partial stochastic analysis based on AGLINK-COSIMO is also used to analyze ex-ante the impacts of specific policy reforms.

An important activity of the European Commission is the annual production of medium-term (10 years) baseline projections for EU agricultural commodity markets (EC 2019), published annually by the Directorate General for Agriculture and Rural Development (DG AGRI) in the second half of the year. AGLINK-COSIMO, which is maintained at the JRC, is the key tool for building those baseline projections as well as for performing uncertainty and sensitivity analyses due to alternative macroeconomic environments and crop yields.

Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

In the Year	AGLINK-COSIMO contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2018	Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy SWD/2018/301 final	AGRI	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - EU Exports & imports - Market share & advantages in international context - Prices, quality, availability or choice of consumer goods and services - Goods traded with developing countries - Emission of greenhouse gases

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RUSLE2015 - Revised Universal Soil Loss Equation

Fact sheet

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 08/10/2020

Overview

Acronym RUSLE2015
Full title Revised Universal Soil Loss Equation

Main purpose:
An erosion model designed to predict the long time average annual soil loss carried by runoff.

Summary
The modified version of the Revised Universal Soil Loss Equation (RUSLE 2015) is an erosion model designed to predict the long time average annual soil loss carried by runoff. It has been developed in JRC during the last 3 years.

RUSLE2015 estimates soil loss in Europe for the reference year 2010, within which the input factors are modelled with the most recently available pan-European datasets. While RUSLE has been used before in Europe, RUSLE2015 improves the quality of estimation by introducing updated, high-resolution, and peer-reviewed input layers.

A major benefit of RUSLE2015 is that it can incorporate the effects of policy scenarios based on land-use changes and support practices. The impact of the Good Agricultural and Environmental Condition (GAEC) requirements of the Common Agricultural Policy (CAP) and the EU's guidelines for soil protection can be grouped under land management and support practices.

Keywords
soil erosion , rainfall erosivity , soil erodibility , USLE , Cover Management , RUSLE , Soil loss by water , Support practices

Model category (thematic)
Environment

Model home page
http://esdac.jrc.ec.europa.eu/themes/rusle2015

Ownership & license

Ownership
Sole copyright [European Union]

Ownership details
The model can be used for free. Publications are the documentation of the model

Licence type
Free software licence. The license grants freedom to run the programme for any purpose; freedom to run the program for any purpose; freedom to study (by accessing the source code) how the program works, and change it so it does enable computing; freedom to redistribute copies; and freedom to distribute copies of modified versions to others.

Details

RUSLE2015 structure and approach

The revised version of the RUSLE is an empirical model that calculates soil loss due to sheet and rill erosion. The new soil loss by water erosion map of Europe uses a modified version of the RUSLE model (RUSLE2015, based on Renard et al., 1997), which calculates mean annual soil loss rates by sheet and rill erosion according to the following equation:

E = R * K * C * LS * P

Where E: Annual average soil loss (t ha^{-1} yr^{-1}),

R: Rainfall Erosivity factor (MJ mm ha^{-1} h-1 yr^{-1}),

K: Soil Erodibility factor (t ha h ha^{-1} MJ^{-1} mm^{-1}),

C: Cover-Management factor (dimensionless),

LS: Slope Length and Slope Steepness factor (dimensionless),

P: Support practices factor (dimensionless).

Each of the input factors is modelled using pan-European harmonized datasets as inputs.

Rainfall erosivity factor (R).

Input for Rainfall erosivity factor: The Rainfall Erosivity Database at European Scale (REDES) (Panagos et al., 2015) which has been developed using high-temporal resolution rainfall data (5 min, 10-min, 15-min, 30-min, 60 min) from 1541 stations in European Union and Switzerland.

Methodology: The intensity of precipitations is one of the main factors affecting soil water erosion processes. R is a measure of the precipitation's erosivity and indicates the climatic influence on the erosion phenomenon through the mixed effect of rainfall action and superficial runoff, both laminar and rill. Wischmeier (1959) identified a composite parameter, EI30, as the best indicator of rain erosivity. It is determined, for the ki-th rain event of the i-th year, by multiplying the kinetic energy of rain by the maximum rainfall intensity occurred within a temporal interval of 30 minutes. In RUSLE20015, the R-factor is calculated based on high-resolution temporal rainfall data (5, 10, 15, 30 and 60 minutes) collected from 1,541 well-distributed precipitation stations across Europe (Panagos et al., 2015a). This first Rainfall Erosivity Database at the European Scale (REDES) was a major advancement in calculating rainfall erosivity in Europe. The precipitation time series used ranged from 7 to 56 years, with an average of 17.1 years. The time-series precipitation data of more than 75% of European Union (EU) countries cover the decade 2000-2010. Gaussian Process Regression(GPR) (Rasmussen and Williams, 2005) has been used to interpolate the R-factor station values to a European rainfall erosivity map at 500m resolution. The covariates used for the R-factor interpolation were climatic data (total precipitation, seasonal precipitation, precipitation of driest/wettest months, average temperature), elevation and latitude/longitude. The mean R-factor for the EU plus Switzerland is 722 MJ mm ha-^{1}1 h-^{1} yr-^{1}, with the highest values (>1,000 MJ mm ha-^{1} h-^{1} yr-^{1}) in the Mediterranean and alpine regions and the lowest (500 MJ mm ha-^{1} h-^{1} yr-^{1}) in the Nordic countries.

Soil Erodibility factor (K).

Input for sol erodiblity factor: LUCAS topsoil database 2009 (and update 2012 for Romania and Bulgaria) and European Soil Database v.2 (Soil structure) (Orgiazzi et al., 2018).

Methodology: The greatest obstacle to soil erosion modelling at larger spatial scales is the lack of data on soil characteristics. One key parameter for modelling soil erosion is the soil erodibility, expressed as the K-factor in the widely used soil erosion model, the Universal Soil Loss Equation (USLE) and its revised version (RUSLE). The K-factor, which expresses the susceptibility of a soil to erode, is related to soil properties such as organic matter content, soil texture, soil structure and permeability. With the Land Use/Cover Area frame Survey (LUCAS) soil survey in 2009 a pan-European soil dataset is available for the first time, consisting of around 20,000 points across 25 Member States of the European Union. The aim of this study is the generation of a harmonised high-resolution soil erodibility map (with a grid cell size of 500 m) for the 25 EU Member States. Soil erodibility was calculated for the LUCAS survey points using the nomograph of Wischmeier and Smith (1978). A Cubist regression model was applied to correlate spatial data such as latitude, longitude, remotely sensed and terrain features in order to develop a high-resolution soil erodibility map. The mean K-factor for Europe was estimated at 0.032 t ha h ha-^{1} MJ-^{1} mm-^{1} with a standard deviation of 0.009 t ha h ha-^{1} MJ-^{1} mm-^{1}. The yielded soil erodibility dataset compared well with the published local and regional soil erodibility data. However, the incorporation of the protective effect of surface stone cover, which is usually not considered for the soil erodibility calculations, resulted in an average 15% decrease of the K-factor. The exclusion of this effect in K-factor calculations is likely to result in an overestimation of soil erosion, particularly for the Mediterranean countries, where highest percentages of surface stone cover were observed.

Cover-Management factor (C)

Input for cover management factor: CORINE Land Cover 2000-2006-2012 , COPERNICUS vegetation density layer , Eurostat statistical data on crops distribution, Tillage practices, Cover crops and Plant residues. Detailed description of datasets can be found in the policy report *Soil-related indicators to support agri-environmental policies (EUR30090)*.

Methodology: Land use and management influence the magnitude of soil loss. Among the different soil erosion risk factors, the cover-management factor (C-factor) is the one that policy makers and farmers can most readily influence in order to help reduce soil loss rates. The present study proposes a methodology for estimating the C-factor in the European Union (EU), using pan-European datasets (such as CORINE LandCover), biophysical attributes derived from remote sensing, and statistical data on agricultural crops and practices. In arable lands, the C-factor was estimated using crop statistics (% of land per crop) and data on management practices such as conservation tillage, plant residues and winter crop cover. The C-factor in non-arable lands was estimated by weighting the range of literature values found according to fractional vegetation cover, which was estimated based on the remote sensing dataset Fcover (Panagos et al 2015). The mean C-factor inthe EU is estimated to be 0.1043, with an extremely high variability; forests have the lowest mean C-factor (0.00116), and arable lands and sparsely vegetated areas the highest (0.233 and 0.2651, respectively). Conservation management practices (reduced/no tillage, use of cover crops and plant residues) reduce the C-factor by on average 19.1% in arable lands. The methodology is designed to be a tool for policy makers to assess the effect of future land use and crop rotation scenarios on soil erosion by water. The impact of land use changes (deforestation, arable land expansion) and the effect of policies (such as the Common Agricultural Policy and the push to grow more renewable energy crops) can potentially be quantified with the proposed model.

Slope Length and Slope Steepness factor (LS)

Input for Length and Slope Steepness factor: Digital Elevation model (DEM) at 25m resolution

Methodology: The Universal Soil Loss Equation (USLE) and the Revised USLE (RUSLE) model is the most frequently used model for soil erosion risk estimation. Among the six input layers, the combined slope length and slope angle (LS-factor) has the greatest influence on soil loss at the European scale. The S-factor measures the effect of slope steepness, and the L-factor defines the impact of slope length. The combined LS-factor describes the effect of topography on soil erosion. The European Soil Data Centre (ESDAC) (https://esdac.jrc.ec.europa.eu/) developed a new pan-European high-resolution soil erosion assessment to achieve a better understanding of the spatial and temporal patterns of soil erosion in Europe. The LS-calculation was performed using the original equation proposed by Desmet and Govers (1996) and implemented using the System for Automated Geoscientific Analyses (SAGA), which incorporates a multiple flow algorithm and contributes to a precise estimation of flow accumulation. The LS-factor dataset was calculated using a high-resolution (25 m) Digital Elevation Model (DEM) for the whole European Union, resulting in an improved delineation of areas at risk of soil erosion as compared to lower-resolution datasets. This combined approach of using GIS software tools with high-resolution DEMs has been successfully applied in regional assessments in the past, and is now being applied for first time at the European scale.

Support practices factor (P)

Input for support practices factor: LUCAS Earth Observation database (stone walls, grass margins) , Good Agricultural Environmental Conditions (GAEC) database. A detailed description of datasets can be found in the policy report *Soil-related indicators to support agri-environmental policies (EUR30090).*

Methodology:

The USLE/RUSLE support practice factor (P-factor) is rarely taken into account in soil erosion risk modelling at sub-continental scale, as it is difficult to estimate for large areas. This study attempts to model the P-factor in the European Union. For this, it considers the latest policy developments in the Common Agricultural Policy, and applies the rules set by Member States for contour farming over a certain slope. The impact of stone walls and grass margins is also modelled using the more than 226,000 observations from the Land use/cover area frame statistical survey (LUCAS) carried out in 2012 in the European Union (Orgiazzi et al., 2018). The mean P-factor considering contour farming, stone walls and grass margins in the European Union is estimated at 0.9702. The support practices accounted for in the P-factor reduce the risk of soil erosion by 3%, with grass margins having the largest impact (57% of the total erosion risk reduction) followed by stone walls (38%). Contour farming contributes very little to the P-factor given its limited application; it is only used as a support practice in eight countries and only on very steep slopes. Support practices have the highest impact in Malta, Portugal, Spain, Italy, Greece, Belgium, The Netherlands and United Kingdom where they reduce soil erosion risk by at least 5%. The P-factor modelling tool can potentially be used by policy makers to run soil-erosion risk scenarios for a wider application of contour farming in areas with slope gradients less than 10%, maintaining stone walls and increasing the number of grass margins under the forthcoming reform of the Common Agricultural Policy.

Additional references for the methdology

Desmet, P., Govers, G., 1996. A GIS procedure for automatically calculating the ULSE LS factor on topographically complex landscape units. Journal of Soil and Water Conservation 51 (5), 427–433.

Renard, K.G., et al., 1997. Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE) (Agricultural Handbook 703). US Department of Agriculture, Washington, DC, pp. 404.

<u>Input and parametrization</u>
Inputs are:

- R: Rainfall Erosivity factor (MJ mm ha^{-1} h^{-1} yr^{-1}),
- K: Soil Erodibility factor (t ha h ha^{-1} MJ^{-1} mm^{-1}),

- C: Cover-Management factor (dimensionless),
- LS: Slope Length and Slope Steepness factor (dimensionless),
- P: Support practices factor (dimensionless).

Each of the input factors is modelled using pan-European harmonized datasets as inputs.

- R: The Rainfall Erosivity Database at European Scale (REDES) which has been developed using high-temporal resolution rainfall data (5 min, 10-min, 15-min, 30-min, 60 min) from 1541 stations in European Union and Switzerland.
- K: LUCAS topsoil database 2009 (and update 2012 for Romania and Bulgaria) and European Soil Database v.2 (Soil structure)
- C: CORINE Land Cover 2000-2006-2012 , COPERNICUS vegetation density layer , Eurostat statistical data on crops distribution, Tillage practices, Cover crops and Plant residues.
- LS: Digital Elevation model (DEM) at 25m resolution
- P: LUCAS Earth Observation database (stone walls, grass margins) , Good Agricultural Environmental Conditions (GAEC) database.

Detailed description of datasets can be found in the policy report *Soil-related indicators to support agri-environmental policies (EUR30090).*

Main output

The model output is

-

Soil erosion by water in Europe in t ha^{-1} yr^{-1} for cells of 100 m x 100 m

The model outputs are aggregated of further analysed to produce a a number of indicators derived from this map:

- The soil erosion can be aggregated at NUTS0, NUTS2 and NUTS Level 3 administrative areas
- Soil erosion of more than 11 tonnes per ha annually in Agricultural areas
- Soil Erosion indicator for the scoreboard of the Roadmap to a Resource Efficient Europe EUROPE2020 Scoreboard (Number of Square Km with soil erosion more than 10 tonnes per ha), see: https://ec.europa.eu/eurostat/databrowser/view/t2020_rn300/default/table?lang=en

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	EU 28
(Spatial) resolution	100 m x 100 m Grid cells
Temporal extent	From 2000 to 2012
Temporal resolution	Annual averages with the objective to produce monthly averages

Quality & transparency

Quality

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	yes	Uncertainties are provided for each of the input layers.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	The model has undergone a sensitivity analysis in the publication(additional material): Borrelli et.al 2013
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	The model has been peer reviewed in the publication and by the scientific community: Panagos, et al 2015.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	Model predictions have been compared with data provided by countries (coming from the EIONET data collection). In 2009, the JRC has collected data on soil erosion from the EIONET network and only 8 countries have provided maps/datasets. RUSLE2015 data are compared well with the EIONET datasets. Comparison with plots is not possible as the plots have short-term measured data and they refer to different land uses. In 2020, the RUSLE2015 data were also compared with data from 21 regional studies (Panagos et al., 2020).

References related to external peer-review and publication in scientific journals:

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- Borrelli, P., Robinson, D., Fleischer, L., Lugato, E., Ballabio, C., Alewell, C., Meusburger, K., Modugno, S., Schutt, B., Ferro, V., Vincenzo, B., Van Oost, K., Montanarella, L. and Panagos, P., An assessment of the global impact of 21st century land use change on soil erosion, NATURE COMMUNICATIONS, ISSN 2041-1723, 8, 2017, p. 2013, JRC107016.

<u>Transparency</u>

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	Input data are accessible from the European Soil Data Centre (ESDAC).
Can model outputs be made publicly available?	yes	Output data are made accessible through the European Soil Data Centre (ESDAC).
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	The model is documented in the European Soil Data Centre (ESDAC), plus in peer review Open Access publications.
Is the model source code publicly accessible or open for inspection?	yes	Open source publication: Panagos, P., Borrelli, P., Poesen, J., Ballabio, C., Lugato, E., Meusburger, K., Montanarella, L., Alewell, .C. 2015. The new assessment of soil loss by water erosion in Europe. Environmental Science & Policy. 54: pp. 438-447

References related to documentation:

- No references provided in MIDAS

The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Agriculture and rural development
- Environment

The model is designed to contribute to the following phases of the policy cycle

- Anticipation
- Formulation
- Implementation

The model's potential

The RUSLE model can contribute to impact assessment of European Policies by identifying the impact of land use/cover change to soil erosion and furthermore to environment. Land Cover is an important factor in RUSLE soil erosion estimation and possible changes in land cover will have direct influence to the model results.

The RUSLE model contributes to the following policies:

1. Impact Assessment of the post 2020 Common Agricultural Policy (CAP) - SWD(2018) 301 final

2. Sustainable Development Goals (SDGs) COM(2016) 739 final

3. Thematic strategy for soil protection (COM/2006/231). Commission of the European Communities, Brussels.

4. Common Agricultural Policy 2014-2020 (context indicator No 42)

5. Resource Efficiency Flagship Initiative - EU Roadmap to a Resource Efficient Europe.

by providing e.g. statistics for the Sustainable Development Goal (SDGs), Eurostat Agro-environmental Indicator No 21, Eurostat Regional Statistics edition 2015, and the Eurostat Europe2020 Resource Efficiency scoreboard.

Potential applications at a global scale include United Nations Convention to Combat Desertification (UNCCD), FAO, Status of the World's Soil Resources, The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem (IPBES) and the OECD Agri-Environmental Indicators.

A major development in 2018 was the use of RUSLE2015 for the Impact Assessment of the post2020 Common Agricultural Policy (CAP). RUSLE2015 scenarios and references can be found in the Impact assessment SWD (2018) 301 final.

Policy Document: Impact assessment SWD (2018) 301 final Accompanying the document for a Regulation on the Post 2020 CAP
Reference: European Commission proposal COM(2018) 392 Final for the post2020 Common Agricultural Policy (CAP).

The model has contributed to run policy scenario analysis for the soil erosion projections in 2030. Those projections have been included in the policy document EU Agricultural outlook for markets and income 2018-2030: https://ec.europa.eu/agriculture/markets-and-prices/medium-term-outlook_en

An additional developmnt was the use of RUSLE2015 for the Sustainable development in the European Union — Monitoring report on progress towards the SDGs in an EU context — 2018 edition .

Previous use of the model in ex-ante impact assessments of the European Commission

In the Year	RUSLE2015 contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2018	Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy SWD/2018/301 final	AGRI	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Ability to adapt to climate change - Availability or quality of Fresh- or ground water - Acidification, contamination or salinity of soil, and soil erosion rates - Environment in third countries

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CENTURY agroecosystem dynamic model

Fact sheet

Source: Commission modelling inventory and knowledge management system (MIDAS)

Date of Report Generation: 08/10/2020

Overview

Acronym CENTURY
Full title CENTURY agroecosystem dynamic model

Main purpose
A biogeochemistry ecosystem model used to assess the impact of climate, land use and management practice changes on C budget of the EU agricultural soils.

Summary
CENTURY is a process-based model designed to simulate Carbon (C), Nitrogen (N), Phosphorous (P) and Sulphur (S) dynamics in natural or cultivated systems, using a monthly time step. The model was originally developed in the late ’80s by Colorado State University and it is, currently, one of the most widely used soil biogeochemistry models.

In the JRC.D.3 model framework, CENTURY is running at a resolution of 1 km2 in the agricultural soils of the EU, incorporating the most recently available pan-European datasets. The main purpose is to quantify the current soil organic carbon (SOC) stock and its change under different scenarios, although many ecosystem outputs (eg. soil respiration, plant productivity, etc.) can also be retrieved.

A major benefit of CENTURY is that it can incorporate the effects of policy scenarios based on land-use changes and support practices. The impact of the Good Agricultural and Environmental Condition (GAEC) requirements of the Common Agricultural Policy (CAP) and the EU’s guidelines for soil protection can be assessed under land management and support practices.

Keywords
climate change , land use , soil organic carbon , crop management

Model category (thematic)
Environment

Model home page
http://www.nrel.colostate.edu/projects/century/

Ownership & license

Ownership
Sole copyright [3rd party]

Ownership details
Developed by Colorado State University. The version utilized is provided and maintained by prof. Paustian Lab Group (http://www.nrel.colostate.edu/paustian-group.html)

Licence type
Non-Free Software licence. The license has one or more of the following restrictions: it prohibits creation of derivative works; it prohibits commercial use; it obliges to share the licensed or derivative works on the same conditions.

Details

CENTURY structure and approach
CENTURY is a typical soil organic carbon (SOC) compartment model based on first order decay: the soil organic matter sub-model includes three SOC pools (active, slow and passive), along with two fresh residue pools (structural and metabolic), each with a different turnover rate. Soil temperature and moisture, soil texture and cultivation practices have different effects on these rates. The model is also able to simulate the water balance, using a weekly time step, and a suite of simple plant growth models are included to simulate C, N, P and S dynamics of crops, grasses and trees.

In our model framework, CENTURY is running at a resolution of 1 km2 in the agricultural soils of the EU, incorporating the most recently available pan-European datasets. The model can also be implemented with the soil erosion component. A daily time-step version of the model (DayCent) is recently running using the same JRC-D.3 model framework inputs.

The CENTURY model was spin-up through a series of management sequences encompassing the main agricultural technological stages of the last 2,000 years, until the actual management representing the business as usual scenario. A validation against the Land Use and Coverage Area frame Survey (LUCAS) soil samples was performed to test the model accuracy of the present SOC stock estimations.

Input and parametrization
Key input to CENTURY are:

- spatial distribution of the agricultural land use categories (arable, pasture, rice, permanent crops) (Source: Corine Land Cover 1990-2000-2006-2012)
- soil texture, pH, bulk density, layers definition and depth, hydraulic properties (source: European Soil Database v.2 and LUCAS-derived spatial layers)
- actual gridded climate (Source: European Climate Assessment & Dataset, E-OBS gridded weather dataset)
- climate projections (Source: Coordinated Regional Climate Downscaling Experiment (CORDEX) climatic projections)
- crop area distribution at NUT2 level, livestock density at NUT2, NUT3 level (source: EUROSTAT)
- crop distribution, fertilizer consumption, irrigation, livestock density (Source: FAO)
- soil erosion map (Source: Revised Universal Soil Loss Equation, RUSLE2015 (optional))

Main output

Main outputs are:

- soil organic carbon pools
- biomass pools (grain, root, straw, etc.)
- ecosystem variables (soil respiration, NPP, etc.)
- eroded C
- N fluxes including N2O emissions (DayCent)

Outputs are provided in raster format (geotiff).

Spatial - temporal extent

The output has the following spatial-temporal resolution and extent:

Parameter	Description
Spatial Extent / Country Coverage	EU28 + Serbia, Bosnia and Herzegovina, Croatia, Montenegro, Albania, Former Yugoslav Republic of Macedonia and Norway
(Spatial) resolution	1 km grid
Temporal extent	from 1901 to 2100
Temporal resolution	monthly time-step (daily time-step in DayCent)

Quality, reliability & transparency

Quality and reliability

Question	Answer	Details
Models are by definition affected by uncertainties (in input data, input parameters, scenario definitions, etc.). Have the model uncertainties been quantified? Are uncertainties accounted for in your simulations?	yes	By multiple runs with sensitive inputs (soil datasets, climate change scenarios).
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Not a fully sensitivity due to the model complexity, but for key inputs.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	There has been no formal evaluation of the model by an external panel, however the model has been published in peer-reviewed journals (see list below).
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	Comparison against LUCAS soil data: comparison with meta-analyses.

References related to external peer-review and publication in scientific journals:

- Lugato E, Panagos P, Bampa F, Jones A, Montanarella L. A new baseline of organic carbon stock in European agricultural soils using a modelling approach. GLOBAL CHANGE BIOLOGY ; 2013. JRC80602
- Lugato, E., Paustian, K., Panagos, P., Jones, A., & Borrelli, P. (2016). Quantifying the erosion effect on current carbon budget of European agricultural soils at high spatial resolution. Global Change Biology, 22(5), 1976–1984. doi:10.1111/gcb.13198

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	European Soil Data Centre (ESDAC).
Can model outputs be made publicly available?	yes	Outputs are made available through the European Soil Data Centre (ESDAC).
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	The model is documented in the European Soil Data Centre (ESDAC).
Is the model source code publicly accessible or open for inspection?	yes	Model and parameters are available from the JRC; model code is available from Colorado State University.

References related to documentation:

- No references provided in MIDAS

The model's policy relevance and intended role in the policy cycle

The model is designed to contribute to the following policy areas

- Agriculture and rural development
- Climate action
- Environment

The model is designed to contribute to the following phases of the policy cycle

- Anticipation
- Formulation
- Evaluation

The model's potential

The model predicts the effect of different management practices on soil organic carbon (SOC) in agricultural soils, hence it may be used to compile regional/national C inventories and to support policies for C sequestration in soil.

The agricultural managements simulated by CENTURY consider the mineral and organic fertilizations, irrigation, grazing, crop rotation, tillage and harvest. Therefore, both, past changes (ex-post) on those practices (including land use change) and scenarios analysis (ex-ante) can be assessed by model runs.

Previous use of the model in ex-ante impact assessments of the European Commission

Use of the model in ex-ante impact assessments since July 2017.

In the Year	CENTURY contributed to the Impact assessment called	Led by	By providing input to the	The model was run by	Details of the contribution
2017	Impact assessment accompanying the document Proposal for a Communication: on modernising and simplifying the common agricultural policy SWD/2018/301 final	AGRI	Baseline and assessment of policy options	*European Commission*	The model helped to assess the following impacts: - Emission of greenhouse gases - Ability to adapt to climate change - Acidification, contamination or salinity of soil, and soil erosion rates

Bibliographic references

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- *Lugato E; Paniagua Alfaro L; Jones A; De Vries W; Leip A. Complementing the top soil information of the Land Use/Land Cover Area Frame Survey (LUCAS) with modelled N2O emissions . PLOS ONE 12 (4); 2017. p. e017611. JRC103717*
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- *Borrelli P, Paustian K, Panagos P, Jones A, Schütt B, Lugato E. Effect of Good Agricultural and Environmental Conditions on erosion and soil organic carbon balance: A national case study. LAND USE POLICY 50; 2016. p. 408-421. JRC96042*
- *Lugato E, Jones A. Modelling soil organic carbon changes under different maize cropping scenarios for cellulosic ethanol in Europe. BIOENERGY RESEARCH 8 (2); 2015. p. 537-545. JRC83895*
- *Lugato E, Bampa F, Panagos P, Montanarella L, Jones A. Potential carbon sequestration of European arable soils estimated by modelling a comprehensive set of management practices. GLOBAL CHANGE BIOLOGY 20 (11); 2014. p. 3557–3567. JRC87987*
- *Lugato E, Panagos P, Bampa F, Jones A, Montanarella L. A new baseline of organic carbon stock in European agricultural soils using a modelling approach. GLOBAL CHANGE BIOLOGY ; 2013. JRC80602*