Inter-Institutional version of the Commission modelling inventory and knowledge management system (MIDAS)
Report generation date 06/10/2020

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.

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Factsheet

SWD/2018/249 final/2

Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: on minimum requirements for water reuse

Supporting model(s)

LISFLOOD, LUISA, EPIC

Impact assessment SWD/2018/249 final/2

Fact sheet on model contributions

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

Date of Report Generation: 06/10/2020

Overview

Title
Impact assessment accompanying the document Proposal for a Regulation of the European Parliament and of the Council: on minimum requirements for water reuse

Document ID
SWD/2018/249 final/2

Year of publication
2018

Led by
ENV

Model(s) used
LISFLOOD, LUISA, EPIC

LISFLOOD

Full title

LISFLOOD hydrological model

Run for this impact assessment by

European Commission

Contributed to

Problem definition

Details of the contribution

LISFLOOD supported the problem definition through the study "Impact of a changing climate, land use, and water usage on Europe's water resources". The 2 degree assessment includes projections of land use change (using JRC's LUISA system, see Jacobs-Crisioni et al. 2017) until 2050, GDP projections, population projections and water demand projections until 2100.

Further details can be found in:

Bisselink, B., Bernhard, J., Gelati, E., Adamovic, M., Guenther, S., Mentaschi, L. and De Roo, A., Impact of a changing climate, land use, and water usage on Europe's water resources: A model simulation study, EUR 29130 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-80288-1 (print), 978-92-79-80287-4 (pdf), doi:10.2760/847068 (online),10.2760/09027 (print), JRC110927.

LUISA

Full title

LUISA Territorial Modelling Platform

Run for this impact assessment by

European Commission

Contributed to

Problem definition

Details of the contribution

The LUISA model provided projections on land use change, used in the study "Impact of a changing climate, land use, and water usage on Europe's water resources" which supported the problem definition.

Further details can be found in:

Jacobs, C., Pinto Nunes Nogueira Diogo, V., Perpiña Castillo, C., Baranzelli, C., Batista E Silva, F., Rosina, K., Kavalov, B. and Lavalle, C., The LUISA Territorial Reference Scenario 2017, EUR 28800 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-73866-1, doi:10.2760/902121, JRC108163.

EPIC

Full title

Environmental impact calculator

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	Water quality and resources	Availability or quality of Fresh- or ground water
Environmental	Water quality and resources	Drinking water
Environmental	Soil quality or resources	Acidification, contamination or salinity of soil, and soil erosion rates
Environmental	Efficient use of resources (renewable & non-renewable)	Use of non-renewable resources

LISFLOOD hydrological model

Fact sheet

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

Date of Report Generation: 06/10/2020

Overview

Acronym LISFLOOD
Full title LISFLOOD hydrological model

Main purpose:
LISFLOOD is a model that simulates the full water cycle from rainfall to water in rivers, lakes and groundwater. The model simulates large areas such as river basins, continents or the entire globe. The model simulates the combined effects of weather and climate changes, land use, socio-economic changes on water demand, as well as policy measures for water savings or flood control. The model is used for water and climate studies, as well as flood and drought forecasting.

Summary
The LISFLOOD model is a grid-based hydrological rainfall-runoff-routing model that is capable of simulating the hydrological processes that occur in a catchment. LISFLOOD is used in large and transnational river basins - and at continental and global scale- for a variety of applications, including flood forecasting, water resources assessments and the balance between water demand, consumption and availability, and assessing the effects of river regulation and conservation measures, land-use changes and climate change.

LISFLOOD is a complex model built-up by several modules, simulating surface and subsurface processes at a grid scale, and arranging transport of water in horizontal and vertical directions through the landscape and soil. It takes also into account of lakes, reservoirs and groundwater storage.

LISFLOOD forms the core modelling of the flood and drought simulation systems developed at JRC, i.e. the European Flood Awareness System EFAS (Thielen et al., 2009), the Global Flood Awareness System GloFas (Alfieri et al., 2013), and the European Drought Observatory EDO (Vogt et al., 2011). The model includes water demand from various sectors, included irrigated agriculture. LISFLOOD is being further developed to include crop yield and energy production, to serve as a model in the Water-Energy-Food-Ecosystem Nexus project.

The model is designed to support water policies and humanitarian aid, and can be used to support each phase of the policy cycle, from anticipation to evaluation. Example applications for anticipation and formulation cover (see appendix to this document): water resources modelling in the Water-Energy-Food-Ecology Nexus and European and Global climate impact studies, and the support to the DG ENV Blueprint of Europe’s water resources assessment (De Roo et al., 2012). Examples for its use in policy implementation are the operational flood (EFAS, GloFAS) and drought (EDO) forecasting within the COPERNICUS programme. Furthermore, LISFLOOD has been used in the various PESETA climate change impact studies (Feyen et al., 2020). At present LISFLOOD is used for the BLUE2 assessment of freshwater and marine water resources (De Roo et al., 2020).

Keywords
irrigation , hydrological modeling , flood forecasting , water resources simulation , drought forecasting , water supply , water demand , crop yield , water nexus , Rainfall-runoff-routing model

Model category (thematic)
Environment

Model home page
https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/lisflood-distributed-water-balance-and-flood-simulation-model-revised-user-manual-2013

Ownership & license

Ownership
Sole copyright [European Union]

Ownership details
Fully owned by JRC, uses public domain PCRaster Dynamic Modelling Software

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

LISFLOOD structure and approach

LISFLOOD is built up from several modules:

- A sub model calculating potential and actual evapotranspiration
- A sub model calculation snow cover and snow melt
- A 3-layer soil water balance sub model
- Groundwater and subsurface flow sub model
- Routing of channel flow sub model
- Irrigation water requirement sub model
- Embedded water abstraction and consumption sub models
- A sub model calculating various indicators and economic impacts

The processes that are simulated by the model include snow melt, infiltration, interception of rainfall, leaf drainage, evaporation and water uptake by vegetation, surface runoff, preferential flow (bypass of soil layer), exchange of soil moisture between the two soil layers and drainage to the groundwater, sub-surface and groundwater flow, flow through river channels, lakes, reservoir operations, polders.

LISFLOOD uses spatio-temporal dynamic input of precipitation and other relevant meteorological variables to simulate water resources, and simulates how this water propagates through the landscape, taking into account temporal storages (snow, snowmelt; groundwater, lakes, reservoirs, soil water storages), water demand and consumption for natural vegetation growth, rainfed agriculture, irrigated agriculture (incl paddy rice), manufacturing industry, energy production (hydropower and thermal cooling), livestock and public water consumption. Remaining water is then routed through the rivers until it arrives at the coast.

LISFLOOD is very (input) data demanding, and limited quality input data will limit its output quality. If good quality daily input is provided, LISFLOOD will deliver state-of-the-art results. The simulation of groundwater is simplified, so it should not be used to carry out detailed groundwater studies. LISFLOOD can use a MODFLOW subroutine though (Trichakis et al., 2017), by which it could be used for detailed groundwater assessments. MODFLOW is a MODular Hydrologic FLOW model developed by the USGS.

LISFLOOD is a water quantity model only; water temperature is being added, as are modules for crop yield simulation. Nutrient and water quality sub-routines are currently not included but maybe envisaged for later development.

Input and parametrization
Main inputs to LISFLOOD are:

- Topography
  - Map local drain direction map
  - Map Slope gradient
  - Map Elevation range
- Land use
  - Map with land use classes
  - Map forest fraction for each cell
  - Map fraction urban area for each cell
  - Look-up tables:
    - Crop coefficient for each land use class
    - Crop group number for each land use class
    - Rooting depth for each land use class
    - Manning's roughness for each land use class
- Water demand from various economic sectors
  - Fraction of irrigated area
  - Fraction of paddy rice irrigation
  - Daily water demand for manufacturing industry
  - Daily water demand for energy production
  - Daily water demand for public water supply
  - Daily water demand for livestock
  - Minimum flow required for ecological purposes
  - Map of water regions (intake areas of water; regions of water management)
- Soil
  - Map Soil texture

- Map Soil depth

- Channel geometry
- Meteorological variables
  - Precipitation rate
  - Average daily temperature
  - Daily potential evaporation rate
- Leaf area index

LISFLOOD now also uses input on water demand from various economic sectors.

- Fraction of irrigated area
- Fraction of paddy rice irrigation
- Daily water demand for manufacturing industry
- Daily water demand for energy production
- Daily water demand for public water supply
- Daily water demand for livestock
- Minimum flow required for ecological purposes
- Map of water regions (intake areas of water; regions of water management)

PARAMETERISATION: LISFLOOD is typically calibrated on a number of parameters influencing infiltration, groundwater fluxes, and river channel roughness. This parameterisation is specific for each sub-river basin.

Main output
LISFLOOD default output time series

- RATE VARIABLES AT GAUGES
  - channel discharge
- NUMERICAL CHECKS
  - cumulative mass balance error
  - cumulative mass balance error, expressed as mm water slice (average over catchment)

  - number of sub-steps needed for gravity-based soil moisture routine

LISFLOOD optional series of output maps

- Discharge
  - Discharge
  - Water level
- Meteorological input variables
  - Precipitation
  - Potential reference evapotranspiration
  - Potential evaporation from soil
  - Potential open water evaporation
  - Average daily temperature
- State variables:
  - Deptyh of water on soil surface
  - Depth of snow cover on soil surface
  - Depth of interception storage
  - Soil moisture content upper layer
  - Soil moisture content lower layer
  - Storage in llower groundwater zone
  - Number of days since last rain
  - Frost index
- Rate variables:
  - Rain (excluding snow)
  - Snow
  - Snow melt
  - Actual evaporation

  - Actual transpiration
  - Rainfall interception
  - Evaporation of intercepted water
  - Leaf drainage
  - Infiltration
  - preferential (bypass) flow
  - percolation upper to lower soil layer
  - percolation lower soil layer to subsoil
  - surface runoff
  - outflow from upper zone
  - outflow from lower zone
  - total runoff
  - percolation upper to lower zone
  - loss from lower zone

LISFLOOD default state variable output maps. These maps can be used to define the initial conditions of another simulation:

- waterdepth at last time step
- channel cross-sectional area at last time step
- days since last rain variable at last time step
- snow cover zone A at last time step
- snow cover zone B at last time step
- snow cover zone C at last time step
- frost index at last time step
- cumulative interception at last time step
- soil moisture upper layer at last time step

- soil moisture lower layer at last time step
- water in lower zone at last time step
- water in upper zone at last time step

LISFLOOD optional output time series

- METEOROLOGICAL INPUT VARIABLES
    - precipitation
    - potential reference evapotranspiration
    - potential evaporation from soil
    - potential open water evaporation
    - average daily temperature
- STATE VARIABLES
    - depth of water on soil surface
    - depth of snow cover on soil surface (pixel-average)
    - depth of interception storage
    - soil moisture content upper layer
    - soil moisture content middle layer
    - soil moisture content lower layer
    - storage in upper groundwater zone
    - storage in lower groundwater zone
    - frost index
- RATE VARIABLES
    - river discharge
    - rain (excluding snow)
    - snow
    - snow melt

- actual evaporation
- actual transpiration
- rainfall interception
- evaporation of intercepted water
- leaf drainage
- infiltration
- preferential (bypass) flow
- percolation percolation upper to middle soil layer
- percolation middle soil layer to lower soil layer
- groundwater recharge
- surface runoff
- outflow from upper zone to surface waters (baseflow)
- outflow from lower zone to surface waters (baseflow)
- total runoff (local)
- percolation from upper to lower groundwater zone
- water abstraction for irrigation
- water consumption by irrigation
- water abstraction for livestock
- water consumption by for livestock
- water abstraction for manufacturing industry
- water consumption by for manufacturing industry
- water abstraction for public water supply
- water consumption by public water supply
- water abstraction for cooling thermal powerplants
- water consumption by cooling thermal powerplants

    - water inflow to hydropower reservoirs
    - water inflow into lakes and reservoirs

LISFLOOD miscellaneous optional output

- average inflow into lower zone [mm day-1]
- average inflow into lower zone [mm day-1]
- average inflow into lower zone [mm day-1]
- number of days since last rain
- water level in river channel

In addition to these, LISFLOOD now also outputs several indicators, such as.

- Water Exploitation Index (WEI) (abstraction versus availability)
- Water Exploitation Index Plus (WEI+) (consumption versus availability)
- Water Demand Index (WD) (demand versus availability)
- Water Dependency Index (WDI) (dependency of water from upstream regions/countries)
- Falkenmark index (Fk) (water availability per capita)
- Soil water stress indicator (RWS)
- Water security index (WSI)
- Water sustainability index (WTI)
- Crop yield (absolute and anomalies) (focussed on water limited growth)

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	The spatial extent is user-defined (any grid size from 100m until 50km can be used) The model is designed to be universal, although local adaptations to local hydrology might be needed Current applications: pan-European, spatial distributed, 5*5km; pan-African, spatial distributed, 0.1*0.1 degree; Global, spatial distributed, 0.1*0.1 degree
(Spatial) resolution	The model is designed to be universal, although local adaptations to local hydrology might be needed. Current applications: pan-European, spatial distributed, 5*5km; pan-African, spatial distributed, 0.1*0.1 degree; Global, spatial distributed, 0.1*0.1 degree.
Temporal extent	The model typically covers a historic reference periods (typically 1990-2016 or 1979-2016) and scenario runs 2010-2100. In a forecasting mode the model simulates 14 days, a month or 6 months ahead.
Temporal resolution	The model is typically run at daily time-step. A 6-hourly version is in final testing. The model can also be run at hourly timescales with minor adaptations.

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	Ensemble runs to account for weather and climate uncertainty; parameter uncertainty runs are executed ad-hoc. The model has now been used so frequently for scenario analysis and has been found to react logically/plausible.
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	On a routine basis since 1998.
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 published in peer review literature (De Roo, A.P.J., Wesseling, C.G., and W.P.A. Van Deursen (2000), Physically-based river basin modelling within a GIS: The LISFLOOD model, Hydrological Processes, Vol.14, 1981-1992, doi: 10.1002/1099-1085(20000815/30)14:11/12<1981::AID-HYP49>3.0.CO;2-F.; 2008 in IJGIS), and has since been used in many peer-reviewed publications; Also the model has been part of several model intercomparisons.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	On a routine basis since 1998.

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

- Van Der Knijff J, Younis J, De Roo A. LISFLOOD: a GIS-based distributed model for river basin scale water balance and flood simulation. INTERNATIONAL JOURNAL OF GEOGRAPHICAL INFORMATION SCIENCE 24 (2); 2010. p. 189-212. JRC45143

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	98%. Some rainfall data used for Europe are copyright material of memberstate authorities, used with permission.
Can model outputs be made publicly available?	yes	JRC Water portal, Eurpean Flood Awareness System (EFAS), European Drought Observatory (EDO), Global Flood Alert System (GloFAS), DispaSET, CAPRI.
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; LISFLOOD is an open source model available on Github: https://ec-jrc.github.io/lisflood/
Is the model source code publicly accessible or open for inspection?	yes	LISFLOOD is an open source model: https://ec-jrc.github.io/lisflood/

References related to documentation:

- Burek P, Van Der Knijff J, De Roo A. LISFLOOD - Distributed Water Balance and Flood Simulation Model - Revised User Manual 2013. EUR EUR 26162. Luxembourg (Luxembourg): Publications Office of the European Union; 2013. JRC78917

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

The model is designed to contribute to the following policy areas

- Climate action
- Environment
- Humanitarian aid and civil protection

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

- Anticipation
- Formulation
- Implementation
- Evaluation

The model's potential

The model is designed to support water policies and humanitarian aid, and can be used to support each phase of the policy cycle, from anticipation to evaluation.

The model is in use in the context of water policies, climate impact analysis and humanitarian aid:

- **Water Policies**: Water Resources Assessment Simulations, Flood and Drought simulations, Scenario simulations on the impact of climate change on water resources and its extremes (floods and droughts & water scarcity); Balancing water demand and supply studies within the Water-Energy-Food-Ecosystem nexus (BLUE2, Blueprint to safeguard Europe's water resources)

- **Humanitarian Aid**: Flood Forecasting (EFAS, see https://www.efas.eu/, GloFas; see https://www.globalfloods.eu/, Drought (EDO, global drought, see https://edo.jrc.ec.europa.eu/edov2/php/index.php?id=1000) Water Policies: Water Resources Assessment

- **Climate Impact Studies**: The model has also been used in various climate change impact studies (PESETA I, II, III, IV, Blueprint to safeguard Europe's water resources, BLUE2)

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	LISFLOOD 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 Regulation of the European Parliament and of the Council: on minimum requirements for water reuse SWD/2018/249 final/2	ENV	Problem definition	*European Commission*	LISFLOOD supported the problem definition through the study "Impact of a changing climate, land use, and water usage on Europe's water resources". The 2 degree assessment includes projections of land use change (using JRC's LUISA system, see Jacobs-Crisioni et al. 2017) until 2050, GDP projections, population projections and water demand projections until 2100. Documented in: - DOI 10.2760/847068

Bibliographic references

- *De Roo, A., Bisselink, B., Guenther, S., Gelati, E. and Adamovic, M., Assessing the effects of water saving measures on Europe`s water resources, EUR 30361 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-21537-0 (online),978-92-76-21536-3 (print), doi:10.2760/739798 (online),10.2760/550523 (print), JRC120388.*

- *Bisselink, B., Bernhard, J., Gelati, E., Adamovic, M., Guenther, S., Mentaschi, L. and De Roo, A., Impact of a changing climate, land use, and water usage on Europe's water resources: A model simulation study, EUR 29130 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-80288-1 (print), 978-92-79-80287-4 (pdf), doi:10.2760/847068 (online),10.2760/09027 (print), JRC110927.*

- *Trichakis, I., Burek, P., de Roo, A., & Pistocchi, A. (2017). Towards a Pan-European Integrated Groundwater and Surface Water Model: Development and Applications. Environmental Processes, 4(S1), 81–93. doi:10.1007/s40710-017-0216-0*

- *Burek P, Van Der Knijff J, De Roo A. LISFLOOD - Distributed Water Balance and Flood Simulation Model - Revised User Manual 2013. EUR EUR 26162. Luxembourg (Luxembourg): Publications Office of the European Union; 2013. JRC78917*

- *Alfieri L, Burek P, Dutra E, Krzeminski B, Muraro D, Thielen Del Pozo J, Pappenberger F. GloFAS – global ensemble streamflow forecasting and flood early warning. HYDROLOGY AND EARTH SYSTEM SCIENCES 17 (3); 2013. p. 1161-1175. JRC78820*

- *Vogt J, Barbosa Ferreira P, Hofer B, Singleton A. Developing a European Drought Observatory for monitoring, assessing and forecasting droughts across the European Continent. In: EGU General Assembly; 04 April 2011; Vienna (Austria). Geophysical Research Abstracts 13; 2011. JRC63421*

- *Climate Adaptation - modelling water scenarios and sectoral impacts : final report. - KH-30-13-482-EN-N*

- *Van Der Knijff J, Younis J, De Roo A. LISFLOOD: a GIS-based distributed model for river basin scale water balance and flood simulation. INTERNATIONAL JOURNAL OF GEOGRAPHICAL INFORMATION SCIENCE 24 (2); 2010. p. 189-212. JRC45143*

- *Thielen Del Pozo J, Bartholmes J, Ramos M, De Roo A. The European Flood Alert System - Part I: Concept and Development. HYDROLOGY AND EARTH SYSTEM SCIENCES 13 (2); 2009. p. 125-140. JRC48790*

LUISA Territorial Modelling Platform

Fact sheet

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

Date of Report Generation: 06/10/2020

Overview

Acronym LUISA
Full title LUISA Territorial Modelling Platform

Main purpose
A territorial modelling platform primarily used for the ex-ante evaluation of EC policies that have a direct or indirect territorial impact.

Summary
The LUISA Territorial Modelling Platform is primarily used for the ex-ante evaluation of EC policies that have a direct or indirect territorial impact. It is based on the concept of 'land function' for cross-sector integration and for the representation of complex system dynamics. Beyond a traditional land use model, LUISA adopts a new approach towards activity-based modelling based upon the endogenous dynamic allocation of population, services and activities.

LUISA can be configured to project a baseline (or reference) scenario, assuming official socio-economic trends (from DG ECFIN and EUROSTAT), business as usual processes, and the effect of established European policies with direct and/or indirect territorial impacts. Variations to that reference scenario may be used to estimate impacts of specific policies, or of alternative macro-assumptions. This highly flexible and customisable structure of LUISA makes it a suitable tool for providing insights to policy-makers in Europe regarding landscape, urban areas, investment policies, environment and, more broadly, aspects pertaining to sustainability and territorial cohesion.

LUISA is based upon the notion of land function – a new concept for cross-sector integration and for representing complex system dynamics. LUISA aims to contribute to the understanding, modelling and assessment of the impacts of land functions dynamics as they interact from local to global scales in the context of multiple and changing drivers. A land function can, for example, be societal (e.g. provision of housing, leisure and recreation), economic (e.g. provision of production factors - employment, investments, energy – or provision of manufacturing products and services – food, fuels, consumer goods, etc) or environmental (e.g. provision of ecosystem services). Land functions are temporally and spatially dynamic, and are constrained and driven by natural, socio-economic, and techno-economic processes. The ultimate product of LUISA is a set of spatially explicit indicators that can be combined according to the 'function' of interest and/or to the sector under assessment.

This is notably a wider notion of just "land use modelling" and of what so far has been referred to in literature.

The LUISA Modelling platform is a de-facto integrative tool because of its coherent linkages with macroeconomic and biophysical models and with thematic databases. The ultimate product of LUISA is a set of territorial indicators that can be grouped and combined according to the 'function' of interest and/or to the sector under assessment.

Keywords

dynamic land function , land use , territorial impact assessment , sustainability , land management , territorial modelling platform , cohesion , urban agenda , convergence

Model category (thematic)

Territory

Model home page

https://ec.europa.eu/jrc/en/luisa

Ownership & license

Ownership
Sole copyright [European Union]

Ownership details
Fully owned by JRC.

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

LUISA structure and approach
The LUISA Territorial Modelling Platform is a system of sub-models designed to assess, ex-ante, the territorial implications of policy decisions. LUISA is composed of multiple interconnected modules that enable it to:

1. Downscale national and regional information at a finer spatial scale
2. Compile, harmonize and relate datasets from various sources
3. Simulate future Land Functions, population distribution and accessibility at a 100m pixel resolution
4. Bring together information relative to future Land Functions and other sources to produce a range of over 50 indicators
5. Share model results to external users and provide them with a capacity to analyse results (Urban Data Platform Plus)

The LUISA territorial modelling framework has the capacity to work across spatial scales with various levels of detail and its outputs can be aggregated at any spatial level (from pixel to national scale). For policy support, LUISA's strength lies in its ability to assess impacts of EU policies that play out because of local interactions between sectors and therefore cannot be observed with typically sector-oriented, spatially-coarse impact assessment approaches.

Input and parametrization
LUISA links specialized models and data within a coherent workflow.

The resource-demand module uses the following outputs to drive the allocation of activities and services:

- demographic (EUROPOP 2008, 2010, 2013 and updates) and
- economic projections (from ECFIN and/or from models such as: CAPRI, GEM-E3, RHOMOLO and others)

The allocation module uses a number of spatially explicit parameters at different resolutions (1 x 1 km, 100 x 100 m) in order to define an overall suitability for every modelled land use/cover type. These individual input are called factor maps.

LUISA integrates factor maps related to

- accessibility measures

- land and soil characteristics and
- topography

In addition, the neighbourhood interactions between land use types are taken into account dynamically, as the land use patterns evolve and change through time.

The definition of policy options requires the development of a range of parameters, which take into account both

- location specific policies (e.g.: demand for each land use class, zoning maps, region-specific support measures, etc.) and
- the characteristics of land-use dynamics (e.g.: transition rules, neighbourhood effects, attractiveness etc.).

The actual conversion from the land-use state to a land use state in tn+1 for each location is based on the most suitable land use type for that specific location at that specific time. The land use state in t0 is given by the LUISA Base Map 2012 (currently updated to 2018) derived by a refined version of the CORINE Land Cover map of 2012of 2012.

<u>Main output</u>
The main direct outputs of LUISA are:

- a simulated map of the land use/cover for a given year in the future;
- projected population maps at high geographical resolution
- detailed accessibility maps

The combination of direct outputs with other data layers and with thematic models further allow the computation of a wide range of indicators, representing the simulated land functions.

Output indicators can be grouped acccording to specific definition of land functions, e.g.:

- Economic development
- Demography (including age-class projections)
- Provision of products
- Settlement and infrastructures
- Transport and Accessibility
- Resource Efficiency
- Environment and Climate

- Urban and Regional Development

Direct outputs and computed indicators can be aggregated at different geographical level (NUTS or grid based).

Spatial - temporal extent

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

Parameter	Description
Spatial Extent / Country Coverage	LUISA is prepared to make simulations for all EU28+ Member States. It can be set to run individual NUTS1/NUTS2 or individual countries alone. In addition, the model can run all EU28 by batching all countries-runs. Each NUTS2 is dealt as a single allocation problems, and results for all Europe are the aggregation of the individual results obtained for each NUTS2. Consequently, it is actually possible to work with irregular regions of interest, composed of any configuration of NUTS2. The model is being extended to cover new Member States of the European Union or to other neighbour countries of interest for which CORINE Land Cover 2012 (or comparable map) is available. A specific version of LUISA has been applied for the whole African continent.
(Spatial) resolution	100 x 100 meters (1km x 1km for Africa)
Temporal extent	The land allocation module of LUISA requires a calibration which is based on the observed/historical land use/cover changes, as reported by the CORINE Land Cover set of maps (1990, 2000, 2006 and 2012). As currently configured, the allocation module runs from 2015, producing yearly results up to 2050. However, the runs can be extended 10 or 20 more years as long as demand is provided for the land use/cover types of interest.
Temporal resolution	Yearly

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	Comparison with similar model (see reference).
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Currently ongoing.
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	Paper on models comparison published.
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	Historical check.

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

- Alexander P; Prestele R; Verburg P; Arneth A; Baranzelli C; Batista E Silva F; Brown C; Butler A; Calvin K; Dendoncker N; Doelman J; Dunford R; Engstrom K; Eitelberg D; Fujimori S; Harrison P; Hasegawa T; Havlik P; Holzhauer S; Humpenoder F; Jacobs C; Jain A; Krisztin T; Kyle P; Lavalle C; Lenton T; Liu J; Meiyappan P; Popp A; Powell T; Sands R; Schaldach R; Stehfest E; Steinbuks J; Tabeau A; Meijl H; Rounsevell M; Wise M. Assessing uncertainties in land cover projections. GLOBAL CHANGE BIOLOGY 23 (2); 2017. p. 767-781. JRC97276

Transparency

Question	Answer	Details
Is the model underlying database (i.e. the database the model runs are based on) publicly available?	yes	Urban Data Platform Plus
Can model outputs be made publicly available?	yes	Outputs are available here: http://urban.jrc.ec.europa.eu/ http://urban.jrc.ec.europa.eu/t-board/index.html
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	Model documentation is available in the report: The LUISA Territorial Reference Scenario 2017.
Is the model source code publicly accessible or open for inspection?	no	Source code can be made open on request for inspection, but cannot be made available for re-running.

References related to documentation:

- Jacobs, C., Pinto Nunes Nogueira Diogo, V., Perpiña Castillo, C., Baranzelli, C., Batista E Silva, F., Rosina, K., Kavalov, B. and Lavalle, C., The LUISA Territorial Reference Scenario 2017, EUR 28800 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-73866-1, doi:10.2760/902121, JRC108163.

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
- Institutional affairs
- Economy, finance and the euro
- Energy
- Environment
- Regional policy
- Transport

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

- Anticipation
- Formulation
- Evaluation

The model's potential

As part of the definition, implementation and review of EU policies, legislation and other measures, the European Commission (EC) performs impact assessments to examine potential economic, social and environmental consequences and evaluate options and improve the effectiveness of the EU action.

The LUISA Territorial modelling platform supports the policy design of different services of the European Commission and provides a comprehensive, consistent and harmonised analysis of the impacts of policies and/or specific proposals.

In order to provide a coherent and harmonised framework for Impact Assessment procedures accompanying EC initiatives, the Land Use Modelling Platform has been configured to be consistent with the definition of the Reference Scenario, as given in the Climate and Energy package. The Reference Scenario is up-dated according to specific policy implementation, following a phased approach.

Contributions have already been provided by its predecessor LUMP (Land use modelling platform) in the Impact Assessments (formal and informal) related to CAP, Integrated Coastal Zone Management, Regional Policy, Energy (shale gas and energy package), EU Water Blueprint, and Resource Efficiency Roadmap.

One of the major milestones in the LUISA development plan is the implementation of a shared EC baseline scenario. The shared baseline scenario includes the full scope of relevant policies assuring coherence among them since it should inform on future prospects in all sectoral domains that are affected by EU policies. Because of its benchmark function, the correct definition and implementation of such a baseline scenario is essential to correctly evaluate EC proposals.

The medium/long term objective is the complete establishment and operation of the “Integrated Sustainability Assessment Platform” whereby models, methods of assessment and databases are further dynamically integrated, in a coherent framework.

The LUISA modelling platform supports the policy design of different services of the European Commission and provides a comprehensive, consistent and harmonised analysis of the impacts of policies and/or specific proposals.

The purpose for which LUISA is most suited for is ex-ante impact assessment of European policies that influence, directly or indirectly land use/cover change. The forecasted land use/cover changes are not only analyzed per se. Land use/cover is an important factor for many services such as provision of food; fibre and timber; biodiversity; water flows and climate regulation; carbon sequestration; provision of recreational opportunities; accessibility and mobility etc.

Because of its multi-thematic dimension, LUISA allows the definition and implementation of scenarios (and their potential alternatives) in a consistent manner, ensuring cross-sectoral policy coherency.

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	LUISA 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 Regulation of the European Parliament and of the Council: on minimum requirements for water reuse SWD/2018/249 final/2	ENV	Problem definition	*European Commission*	The LUISA model provided projections on land use change, used in the study "Impact of a changing climate, land use, and water usage on Europe's water resources" which supported the problem definition. Documented in: - DOI 10.2760/902121

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EPIC Environmental impact calculator

Fact sheet

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

Date of Report Generation: 06/10/2020

Overview

Acronym EPIC
Full title Environmental impact calculator

Main purpose
EPIC simulates approximately eighty crops, predicting effects of management decisions on soil, water, nutrient and pesticide movements, and their combined impact on soil loss, water quality, and crop yields for areas with homogeneous soils and management.

Summary
The EPIC model was developed by the United States Department of Agriculture to assess the status of U.S. soil and water resources and has been continuously expanded and refined to better analyze the exchange of GHG fluxes between terrestrial ecosystems and the atmosphere. It is used around the world by research groupsinstitutions, like IIASA (nternational Institute for Applied Systems Analysis), who calibrate EPIC to meet their own needs.

It is a biophysical, continuous, field scale agriculture management model. It integrates a large number of biophysical processes and allows assimilation of Earth Observation products allowing for global calibration of environmental impact assessments. It simulates crop water requirements and the fate of nutrients and pesticides as affected by farming activities such as the timing of agrochemicals application, tillage, crop rotation, irrigation strategies, etc., while providing at the same time a basic farm economic account. The main components can be divided in the following items: hydrology, weather, erosion, nutrients, soil temperature, and plant growth. EPIC maintains a daily water balance taking into account runoff, drainage, irrigation and evapotranspiration. EPIC simulates nitrogen phosphorus cycling and losses. Nitrogen and phosphorus can be lost in dissolved and particulate forms. Losses occur through surface runoff, leaching to the aquifer, gaseous losses and sediment transport.

EPIC is used to assess the economic and environmental effects on agricultural and forest lands of enhancing carbon sinks and GHG abatement measures.

Keywords
agriculture , nitrogen cycle , phosphorus cycle , pesticides , irrigation , farming practices

Model category (thematic)
Environment

Model home page
http://epicapex.tamu.edu/epic/

Ownership & license

Ownership
Sole copyright [3rd party]

Ownership details
Texas A&M AgriLife Research

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

EPIC structure and approach
The EPIC model was developed to evaluate the effect of various land management strategies on agricultural sustainability including erosion, water supply and quality, soil quality, plant competition, weather, pests, and economics. Management capabilities include irrigation, drainage, furrow diking, buffer strips, terraces, waterways, fertilization, manure management, lagoons, reservoirs, crop rotation and selection, pesticide application, grazing, and tillage. Besides these farm management functions, EPIC can be used to evaluate the effects of global climate change. EPIC is an application written in Fortan with the possibility to use a user friendly graphical interface (WinEPIC).

Input and parametrization
Model inputs:

- daily meteorological data
- soil profile information: texture, organic matter content
- landuse data with crop distribution
- farm management data: planting, harvesting, tillage, fertilization, pesticide application, irrigation

More specifically:

- regional and global weather/climate change data (statistics)
- regional and global soil data
- regional and global land use data and representative crop rotations
- regional and global topography data
- regional and global crop management data (e.g. fertilization, irrigation, tillage)

Main output
Model output:

- biomass production
- nutrient losses:
    - nitrate losses ins surface runoff and leaching to aquifers
    - organic N losses in sediments
    - gaseous losses of N

- phosphorus leaching to aquifer and losses with sediments and surface runoff

- nutrient pool

More specifically:

- crop yields
- hydrology (PET, runoff, percolation)
- sediment transport
- N-leaching
- greenhouse gases
- soil carbon sequestrations

<u>Spatial - temporal extent</u>

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

Parameter	Description
Spatial Extent / Country Coverage	EU27+Switzerland and Turkey
(Spatial) resolution	10X10 km grid
Temporal extent	1990-2010
Temporal resolution	daily

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	Large body of literature is available about the model use, validation, calibration (https://www.card.iastate.edu/swat_articles/)
Sensitivity analysis helps identifying the uncertain inputs mostly responsible for the uncertainty in the model responses. Has the model undergone sensitivity analysis?	yes	Large body of literature is available about the model use, validation, calibration (https://www.card.iastate.edu/swat_articles/)
Has the model undergone external peer review by a panel of experts, or have results been published in peer-reviewed journals?	yes	Large body of literature is available about the model use, validation, calibration (https://www.card.iastate.edu/swat_articles/)
Has model validation been done? Have model predictions been confronted with observed data (ex-post)?	yes	Large body of literature is available about the model use, validation, calibration (https://www.card.iastate.edu/swat_articles/)

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	An internal database has been built by the Water and Marine Resources Unit. It has been aligned when possible with the data used by the LISFLOOD model.
Can model outputs be made publicly available?	yes	The model results, in particular those linked to estimation of irrigation have been made available.
Is the model transparently documented (including underlying data, assumptions and equations, architecture, results) and are these documents available to the general public?	yes	User manual available, see https://epicapex.tamu.edu/epic/.
Is the model source code publicly accessible or open for inspection?	yes	Upon request.

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

- Climate action
- Environment

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

- Formulation

The model's potential

Not provided.

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

In the Year	EPIC 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 Regulation of the European Parliament and of the Council: on minimum requirements for water reuse SWD/2018/249 final/2	ENV	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 - Availability or quality of Fresh- or ground water - Drinking water - Acidification, contamination or salinity of soil, and soil erosion rates - Use of non-renewable resources

Bibliographic references

- *No references provided in MIDAS*