Main models, databases, tools (covering period 2005-2011)

Land Use Change and Agriculture Program

MetaData v.1.0

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IIASA
March 2012
IIASA, Laxenburg

Land Use Change and Agriculture Program

MetaData

Introduction

Since 1972 the International Institute for Applied Systems Analysis (IIASA) has contributed to finding solutions to global problems by conducting independent and interdisciplinary systems analysis across a wide spectrum of environmental, social, technological, and economic issues.

The IIASA Mission is defined as providing insights and guidance to policymakers worldwide by finding solutions to global and universal problems through applied systems analysis in order to improve human and social wellbeing and to protect the environment.

IIASA's choice of research areas is based on the following criteria: the importance of the problem on the global agenda; the interest of IIASA member countries in studying the problem; and IIASA's capabilities in terms of providing research solutions. As a result, three interlinked problem areas were selected for Research in 2011-2015: *Food and Water*, *Energy and Climate Change*, and *Poverty and Equity*.

IIASA has several programs with experience relating to the Food and Water problem area. Among them, the former Land Use Change and Agriculture (LUC) Program has significant strengths in systems analysis of agriculture, land use change and ecosystems studies, providing core experience in the Food and Water problem area and with strong linkages to Poverty and Equity, climate change impacts and adaptation, and transition to a bio-based economy. Products developed or initiated by LUC serve many of the modeling and analysis needs in the area of food security, food systems analysis, as well as food-environment impacts and food–water linkages.

Past LUC research has produced some of the IIASA's most *internationally recognized, demanded, and applied* results and products. Major international organizations as well as research groups in IIASA member countries currently use and rely on these products for consistent global analyses and national policy guidance, providing opportunities for IIASA that strongly support its mission statement. In addition to supporting existing clients, updating and further methodological developments of these products is fully consistent with the IIASA Vision and 2011-2015 Research Plan objectives. Since these products are IIASA-owned products, they also provide differentiated *niche specialty for IIASA*.

LUC has created several models and tools that have been used world-wide. They include most notably bottom-up agricultural models (AEZ global, regional and national databases and models), economic agro-systems models (WFS, CHINAGRO), as well as comprehensive and rigorous resource tracking models (LANDFLOW), among others.

LUC research has been establishing comprehensive integrated databases of land and water use and associated geophysical, ecological and socioeconomic dynamics. Consistent spatial data are essential for achieving high quality robust results in modeling and international policy analysis. LUC's focus on intelligent data and information systems is responding to an internationally recognized lack of solid and persistent commitment to establishing and maintaining comprehensive information and monitoring services in soil and land use management.

For instance, the land use group is now finalizing work to update one of its core databases and methodologies of GAEZv3.0. The public release of these databases and methodologies by FAO and IIASA is scheduled for May 2012. The release will serve as the basis and launching pad for new research proposals supporting the IIASA Food and Water research plan and building on the analytical capabilities of the updated tool set.

LUC's core activities are based on a well-tested integrated modeling framework comprising a spatially detailed eco-physiological model and bottom-up assessment of agricultural land and water use options (food and feed crops; biomass for energy use; fodder crops and pastures) and a regionalized general equilibrium model featuring the food and agriculture economy and its linkages to other sectors and human well-being. Downscaling/upscaling methodologies together with these two types of models form the basis of scenario evaluation, impact assessment and policy analysis of food, agriculture and land use options at the national, regional, and global levels.

The research combines spatially detailed modeling of land use options in diverse social and environmental conditions and accounts for physical and financial flows across multiple scales to accomplish global coverage and systems closure. The integrated modeling framework is applied in analyses of land use competition, responsible land development investment strategies, impacts of and adaptation to climate change, and issues of sustainable consumption to guide decision making toward improved and integrated resource use strategies.

LUC brings in its internationally recognized experience regarding formulation and application of global and regional land use change scenarios; the European Biofuel Roadmap; Biofuels and Food Security; Rising Global Interest in Farmland; and land use scenarios for IPCC emission pathways.

Collaboration and consultation with leading scientists, stakeholders, and policy makers are the keys for knowledge and skill development as well as established contacts and reputation in the dissemination of policy-relevant information to international and national policy makers and stakeholders (e.g. European Commission, FAO, UNEP, World Bank, leading policy researchers in China, Ukraine).

LUC has been benefiting from a relatively small core team with mutual respect and complementary skills, knowledge and experience that is well integrated and with common focus to support policymakers in developing rational, science-based and realistic national, regional and global strategies for the production of food, feed, and bio-energy to achieve sustainability of land and water resources, safeguard food security while promoting rural development.

Objectives

For the benefit of IIASA's research credibility, effectiveness and future research planning, Directorate is initiating an Institute-wide overview and meta-data collection with regard to the main models, methodological frameworks, tools and global/regional data sets currently available and in use at IIASA.

The main purpose of the meta-data creation is to generate concise and adequate information for use across the Institute on the purpose, sources, methodological foundations, main applications, availability and updating cycles of IIASA's major databases and modeling frameworks. It is expected that such standardized information will raise awareness on available IIASA products, facilitate cross-program collaboration and application, and may help to better present the value added to the public provided by IIASA research.

As a first step in this process, Directorate is requesting LUC researchers T. Ermolieva, G. Fischer, E. Hizsnyik, S. Prieler, L. Sun, G. Toth, H. van Velthuizen, and D. Wiberg to develop suitable meta-data templates and to compile relevant meta-data on major current databases, models and web-tools developed and maintained in LUC research.

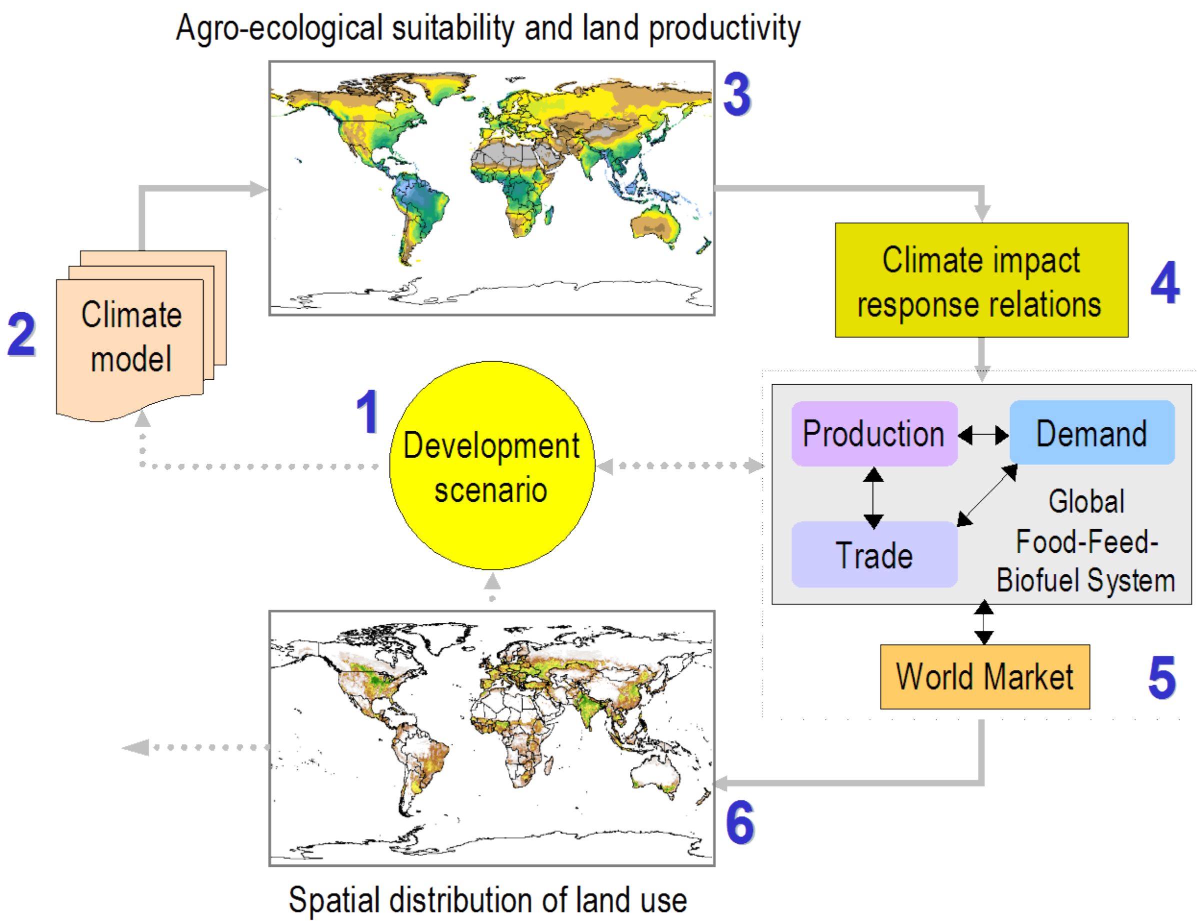
Concerning models, this will include meta-data on the IIASA/FAO AEZ framework and models; the integrated assessment framework used for global food system analysis; the model framework used for national agro-system and policy analysis in China; the global LANDFLOW models tracking resource use from agriculture and forest production via trade to final utilization, and the agricultural planning model (APPA) developed for national agricultural applications in Ukraine.

Global databases to be described in the meta-data compilation include various domains of the AEZ data portal, the Harmonized World Soil Database (HWSD), global databases obtained in LANDFLOW analysis, and spatial land use scenario components developed in international research collaboration for IPCC, WATCH and SCENES projects. The meta-data collection will also provide information on two major database tools, namely the HWSD Viewer and the GAEZ v3.0 web portal.

Content

Modeling Framework Overview

LUC's modeling framework has been developed to analyze spatially the world food and agriculture system and evaluate the impacts and implications of agricultural policies, including the issues of biofuel development.
The modeling framework includes two main components: the FAO/IIASA Agro-ecological Zone model and the IIASA global food system model, moreover encompasses climate scenarios, agro-ecological zoning information, demographic and socio-economic drivers, as well as production, consumption and world food trade dynamics.



The modeling framework consists of six main elements:

1. A storyline and quantified development scenario (usually chosen from the extensive integrated assessment literature) is selected to delineate the broader socioeconomic development context for the World Food System model, such as demographic changes in each region and projected economic growth in the non-agricultural sectors. The storyline also provides assumptions characterizing in broad terms the international settings (e.g. trade liberalization; international migration) and the priorities regarding technological progress. It quantifies selected environmental variables, e.g.

greenhouse gas emissions and atmospheric concentrations of CO_2. Scenarios of demand for first- and second-generation biofuels can also be defined.

2. The emissions pathway associated with the chosen development scenario is used to select among available and matching published outputs of simulation experiments with general circulation models (GCMs). The climate change signals derived from the GCM results are combined with the observed reference climate to define future climate scenarios.
3. The agro-ecological zones (AEZ) method takes a climate scenario as input, estimates the likely agronomic impacts of climate change on a spatial grid of 5′ by 5′ latitude/longitude and identifies adaptation options.
4. Estimated spatial climate change impacts on yields for all crops are aggregated and incorporated into the parameterization of the national crop production modules of a regionalized World Food System model.
5. The global general equilibrium World Food System model– informed by the development storyline and estimated climate change yield impacts – is used to evaluate internally consistent world food system scenarios.
6. In a final step, results of the world food system simulations are ‘downscaled’ to the spatial grid of the resource database for quantification of land cover.

GAEZ MODELING FRAMEWORK

GAEZ Model Description

Date: 2012-03-31
Edition: Version 3.0 (latest update: 2012.03.15)
Presentation form: Model system

Spatial representation

Extent: Global
Type: GIS based biophysical modeling framework
Resolution: Scale and resolution neutral

Temporal extent

Time period: n.a.

Abstract

The AEZ approach is a GIS-based modeling framework that combines land evaluation methods with socioeconomic and multi-criteria analysis to evaluate spatial and dynamic aspects of agriculture. The International Institute for Applied Systems Analysis (IIASA) and the Food and Agriculture Organization of the United Nations (FAO) have been continuously developing the Agro-Ecological Zones (AEZ) methodology over the past 30 years for assessing agricultural resources and potential. The AEZ approach became global in 2000 with the availability of digital global databases of climatic parameters, topography, soil and terrain, land cover, and population distribution.

GAEZ v3.0 provides the most ambitious assessment yet, and the entire database and all results of this assessment are available through the GAEZ Data Portal, which is publically accessible from the IIASA and FAO Web sites.

Purpose

To provide comprehensive information for rational land use planning and decision making for food security and agricultural development. The GAEZ system assists rational land-use planning on the basis of an inventory of land resources and evaluation of the biophysical limitations and production potentials of land.

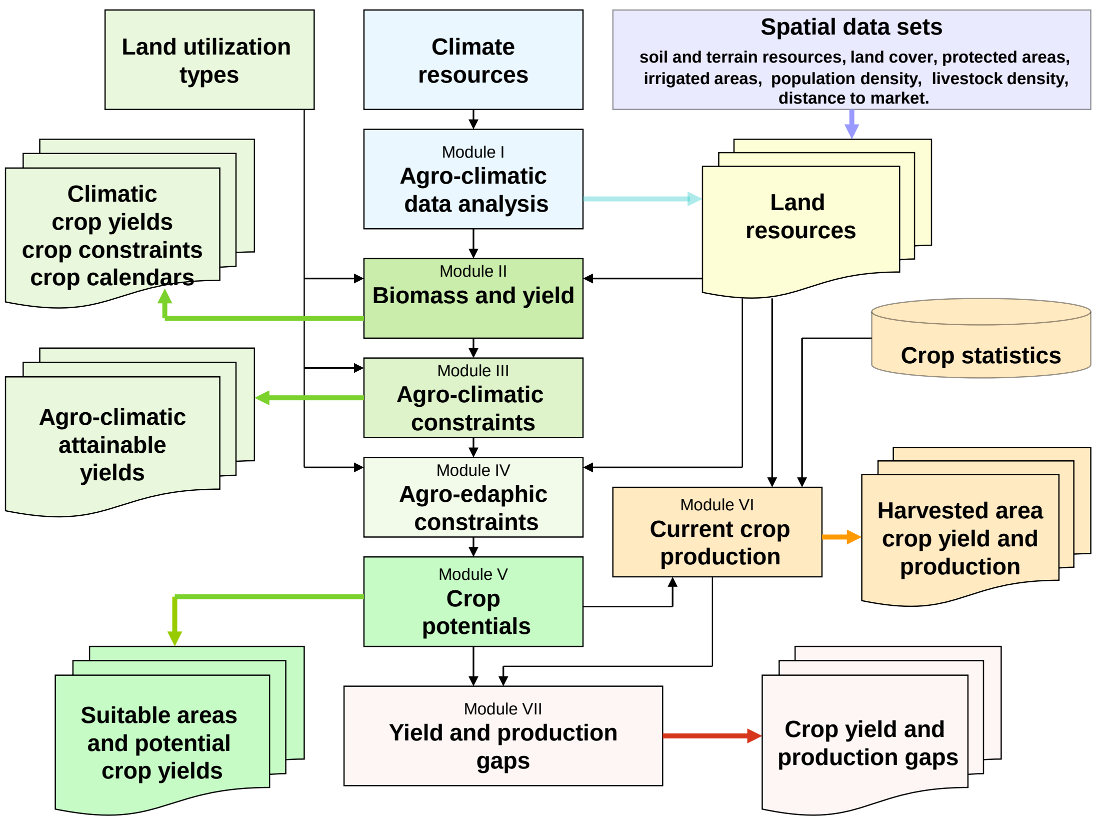
Methodology/Data generation

The GAEZ methodology uses a land resources inventory to assess, for specified management conditions and levels of inputs, all feasible agricultural land-use options and to quantify anticipated production of cropping activities relevant in the specific agro-ecological context. The GAEZ methodology follows an environmental approach. It provides a standardized framework for the characterization of climate, soil, and terrain conditions for analyzing synergies and trade-offs of alternative uses of agro-resources (land, water, technology) for food and energy production, while preserving environmental quality. Examples of GAEZ applications are:

- Quantification of land productivity;
- Estimations of rain-fed or irrigated cultivation potential for food, feed, fiber, and bio-energy feedstock production;
- Identification of environmental constraints to agricultural production; and

- Identification of potential hot spots of agricultural conversion and possible geographical shifts in agricultural land potentials due to changing climate.

Overall GAEZ model structure and data integration: There are five main steps involved in calculation procedures for establishing crop suitability estimates: 1) climate data analysis and compilation of general agro-climatic indicators; 2) crop-specific agro-climatic assessment and water-limited biomass/yield calculation; 3) assessments of yield reduction due to agro-climatic constraints; 4) implementation of edaphic assessments to calculate yield reduction due to soil and terrain limitations; and 5) integration of results into crop-specific grid-cell databases. Two main activities are involved in obtaining the grid-cell level area, yield, and production of the main crops: Estimation of shares of rain-fed or irrigated cultivated land by grid cell; and estimation of the area, yield, and production of the main crops in rain-fed and irrigated cultivated land. Global inventories of yield gaps were created by comparing potential rain-fed yields with yields of downscaled statistical production.



Overall model structure and data integration of GAEZ v3.0 (Module I-VII)

Application

The ability to assess Earth's available resources in great detail using GAEZ v3.0 is already supporting policymakers in developing national, regional, and global strategies for the production of food in a way that ensures long-term sustainability of land and water resources.
AEZ methodology has been applied in more than 20 countries, including Bangladesh, Canada, China, Ghana, Kenya, and Mozambique.

The GAEZ modeling framework has been used for the spatial assessment of biofuel feedstock potential in a global study of biofuels and food security.
GAEZ is being used to estimate "fair" land values in a World Bank study of responsible investment in agriculture “Rising Global Interest in Farmland—Can it Yield Sustainable and Equitable Benefits?”

Descriptive keywords

Agro-ecological zoning, AEZ, GAEZ, land-use planning, land resources, production potentials, agro-climatic potential, potential yield, yield gap

Data access

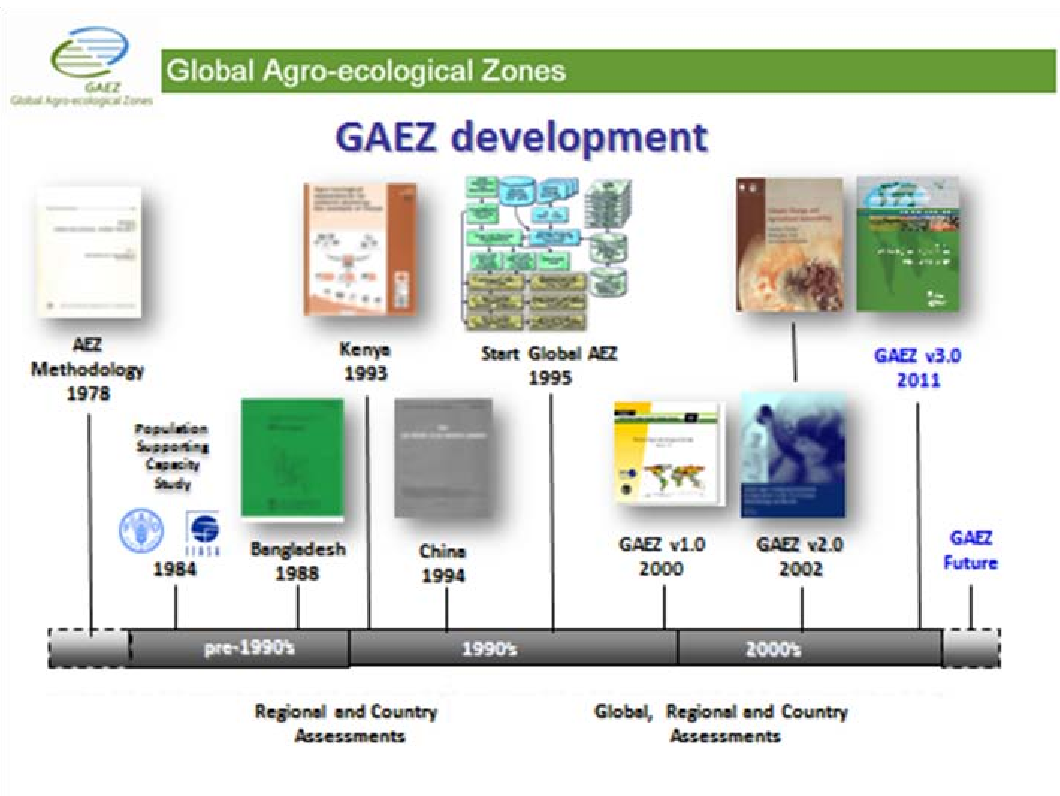
http://www.iiasa.ac.at/Research/LUC/Research-GAEZ_Workshop/index.html?sb=19

Supplemental Information

GAEZ is an integral part of an advanced modeling framework that includes the FAO/IIASA Global Agro-ecological Zone model, and the IIASA World Food System model.
The current version (GAEZ v3.0) provides a major update of data and extension of the methodology used in the 2000 and 2002 GAEZ releases. GAEZ v3.0 incorporates two important new global data sets on actual yield and production and gaps between actual and potential yield and production.

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy,



GAEZ Data Portal v3.0

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps, map statistics at various administrative aggregation levels (sub-national to regional), crop summary tables providing details of crop potentials and crop production constraints (sub-national to regional).

Spatial representation

Extent: Global
Type: Grid data is used to represent geographic data
Resolution: 5 arc-minute and 30 arc-second

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

The International Institute for Applied Systems Analysis (IIASA) and the Food and Agriculture Organization of the United Nations (FAO) have been continuously developing the Agro-Ecological Zones (AEZ) methodology over the past 30 years for assessing agricultural resources and its potentials. Datasets generated with GAEZ v3.0 contain spatial data and tabular data (about 25 TB) covering five thematic areas:

- land resources, including soils, terrain, and land cover;
- agro-climatic resources, including a variety of climatic indicators;
- agricultural suitability and potential yields under multiple management levels;
- downscaled actual yields and production of the main crop commodities; and
- yield and production gaps, in terms of ratios and differences between actual yield and production and potentials for the main crops.

Purpose

The Global Agro-ecological Zones (GAEZ) system is developed for assisting rational land-use planning on the basis of a inventories of land resources and evaluations of biophysical limitations and production potentials of land. Data Portals have been set up at IIASA and FAO to make the data accessible to a variety of users. The GAEZ Portal provides access, allows visualization of data and offers the user with various analysis and download options.

Methodology/Data generation

GAEZ provides a standardized framework for the characterization of climate, soil, and terrain conditions for analyzing synergies and trade-offs of alternative uses of agro-resources (land, water, technology) for food feed, fiber and bio-energy production, while preserving environmental quality (See description of the GAEZ modeling framework).

Data Sets:

- Soil Resources Datasets
- Terrain Resources Datasets
- Land Cover Datasets
- Thermal Regimes Datasets
- Thermal Regimes Datasets
- Growing Period Datasets
- Agro-climatic Yield Datasets
- Climate Yield Constraint Datasets
- Crop Calendar Datasets
- Agro-ecological Suitability and Productivity Datasets
- Crop Summary Tables
- Actual Yield and Production Datasets
- Yield and Production Gaps Datasets

Descriptive keywords

Land resources, agro-climatic resources, agricultural suitability and potential yields, downscaled actual yields and production, yield and production gaps

Data access

IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez

Supplemental Information

GAEZ v3.0 provides the most ambitious assessment yet, and the entire database and all results of this assessment will be available shortly through dedicated GAEZ Data Portals, which are shortly publically accessible from the IIASA and FAO Web sites. The official release of the IIASA and FAO data portals takes place at the GAEZ side event of FAO's COAG meeting scheduled for May 23 2012, at FAO HQ, Rome.

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

GAEZ v3.0 Data Portal/Viewer

Date: 2012-03-31
Edition: Version 1.0 (2012.03.15)
Presentation form: Digital maps, map statistics at various administrative aggregation levels (sub-national to regional), crop summary tables providing details of crop potentials and crop production constraints (sub-national to regional).

Spatial representation

Extent: Global
Type: Data access facility for viewing and downloading GAEZ data
Resolution: 5 arc-minute

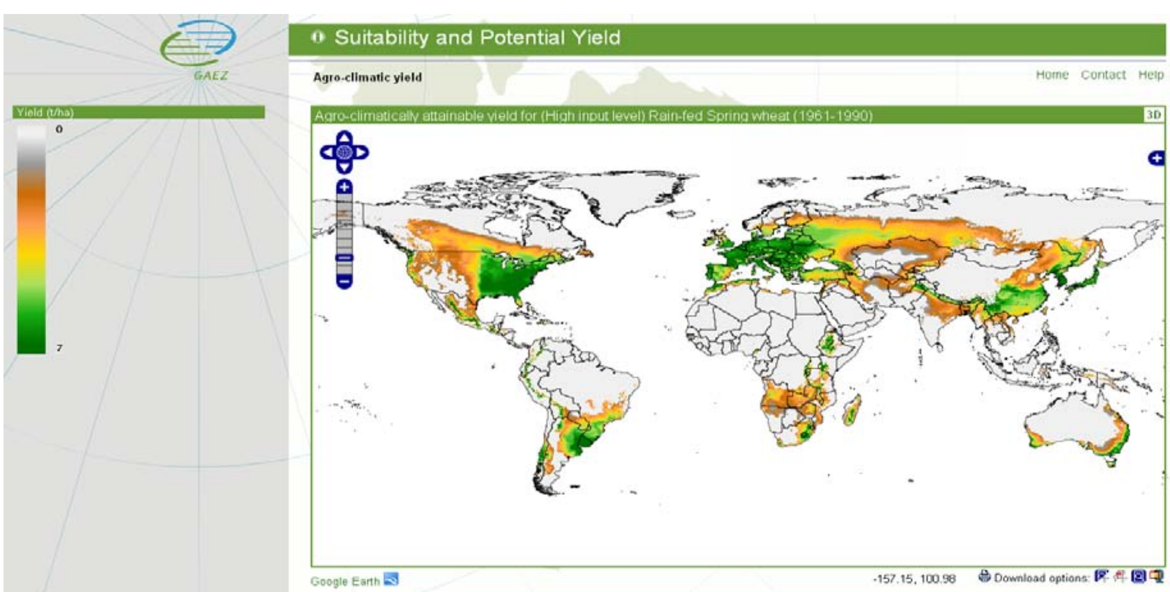
Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

The GAEZ Data Access Facility is a Data Portal that provides thematically structured access to major results of the GAEZ assessment. It contains about 25 terabytes of 5 arc-minute resolution map data and tables aggregated from the gridded data to global, regional, national and sub-national administrative levels. It includes spatial databases for generating map and tabular outputs of five thematic areas: Land resources, Agro-climatic Indicators, Suitability and Potential Yield, Actual Yield and Production and Yield and Production Gaps. With this large amount of data, a new system had to be created to make the data accessible to a variety of users. The GAEZ-Viewer is a geographical tool and interactive data access facility, which not only gives access and allows visualization of data but also provides the user with various analysis and download options. The GAEZ Data Portal allows zooming and panning, selection of specific filters, viewing attribute information and geographic location by clicking on the map, creation of complicated queries to search and extract only desired information, and overlays of other maps.



Purpose

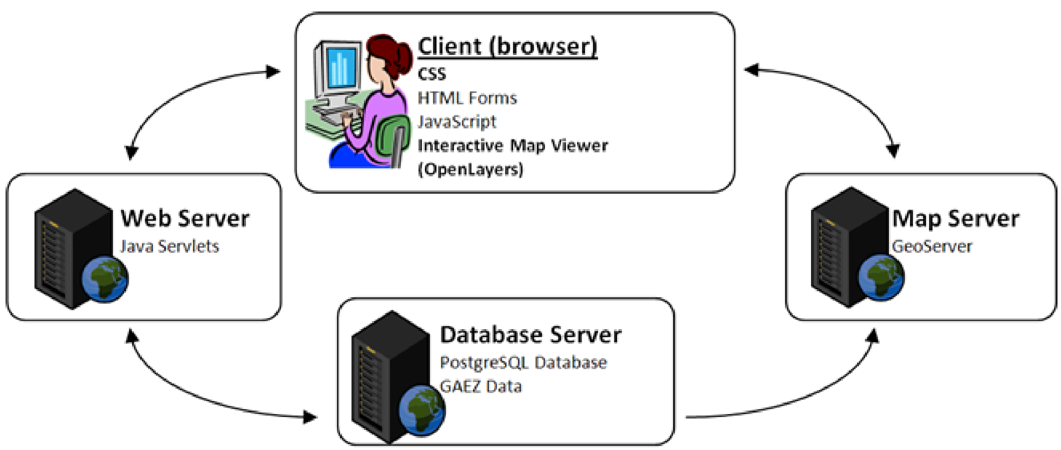
The purpose of the GAEZ data access facility is to enable viewing, query and download of GAEZ databases.

Methodology/Data generation

The GAEZ Data Portal is available via the Internet. The underlying technical implementation of the AEZ Web Interface consists of three primary elements:

1. GAEZ web interface (GAEZ Portal);
2. GAEZ web server;
3. GAEZ data base.

The GAEZ Data Portal uses html forms and javascript and communicates with java servlets on the web server. The servlets are used to dynamically create html pages and send it to the user's browser, to communicate with the database and extract the requested data, and to prepare the results in the requested format. If the user chooses to view an interactive map of the requested data, the data is sent to GeoServer, which prepares the data to be displayed on the website using OpenLayers. GeoServer was modified and customized to the functionality of the GAEZ implementation. A schematic representation of the implementation is shown below:



Hardware and software requirements for end-users of the Portal

A regular PC or Mac is required to start using the GAEZ Portal. The viewer has been tested in Firefox, Safari, Chrome Opera and Opera Mobile. A minimum screen resolution of 1024 x 768 is recommended. Hard disk drive space is only necessary to download data and the required disk space depends on how much data is downloaded and in what format.

Descriptive keywords

GAEZ data portal, data viewer, GIS, data visualization tool

Data access

IIASA: www.gaez.iiasa.ac.at/w;
FAO: http://review.fao.org/gaez

Use limitation

GAEZ Datasets

GAEZ datasets: Land Resources

GAEZ provides a framework for establishing a spatial inventory of land resources compiled from global environmental data sets, providing the spatial characteristics required for the assessments of land productivity for location-specific agro-ecological conditions. The land resources inventory includes multiple spatial layers of climate, soil, terrain, water, land cover, protected areas, population density, livestock density and accessibility. In the Data portal land resources has been split in a terrestrial part (land resources) and an agro-climatic part (agro-climatic resources).

Soil Resources Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 30 arc-second

Temporal extent

Time period: n.a.

Abstract

The land resources inventory of GAEZ includes multiple spatial layers of climate, soil, terrain, water, land cover, protected areas, population density, livestock density and accessibility. The inventory consists of two parts, a terrestrial part (land resources) and an agro-climatic part (agro-climatic resources).

The recently developed Harmonized World Soil Database (FAO/IIASA/ISRIC/ISS-CAS/JRC 2009) is used as soil resources inventory. This data base was developed from data of the European Soil Database (ESDB), the CHINA 1:1 million soil map, various regional SOTER databases (SOTWIS Database), and the FAO/UNESCO Soil Map of the World.. The structure and content of the HWSD database was designed by IIASA, FAO and ISRIC- World Soils for use in GAEZ.

Purpose

The spatial representation of soil resources data contained in the HWSD is used in the agro-edaphic suitability assessment for individual crop LUTs at 3 basic levels of inputs and 5 water-supply systems. In the evaluation use is made of soil association composition data, soil phase information, and a range of soil unit attributes for topsoil (0-30cm) and subsoil (30-100cm) separately.

Methodology/Data generation

In the context of this complete update of the global agro-ecological zones study, FAO and IIASA recognized that there was an urgent need to combine existing regional and national updates of soil information worldwide. In order to do this, partnerships were sought with the International Soil Resources Information Centre (ISRIC) who had been largely responsible for the development of regional Soil and Terrain databases, the European Soil Bureau Network (ESBN) who had undertaken a major update of soil information for Europe and northern Eurasia and the 1:1,000,000 scale Soil Map of China in cooperation with the Academia Sinica.
The resulting global database uses raster grids at 30 arc-seconds which are linked to a harmonized attribute database quantifications of composition of soil units within soil associations and characterization of harmonized depth layers i.e., topsoil (0-30cm) and subsoil (30-100 cm). The attributes included by the following soil parameters: Organic carbon, pH, water storage capacity, soil depth, cation exchange capacity of the soil and the clay fraction, total exchangeable nutrients, lime and gypsum contents, sodium exchange percentage, salinity, textural class and granulometry. Apart from this depth layer specific attributes, data on soil phases and other soil unit specific characteristics not covered by the soil attributes and soil phases, such as vertic and gelic soil unit characteristics, are included.

Data Sets:

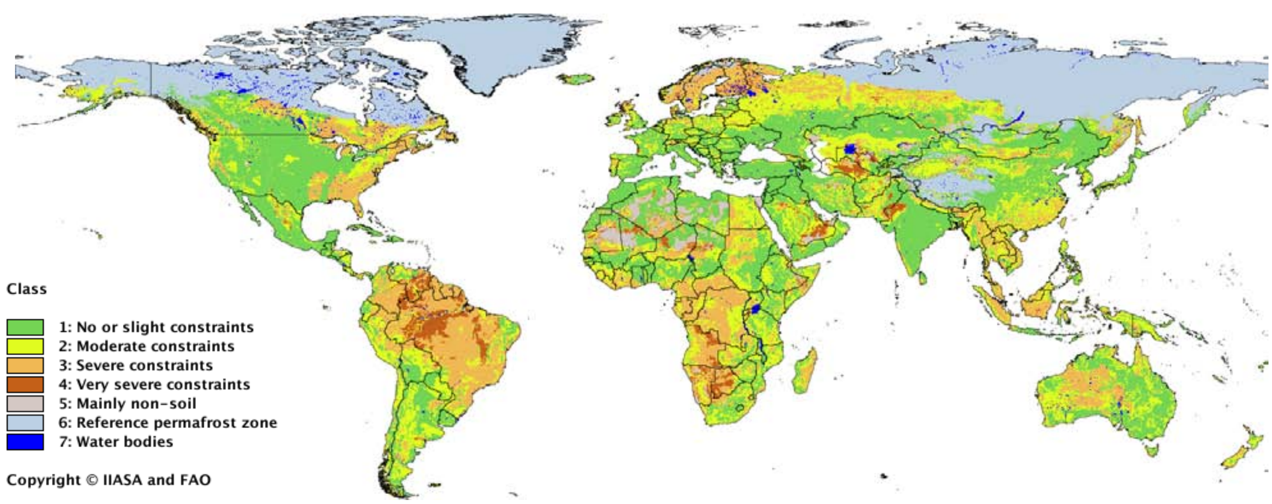
Global spatial databases created at 30 arc second resolution (see HWSD) and are available for viewing and downloading at 5 arc-minute resolution from the GAEZ Data Portal. Map statistics are available at national, sub-national and regional aggregations of the spatial datasets:

(i) Dominant soil, representing the soil unit with the largest extent within a soil mapping unit. Information on soil association composition is available at 30 arc-second resolution from the separate HWSD website.

(ii) Generic soil qualities relevant for edaphic suitability assessments are estimated. These are:

- Nutrient availability, natural soil fertility, particularly important for low input farming.
- Nutrient retention capacity, capacity of soils to retain nutrients, particularly important for the effectiveness of fertilizer application.
- Rooting conditions that are soil depth/volume limitations of a soil unit, affecting root penetration and constrain yield formation.
- Oxygen availability or limitation of oxygen availability to roots, affecting root development and plant growth.
- Excess salts that inhibit the uptake of water and sodicity may affect soil structure and soil permeability.
- Toxicities, limitations due to calcium carbonate and or gypsum: Calcareous and gypsic soils may affect plant growth through micronutrient deficiencies or through limited available soil moisture.
- Workability

(iii) Soil and terrain information has been used to identify water collecting sites. Water collecting site in inventory is represented by the prevalence of Fluvisols and Gleysols in combination with flat terrain slopes.



Nutrient availability map

Soil related information for specific purposes is available on request.

Descriptive keywords

HWSD, soil quality, edaphic suitability

Supplemental Information

Soil attributes are accessible from the [Harmonized World Soil Database.]

Data access

IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Terrain Resources Datasets

Date: 2012-03-31
Edition: Version 1.2 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics.
Resolution: 30 arc-second and 5 arc-minute

Temporal extent

Time period: n.a.

Abstract

The global terrain slope and aspect database has been compiled using elevation data from the Shuttle Radar Topography Mission (SRTM, Ref). The SRTM data is publicly available as 3 arc-second (approximately 90 meters resolution at the equator) DEMs (CGIAR-CSI, 2006). The SRTM data cover the globe for areas up to 60° latitude. For the areas north of 60° latitude, 30 arc-second elevation data and derived slope and aspect information were compiled from GTOPO30 (USGS-GTOPO30 2002).

Purpose

The terrain-slope suitability rating used in the Global AEZ study captures the factors described above which influence agricultural production and sustainability. This is achieved through: (i) defining for the various crops permissible slope ranges for cultivation, by setting maximum slope limits; (ii) for slopes within the permissible limits, accounting for likely yield reduction due to loss of fertilizer and topsoil, and (iii) distinguishing among farming practices ranging from manual cultivation to fully mechanized cultivation.

Methodology/Data generation

The DEM files have been mosaiced into a seamless global coverage, and are available for download as 5˚ x 5˚ tiles, in geographic coordinate system - WGS84 datum. The available data cover a raster of 24 rows by 72 columns of 5˚ x 5˚ latitude/longitude tiles, from north 60 degree latitude to 56 degree south. These processed SRTM data, with a resolution of 3 arc second (approximately 90m at the equator), i.e. 6000 rows by 6000 columns for each 5˚ x 5˚ tile, have been used for calculating the output datasets, as described below.

Data Sets:

The global terrain slope and aspect database comprises the following elements:

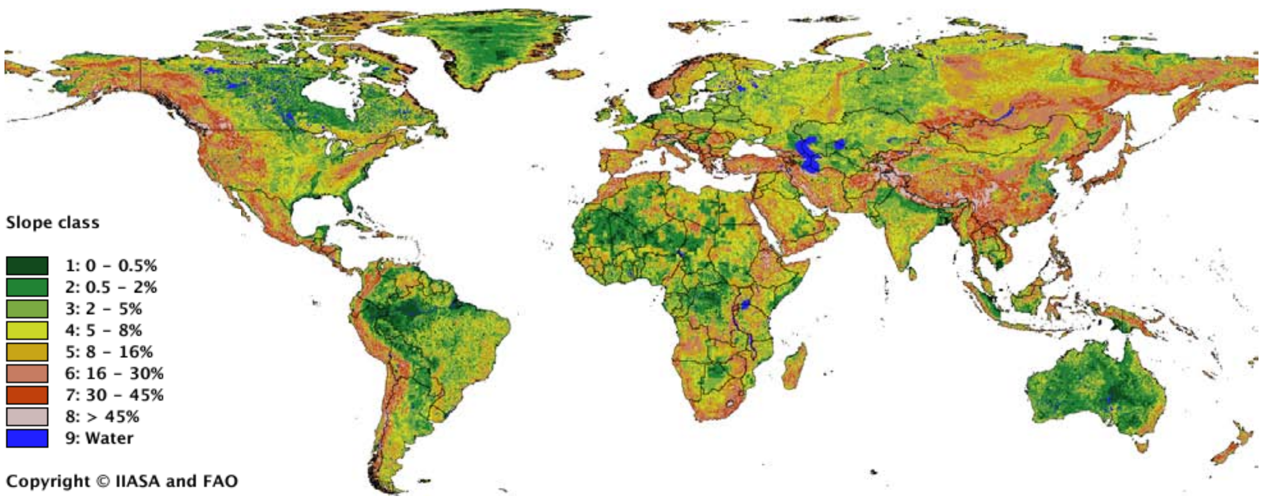
- Elevation (median):
  - Median altitude,
  - Median terrain slope class.
- Slope gradient: Distributions of nine slope gradient classes are available for each grid-cell: 0–0.5%, 0.5–2%, 2–5%, 5–8%, 8–16%, 16–30%, 30–45%, and > 45%.

Additional slope class aggregations were produced as follows:

  - Share of terrain slopes in the 0-2 % class.

- Share of terrain slopes in the 2-8 % class.
- Share of terrain slopes in the 0-8 % class.
- Share of terrain slopes in the 0-16 % class.
- Share of terrain slopes in the >16 % class.
- Share of terrain slopes in the >30 % class.

- Slope aspects: Slope aspect data is stored in distributions of five classes namely:
    - Class 1: slopes below 2% undefined aspect;
    - Class 2: slopes facing North (315°–45°);
    - Class 3: East (45°–135°);
    - Class 4: South (135°–225°), and
    - Class 5: West (225°–315°).



Median terrain slope (class) map

Descriptive keywords

SRTM DEM, elevation, terrain slope, aspect

Data access

IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Supplemental information:

Terrain data is also available through the [Harmonized World Soil Database.]()

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Land Cover Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 5 arc-minute

Temporal extent

Time period: n.a.

Abstract

An inventory of major land cover/land use categories has been compiled using an iterative calculation procedure to estimate land cover class weights, consistent with aggregate FAO land statistics and spatial land cover patterns obtained from remotely sensed data and geographic datasets, including GLC2000 land cover database, an IFPRI global land cover categorization data set, FAO's Global Forest Resources Assessment, the Global Map of Irrigated Areas (GMIA) of FAO/University of Frankfurt, and a population density inventory developed by FAO-SDRN. The results provide shares of major land use and land cover categories within individual 5 arc-minute grid-cells. These categories are: (i) Rain-fed cultivated land; (ii) irrigated cultivated land; (iii) forest land; (iv) grassland and woodland; (v) barren and sparsely vegetated land; (vi) urban and other land required for housing and infrastructure, and (vii) inland water bodies.

Purpose

The quantification of suitability and productivity of rain-fed and irrigated cultivated land as well as for land currently under grassland woodland and forest ecosystems

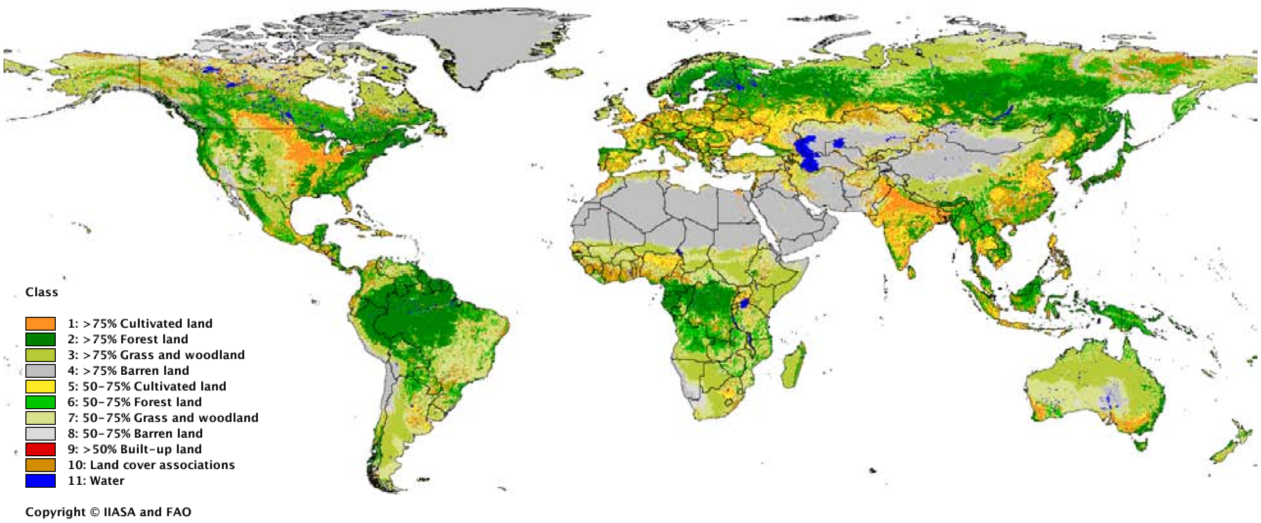
Methodology/Data generation

For the estimation of land shares by major land uses in individual 5 arc-minute grid cells, data from several land cover datasets was used. For the year 2000 the database combines (i) the GLC2000 land cover regional and global classifications (http://www-gvm.jrc.it/glc2000), (ii) a global land cover categorization, compiled by IFPRI (IFPRI, 2002), based on a reinterpretation of the Global Land Cover Characteristics Database (GLCC) ver. 2.0, EROS Data Centre (EDC, 2000), and (iii) a special layer of forest land from the Forest Resources Assessment of FAO (FAO, 2001). Furthermore, global 5 arc-minute inventories of irrigated land (GMIA version 4.0; FAO/University of Frankfurt, 2006) were used and an interpretation of the IUCN-WCMC protected areas inventory (WPDA, 2009) (along with other convention types of legally protected areas) to distinguish protected land in two categories, namely areas where some restricted agricultural use is permitted and protected areas where cultivation is strictly prohibited. Finally, a population inventory for year 2000 has been used to estimate land required for housing and infrastructure (population density map developed by FAO-SDRN, based on spatial data of LANDSCAN 2003, with calibration to UN 2000 population figures). In step (i) various land cover interpretations are combined to produce a quantification of each grid-cell in the spatial raster in terms of seven main land use/land cover shares. These shares are: cultivated land, subdivided into (i) rain-fed and (ii) irrigated land; (iii) forest; (iv) pasture and other vegetated land; (v) barren and very sparsely vegetated land; (vi) water, and (vii) urban land and land required for housing and infrastructure. An iterative calculation procedure was used to estimate land cover class weights, consistent with aggregate FAO land statistics (of arable land and forest land) and spatial land cover patterns obtained from remotely sensed data. The estimated class weights define for each land cover class and spatial allocation unit (e.g., country) the contents in terms of respectively cultivated land and forest. Starting values of class weights used in the iterative procedure were obtained by cross-country regression of statistical data of cultivated and forest land against aggregated extents of national land cover class distributions obtained from GIS.

Data sets:

The following output types are available for viewing and downloading from the GAEZ Data Portal at 5 arc min resolution:

- Dominant land cover pattern, land use/land cover category with the largest extent in a grid cell.
- Share of cultivated land.
- Share of rain-fed cultivated land.
- Share of irrigated cultivated land.
- Share of forest land.
- Share of grassland & woodland.
- Share of barren and sparsely vegetated land.
- Share of land for infrastructure and settlement.
- Share of inland water bodies.



Dominant Land Cover

Descriptive keywords

Land use/land cover shares, GLC2000, IFPRI, GMIA, FRA

Data access

IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Supplemental information:

Land cover data is also available through the Harmonized World Soil Database.

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

GAEZ datasets: Agro-climatic Resources

Temperature regimes, radiation and soil moisture conditions determine the rates of net photosynthesis, which allows plants to accumulate dry matter and to accomplish their successive plant development stages. Data on climatic requirements of crop growth, development and yield formation are the basis for the compilation of GAEZ agro-climatic inventories. These inventories include agronomically relevant characteristics of prevailing thermal regimes, moisture regimes and growing periods. The agro-climatic inventories are an integral part of the GAEZ v3.0 land resources inventory, providing spatial characteristics used for estimating crop suitability and potential yields.

Thermal Regimes Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics.
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

Temperature regimes, radiation and soil moisture conditions determine the rates of net photosynthesis, which allows plants to accumulate dry matter and to accomplish their successive plant development stages. Data on climatic requirements of crop growth, development and yield formation are the basis for the compilation of GAEZ agro-climatic inventories. These inventories include agronomically relevant characteristics of prevailing thermal regimes, moisture regimes and growing periods. The agro-climatic inventories are an integral part of the GAEZ v3.0 land resources inventory, providing spatial characteristics used for estimating crop suitability and potential yields.

Purpose

Thermal regime indicators are required for GAEZ land potential assessments.

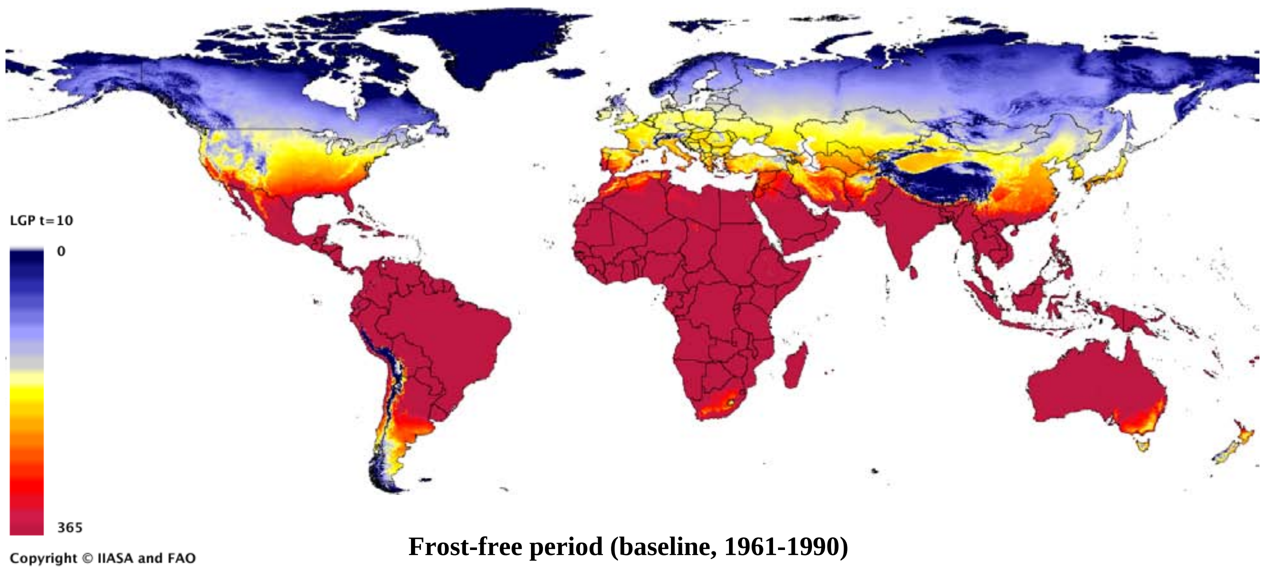
Methodology/Data generation

Characterization of temperature regimes includes thermal climates, representing major latitudinal climatic zones, thermal zones, representing actual temperature conditions throughout the year, temperature profiles, providing quantification of temperature seasonality; temperature growing periods representing the periods during which average daily temperatures exceed specified minimum levels, and accumulated temperatures or temperature sums quantifying available heat units.

Data sets:

- Mean annual temperature, average annual 24-hour temperature.
- Annual temperature range, difference between average monthly 24-hour temperatures of July and January.
- Thermal climates, inventory of latitudinal climates.
- Thermal zones, inventory of prevailing temperature regimes.
- Temperature growing period, number of days during the year when temperatures are conducive to plant growth and development (days with T24-hour > 5^{o}C).
- Frost-free period, number of days during the year with low risk of early and late frosts (days with Tmean > 10^{o}C).

- Tsum during temperature growing period, reference accumulated temperature (base temperature 0°C) during temperature growing period.
- Tsum during frost-free period, reference accumulated temperature (base temperature 0°C) during frost-free period.
- Air frost number, a climatic indicator obtained by dividing the accumulated temperature during the freezing period by the sum of accumulated temperatures during respectively freezing and thawing periods. An air frost number of more than 0.5 indicates that accumulated absolute values of temperature during the cold period dominate the annual temperature profile.
- Snow-adjusted air frost number, a climatic indicator computed in a way similar to the air frost number, but with temperatures adjusted for the insulation effect of snow cover.
- Reference permafrost zones, reference permafrost zones are delineated based on the calculated air frost numbers derived from baseline climate (1961-1990).



Frost-free period (baseline, 1961-1990)

Descriptive keywords

Temperature, annual temperature range, thermal climate, thermal zone, temperature growing period, frost free period, temperature profile, temperature sum

Data access

IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Moisture Regimes Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics.
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

Data on climatic requirements of crop growth, development and yield formation are the basis for the compilation of GAEZ agro-climatic inventories.
Characterization of moisture regimes includes annual precipitation, amount and temporal distribution of precipitation represented by the Fournier index, reference evapotranspiration calculated according to Penman-Monteith, and annual and seasonal precipitation over potential evapotranspiration ratios.

Purpose

Derived moisture regime data sets are required for GAEZ land potential assessment.

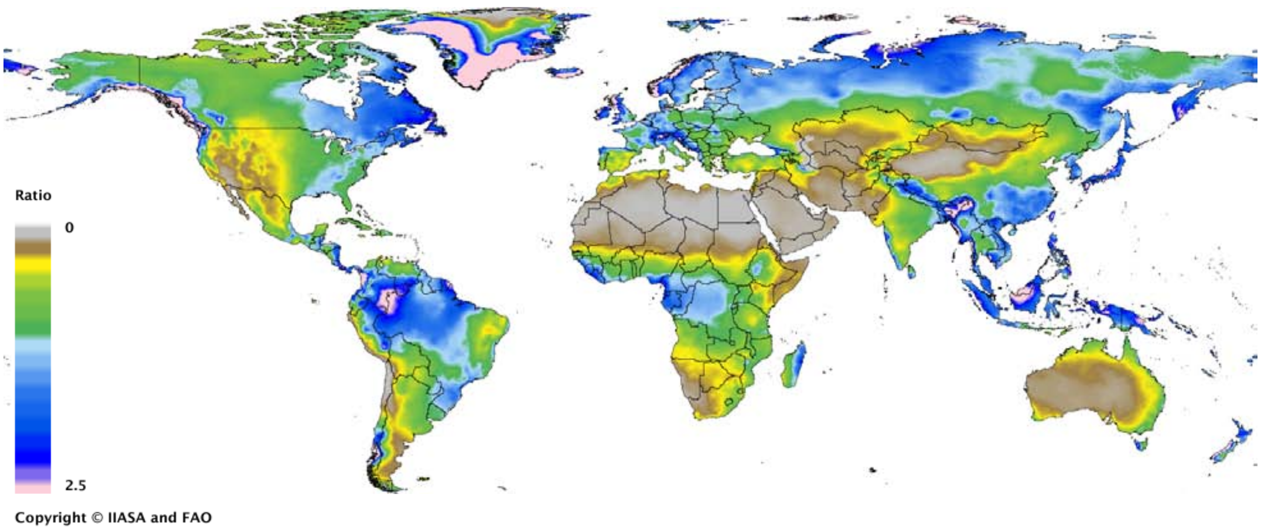
Methodology/Data generation

Reference daily soil water balance for each grid-cell and actual evapotranspiration (ETa) for a reference crop are estimated. Daily soil moisture balance calculation procedures follow the methodologies outlined in “CROPWAT” and “Crop Evapotranspiration”. The quantification of a crop-specific water balance determines crop “actual” evapotranspiration used for calculating water-constrained crop yields The volume of water available for plant uptake is calculated by means of a daily soil moisture balance, accounting for accumulated daily water inflow from precipitation or snowmelt and outflow from actual evapotranspiration, and excess water lost due to runoff and deep percolation.

Data sets:

- The following output types are available for view and download from the GAEZ Data Portal:
- Total annual precipitation.
- Fournier index, precipitation index reflecting amount and within-year precipitation distribution.
- Reference potential evapotranspiration according to Penman-Monteith.
- Ratio of annual precipitation over reference evapotranspiration.
- Ratio of seasonal precipitation over reference evapotranspiration (April to September).
- Ratio of seasonal precipitation over reference evapotranspiration (October to March).
- Ratio of quarterly precipitation over reference evapotranspiration (January to March).
- Ratio of quarterly precipitation over reference evapotranspiration (April to June).
- Ratio of quarterly precipitation over reference evapotranspiration (July to September).

- Ratio of quarterly precipitation over reference evapotranspiration (October to December).



Annual P/PET ratio (1961-1990)

Descriptive keywords

Annual precipitation, Fournier Index, reference evapotranspiration, precipitation- evapotranspiration ratios

Data access

IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Growing Period Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

The agro-climatic potential productivity of land depends largely on the number of days during the year when temperature regime and moisture supply are conducive to crop growth and development. This period is termed the length of the growing period (LGP). The LGP is determined based on prevailing temperatures and the above described water balance calculations for a reference crop. In a formal sense, LGP refers to the number of days when average daily temperature is above 5^{o}C (i.e. within LGPt5) and ETa is above a specific fraction of ETo. In the current GAEZ parameterization, LGP days are considered when ETa ≥ 0.5 ETo, which aims to capture periods when sufficient soil moisture is available to allow the establishment of a reference crop

Purpose

Growing period data sets are required for GAEZ land potential assessments.

Methodology/Data generation

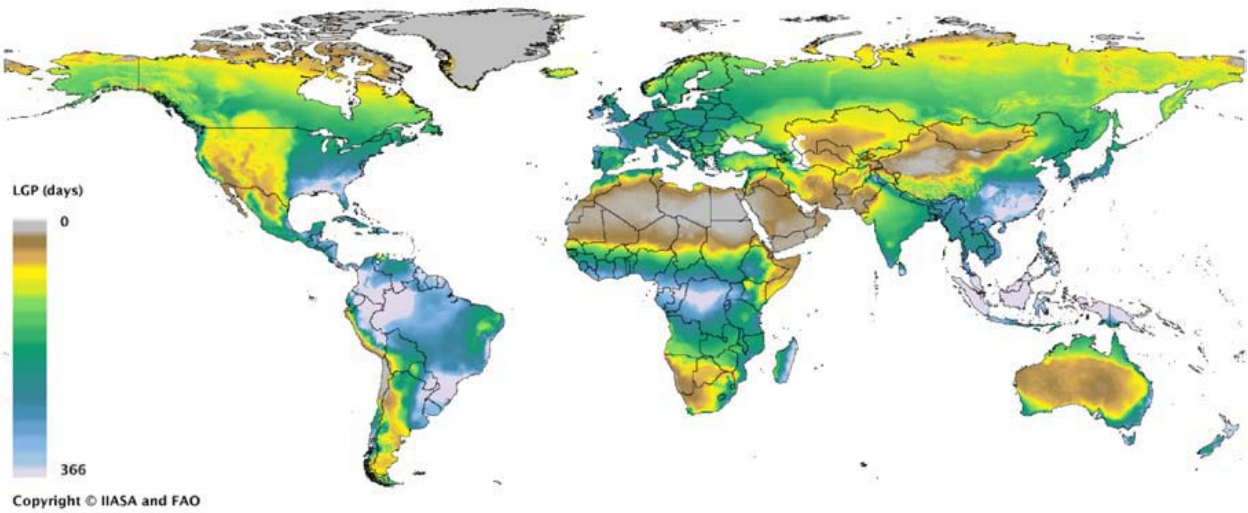
Daily water balances growing period length and variability. LGPs are calculated for historical, baseline and future time periods.

Net primary production (NPP) is estimated as a function of incoming solar radiation and soil moisture at the rhizosphere. Actual crop evapotranspiration (ETa) has a close relationship with NPP of natural vegetation as it is quantitatively related to plant photosynthetic activity which is also driven by radiation and water availability. NPP is estimated according to Zhang (1995)

Data sets:

- Reference length of growing period, number of growing period days (LGP) calculated for average climatic parameters.
- Reference length of growing period zones, which is the number of growing period days (LGP-classes) calculated on the basis of average climatic parameters.
- Reference length of growing period SD (days). Coefficient of Variation of LGP, calculated for reference growing periods over the period 1961-1990.
- Reference length of growing period CV (%).Standard Deviation of LGP, calculated for reference growing periods over the period 1961-1990.

- Net primary production (rain-fed), a climatic indicator of net primary production (NPP) calculated for rain-fed conditions.
- Net primary production (irrigated), a climatic indicator of net primary production (NPP) calculated for irrigated conditions.



Reference length of growing period (based on reference soil moisture holding capacity of 100 mm)

Descriptive keywords

Length of growing period, net primary production, reference water balance, moisture storage, precipitation, reference evapotranspiration

Data access

IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

GAEZ datasets: Suitability and Potential Yield

The GAEZ modeling framework assesses land suitability, potential attainable yields and potential production of crops for specified management assumptions and input levels, both for rain-fed and irrigated conditions. This domain provides maps and tabular information on agro-climatic yields, yield constraints, crop calendars, and potential production estimates for 11 major crop groups, 49 major crops and 92 crop sub-types subdivided into 280 crop/land utilization types (LUTs) at three basic levels of inputs (high, intermediate, low). Productivity estimates were made respectively for rain-fed production, rain-fed production with water conservation, and gravity, sprinkler and drip irrigation systems. Results presented include agro-climatically attainable yields, climate related yield constraints, crop calendar data and agro-ecological suitability and productivity assessment data. In addition suitability and yield related data which are contained in sub-grid-cell level datasets have been summarized at various aggregation levels and by major landuse land cover categories as well as by protection status information. These datasets are referred to as “Crop Summary Tables”

Agro-climatic yield datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

Agro-climatic yields are calculated for individual land utilization types for prevailing temperature and radiation regimes using the GAEZ eco-physiological biomass and yield calculator. Results account for temperature and moisture constraints that are affecting growth and development and yield reducing effects caused by pests, diseases and weeds as well as climate related workability constraints. Estimated yields are referred to as agro-climatically attainable yields.

Purpose

The main purpose is the calculation of agro-climatically attainable biomass and yield for specific land utilization types (LUTs) under various input/management levels for rain-fed and irrigated conditions.

Methodology/Data generation

The yield calculations are done in three steps:

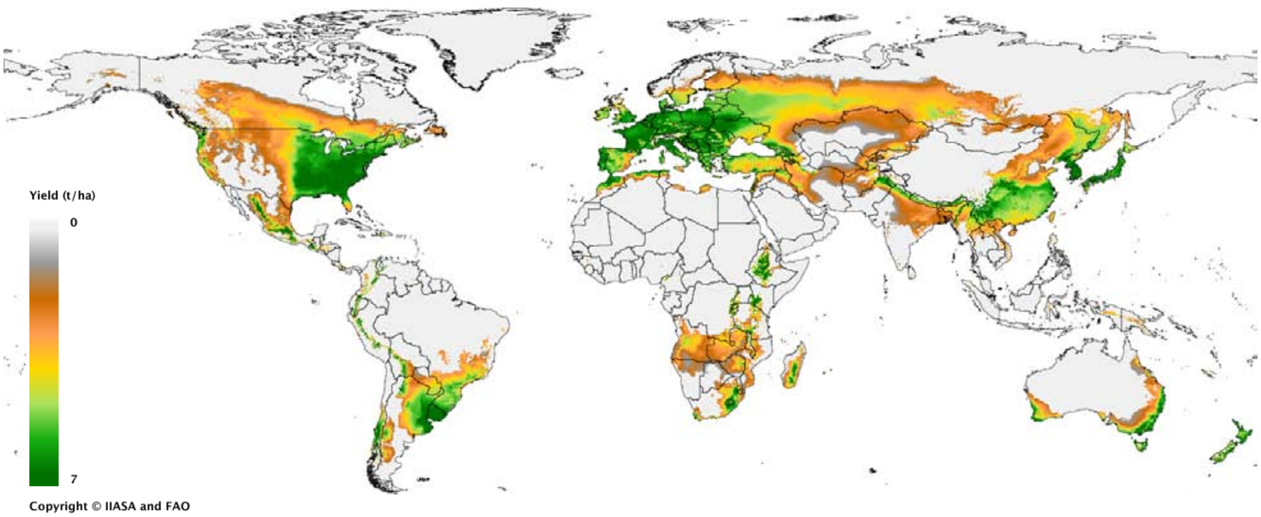
(i) Calculation of crop biomass and yield potentials considering only prevailing radiation and temperature conditions;
(ii) Computation of yield losses due to water stress during the crop growth cycle. The estimation is based on rain-fed crop water balances for different levels of soil water holding capacity, with and without water conservation measures. Yield estimation for irrigation conditions assumes that no crop water deficits will occur during the crop growth cycle.
(iii) Agro-climatic constraints cause direct or indirect losses in the yield and quality of produce. The relationships between these constraints with general agro-climatic conditions such as moisture stress and excess air humidity, and risk of early or late frost are varying by location, between agricultural activities as well as by the use of control measures. It has therefore been attempted to approximate the impact of these yield constrains on the basis of prevailing climatic conditions. The efficacy of control of these constraints (e.g. pest management) is accounted for through the assumed three levels of inputs.

Application:

Various utility programs have been developed to map the contents of crop databases in terms of agro-climatically attainable yields, agro-climatic reduction factors and overall yield reduction factors. Agro-climatic yields are calculated for individual land utilization types for prevailing temperature, radiation and soil moisture regimes using the GAEZ eco-physiological model. Several data sets have been generated and stored in the GAEZ Data Portal. Calculations were done for combinations of 280 Crop/LUTs, three input levels (low, intermediate high), historical (40 individual years), baseline (1 time step: 1961-1990) and future time periods (for the 2020s, 2050s and 2080s by IPCC scenarios and GCMs (33) and for 2 water supply types (rain-fed and irrigated).   The agro-climatic attainable yield data set alone comprises of about one million maps and map statistics tables.

Data sets:

Agro-climatically attainable yield
Crop/LUT selection by grid-cell, best yielding crop/LUT (agro-climatically attainable yields).
Crop-specific actual evapotranspiration (mm) during the crop cycle of the selected crop.
Crop-specific accumulated temperature (Tsum) during the crop cycle of the selected crop.
Standard Deviation (SD) of agro-climatically attainable yields (1961-1990).
Coefficient of Variation of agro-climatically attainable yields (1961-1990).



Agro-climatically attainable yield of spring wheat

Descriptive keywords

Agro-climatic attainable yields, land utilization type, actual evapotranspiration, accumulated temperatures, temperature constraints moisture constraint, agro-climatic constraints, yield variability

Data access

IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Climate Yield Constraint Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

Climatic yield constraints are determined by individual land utilization types (LUT). The quantified constraint factors include temperature constraints (fc1), moisture constraints (fc2) agro-climatic constraints (fc3) and a resulting overall yield reduction factor (fc0).

Purpose

Climate yield constraints datasets are outputs of the GAEZ suitability and potential yield assessment.

Methodology/Data generation

Thermal constraints have been determined by Crop LUT level. The following temperature (and air humidity) related constraints have been considered: (i) Thermal (latitudinal) climatic conditions; (ii) permafrost conditions; (iii) length of temperature growing period ($LGP_{t=5}$); (iv) length of frost free period ($LGP_{t=10}$); (v) temperature sums ($Tsum_t$); (vi) temperature profiles; (vii) vernalization conditions; (viii) diurnal temperature ranges (for selected tropical perennials); and (ix) relative humidity conditions (for selected tropical perennials). The various temperature related constraints are combined in an overall temperature constraint (fc1)

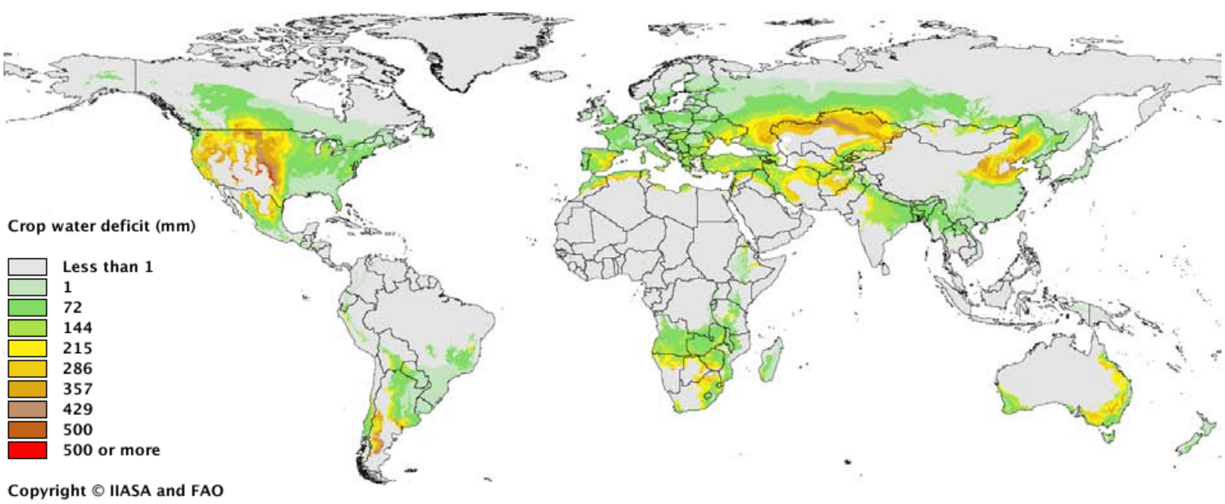
Moisture constraints are derived from LUT-specific water balances and actual evapotranspiration and used for determining water-stress yield-reduction factors (fc_2).

Agro-climatic constraints cause direct or indirect losses in the yield and quality of produce. Yields losses in a rain-fed crop due to agro-climate related constraints

Four different constrains (i.e. yield-reducing factors) are taken into account:
a. Long-term limitation to crop performance due to year-to-year rainfall variability
b. Pests, diseases and weeds damage on plant growth
c. Pests, diseases and weeds damage on quality of produce
d. Climatic factors affecting the efficiency of farming operations

Data sets:

- Temperature constraints factor that includes; constraints related to temperature profile, accumulated temperature, temperature growing period and risk of early and late frost.
- Yield reduction due to soil moisture deficit.
- Agro-climatic constraints factor that entails climate related yield reductions: pests, diseases, weeds and workability constraints.
- Combined climate related constraints factor that includes: Temperature, moisture and agro-climatic constraints.
- Crop water deficit (mm): difference between LUT-specific maximum and actual evapotranspiration (= net irrigation requirements).



Crop Water deficit for spring wheat

Descriptive keywords

Temperature constraints, moisture constraints, agro-climate related constraints, water deficit

Data access

Accessible through the GAEZ v3.0 Data Portal at:
IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Crop Calendar Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

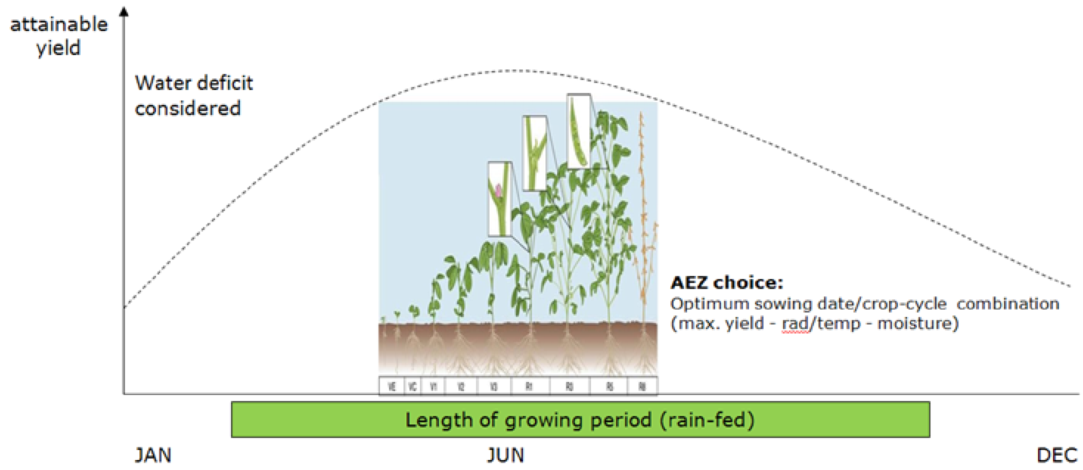
Yield calculations, repeated for possible growth cycle starting days during the prevailing growing period, determine an optimum crop calendar in terms of attainable potential yield. Information provided includes the start and duration of the LUT growth cycle reflecting the period from crop emergence to full maturity, or –in case of hibernating crops- from start of post- dormancy period to full maturity.

Purpose

Crop calendar datasets are outputs of the GAEZ suitability and potential yield assessment.

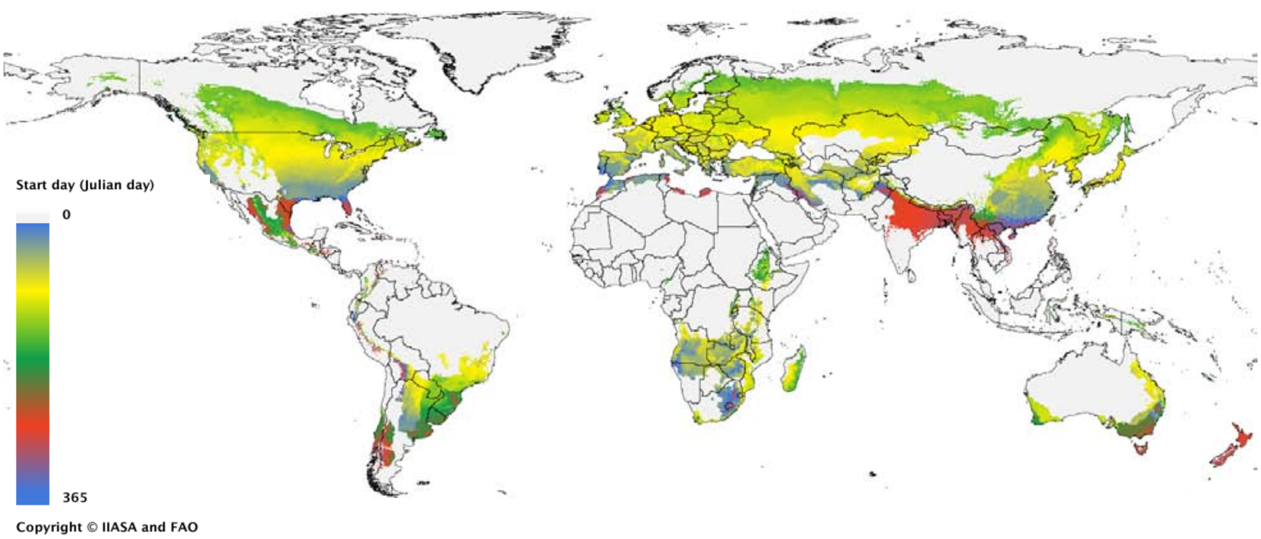
Methodology/Data generation

The crop calendar (i.e. sowing and harvesting dates) for a given LUT and grid-cell is determined by identifying the sowing date that leads to the highest attainable yield. GAEZ tests all possible LUT/sowing-dates combinations within each grid-cell.
For each LUT, the total crop cycle expected for the 'average climate' (30-year time period from 1961-1990) is given in days as an input parameter. For the average base climate, an accumulated temperature sum ($Tsum_5$) is calculated during each crop LUT. This crop-specific value of $Tsum_5$ is assumed to represent for a location the specific crop cycle requirement of the LUT. When simulating individual years, the crop cycle is adjusted until the specific $Tsum_5$ is reached, as calculated for average climate conditions, e.g. is shortened in years warmer than normal.
For rain-fed production GAEZ calculates potential crop yields by shifting computed calendars within the permissible part of the LGP, and selects the start date of the crop when yield is the highest. This optimum crop calendar for rain-fed conditions is reflecting, for a particular crop/LUT, the optimum combination of radiation regime, temperature regime and soil moisture availability.
For irrigated production GAEZ tests all possibilities of crop yield performance in LGP_{t5} (i.e., in the period during the year when Ta >5^{o}C) and selects the period with highest attainable yields, thus driven mainly by radiation and temperature regime. Alternatively, GAEZ could also use a selection criterion which would account for the trade-off between additional water use and additional yield generated.



Data sets (annual crops only):

- Start crop growth cycle (day)
- Length of crop growth cycle (days)



Start crop growth cycle (day) of spring wheat (1961-1990)

Descriptive keywords

Crop calendar, growth cycle start, growth cycle duration

Data access

Accessible through the GAEZ v3.0 Data Portal at:
IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Agro-ecological Suitability and Productivity Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

Agro-ecological suitability provides a complete environmental picture of crop potentials accounting for climatic conditions, pest diseases and climatic workability constraint impacts soil and terrain constraints, as well as highly input dependent requirements for fallow periods.

Purpose

Soil and slope distributions within a 5 arc-minute grid-cell on the one hand, and crop, environment and management specific fallow period requirements on the other hand are used to estimate suitability distributions and aggregate potential productivity of crops. Derived crop suitability and productivity values provide suitability distributions and are the source for aggregated crop potential productivity.

Methodology/Data generation

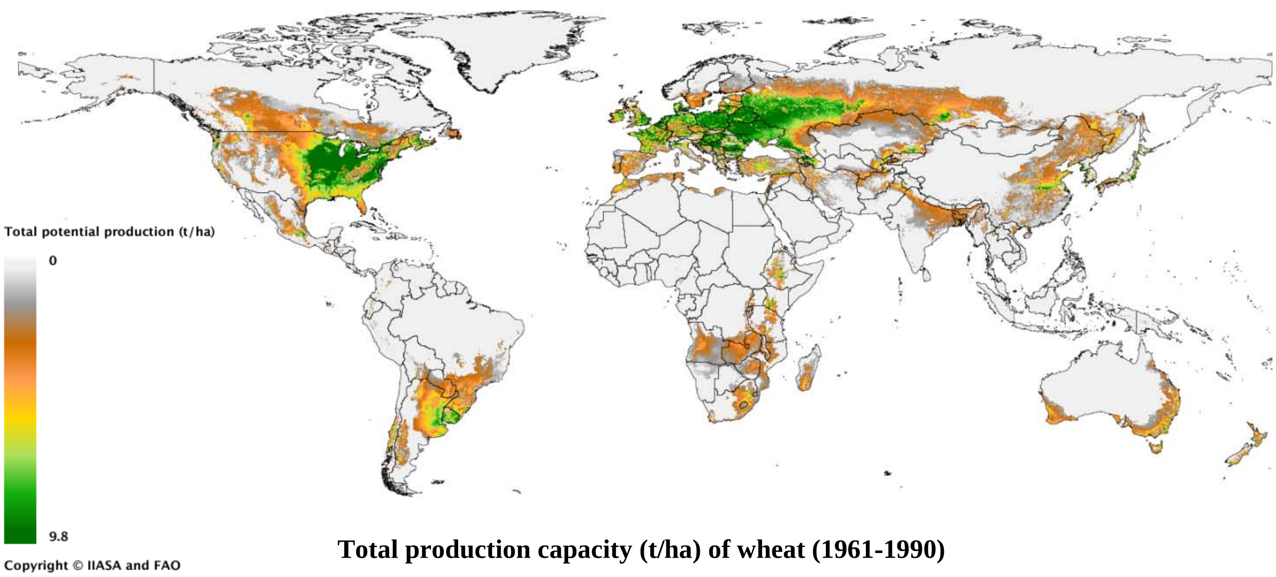
Agro-ecological Suitability and Productivity data is calculated by an algorithm from cells of the spatial soil association layer of the Harmonized World Soil Database (HWSD). It determines for each grid cell the respective make-up of land units in terms of soil types and slope classes. Each of these component land units is separately assigned the appropriate suitability and yield values and results are accumulated for all elements. Processing of soil and slope distribution information takes place at 30 arc-second grid cells. One hundred of these produce the edaphic characterization at 5 arc-minute, which is the resolution used for providing GAEZ results. As a result, information stored for 5 arc-minute grid cells contains distributions of the individual sub-grid evaluations. The main purpose is to compile a grid-cell database for each crop or crop group storing evaluation results that summarize the processed sub-grid information. Computations include the following steps:

- Reading agro-climatic yields calculated for separate crop water balances of six broad soil AWC classes;
- applying rules for water-collecting sites (defined as Fluvisols and Gleysols on flat terrain);
- applying reduction factors due to edaphic evaluation for the specific combinations of soil types/slope classes making up a grid-cell;
- aggregating results over component land units (soil type/slope combinations), and
- calculating applicable fallow requirement factors depending on climate characteristics, soil type and crop group.

Data sets:

Spatial databases created at 5 arcmin resolution available for viewing and downloading from the GAEZ Data Portal in national, sub-national and regional aggregations of the spatial datasets. Output types are available in the form of maps and map statistics for 49 maincrops, and 11 crop groups for 4 levels of inputs, 5 water supply types for historical years (1961-2000, 2009), baseline period (1961-1990) and future climates (33 GCM/ IPCC scenario combinations):

- Crop suitability index (class) reflects suitability levels and distributions (0 and 100).
- Crop suitability index (value)
- Total production capacity (t/ha)
- Crop suitability index (class) for current cultivated land
- Crop suitability index (value) for current cultivated land
- Potential production capacity (t/ha) for current cultivated land



Total production capacity (t/ha) of wheat (1961-1990)

Descriptive keywords

Agro-ecological suitability, suitability index, soil and terrain constraints

Data access

Accessible through the GAEZ v3.0 Data Portal at:
IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Crop Summary Tables

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.02.22)
Presentation form: MS Excel tables

Spatial representation

Extent: Global
Type: Sub-grid cell data is used for spatial data aggregation of the crop summary tables
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

Various utility programs have been developed to aggregate and tabulate potential production results by administrative units or to map the contents of crop databases in terms of suitability index and potential grid cell output.

Purpose

The crop summary tables provide standardized information on crop potentials. The tables are based on distributions of crop suitability and crop yield data within the grid cells, and therefore provide more detailed information than the map statistics tables that use information that has already been aggregated to grid cell level.

Methodology/Data generation

Crop summary tables provide standardized information on distributions of crop suitability and crop yield data aggregated at sub-national level (10 countries), national level and 3 different regional levels. The data is based on aggregations of sub-grid cells distributions. The tables are further organized by:

- Land cover class (11);
- Protection status (3)
- Crop (49),
- Water supply type (5),
- Input level (4) and
- Time period

The summary tables are organized by crop or crop group, by input level, by water supply type, by land cover category and by protection status for subnational national (10 countries) and regional aggregation levels. The tables provide data on suitability, production potentials, agronomically attainable yields, crop production constraints, water deficits (irrigation requirements), fallow land requirements, and area, yield and production by individual and combined suitability classes.

Data sets:

A total of about 80000 crop summary tables are uploaded in the GAEZ Data Portals.

Descriptive keywords

Crop suitability, crop yield, sub-grid cell distributions, predefined land cover and protection classes, production potentials, constraint factors

Data access

Accessible through the GAEZ v3.0 Data Portal at:
IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

GAEZ datasets: Actual Yield and Production

Actual yields and production from downscaling year 2000 statistics of main food and fiber crops (statistics derived mainly from FAOSTAT and the FAO study AT 2010/30). Results are presented as (i) Crop production value, and (ii) crop harvested area, yield and production for 23 major commodities.

Actual Yield and Production Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.03.15)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

Actual yields and production from downscaling year 2000 statistics of main food and fiber crops (statistics derived mainly from FAOSTAT and the FAO study AT 2010/30). Results are presented as (i) crop production value, and (ii) crop harvested area, yield and production for 23 major commodities.

Purpose

Downscaling harvested area yield and production of main commodities to grid-cells of current rain-fed and irigated cultivated land provides a useful spatial stratification of national or sub-national agricultural statistics. This information on actual yield and production is compatible with potential suitability and yield in the same grid-cells as calculated in GAEZ assessments.

Methodology/Data generation

Actual yields and production are estimated from downscaling year 2000 (2005) statistics of main food and fiber crops (statistics derived mainly from FAOSTAT and the FAO study AT 2015/30). Results are presented as (i) crop production value, and (ii) crop area, production and yields for 23 major commodities. Two main activities were involved in obtaining grid-cell level area, yield and production of prevailing main crops:

1) Estimation of shares of rain-fed or irrigated cultivated land by 5' grid cell. Land cover interpretations schemes were devised that allow a quantification of each 5-arc-min. grid-cell into seven main land use cover shares. Shares of cultivated land, subdivided into rain-fed and irrigated land, were used for allocating rain-fed and irrigated crop production statistics;
2) Estimation of area, yield and production of the main crops in the rain-fed and irrigated cultivated land shares. Agricultural production statistics are available at national scale from FAO. Various layers of spatial information are used to calculate an initial estimate of location-specific crop-wise production priors. The priors are adjusted in an iterative downscaling procedure to ensure that crop areas and production are consistent with aggregate statistical data, and are allocated to the available cultivated land and reflect available ancillary data, e.g., selected crop area distribution data (Montfreda *et al*., 2008) and agronomic suitability of crops estimated in AEZ.

The downscaling procedures and implementation for the year 2000 (respectively 2005) agricultural statistics have resulted in the following data sets:

(i) Global inventory of shares of cultivated land, forest land, grass and other vegetated land, barren and very sparsely vegetated land, infrastructure and built-up urban areas and water by grid-cell. The cultivated land shares are subdivided in rain-fed and irrigated land;

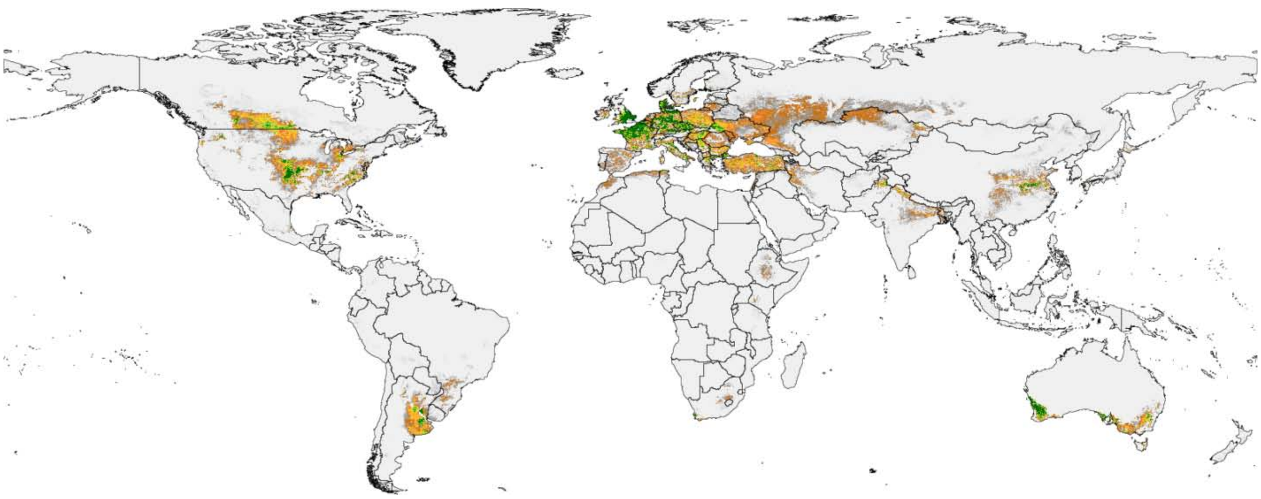
(ii) Area, yield and production for major crops in rain-fed cultivated land, based on year 2000 and 2005 statistics, and

(iii) Area, yield and production for major crops in rain-fed and irrigated land based on year 2000 and 2005 statistics.

(iv) Estimates of the spatial distribution of total crop production and production of major crop groups (cereals, root crops, oil crops), valued at year 2000 international prices.

Data sets:

- Crop production value (GK$)
  - Total crop production value (by 5 min latitude/longitude grid cell)
  - Cereal production value (by 5 min latitude/longitude grid cell)
  - Oil crops production value (by 5 min latitude/longitude grid cell)
  - Root & tubers production value (by 5 min latitude/longitude grid cell)
  - Total crop production value per hectare
  - Cereal production value per hectare
  - Crop harvested area, yield, and production



Production for rain-fed wheat

Descriptive keywords

Cultivated land, crop production value, area, yield, downscaled agricultural statistics

Data access

Accessible through the GAEZ v3.0 Data Portal at:

IIASA: www.gaez.iiasa.ac.at/w

FAO: http://review.fao.org/gaez/flex/Main.html

Supplemental Information

Crop production value is expressed in Geary Khamis dollars (GK$), i.e., an international price weight (year 2000), used by UN, to compare different commodities in value terms.

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

GAEZ datasets: Yield and Production Gaps

Yield gaps and production gaps have been estimated by comparing potential attainable yields and production (estimated in GAEZ v3.0) and actual yields and production from downscaling year 2000 statistics of main food and fiber crops (statistics derived mainly from FAOSTAT and the FAO study AT 2010/30). Yield gaps provide important information for identifying causes and addressing rural poverty and food security issues.

Yield and Production Gaps Datasets

Date: 2012-03-31
Edition: GAEZ v3.0 (latest update: 2012.02.22)
Presentation form: Digital maps and map statistics at various administrative aggregation levels (sub-national to regional)

Spatial representation

Extent: Global
Type: Gridded data sets and tabular formats with map statistics
Resolution: 5 arc-minute

Temporal extent

Time period:

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

Yield gaps and production gaps have been estimated by comparing agronomically attainable yields and production (estimated in GAEZ v3.0) and actual yields and production from downscaling year 2000 statistics of main food and fiber crops (statistics derived mainly from FAOSTAT and the FAO study AT 2010/30).

Purpose

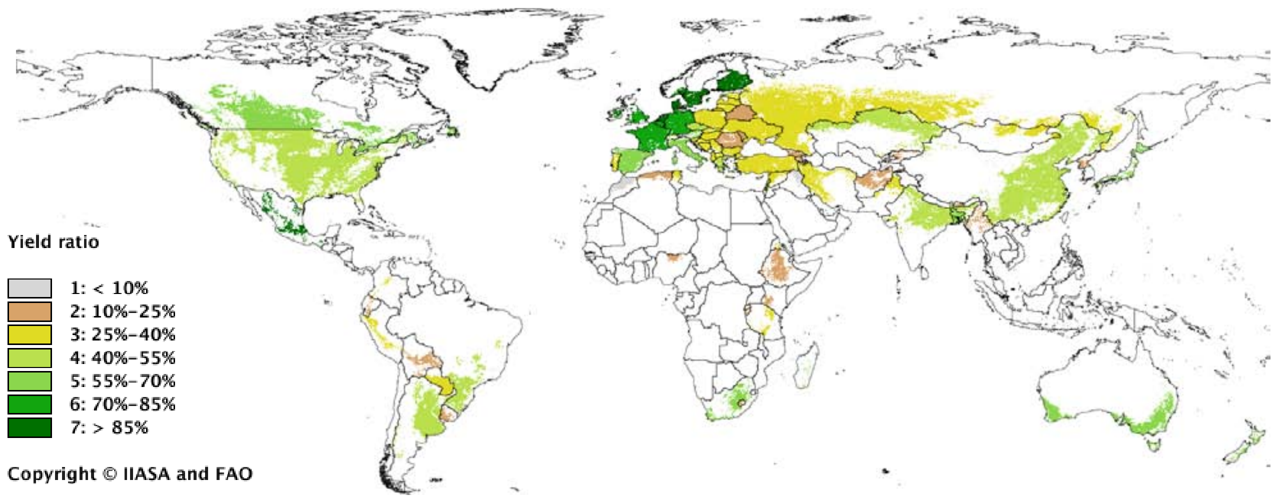
Yield gaps provide important information for identifying causes and addressing rural poverty and food insecurity issues.

Methodology/Data generation

The production gap represents the difference in percentage between potential production and actual production achieved or alternatively the difference between potential production and actual production. The yield gap represents the difference between potential yield and actual yield achieved in percentage or alternatively the difference between potential yield and actual yield in t/ha.

Data sets:

- Aggregate yield ratio
  - Ratio of actual over potential yield, Main crops
  - Ratio of actual over potential yield, Cereal crops
  - Ratio of actual over potential yield, Oil crops
  - Ratio of actual over potential yield, Roots and tubers
- Crop yield ratio and production gap
  - Ratio of actual over potential yield
  - Difference of potential and actual production



Difference of potential and actual production for Rain-fed Wheat

Descriptive keywords

Agronomically attainable yields, actual yields, yield gaps, production gaps, yield ratios

Data access

Accessible through the GAEZ v3.0 Data Portal at:
IIASA: www.gaez.iiasa.ac.at/w
FAO: http://review.fao.org/gaez/flex/Main.html

Supplemental Information

Further expansion of yield gaps estimates is foreseen using more recent actual production statistics (year 2005)

Use limitation

Citation: IIASA/FAO, 2012. Global Agro-ecological Zones (GAEZ v3.0). IIASA, Laxenburg, Austria and FAO,Rome, Italy.

Various AEZ applications and databases

Various AEZ applications and Databases

Date: 2012-03-31
Edition: various in period 2001-2012
Presentation form: Methodologies, Models, Reports, Results both in form of maps and databases

Spatial representation

Extent: Global, Regional and National
Type: AEZ food, feed, fiber crops, grassland and bio-energy feedstock suitability and productivity assessments under historical, baseline and future climate change conditions
Resolution: Between 5 arc-minute and 3 arc-second.

Temporal extent

Time period: depending on study

- Individual years: 1961 – 2000 (2009)
- Baseline: 1961-1990
- Future: 2020s, 2050s, 2080s

Abstract

During the last decade the Land Use Change and Agriculture Program has used the AEZ modeling framework in a number of activities and projects. The data generated for these activities include spatial inventories and spreadsheet data of potential production capacities of an array of land uses from pasture land, first and second generation bio-energy feedstock to subsistence food crops and commercial food feed and fiber cash crops.

Purpose

The Agro-ecological Zones (GAEZ) system is developed for assisting rational land-use planning on the basis of a inventories of land resources and evaluations of biophysical limitations and production potentials of land.

Methodology/Data generation

An AEZ companion model was developed with financial support of the Netherlands Organization for Scientific Research (NWO) for the assessment of production capacity of *conservation forestry, traditional production forestry and biomass forestry* in Europe, Northern Asia and China. The assessment is based on 52 most common forest species. The AEZ companion model has been successfully applied in a range of other projects concerned with assessing bio-energy potentials of available land.

The data generated in the AEZ activities (IIASA core activities) and externally funded projects is consisting of spatial data bases with resolutions between 5 arc-minute (typical for global assessments) to 30 arc–second resolutions (used for national and regional studies). Recently, the GAEZ modeling framework has been applied successfully at a 3arc-second (90 m) resolution for a case study of Mauritius for formulating Climate, Land, Energy and Water Strategies. This high resolution IAEA sponsored study demonstrates scale neutrality of GAEZ procedures

Data Sources

List of main projects containing AEZ assessments (with spatial resolutions)

- Assessment of Potential Productivity of Tree Species in China, Mongolia and the Former Soviet Union (2001). AEZ companion model for assessing tree species suitability and productivity at 5 arc-minute resolution
- **Climate change and agricultural Vulnerability (2002)** Global AEZ crop suitability and productivity assessments under climate change conditions at 5 arc minute resolution
- **Chinagro (2005)**. AEZ crop suitability and productivity assessments for China at 30 arc–seconds resolution
- CATSEI. Chinese Agricultural Transition: Trade, Social and Environmental Impacts) (2007). AEZ crop suitability assessments and productivity for China at 30 arc–seconds resolution
- **Mapping Biophysical Factors That Influence Agriculture (2008).** Global AEZ crop suitability and productivity assessments at 5 arc minute resolution
- **Land use dynamics and sugarcane production.(2008)** AEZ crop suitability and productivity assessments under climate change conditions at 30 arc-second resolution
- **Biofuels and food security (2009).** Global AEZ bio-fuel feedstock suitability and productivity assessments at 5 arc minute resolution
- **High Level Expert Forum - "How to Feed the World in 2050" (2009)** Global AEZ crop suitability and productivity assessments under climate change conditions at 5 arc minute resolution
- **Agricultural development in Ukraine (2009)** AEZ crop suitability and productivity assessments for Ukraine at 30 arc–second resolution
- Common criteria for the redefinition of Intermediate Less Favoured Areas in the European Union (2010) AEZ crop suitability assessments and productivity for EU at 30 arc–seconds resolution
- **Refuel (2010)** AEZ bio-fuel feedstock suitability and productivity assessments for EU27 at 30 arc–seconds resolution
- **Elobio, Biofuel policies for dynamic markets (2011**). Global AEZ bio-fuel feedstock suitability and productivity assessments at 5 arc minute resolution
- **Biofuel Potentials of Residual Land in Brazil (2011)** AEZ bio-fuel feedstock suitability and productivity assessments of residual lands in Brazil at 30 arc–seconds resolution
- **Rising Global Interest in Farmland - Can it Yield Sustainable and Equitable Benefits (2011)** Global AEZ crop suitability and productivity assessments at 5 arc minute resolution
- **SOLAW (2011) State of the Worlds Land and water Resources.** Various Global AEZ crop suitability and productivity assessments at 5 arc-minute resolution.
- **CLEW. Climate Land and Water Strategies for Mauritius (2012):** AEZ crop suitability and productivity assessments for at 3 arc–seconds resolution.

Descriptive keywords

AEZ assessments, AEZ companion model, climate change, food feed, fiber and bio-energy feedstock assessments

Data access

On request

Use limitation

HWSD

Harmonized World Soil Database

Date: 2012-03-31
Edition: Version 1.2 (latest update: 2012.03.07)
Presentation form: Digital map in raster or vector form and linked attribute database

Spatial representation

Extent: Global
Type: Grid data is used to represent geographic data
Resolution: 30 arc-second

Temporal extent

Time period: n.a

Abstract

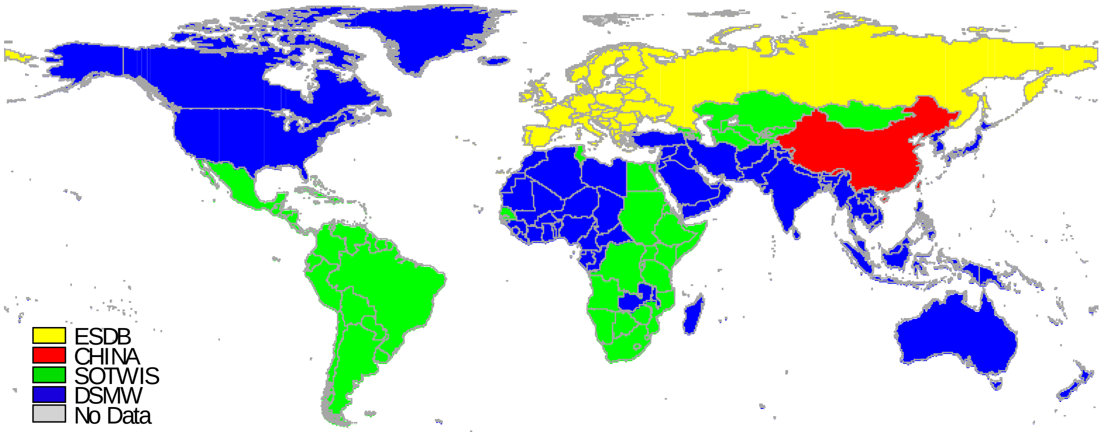
The HWSD is a 30 arc-second raster database with over 16000 different soil mapping units that combines existing regional and national updates of soil information worldwide (SOTER, ESDB, Soil Map of China, WISE) with the information contained within the 1:5 000 000 scale FAO-UNESCO Soil Map of the World (DSMW) (FAO, 1971,1981). The raster database consists of 21600 rows and 43200 columns, which are linked to harmonized soil property data. The use of a standardized structure allows for the linkage of the attribute data with the raster map to display or query the composition in terms of soil units and the characterization of selected soil parameters (organic carbon, pH, water storage capacity, soil depth, cation exchange capacity of the soil and the clay fraction, total exchangeable nutrients, lime and gypsum contents, sodium exchange percentage, salinity, textural class and granulometry).

Purpose

The HWSD contributes sound scientific knowledge for planning sustainable expansion of agricultural production to achieve food security and provides information for national and international policymakers in addressing emerging problems of land competition for food production, bio-energy demand and threats to biodiversity.
The HWSD is of immediate use in the context of the Climate Change Convention and the Kyoto Protocol for soil carbon measurements. A main objective of HWSD development was to provide updated information for the FAO/IIASA Global Agro-ecological Assessment (GAEZ-v3.0).

Methodology/Data generation

A harmonization process has been applied to bring the four soil database components (see figure) into the uniform HWSD format, including numerical recoding of data fields and conversions, and handling of missing data, and linking the DSMW, China and ESDB mapping unit information to respectively topsoil and subsoil parameters derived from the World Inventory of Soil Emissions (WISE) soil profile database.
The HWSD is composed of a GIS raster image file linked to an attribute database in Microsoft Access format. A viewer provides direct access to the two data sources. The database shows the composition of each soil mapping unit, and standardized soil parameters for top- and subsoil. A soil mapping unit can have up to nine soil unit/topsoil texture combination records in the database.



Application

The HWSD is widely used as academic resource in universities and as background information in international organizations like the EU, the UN and World Bank to improve technical support measures to developing countries. Version 1.0 was released in 2008. Since then, it has been updated with new information several times, and has recently been adopted by the Global Soil Partnership (GSP) as the definitive soil database at present, with plans for further updates made as part of the GSP process.

Descriptive keywords

HWSD, SOTER, ESDB, organic Carbon, pH, water storage capacity, soil depth, soil cation exchange capacity, clay fraction, total exchangeable nutrients, lime content, gypsum content, sodium exchange percentage, salinity, textural class, granulometry, soil map of the world, edaphic assessment

Data access

http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/index.html?sb=20

Supplemental information

The HWSD constitutes significant improvements for about 60% of the land area in comparison with the FAO/UNESCO Soil Map of the World.

Further expansion and update of the HWSD is foreseen for the near future, notably with the excellent databases held in the USA (STATSGO), Canada: (AAFC, NSDB), Australia: (CSIRO, ASRIS).

Key references: F. Nachtergaele, H. van Velthuizen, L. Verelst, D. Wiberg (2008) Harmonized World Soil Database – User Guide. FAO, Rome, Italy and IIASA, Laxenburg, Austria.

Supplementary data

Global Terrain Slope and Aspect Data: The data include an elevation map describing median elevation in each grid cell, eight slope maps, and five aspect maps describing distributions (i.e. pixel counts) of the respective slope or aspect classes calculated for 3 arc-sec data and accumulated to 30 arc-sec and 5 min latitude/longitude grid cells respectively. Based on NASA Shuttle Radar Topographic Mission (SRTM) and USGS GTOPO30 data a computer algorithm was used to calculate slope gradient and slope aspect for grid cells.
Land Use and Land Cover Data: The data is presented as a percentage share of the total grid-cell extent for a 5' latitude by 5' longitude grid-cell. An iterative calculation procedure has been implemented to estimate land cover class weights, consistent with aggregate FAO land statistics and spatial land cover patterns obtained from remotely sensed data of six geographic datasets, allowing the quantification of

major land use/land cover shares in individual 5’ by 5’ latitude/longitude grid cells. The resulting seven land use land cover categories shares are: Rain-fed cultivated land; Irrigated cultivated land; Forest; Pastures and other vegetated land; Barren and very sparsely vegetated land; Water; and Urban land and land required for housing and infrastructure.
Soil Qualities for Crop Production On the basis of soil parameters provided by HWSD seven key soil qualities important for crop production have been derived, namely: nutrient availability, nutrient retention capacity, rooting conditions, oxygen availability to roots, excess salts, toxicities, and workability.

Use limitation

2008-2012 COPYRIGHT FAO, IIASA, ISRIC, ISSCAS, JRC All rights reserved.
Citation: FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria

HWSD viewer

Date: 2012-02-22
Edition: Version 1.21 (2012-03-07)
Presentation form: Windows installation file on CD or downloadable from web

Spatial representation

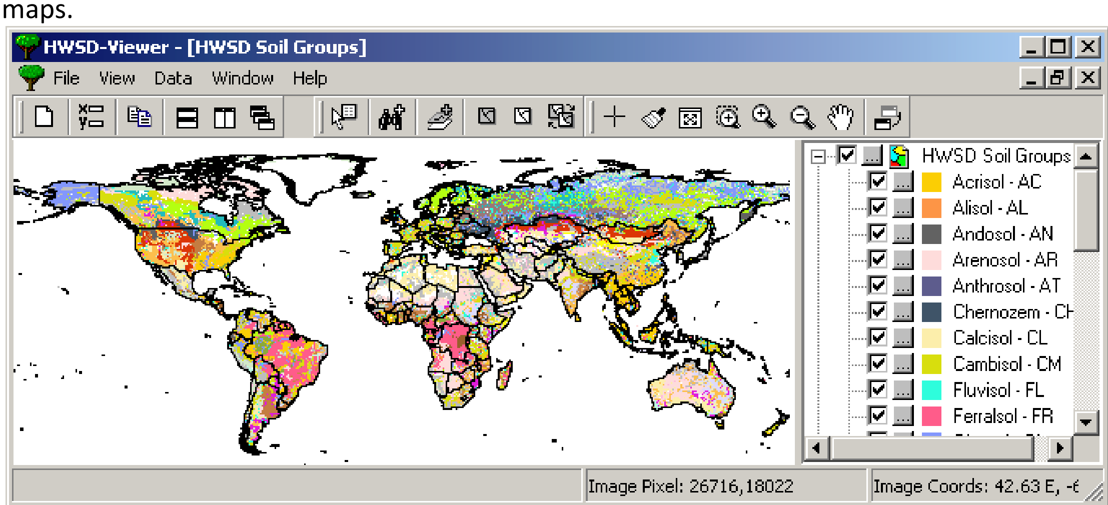
Extent: Global
Type: GIS viewer
Resolution: 30 arc-second

Temporal extent

Time period: n.a.

Abstract

The HWSD consists of a 30 arc-second (or ~1 km) raster image and an attribute database in Microsoft Access 2003 format. The HWSD-Viewer is a geographical tool which allows direct queries of the database combined with visualization of the raster map. The HWSD-Viewer allows zooming and panning, selection of specific soil groups, viewing soil attribute information and geographic location by clicking on the map, creation of complicated queries to search and extract only desired information, and overlays of other maps.



Purpose

The purpose of the HWSD-Viewer is to provide a geographical tool to query and visualize the Harmonized World Soil Database.

Methodology/Data generation

The HWSD-viewer is written in Pascal using Borland Delphi, is distributed with the HWSD in an installation package, and is available on CD and via the Internet.

Descriptive keywords

HWSD, data viewer, GIS, soil map, soil visualization tool

Data access

http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/

Use limitation

Citation: FAO/IIASA/ISRIC/ISSCAS/JRC, 2012. Harmonized World Soil Database (version 1.2). FAO, Rome, Italy and IIASA, Laxenburg, Austria.

WFS

World Food System (WFS) model

Date: 2012-03-31
Edition: Version 5.2 (latest update: 2011-July)
Presentation form: Executables under MS Windows operating system

Spatial representation

Extent: Global
Type: Recursive dynamic applied general equilibrium model
Resolution: 34 countries and regional groups of countries with global coverage

Temporal extent

Time period: annual time steps for period 1990 - 2080

Abstract

The WFS is made up of 34 national and/or regional geographical components. The individual models are linked by means of a world market, i.e., an international linkage mechanism. The model is formulated as a recursively dynamic system, working in annual steps, the outcome of each step being affected by the outcomes of earlier ones. Each individual model covers the whole economy of the respective geographical area. For the purpose of international linkage, production, consumption, and trade are aggregated to nine agricultural sectors and one non-agricultural sector. All physical and financial accounts are balanced and mutually consistent: the production, consumption, and financial ones at the national level, and the trade and financial flows at the global level.

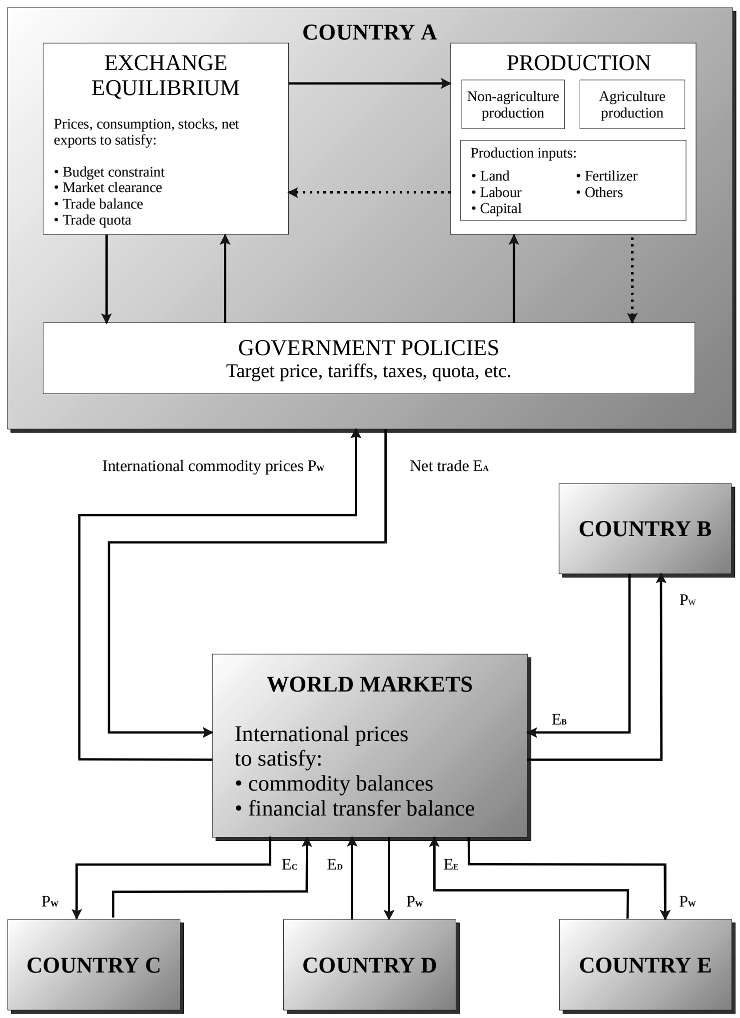
Purpose

The World Food System model provides a framework for analyzing—in annual steps—how much food will be produced and consumed in the world, where it will be produced and consumed, and the trade and financial flows related to such activities. It is used to simulate alternative development scenarios, to investigate climate change impacts on food provision, and to assess the implications of alternative biofuel targets.
For current applications, a state-of-the-art ecological-economic modeling framework is used that includes as three major components: the Global Agro-ecological Zone (GAEZ) model, the WFS model, and upscaling/downscaling methods to transfer information between these modules and the spatial resource database. The modeling framework and models have been developed to analyze spatially the world food and agriculture system, its impacts on food security and the environment and to evaluate the impacts and implications of agricultural policies.

Methodology/Data generation

The world food system model comprises a series of national and regional agricultural economic models. It provides a framework for analyzing the world food system, viewing national food and agricultural components as embedded in national economies, which in turn interact with each other at the international trade level. The model consists of 34 national and regional geographical components covering the world. The individual national/regional models are linked together by means of a world market, where international clearing prices are computed to equalize global demand with supply (see Figure below).

The world food system model is an applied general equilibrium (AGE) model system. While focusing on agriculture, this necessitates that also all other economic activities are represented in the model. Financial flows as well as commodity flows within a country and at the international level are kept consistent, in the sense that they must balance, by imposing a system of budget constraints and market-clearing conditions. Whatever is produced will be demanded, either for human consumption, feed, biofuel use, or as intermediate input. Alternatively, commodities can be exported or put into storage. Consistency of financial flows is imposed at the level of the economic agents in the model (individual income groups, governments, etc.), at the national as well as the international level. This implies that total expenditures cannot exceed total income from economic activities and from abroad, in the form of financial transfers, minus savings. On a global scale, not more can be spent than what is earned.



Schematic representation of the World Food System model

Each individual model component focuses primarily on the agricultural sector, but includes also a simple representation of the entire economy as necessary to capture essential dynamics among capital, labor and land. For the purpose of international linkage, production, consumption and trade of goods and services are aggregated into nine main agricultural sectors, namely: wheat; rice; coarse grains; bovine and ovine meat; dairy products; other meat and fish; oilseed cakes and protein meals; other food; non-food agriculture. The rest of the economy is coarsely aggregated into one simplified non-agricultural sector. Agricultural commodities may be used in the model for human consumption, feed, as biofuel feedstock, for intermediate consumption, and stock accumulation. The non-agricultural commodity contributes also as investment, and as input for processing and transporting agricultural goods. All physical and financial accounts are balanced and mutually consistent: the production, consumption, and financial ones at the national level, and the trade and financial flows at the global level.

Linkage of country and country-group models occurs through trade, world market prices, and financial flows. The system is solved in annual increments, simultaneously for all countries in each time period. Within each one-year time period, demand changes with price and commodity buffer stocks can be adjusted for short-term supply response. Production in the following marketing year (due to time lags in the agricultural production cycle) is affected by changes in relative prices. This feature makes the world food model a recursively dynamic system.

The market clearing process results in equilibrium prices, i.e., a vector of international prices such that global imports and exports balance for all commodities. These market-clearing prices are then used to determine value added in production and income of households and governments.

Within each regional unit, the supply modules allocate land, labor and capital as a function of the relative profitability of the different crop and livestock sectors. In particular, actual cultivated acreage is computed from both agro-climatic land parameters (derived from AEZ) and profitability estimates. Once acreage, labor and capital are assigned to cropping and livestock activities, yields and livestock production is computed as a function of fertilizer applications, feed rates, and available technology.

Simulations with the WFS generate a variety of outputs for model variables and indicators. At the global level these include world market prices, global population, global production and consumption, and global income. At the country level the information varies with the type of model, including in general the following variables: producer and retail prices, level of production, use of primary production factors (land, labor, and capital), intermediate input use (feed, fertilizer, and other chemicals), human consumption, stock levels and commodity trade, gross domestic product and investment by sector, levels of taxes, tariffs, and income by group and/or sector.

Application

Several applications of the model to international agricultural policy analysis, climate-change vulnerability, and to the food vs. fuel debate have been published (e.g., Fischer et al., 1988; Fischer et al., 1994; Rosenzweig and Parry, 1994; Fischer et al., 2002; Fischer et al., 2005; Tubiello and Fischer, 2006; Fischer et al., 2009; Fischer et al., 2010).

Descriptive keywords

General equilibrium analysis, world food system, food security, policy analysis, climate change impacts, food vs fuel debate, biofuels and food security

Model access

http://www.iiasa.ac.at/Research/LUC/Research-World-food-policy/bls-model.html

Supplemental information

IIASA released a first version of the WFS model in 1988, termed the Basic Linked System, in response to the energy and food crisis of the1980s. The WFS model and its databases have been updated and extended on several occasions. The model has been calibrated and validated over past time windows.

Key references:

Fischer, G., M. Shah and H. van Velthuizen (2002). Climate Change and Agricultural Vulnerability. Special Report as contribution to the World Summit on Sustainable Development, Johannesburg 2002. International Institute for Applied Systems Analysis, Laxenburg, Austria. pp 152.

Fischer, G., M. Shah, F.N. Tubiello, H van Velhuizen (2005). Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080. Phil. Trans. Royal Soc. B, doi:10.1098/rstb.2005.1744.

Fischer, G., E. Hizsnyik, S. Prieler, M. Shah, and H. van Velthuizen (2009). Biofuels and Food Security. The OPEC Fund for International Development (OFID) and International Institute of Applied Systems Analysis (IIASA), Vienna, Austria, 228 pp.

Use limitation

Citation: IIASA World Food System Model, IIASA, Laxenburg, Austria.

LANDFLOW

Tracing land from primary production to final utilization (LANDFLOW) - model

Date: 2012-03-31
Edition: Version 2 (latest update: 2012.01.10)
Presentation form: Executable programs under MS Windows operating system

Spatial representation

Extent: Global
Type: Accounting model solving for all commodities a system of linear equations across regions for land content of traded products
Resolution: Country level

Temporal extent

Time period: Annual calculation steps; 1980 – 2008

Abstract

In a globalized world with its complex supply chains and trade relations, consumption patterns in one country can cause land use changes far away. LANDFLOW tracks 'total land' and 'deforested land' embodied in agricultural and forestry products from primary production in the country of origin to final utilization. It accounts for intermediate and joint products along the agricultural and forestry processing chain and records cross-country flows of primary and secondary commodities. The resulting database records for each country/region supply (production + imports) and utilization (consumption + exports) for the period 1990 to 2008. Variables include i) physical quantities; ii) land area; and iii) embodied deforested land area. LANDFLOW applies in calculations a detailed commodity list and then generates results for hierarchically organized aggregate commodity groups including:

- Crops: Total and sub-categories (Cereals; Roots & tubers; Sugar crops; Oil crops; Fruits/Vegetables/Spices; Stimulants; Industrial crops; Fodder crops)
- Livestock: Ruminants are treated separately from other animals (mainly pigs & poultry);
- Forestry: Total and sub-categories: Industrial roundwood comprising of 'Wood products' and 'Pulp and Paper'; Fuel wood

Purpose

The increasing importance of international trade, as well as the growing competition for resources among developed economies and emerging economies, influences access to and distribution of natural resources. When a country imports commodities it also "imports" resources associated with the production of those commodities, and vice versa in the case of exports. Analyzing the complex drivers and interactions involved in using domestic and foreign natural resources including sparse land resources, is essential for identifying and promoting responsible consumption patterns. LANDFLOW quantifies commodity flows and associated resource use as agents of environmental change and thus contributes important insights required for policies aiming at sustainable consumption and resource use.

Methodology/Data generation

Input Data: Time series country data from different domains of the FAOSTAT online agriculture and forestry databases including primary crop and livestock production, land use data, animal stock numbers, commodity supply and utilization balances of primary and derived products, national commodity trade data, and bilateral commodity trade data by country in physical units and dollar values, production of raw timber materials and wood-based products.

Methodology:

LANDFLOW first allocates physical land areas to primary production of crops and timber by applying country-specific yields for cropland and forest land productivity to the recorded domestic production of individual commodities. Land estimates of the crop sector account for multi-cropping and joint production to allocate individual crop commodities to physical cropland. Pasture land is allocated to ruminant livestock. 'Deforested' land is allocated to primary commodities by the sub-module 'Attribution of deforestation to main sectors and primary commodities'.

Second, FAO's supply utilization accounts for agricultural products and wood balances for forestry are connected with trade matrixes to track physical quantities and embodied land areas from primary production via intermediate products and trade to final utilization (see figure below).

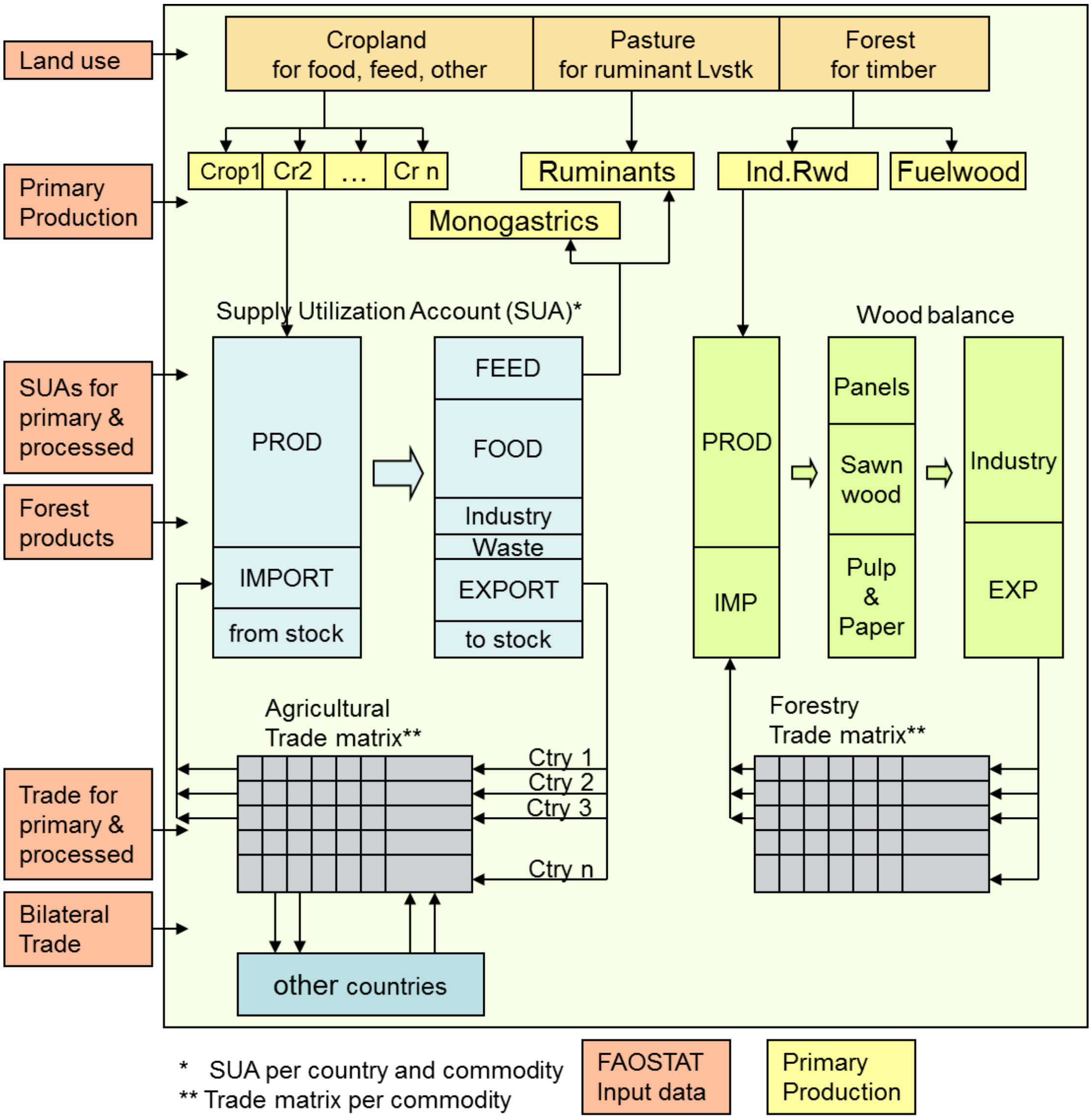
Tracking land in produced commodities starts from the countries of origin. Land areas associated with utilization of crops are estimated by applying country specific yields to domestic production, adding imports (using relevant yields in country of origin), and subtracting exports of individual commodities (using land content of both domestic production and imports).

In the livestock sector, ruminants (e.g. cattle, sheep, goats, horses) are treated separately from monogastric animals (pigs and poultry). Ruminants rely on pastures, cultivated green fodder as well as feed from primary crops produced on arable land. Monogastrics animals are fed with primary crops or crop by-products. By comparing energy supply from reported feed use with livestock energy requirements it is possible to attribute total feed use of primary crops and crop by-products (e.g. brans or soybean cake) separately to different livestock categories. Pasture requirements are then estimated to fill any feed energy supply gap of ruminants.

For forestry, a separation of forest products and associated land areas including trade was estimated for three sub-sectors: primary sector 'industrial roundwood and wood fuel'; and two sectors for manufactured forest products, 'wood and products of wood' and 'pulp, paper and paper products'. Land use in the paper sector takes into account recycled paper use and only land area requirements of each year's roundwood use in paper production is counted.

Annual trade matrices of individual commodities are compiled based on large time series data of more than ten million recorded bilateral trade flows of agricultural and forestry commodities published in FAOSTAT. For this purpose countries are grouped into fourteen regional markets. Starting from a trade matrix compiled from the physical commodity flows per country, an iterative procedure is applied for each commodity and year for the period 1990 to 2008 to calculate balanced trade shares and to ensure the full mutual consistency of export and import flows, i.e., whatever a country in region i reports as export to region k must also show up as import from region i by a country of region k.

LANDFLOW is able to deal with intermediate uses (livestock feeds being the most important), land content in trade and utilization of joint products (e.g. soybean oil and soybean cake used in different sectors or countries) as well as re-exports of imported raw materials in the form of derived products.



LANDFLOW operates on an annual basis. It uses for calculations a detailed commodity list and then generates results for aggregate commodity groups allowing a complete land balance of agricultural and forestry production. In addition, flows of selected important commodities of interest can be traced separately.

The current version of LANDFLOW comprises of three main modules:

i) LANDFLOW Crop sector
ii) LANDFLOW Livestock sector
iii) LANDFLOW Forestry sector

In addition, a module for tracking deforestation embodied in production, trade and final utilization of agricultural and forestry commodities has been added.

iv) Attribution of deforestation to main sectors and primary commodities

Output files:

The most recent version of LANDFLOW produced annual results per country and region for the period 1990 to 2008 for large number of agricultural and forestry commodities. These individual commodities were summed up and presented in terms of the following main commodity aggregates:

i) **Crop** products**:** Total and sub-categories: 1) Cereals; 2) Roots & tubers; 3) Sugar crops; 4) Oil crops; 5) Fruits/Veg/Spice; 6) Stimulants; 7) Industrial crops; 8) Fodder crops; 9) Total crops

ii) **Livestock** products: Total and sub-categories: 1) Ruminants; 2) Other animal (mainly pigs & poultry); 5) Total

iii) **Forestry** products: Total roundwood and sub-categories: 1) Wood products (sawnwood and panels); 2) Pulp and Paper; 3) Industrial roundwood, i.e. the sum of 1) and 2); 4) Fuel wood; 5) Total roundwood, i.e. sum of 3) and 4)

Application

A first version of LANDFLOW was developed for the project, "Modeling Opportunities and Limits for Restructuring Europe towards Sustainability" (MOSUS) to track embodied land in commodities of the agriculture and forestry sectors and to provide input for input-output modeling. In 2011 LANDFLOW has been extended and applied to track deforested land embodied in trade and final use of agricultural and forestry products, in the context of the project: "The impact of EU consumption of food and non-food imports on deforestation."

Descriptive keywords

Land embodied in trade; deforestation drivers, sustainable consumption

Supplemental information

Further development: The LANDFLOW agricultural module can be extended to track volumes of irrigation water and nutrients (nitrogen, phosphorus, potassium) embodied in traded agricultural products.

Key references: European Commission, 2012. Comprehensive analysis of the impact of EU consumption of imported food and non-food commodities and manufactures goods on deforestation, *forthcoming*

Use limitation

Use restrictions for the 2011 version until end of contract no. N93Q7-EC-ENV-Consumption&Deforestation.

Land associated with production and utilization of crop and livestock products

Date: 2012-03-31
Edition: Version 1 (latest update: December 2011)
Presentation form: Data Tables
Data source: LANDFLOW

Spatial representation

Extent: Global
Type: Tabular
Resolution: Country level

Temporal extent

Time period: 1990 – 2008

Abstract

A growing share of agricultural products is traded. Hence utilization of land and water resources increasingly takes place far away from consumption. Total land area uses have been attributed to final utilization of different agricultural and forestry products, taking into account the complex commodity flows via trade from primary production to final use, intermediate products (notably animal feeds), and joint products (e.g., livestock producing milk and meat). The database includes for each country/region annual supply/utilization accounts for the period 1990 to 2008 for eight major crop groups and two groups of animal products. In the accounts supply equals utilization and comprises of the following elements:

Supply:	Production + Imports + 'from Stock'
Utilization:	'Consumption of crops and crop products' +'Consumption of livestock products' + + 'Seed and waste' + 'to Stock' + Exports

The database records physical quantities (normalized using international price weights) and land area (in hectares) for cultivated land:

i. Cultivated Land in Supply and Utilization of Crop Products (Crop-Amat1; Crop-Qmat1)
ii. Cultivated Land in Supply and Utilization of Livestock Products (Lvst-Amat1; Lvst-Qmat1)
iii. Cultivated Land in Supply and Utilization of Agricultural Products - i.e. the sum of Crop and Livestock Products (Total-Amat1; Total-Qmat1)

The eight crop groups include 1) Cereals; 2) Roots & tubers; 3) Sugar crops; 4) Oil crops; 5) Fruits/Veg/ Spice; 6) Stimulants; 7) Industrial crops; 8) Fodder crops. 9) Total crops; i.e. the sum of 1 to 8;
The two animal groups include 1) Ruminants; 2) Pigs & Poultry; 5) Total livestock, i.e. the sum of 1 and 2.
In addition to cultivated land, pasture land use for ruminant livestock is recorded as well

iv. Pasture land in Supply and Utilization of Livestock Products (Lvst-Gmat1)

All items are also calculated in per capita terms using time series of UN population estimates (2010 revision).

Purpose

The increasing relevance of international trade and the growing competition for resources between developed economies and emerging economies influence access to and distribution and use of natural resources. When a country imports commodities it also appropriates resources associated with the production of these commodities and vice versa in the case of exports. Trade volumes of the land-intensive agricultural and forestry sector commodities have increased substantially over the past decades. Consequently 'land embodied in trade' associated with imported and exported goods has been growing as well. The trade implied cross-country flows of land resources result in a complex pattern of sparse land resource uses and may contribute to environmental degradation far away from consumption. When a country imports, say palm oil, it may be contributing to environmental deterioration and even social disruption in another country. LANDFLOW quantifies commodity flows as agents of environmental change, revealing such possible tele-connections, and thus makes an important contribution toward the ultimate goal of achieving sustainable global consumption.

Methodology/Data generation

Input Data: The main data source used for the attribution of land to agricultural crops and livestock products are the online databases (FAOSTAT) of the statistical service of the United Nations Food and Agricultural Organization. This database contains various domains of national level time-series data, including primary crop and livestock production, land use data, animal stock numbers, commodity supply and utilization balances of primary and derived products, national commodity trade data, and bilateral commodity trade data by country in physical units and dollar values.

Methodology:
LANDFLOW tracks the extents of land associated with exported and imported primary and processed agricultural commodities in order to provide consistent accounts of land use from farm production, to international trade, and to final use. Exported agricultural products may come from domestic production or may derive from imported primary commodities. Processed agricultural commodities use primary crops from both domestic production and imports. LANDFLOW includes a crop and a livestock module.

For individual crop data (harvested area and production) the physical land base ('land in production') was estimated accounting for multi-cropping, fallow land, joint production (by-products, e.g. soy for cakes and oil) and consistency with the land use domain. Feed areas include pastures for grazing and various fodder and feed crops grown on cropland as well as by-products from processing of food crops (e.g. cereal brans, oilseed cakes). LANDFLOW estimates the feed area used to produce the feed required for a country's domestic livestock herd. Feed items may either be produced domestically or may be imported. Corresponding to their feed composition, ruminants (cattle, sheep, goats and horses) are treated separately from 'other livestock, primarily pigs and poultry. The allocation of fodder crops and primary crops and associated land areas to the two animal groups is estimated according to the energy requirements of the livestock herd as compared to energy supply provided by the different feed sources.

The estimation of trade flows and associated land areas uses information on bilateral trade flows, which was compiled in the form of trade matrices of individual SUA commodities based on a large time series data set of more than ten million recorded bilateral trade flows of agricultural commodities published in FAOSTAT. An iterative procedure was applied for each commodity and year for the period 1990 to 2008 to calculate balanced trade shares and to ensure the full mutual consistency of export and import flows.

Besides land area required for agricultural production and trade, physical volumes of produced, traded and utilized (food, feed, seed/waste, other) commodities are also recorded.

In order to aggregate physical volumes (tons) of a rather detailed and diverse commodity list, a set of international price weights of the year 2000 were applied, the so-called Geary-Khamis prices compiled by FAO. Original units of physical production volumes were multiplied with Geary-Khamis prices and converted into a new unit, representing the physical production volumes in Geary-Khamis dollar equivalent.

Output files:
a) Output Version 2, Dec.2011 for period 1990-2008
CropLand-Regions_08Jan2012.xls (Regions)

b) Output Version 1, 2009 for period 1985-2000 (MOSUS project)
WP3-res1_Countries.doc; WP3-res1.txt (Version from 2009; for period 1985-2000; 80 Countries; Rest of World; EU25, EU10, EU12, OPEC (ex.Indo)
WP3-res2.doc; WP3-res2.txt (Aggregate for 28 Regions)

Application

The database has first been developed for the project "Modeling Opportunities and Limits for Restructuring Europe towards Sustainability (MOSUS)" (www.mosus.net). In 2011 all input databases were updated for 2008 results (based on availability of FAO data). New results were compiled in the project 'The impact of EU consumption of food and non-food imports on deforestation', contracted by the European Commission.

Descriptive keywords

Land embodied in trade, sustainable consumption, land use for crop and livestock consumption

Data access

Excel file: CropLand-Regions_31Dec2011.xls

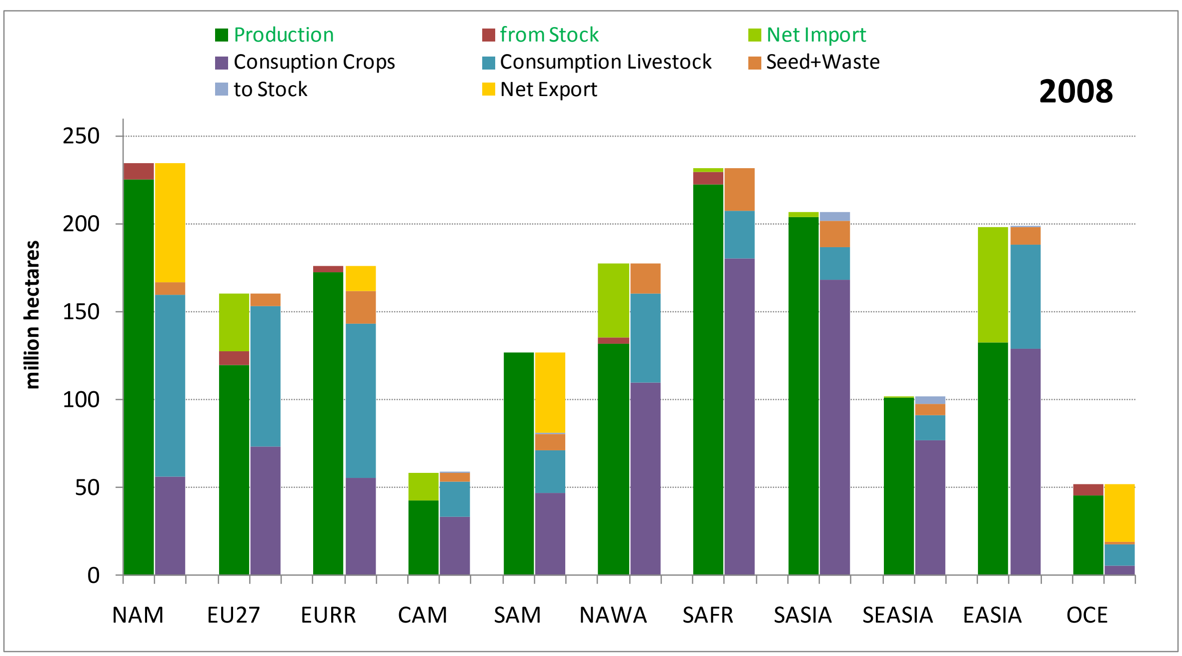
Supplemental information

Further expansion and update is foreseen when additional years of FAOSTAT data become available.
Key references: European Commission, 2012. Comprehensive analysis of the impact of EU consumption of imported food and non-food commodities and manufactured goods on deforestation, *forthcoming.*

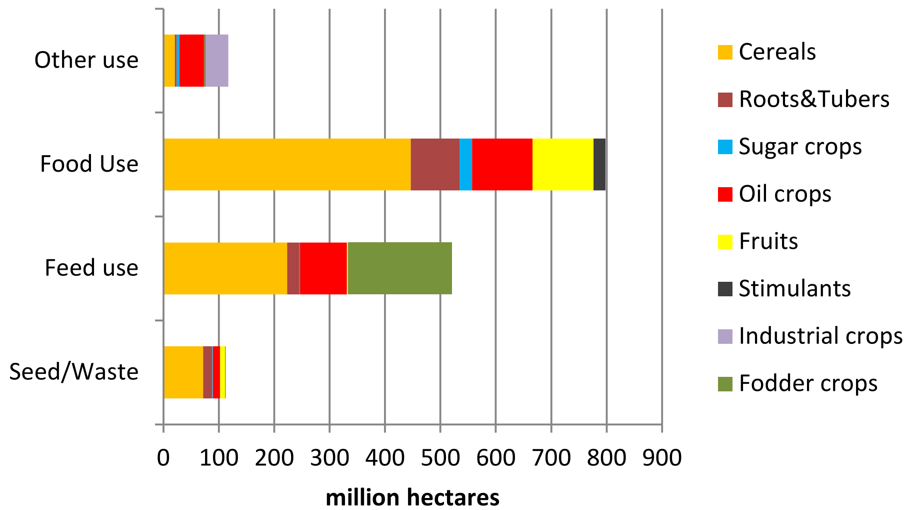
Use limitation

Use restrictions for the 2011 version until end of contract no. N93Q7-EC-ENV-Consumption&Deforestation.

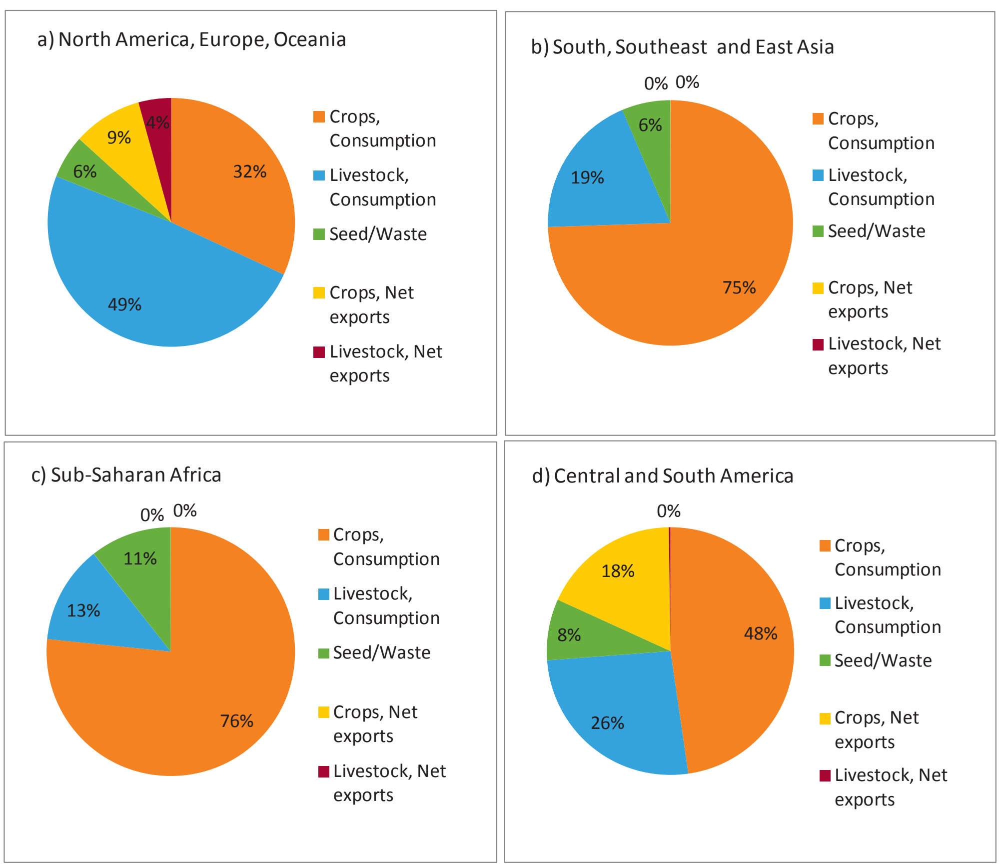
Selected figures:



Cropland in regional net supply and utilization of crop and livestock products (2008)



Global utilization of cropland, by commodity group, 2008 'Seed/Waste': Land used for seed production requirements and or land equivalents for losses due to on farm waste; 'Other use' includes industrial crops (e.g. cotton, tobacco, natural rubber), and oil crops, cereals and sugar crops for industrial products (e.g. soap, cosmetics, biofuel).



Regional utilization of cropland (2006–08); a) North America, EU27 and Oceania; b) South, Southeast and East Asia; c) Sub-Saharan Africa; d) Central and South America

Example: part of MOSUS output file

WORLD

Population (in 1000):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Population (total)	4926725.0	5357907.0	5765099.0	6158590.0	1.50
Population (agriculture)	2353362.0	2461117.0	2532565.0	2581275.0	.61

Production Volumes (in mill GK$):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Crops	779239.6	830977.9	898839.1	987142.2	1.59
Cereals	262831.1	285004.1	299076.5	307413.5	1.04
Other food & fibre	418305.1	458137.5	528565.4	608237.7	2.56
Fodder crops	98103.5	87836.3	71197.3	71490.9	-2.29
Livestock	519278.1	572299.9	620908.2	690684.1	1.89
Ruminants	332913.0	350332.1	355008.8	375865.8	.76
Other livestock	186365.2	221967.8	265899.5	314818.2	3.57
Fisheries	194774.2	216883.9	277451.4	318645.2	3.51
Forestry	232911.3	236571.9	234948.6	239955.1	.17
Wood fuel	118686.1	122850.7	126091.8	126834.6	.45
TOTAL	1726203.0	1856734.0	2032147.0	2236427.0	1.75
Recovered paper	15245.1	20483.7	25045.1	32353.8	5.04

Import Volumes (in mill GK$):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Crops	106754.8	124693.6	147910.5	176752.1	3.42
Cereals	31929.2	35681.3	38684.6	43775.5	2.08
Other food & fibre	74825.6	89012.3	109225.9	132976.7	3.93
Livestock	61017.9	67779.0	82107.8	91829.1	2.88
Ruminants	48022.8	51048.5	56935.1	59488.6	1.51
Other livestock	12995.1	16730.5	25172.7	32340.6	6.49
Fisheries	52095.0	61149.0	78939.4	92694.7	4.05
Forestry	30393.5	35278.3	43401.7	50903.2	3.57
Wood fuel	24.7	54.5	198.1	270.3	18.45
Primary Ind.Rwd.	6571.1	6431.7	6337.2	8600.0	1.60
Wood products	9403.0	11014.9	14271.4	15977.3	3.77
Pulp & paper	14394.6	17777.2	22595.0	26055.6	4.12
TOTAL	250261.1	288899.8	352359.4	412179.2	3.45
Recovered paper	1985.9	2985.7	3791.6	5818.1	7.17

Export Volumes (in mill GK$):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Crops	106754.8	124693.6	147910.3	176753.0	3.42
Cereals	31929.2	35681.3	38684.6	43775.5	2.08
Other food & fibre	74825.6	89012.3	109225.7	132977.5	3.93
Livestock	61017.8	67778.9	82107.8	91829.1	2.88
Ruminants	48022.7	51048.5	56935.1	59488.6	1.51
Other livestock	12995.1	16730.5	25172.7	32340.6	6.49
Fisheries	52095.0	61149.0	78939.4	92694.7	4.05
Forestry	30394.1	35290.6	43393.5	50898.2	3.57
Wood fuel	24.7	54.5	198.1	270.3	18.44
Primary Ind.Rwd.	6571.1	6431.7	6337.2	8600.0	1.60
Wood products	9403.0	11014.9	14271.4	15977.3	3.77
Pulp & paper	14395.2	17789.5	22586.7	26050.7	4.12
TOTAL	250261.7	288912.1	352351.0	412175.0	3.45
Recovered paper	1985.9	2985.7	3791.6	5818.1	7.17

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Per capita Use (in GK$ / cap):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Crops	157.7	154.4	155.4	160.7	.12
Cereals	53.1	52.6	51.7	50.1	-.38
Other food & fibre	84.7	85.4	91.3	99.0	1.07
Livestock	105.4	106.8	107.7	112.0	.38
Ruminants	67.6	65.4	61.6	60.9	-.74
Other livestock	37.8	41.4	46.1	51.1	2.04
Fisheries	39.6	40.5	48.1	52.0	2.01
Forestry	47.3	44.2	40.8	39.0	-1.31
Wood fuel	24.1	22.9	21.9	20.6	-1.03
TOTAL	350.0	345.9	352.0	363.7	.27
Recovered paper	3.1	3.8	4.3	5.3	3.49

Per capita Use (in m^2 / cap):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Crops	1899.4	1791.2	1730.8	1643.8	-.93
Livestock (arable feed)	1117.3	1010.0	898.5	838.0	-1.94
Ruminants	717.3	625.6	522.7	471.4	-2.84
Other livestock	400.0	384.3	375.8	366.6	-.57
Livestock (pasture)	3058.4	2815.1	2555.5	2401.4	-1.63
Forestry	2572.8	2340.9	2032.1	1963.2	-1.89
Wood fuel	1256.5	1174.5	1095.7	1050.7	-1.20
TOTAL	8648.0	7957.1	7216.8	6846.4	-1.58

Self-reliance Ratio (percent):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Crops	100.3	100.4	100.3	99.7	-.03
Cereals	100.5	101.1	100.3	99.6	-.07
Other food & fibre	100.2	100.1	100.4	99.8	-.02
Livestock	100.0	100.0	100.0	100.1	.01
Ruminants	99.9	100.0	100.0	100.2	.01
Other livestock	100.1	100.0	100.1	100.0	.00
Fisheries	99.9	99.8	100.1	99.4	-.03
Forestry	100.0	100.0	100.0	100.0	.00
Wood fuel	100.0	100.0	100.0	100.0	.00
TOTAL	100.1	100.2	100.2	99.8	-.02

Production Volume-Land ratios (GK$/ha):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Crops	524.3	553.7	593.0	645.9	1.40
Cereals	333.4	366.5	387.2	407.3	1.32
Other food & fibre	902.8	936.3	996.3	1069.4	1.15
Livestock (arab+pasture)	252.4	279.2	311.8	346.2	2.14
Ruminants (arab+past.)	179.0	190.0	200.1	212.4	1.14
Other livestock	945.7	1077.9	1227.3	1394.4	2.62
Forestry	183.7	188.6	200.5	198.5	.59
TOTAL	318.3	341.3	375.1	405.2	1.65

Import Volume-Land ratios (GK$/ha):

	1985-87	1990-92	1995-97	2000-02	% p.a.
Crops	541.4	588.0	603.7	654.4	1.20
Cereals	368.9	401.6	409.6	441.4	1.12
Other food & fibre	676.4	722.5	725.4	777.9	.85
Livestock (arab+pasture)	292.8	333.3	354.2	380.7	1.71
Ruminants (arab+past.)	241.9	265.5	263.5	268.2	.61
Other livestock	1310.8	1509.8	1601.5	1662.3	1.56
Forestry	178.6	192.2	199.0	201.4	.79
TOTAL	344.2	380.3	393.4	418.1	1.24

Land associated with round wood production and derived products

Date: 2012-03-31
Edition: Version 1 (latest update: December 2011)
Presentation form: Data Tables – MS Excel
Data source: LANDFLOW model

Spatial representation

Extent: Global
Type: Tabular
Resolution: Country level

Temporal extent

Time period: 1990 –-2008, annual time series

Abstract

Trade volumes of forestry products have increased significantly over the past decades. The LANDFLOW model was used to attribute roundwood quantities and associated total forest areas to supply and final utilization of main forestry products based on consistent national wood balances and commodity flows in terms of (primary and derived products recorded in FAO databases) trade, tracking wood equivalent volumes and land trade from primary production to final use. The database includes for each country/region annual supply/utilization accounts for the period 1990 to 2008 for wood and paper products.
Supply (production + imports) equals utilization (domestic utilization + exports). The database records physical quantities (in cubic meter roundwood equivalent) and land area (in hectares) of supply and utilization for the following commodities:

i) Wood products (sawnwood and panels)
ii) Pulp and Paper
iii) Industrial roundwood (i.e. Sum of wood products and pulp and paper)
iv) Fuel wood
v) Total roundwood (i.e. Sum of industrial roundwood and fuel wood)

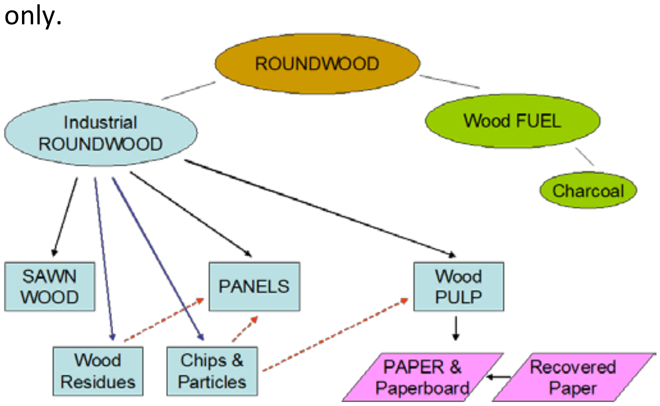
Purpose

The increasing relevance of international trade and the growing competition for resources between developed economies and emerging economies influence access to and distribution and use of natural resources. When a country imports commodities it also appropriates resources associated with the production of these commodities and vice versa in the case of exports. There are substantial cross-country flows of roundwood and land resources embodied in trade resulting in a complex pattern of land-resources use which may contribute to environmental degradation far away from consumption. LANDFLOW reveals and makes transparent embodied resource flows and thus makes an important contribution toward the ultimate goal of achieving sustainable global consumption.

Methodology/Data generation

Input Data: Time series production and trade data from the FAOSTAT online database of the forestry sector. It covers all countries of the world and includes raw timber materials as well as various wood-based products, including sawn wood, panels, wood pulp, paper and paper board, among others. Forest yields are derived from the Temperate and Boreal Forest Resource Assessment (TBFRA). For all countries not included in TBFRA, forest yield is estimated based on net primary productivity calculated from the spatial IIASA-GAEZ database.

Methodology:
Wood and paper commodities reported in FAOSTAT are processed in the LANDFLOW model in terms of three main sub-sectors: (i) a primary roundwood sector; (ii) a sector of derived wood products including sawn wood and wood panels; and (iii) the pulp and paper sector. Following the relationships sketched in the figure below, the LANDFLOW analysis first constructs a consistent wood balance for each country and year, taking into account domestic roundwood production, trade of primary roundwood, production and trade of the derived wood products, as well as of wood pulp and paper (including recycled paper). Starting from a mutually consistent trade matrix compiled from the physical bilateral commodity flows per country reported by the FAO, an iterative procedure was applied for each commodity and year for the period 1990 to 2008 to calculate balanced trade shares and to ensure the full mutual consistency of export and import flows, i.e., whatever a country in region i reports as export to region k must also show up as import from region i by a country of region k.
LANDFLOW then calculates the extent of forest land associated with roundwood production using each country's respective estimate of forest land productivity. The commodity balances and associated land balances form a system of linear equations that is solved each year for all commodities and markets to obtain a vector of land intensities in a country's domestic supply by commodity and for each market. These intensities are then further applied to calculate the respective land embodied in the production and utilization of each sub-sector (e.g. sawn wood, panels, pulp and paper, etc.).
In order to avoid double counting in wood and land balances, recycled paper in LANDFLOW is treated as containing no land. In other words, the land use/deforestation associated with the volume of roundwood required for paper production is attributed to the first cycle of paper production and use only.



Output files:

1) Output Dec.2011 for period 1990-2008, 14 world regions

1a) Roundwood volumes and forest land in supply and utilization:

FOR-Ama1.prn	Forest Land in Supply and Utilization, by Market, (1000 ha)
FOR-Qmat1.prn	Roundwood in Supply and Utilization, by Market, (1000 cum)

1b) Trade matrices:

FOR-TmatA2.prn	Trade Volumes, Exports by Market, (1000 ha)
FOR-TmatQ2.prn	Trade Volumes, Exports by Market, (1000 CUM)

2) Output Version 2005 for period 1985-2000 (MOSUS project)
New-FOR_RwdArea0.xls
FORarea-bal.prn
FORarea-res.prn

Application

The database has first been developed for the project "Modeling Opportunities and Limits for Restructuring Europe towards Sustainability (MOSUS)". Recently results have been included in the project ‘The impact of EU consumption of food and non-food imports on deforestation’, contracted by the European Commission.

Descriptive keywords

Land embodied in trade, sustainable consumption, land use for forestry product consumption

Data access

Ascii and excel files

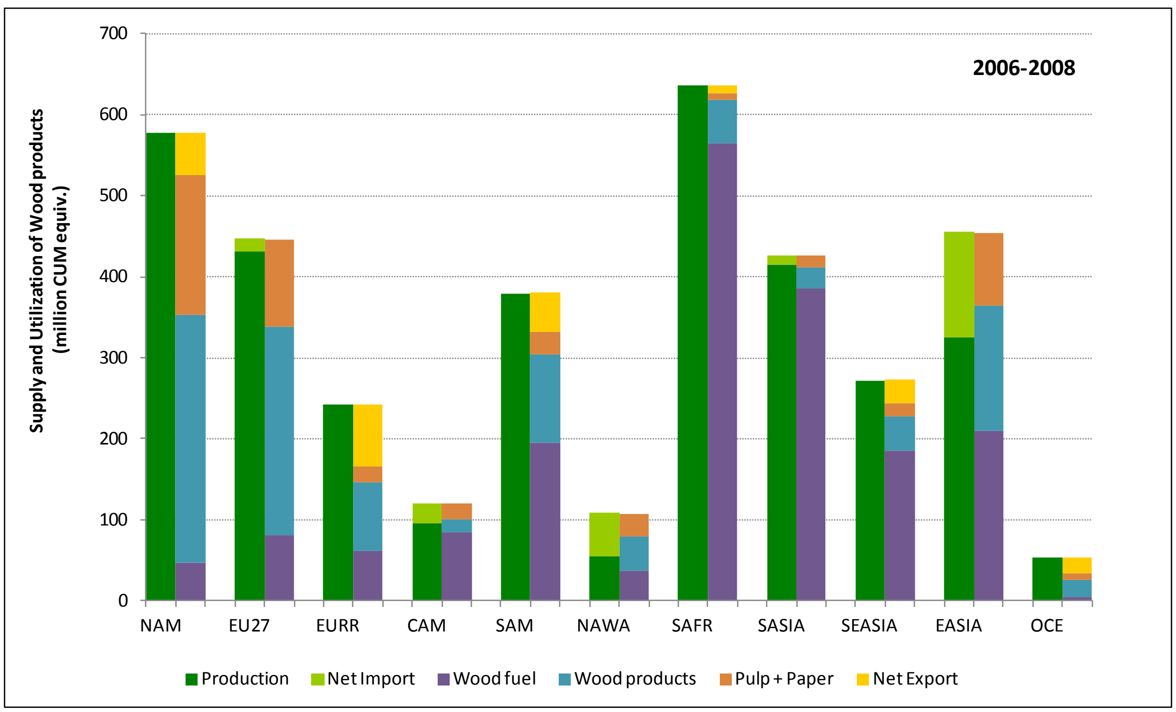
Supplemental information

Further expansion update when more recent years of FAOSTAT data become available
Key references: European Commission, 2012. Comprehensive analysis of the impact of EU consumption of imported food and non-food commodities and manufactures goods on deforestation, *forthcoming*

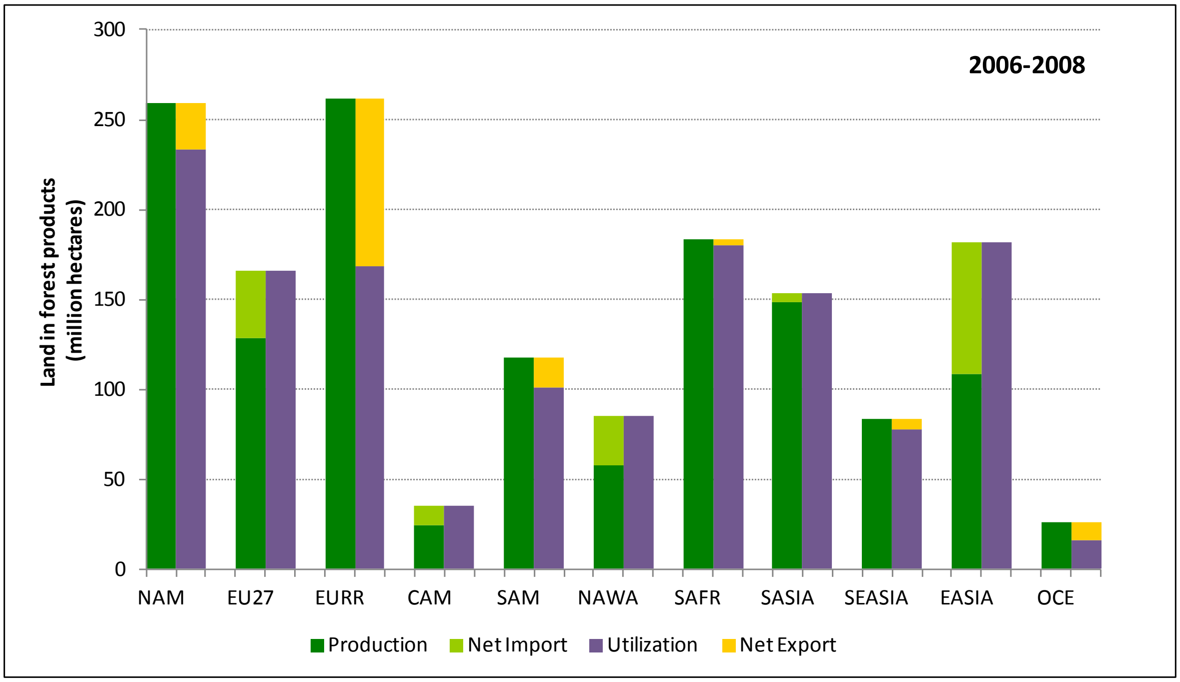
Use limitation

Use restrictions for the 2011 version until end of contract no. N93Q7-EC-ENV-Consumption&Deforestation.

Selected figures:



Total roundwood (CUM equiv.) in the regional supply and utilization of wood and paper products (2006-2008)



Forest land in regional supply and utilization of wood and paper products (2006-2008)

Attribution of deforestation to main sectors and primary commodities

Date: 2012-03-31
Edition: Version 1 (latest update: 2011.12.01)
Presentation form: Data Tables, Executable program under Windows operating system
Data source: LANDFLOW model

Spatial representation

Extent: Global
Type: Tabular
Resolution: Country level

Temporal extent

Time period: cumulative for periods 1990 – 2000 and 2000 – -2008

Abstract

A global and consistent country-level database of main sectors contributing directly or indirectly to deforestation between 1990 and 2008 has been compiled. Estimated gross deforestation (based on reported net deforestation and regional/national afforestation) is attributed to the following main sectors:

i) cultivated land expansion and related crop production increases (agriculture - cropland)
ii) pasture expansion and ruminant livestock production increases (agriculture - livestock)
iii) industrial round-wood extraction prior to agricultural expansion (logging)
iv) expansion of rural settlement, urban areas and infrastructure (built-up)
v) natural hazards - fires mainly (natural)
vi) residual deforestation that cannot be explained by the above drivers was assigned to category 'unexplained' (as recommended by export workshop)

Deforested land associated with expansion of crop cultivation and plantations of perennials is attributed to specific individual crops/perennial plants in proportion to each crop's magnitude of harvested area expansion.

Purpose

In a globalized world with its complex supply chains and trade relations, consumption patterns in one country can cause land use changes far away. Avoiding deforestation, the permanent conversion of forest to other uses, is a key concern for GHG emission reduction and safeguarding biodiversity. The aim was to quantify the association of national/regional consumption/utilization of primary and processed or manufactured goods with observed deforestation. Causes of deforestation are multiple, complex, and vary from region to region and over time with cascades of drivers, a clear cause-consequence relationship is difficult to establish. An important first step is to estimate 'deforested land content' associated with main sectors and primary commodities.

Methodology/Data generation

Input Data: Time series data of 1990 to 2008 on land use and agricultural production published by the FAO's FAOSTAT domain are used as the basis for the allocation of deforested area loss to agricultural expansion for crops and livestock production, and natural hazards. The Forest Resource Assessment 2010 (FRA 2010) provides country-level data on net deforestation for three periods 1990-2000, 2000-2005 and 2005-2010, and regional estimates of afforestation rates (and sometimes natural expansion). FRA reports and FAO expert judgment were consulted for estimates of forest land seriously affected by fire. National estimates of deforestation were extracted from FRA2010 country reports, gaps were closed using regional estimates from the FRA2010 report.

Methodology: The methodology follows a three-stage approach.
First for each country a land-use transition model estimates area conversions between 1990 and 2000 and between 2000 and 2008 for the following main land use categories: forest, agriculture, built-up land and all other land. Deforestation is attributed to the following land-use change categories: i) forest land converted to agriculture; ii) forest land converted to built-up land in the process of urban expansion and infrastructure development; iii) forest land converted to 'other land' due to natural causes (e.g. fires); and iv) other unexplained deforestation.
Secondly, the deforested land attributed to agriculture is separated into land used for cropping and land converted to pastures for ruminant livestock production. A small fraction of deforestation is allocated to the forestry sector (logging for industrial roundwood) to account for wood extraction on forest land that has been converted for agriculture. In a third step, deforested land associated with expansion of crop production is then attributed to specific individual crops.

Output variables:
Table Defor_by_Sector reports deforestation and attribution of deforestation to main sectors including the following variables: Country Code; Country name; Region; Time period; Gross deforestation; Net deforestation; Afforestation; Crops; Livestock; Logging; Built-up; Natural causes; Unexplained. All variables reported in 1000 ha.
Table Defor_by_Crop reports attribution of deforestation to individual crops based on respective cropland expansion including the following variables: Country Code; Country name; Region; Time period; Crop commodity code; Crop commodity name; Defor_Crop_Share (percentage); Defor_Crop_Area (1000 ha)
Results have been input into two models (LANDFLOW and CICERO MRIO) to track commodity flows and 'embodied' deforestation from primary production via intermediate products and trade to final use and consumption.

Application

This global database is a key input for the project 'The impact of EU consumption of food and non-food imports on deforestation', contracted by the European Commission, DG Environment.

Descriptive keywords

Deforestation, sustainable consumption

Data access

Excel file: Defor_v6_Dec2011_final.xls

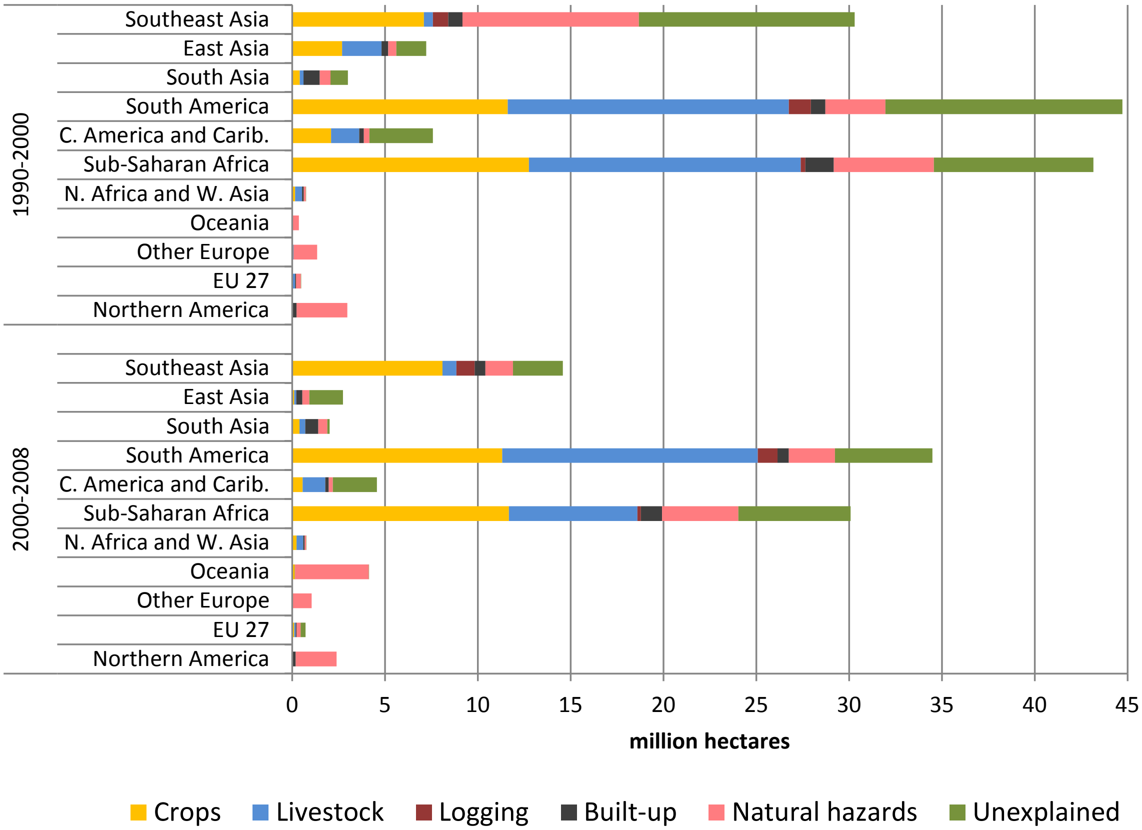
Supplemental information

Further expansion and update is possible when additional years of FAOSTAT data become available and when results of the Remote Sensing Analysis associated with FRA 2010 are published.
Key references: European Commission, 2012. Comprehensive analysis of the impact of EU consumption of imported food and non-food commodities and manufactures goods on deforestation, *forthcoming.*

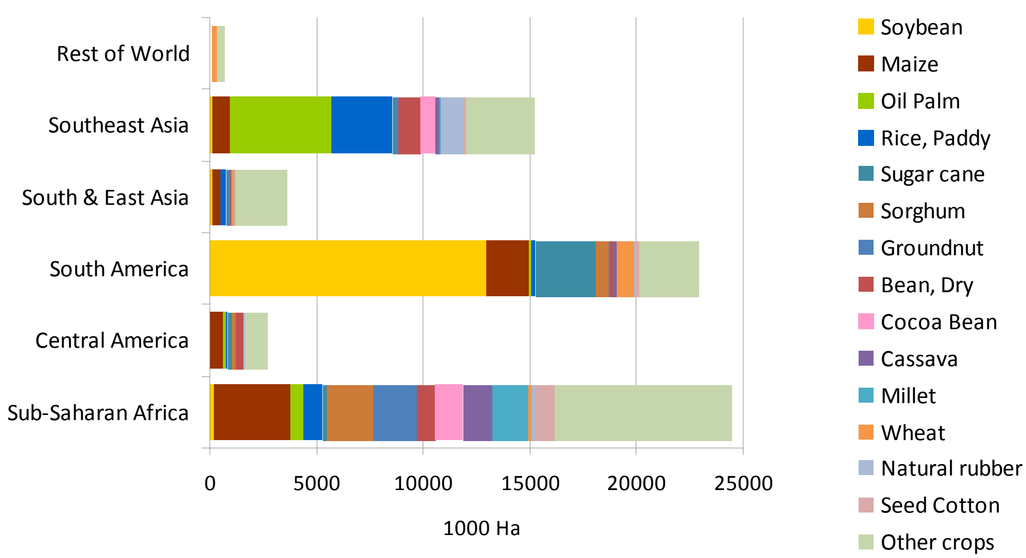
Use limitation

Use restrictions until end of contract no. N93Q7-EC-ENV-Consumption&Deforestation

Selected figures:



Regional deforestation by main sectors, cumulative 1990-2008



Contribution of specific crops to deforestation associated with the expansion of cultivated land for crop production between 1990 and 2008, per region

Deforestation associated with the consumption of crop, livestock and forestry products

Date: 2012-03-31
Edition: Version 1 (latest update: January 2012)
Presentation form: Data Tables
Data source: LANDFLOW model

Spatial representation

Extent: Global
Type: Tabular
Resolution: Country level

Temporal extent

Time period: cumulative for period 1990 – 2000 and 2000 – -2008

Abstract

Agriculture is a prime driver of deforestation, often preceded by roundwood extraction. In a globalized world with its complex supply chains and trade relations, consumption patterns in one country can cause deforestation far away. For instance, the demand for palm oil as a manufacturing ingredient or soybean cakes as animal feed in one country may contribute to deforestation in another. Agricultural consumption patterns were attributed to deforestation providing a complete and consistent global analysis of agricultural production, trade and consumption. The LANDFLOW model quantifies deforestation embodied in agricultural and forestry commodity flows, taking into account the complex commodity flows via trade from primary production to final use, intermediate products (notably animal feeds), and joint products (e.g., livestock producing milk and meat).
The database includes for each country/region annual supply/utilization accounts of agricultural and forestry commodities and their embodied deforestation for the period 1990 to 2008 for eight major crop groups and two animal groups. Supply (i.e. Production + Imports + 'from Stock') equals utilization (i.e 'Consumption of livestock products' + 'Consumption of crops and crop products' + Exports + 'Seed and waste').
The database records embodied 'deforested land' (in hectares) in supply and utilization for:

- 'Deforested land' attributed to cultivated land expansion for crop products (Crop-Amat1F.prn)
- 'Deforested land' attributed to cultivated land expansion for livestock products (Lvst-Amat1F.prn)
- 'Deforested land' attributed to cultivated land expansion for agricultural products (Total-Amat1F.prn) (i.e. the sum of Crop and Livestock Products)
- 'Deforested land' attributed to pasture expansion for ruminant livestock products (Lvst-Gmat1F.prn)
- 'Deforested land' attributed to industrial round wood extraction preceding agricultural expansion (FOR-Amat1F.prn)

The eight crop groups include 1) Cereals; 2) Roots & tubers; 3) Sugar crops; 4) Oil crops; 5) Fruits/Veg/Spice; 6) Stimulants; 7) Industrial crops; 8) Fodder crops. 9) Total crops.
The two animal groups include 1) Ruminants; 2) Pigs and Poultry; 5) Total livestock.
Industrial round wood products are traced separately for 1) Wood products and 2) Pulp & Paper.
All data are also recorded in per capita terms.

Trade matrices of embodied deforested land flows were constructed for crop products (Crop-TmatA1F.prn), livestock products (Lvst-TmatA1F.prn, Lvst-TamtG1F.prn), and forestry products (For-Tmat1F.prn).

Purpose

Deforestation – mainly the conversion of tropical forest to agricultural land – is still alarmingly high. The forestry sector, mainly through deforestation, accounts for about 17% of global greenhouse emissions, making it the second largest source after the energy sector. Deforestation also has severe adverse impacts on forest biodiversity, soil and water resources and local livelihoods. Agricultural products are increasingly traded and consumption patterns in one country may cause deforestation far away. LANDFLOW tracks the cross country flows of deforestation embodied in trade associated with the consumption of crops and livestock products and with forestry products from round wood preceding agricultural expansion. The resulting database thus makes an important contribution towards the identification and prioritization of rational policies to reduce deforestation and achieve sustainable global consumption.

Methodology/Data generation

Input Data: The main input data source is the FAO online databases (FAOSTAT), which contain various domains of national level time-series data, including primary crop and livestock production, land use data, animal stock numbers, commodity supply and utilization balances of primary and derived products, national commodity trade data, and bilateral commodity trade data. The Forest Resource Assessment 2010 provides information on deforestation, afforestation, and selected variables required for the attribution of main sectors to deforestation.

Methodology:

First, a global and consistent country-level database was compiled attributing deforestation recorded between 1990 and 2008 to main sectors. They include i) cultivated land expansion and related crop production increases; ii) pasture expansion and ruminant livestock production increases; iii) industrial round-wood extraction prior to agricultural expansion; iv) built-up land increases; v) natural hazards; and vi) 'unexplained', which constitutes the residual amount of deforestation that could not be attributed to agricultural expansion and forestry on the basis of available time series data. It may include unsustainable forestry and/or illegal unrecorded activities.

Second, deforested land associated with expansion of crop cultivation is attributed to specific crops/perennial plants in proportion to each crop's harvested area expansion during the reporting period, in order to account for direct and indirect effects of expansion (see data-sheet: 'Attribution of deforestation to main sectors and primary commodities).

Third, LANDFLOW tracks the extents of past deforestation during the reporting periods of 1990-2000 and 2000-2008, from production to final use. Calculations are based on country data at detailed SUA commodity level and follow the logic outlined for physical land resources associated with agricultural production and utilization (see data-sheet 'Land associated with production and utilization of crop and livestock products), using instead of total cultivated and pasture land the extents of deforestation attributed to the crop and livestock sectors, and consequently to individual cropping sectors in the countries where deforestation occurred.

For the forestry sector, calculations start from the country of origin for each wood commodity, estimate the deforestation content/intensity in a country's national roundwood supply and track the embodied 'deforested' land content and flows associated with processing and trade of forest products and their utilization. Solving this system of inter-linked flows gives a complete account of land content and extent of deforestation associated with intermediate use and final utilization of wood-based products in each country/region.

Output files:

CropLand-Regions_08Jan2012.xls (Regions, cumulative for period 1990-2000, 2000-2008)
FOR-Amat1F.prn; FOR-Tmat1F.prn

Application

The global database has been developed for the project 'The impact of EU consumption of food and non-food imports on deforestation', contracted by the European Commission.

Descriptive keywords

Deforestation, sustainable consumption, agricultural expansion

Data access

Excel files

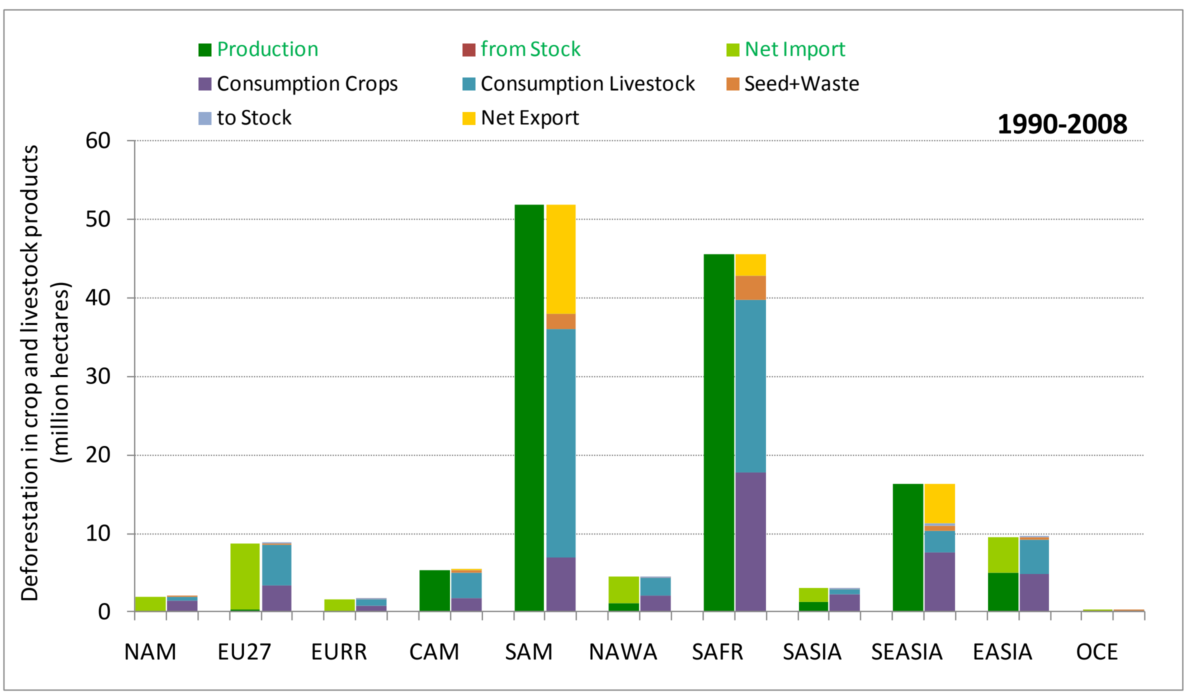
Supplemental information

Maintenance: Update when longer time series and improved deforestation data become available, e.g., results of the FRA 2010 remote sensing survey.
Key references: European Commission, 2012. Comprehensive analysis of the impact of EU consumption of imported food and non-food commodities and manufactures goods on deforestation, *forthcoming*

Use limitation

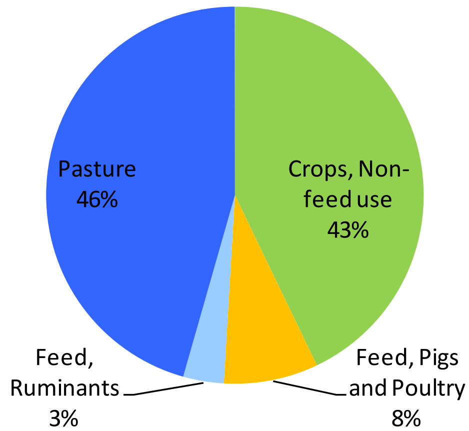
Use restrictions for the 2011 version until end of contract no. N93Q7-EC-ENV-Consumption&Deforestation.

Selected figures:



Cumulative deforestation embodied in supply and utilization of crop and livestock products
In the left bar shown for each region, the diagram indicates the estimated amount of deforestation associated with production and net imported extents associated with the trade of crop and livestock products. This represents the amount of deforestation in a country's supply of crop and livestock products. The second bar provides a distribution of the deforestation embodied in supply in terms of utilization of crop products (i.e., all domestic crop

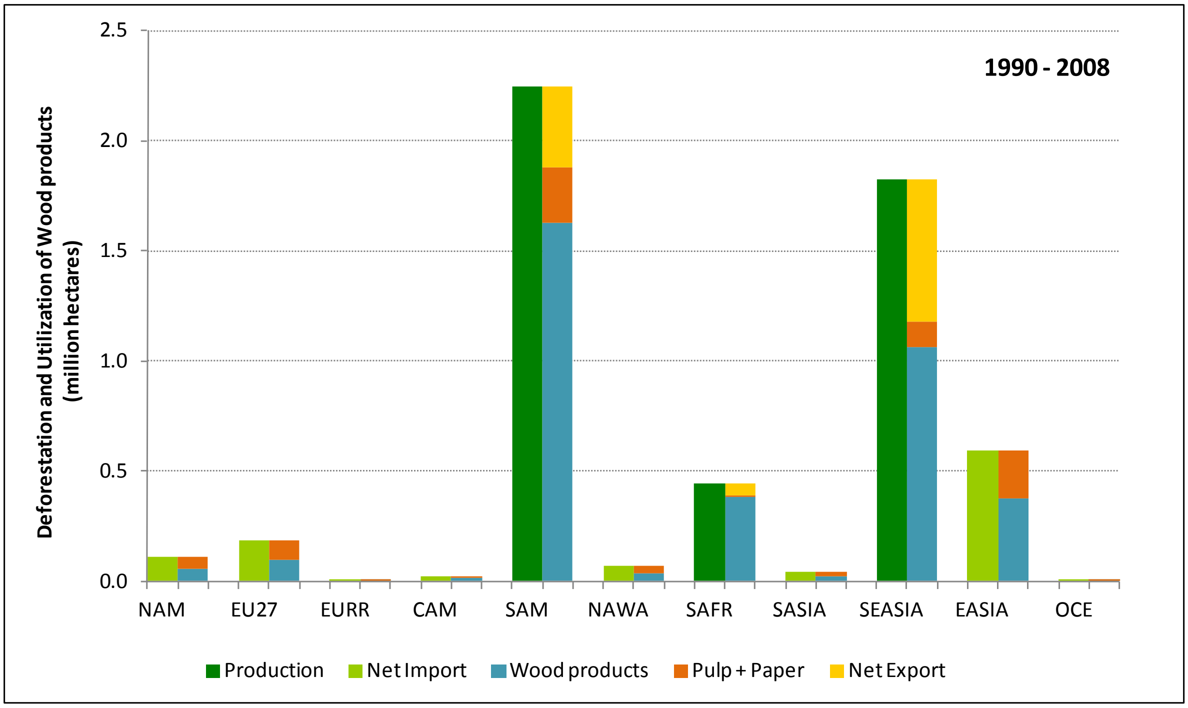
uses excluding feed, seed and waste), utilization of livestock products, a seed/waste category, to stock changes, and net exported extents of deforestation associated with a region's agricultural commodity trade.



Cumulative deforestation by use category of agricultural products, 1990-2008, representing a global total deforestation of 127 million hectares associated with agricultural expansion

	North America	EU27	Other Europe	Central America	South America	North Africa, Western and Central Asia	Sub Saharan Africa	South Asia	Southeast Asia	East Asia	Oceania	TOTAL EXPORT	EXPORT (excl. intra-region)
North America	4	0	2	13	0	2	0	0	0	7	0	28	24
EU27	28	768	129	28	13	198	88	12	31	97	4	1,396	628
Other Europe	3	17	15	0	0	11	1	0	0	4	0	51	36
Central America	290	125	27	177	24	29	4	2	1	56	2	737	560
South America	637	5,700	1,077	378	1,852	2,163	505	464	645	2,352	45	15,818	13,966
North Africa, Western and Central Asia	4	20	10	0	0	46	4	11	2	7	1	105	59
Sub Saharan Africa	331	1,638	150	19	43	467	482	150	181	561	12	4,034	3,552
South Asia	3	11	9	0	1	21	11	9	8	4	1	78	69
Southeast Asia	651	1,446	192	76	86	506	302	1,144	349	1,434	94	6,280	5,931
East Asia	4	13	10	1	2	7	3	1	8	38	1	88	50
Oceania	5	4	0	2	0	20	5	4	24	43	2	109	107
TOTAL IMPORT	1,960	9,742	1,621	694	2,021	3,470	1,405	1,797	1,249	4,603	162	28,724	
IMPORT (excl. intra-region)	1,956	8,974	1,606	517	169	3,424	923	1,788	900	4,565	160		24,982

Deforestation associated with regional trade of agricultural products (1000 ha), cumulative 1990-2008



Cumulative deforestation embodied in the regional supply and utilization of wood and paper products
In the left bar shown for each region, the diagram indicates the estimated amount of deforestation associated with domestic roundwood production and the net extents of deforestation associated with imports of wood and wood-based products. The second bar provides a distribution of the deforestation extents embodied in supply in terms of domestic utilization of roundwood and related wood products, and the net extents of deforestation associated with a region's wood and wood product exports.

PROJECTS AND APPLICATIONS

CATSEI, CHINAGRO

Policy Decision Support for Sustainable Adaptation of China's Agriculture to Globalization (CHINAGRO)

Date: 2012-03-31
Edition: Version 2 (latest update: 2011.11.31)
Presentation form: Dataset in GAMS storage, Digital maps

Spatial representation

Extent: China
Type: Data at the Grid-cell, County, Province, Region, and National levels.
Resolution: Digital maps are at the 1×1 km grid-cell level

Temporal extent

Time period: 1997 – 2030

Abstract

The data set has been compiled and consolidated for the Chinagro-I and Chinagro-II general equilibrium model. The model is a 17-commodity, 8-region welfare model with 6 income groups per region and agricultural supply represented separately for as much as 2844 counties. In every county several land use types in cropping and livestock production are distinguished, with in total 28 aggregate outputs. Apart from the 17 tradable commodities, local commodities such as manure, household waste and crop residuals are accounted for. Data are collected from various basic sources, reclassified into Chinagro taxonomy and made consistent for the Chinagro-I's base-year 1997 and Chinagro-II's base-year 2005. Consistency requirements for commodity balances and price margins follow from the general equilibrium structure of the model. The same data set is also used to provide benchmark information at county level to spatially explicit partial models that have been developed as a parallel activity in the Chinagro and CATSEI projects. The construction of the data set is programmed in GAMS, with a modular set-up that shows the steps from source data to final data and facilitates revisions of specific components. Base-year tabulations are also available in ascii format.

Purpose

The Chinagro and CATSEI projects (both sponsored by the EU Commission) study the development of China's food supply and feed availability, the growth of farm incomes and likely changes in land use patterns in the next three decades. The projects emphasize the geographical diversity of the country, as reflected by differences in land and livestock resources and prevailing farm technologies, as well as by differences in population pressure and non-agricultural income opportunities. The cost structure of trade and transportation in the country is a key element of the analysis which is conducted against the background of changing foreign trade conditions related to China's access to WTO, increasing concerns about water availability in the North and diverging speculations about future climate changes.

Methodology/Data generation

The projects Chinagro and CATSEI have developed and implemented models of two kinds. On the one hand a series of single-commodity, spatially explicit partial equilibrium models covering China with around 94,000 grid cells (at 10 km by 10 km), and on the other hand a single 17-commodity, 8-region general equilibrium welfare model with 6 income groups per region was implemented. Both kinds of models are run in parallel and have relative strengths of their own. The spatial detail of the partial equilibrium models provides a transparent geographical representation of supply, demand and trade flows between grid cells and also of price transmission through the delivery chain. The general equilibrium welfare model describes the diversity of the agricultural resources and farming patterns within a proper multi-commodity, multi-agent setting that allows for a rather detailed account of the interactions between crop and livestock sectors. It distinguishes farm supply for 2844 counties (virtually all) in which crop and livestock output follows from optimal resource use, at prevailing prices. Consumption, market clearing and nonfarm supply are modeled at a more aggregated level, i.e. at the level of 8 regions. The welfare model is the central tool of analysis for simulations of China's food economy over the next decades. The simulation experiments period of Chinagro-II cover the period 2010-2030.

The welfare model is fed by three data files, one with consumption and trade parameters, one with supply parameters and one with (alternative) scenario parameters. The data processing has collected basic information from various sources, brought the different components into Chinagro classifications, made them consistent, filled gaps and produced the model input files. The same data files are also used to provide benchmark information at county level to the partial equilibrium models, and of course these models require additional data with more spatial detail.

The data set covers the full economy, albeit with considerably more detail in agriculture than in non-agriculture. It distinguishes local and tradable commodities. Local commodities are traded only inside and the vicinity of a county, tradable commodities are traded across the country as well as internationally. Prices and quantities are collected for both types of commodities. Since a general equilibrium model requires balanced accounting in prices and volumes, consistency of supply and demand volumes is explicitly imposed, as well as plausibility of price margins. Transaction values are calculated from prices and volumes. Obtaining a plausible picture of the value added of land use activities is an additional consistency requirement on prices and volumes. At the same time, the relation between agricultural resources (land, animals), intermediate inputs (feed, fertilizer), factor inputs (labour, power) and output (crops, meat, milk, eggs) should reflect current cultivation practices in Chinese agriculture.

All data work is integrated into one consistent set of computer programs in GAMS. A modular set-up is followed. First, the source data are derived topic by topic, then they are integrated and finally the model input files are produced. This set-up allows for revisions of individual modules, without giving up the mutual links between the modules. Documentation of source data and explanation of calculations is achieved inside the programs themselves. This approach must be seen as an investment effort that facilitates maintenance and future updates of the Chinagro model.

Application

The research outputs of Chinagro and CATSEI projects had a very significant policy impact in China. One policy report on "Who will feed China's livestock", of which L. Sun and G. Fischer are the leading authors and which put an emphasis on protein feed imports (in particular, DDGS import from the USA), was commented in hand-writing by one of China's top leaders within two weeks after the submission in September 2011, and then was well discussed in relevant policy making bodies of the State Council. A number of policy reports were commented in hand-writing by ministerial and provincial level leaders and then circulated for discussion. The Centre for Chinese Agricultural Policy of the China Academy of Sciences (CCAP-CAS) has adopted Chinagro-II for routine policy simulations and evaluation.

Descriptive keywords

China's agricultural transition, spatially detailed general equilibrium modeling, scenario simulations and analyses, agricultural trade, rural income, environmental impacts, food security, feed security, bio-fuel development, trade liberalization, WTO

Data access

CCAP-CAS, SOW-VU, IIASA

Supplemental information

Key references:

Fischer, G., J. Huang, M. A. Keyzer, H. Qiu, L. Sun, and W.C.M. van Veen. 2007. China's Agricultural Prospects and Challenges: Report on Scenario Simulations until 2030 with the Chinagro Welfare Model Covering National, regional and County Level. Project Report submitted to the EU and Dutch Government, Centre for World Food Studies, Free University of Amsterdam, Dec. 2007. VII+143 pp. Available at: www.iiasa.ac.at/Research.../...Chinagro/CHINAGRO-FinalReport2.pdf.

van Veen, W., P. Albersen, G. Fischer, and L. Sun. 2005. "Data set for the Chinagro welfare model: Structure and composition." SOW-VU Working Paper WP-05-03 (December 2005) the Centre for World Food Studies of the Vrije Universiteit (SOW-VU), The Netherlands. Available at: www.sow.vu.nl/pdf/wp05.03maintext.pdf.

Use limitation

Citation: Chinagro database, CCAP-CAS, IGSNRR-CAS, Beijing, China; SOW-VU, Amsterdam, The Netherlands, and IIASA, Laxenburg, Austria

Regional population projections for China

Date: 2012-03-31
Edition: Version 2 (latest update: November 2008)
Presentation form: Data Tables, MS Excel

Spatial representation

Extent: China
Type: Tabular
Resolution: China, regions, provinces

Temporal extent

Time period: five-year intervals for period 2000 – 2030

Abstract

The dataset combines national-level demographic scenarios for the period 2000 through 2030 with information about the provincial population distribution from the year 2000 census and projections of provincial birth-rate, death-rate, urbanization, and interprovincial migration based on historical data. Results are available for four projection scenarios at three levels of regional resolution and in age-group aggregation.

Purpose

In the CATSEI/CHINAGRO modeling and policy analysis regionally disaggregated population projections were needed for estimating regional food demand and regional labor supply. These regional and province-level population projections were developed primarily for use in the CATSEI and CHINAGRO projects.

Methodology/Data generation

The general objective of the project on "Chinese Agricultural Transition: Trade, Social and Environmental Impacts" (CATSEI) was to investigate the impact of China's current economic transition on its agricultural economy with special reference to the consequences of trade liberalization and of changing trade flows. A key component of future scenarios is the evolution of China's population and distribution across different regions. The core building blocks of the projection model are the national-level projections of urban and rural populations by age groups and the population distribution across provinces in rural and urban areas by age groups reported by the year 2000 census. Based on these an appropriate decomposition procedure was developed that provides the future evolution of provincial population, and was enhanced by information from supplementary models like statistics-based projections of regional birth rates, death rates, urbanization rates, and interprovincial migration.
The four population scenarios are: MEDIUM, LOW (low total, high urban), HIGH (high total, low urban), HIGH2 (high total, higher urban fertility).
The numerical results are available at three levels of aggregation. The most aggregated results are: rural and urban populations in three large age groups in eight regions and their national totals; province-level details: rural and urban populations in three large age groups; full-size output (31 provinces, 17 age groups, 5-year time steps from 2000 to 2030).

Application

Projects: CATSEI, CHINAGRO

Descriptive keywords

China, regional population projection

Data access

<<Chinapop-regional-2008.xls>>

Supplemental information

This set of projections is an update of a previous projection (see IIASA Interim Report IR-03-042). In the present version fertility, mortality, and other demographic parameter estimations were updated based on the year 2000 census.

Key references:

Toth FL, Cao G-Y, Hizsnyik E (2003). Regional Population Projections for China. IIASA Interim Report IR-03-042.

	Medium projection									
YEAR:2030	(1000 people)									
	Urban			**Rural**			**Urban**	**Rural**	**Prov/Reg**	**Urban**
Prov/Reg	**0-14**	**15-64**	**65+**	**0-14**	**15-64**	**65+**	**total**	**total**	**total**	**share %**
Beijing	1945	15170	3064	208	709	588	20179	1506	21684	93.1
Tianjin	1136	7162	1954	308	822	460	10252	1589	11842	86.6
Hebei	4621	26500	4587	5337	22846	8918	35709	37101	72810	49.0
Shanxi	3202	16593	2763	3064	10801	3526	22557	17392	39949	56.5
Inner-Mongoli	2266	11304	2364	1538	5713	2412	15934	9662	25596	62.3
Liaoning	3265	19309	6151	1772	6446	3573	28725	11791	40515	70.9
Jilin	2333	13734	3512	1250	5514	2549	19579	9313	28893	67.8
Heilongjiang	2741	14619	4793	1463	5998	3192	22154	10653	32806	67.5
Shanghai	2444	17588	4156	1	117	234	24188	352	24539	98.6
Jiangsu	5783	35492	7507	3614	15976	7474	48783	27065	75847	64.3
Zhejiang	4125	27610	5602	2392	9459	4591	37338	16442	53779	69.4
Anhui	3906	18366	3402	4601	16743	6047	25675	27391	53066	48.4
Fujian	3266	20228	3115	2507	10317	3106	26609	15930	42540	62.6
Jiangxi	3070	14814	2439	3828	13395	4181	20323	21403	41726	48.7
Shandong	7486	42704	8391	5314	21953	10319	58580	37586	96166	60.9
Henan	5868	31111	5086	7579	30360	10864	42064	48802	90867	46.3
Hubei	5317	28953	5562	3595	14947	5834	39832	24375	64207	62.0
Hunan	3770	20564	4141	4300	18277	7307	28475	29884	58359	48.8
Guangdong	15423	94265	10222	8498	25083	6113	119909	39694	159603	75.1
Guangxi	2926	15179	2636	3573	12877	4261	20741	20711	41452	50.0
Hainan	928	4792	657	728	2504	645	6377	3877	10253	62.2
Chongqing	2003	12281	2562	2196	9248	3353	16846	14797	31643	53.2
Sichuan	4902	24373	5098	6237	23020	9241	34373	38497	72870	47.2
Guizhou	2861	11868	1646	4227	12250	3216	16375	19694	36069	45.4
Yunnan	3812	18080	2131	5526	18364	4397	24023	28287	52311	45.9
Tibet	311	1186	112	621	1503	255	1609	2378	3987	40.4
Shaanxi	2501	13649	2590	2585	10219	3904	18740	16708	35448	52.9
Gansu	1905	10204	1470	2730	10780	2871	13579	16380	29960	45.3
Qinghai	482	2243	330	595	1908	408	3055	2910	5965	51.2
Ningxia	605	3209	415	739	2528	528	4230	3795	8025	52.7
Xinjiang	2404	12211	1389	2624	9206	1699	16005	13530	29534	54.2
Total 31prov	107610	605362	109845	93547	349882	126067	822816	569497	1392313	59.1
North	24258	139238	25844	21810	87491	34676	189341	143977	333318	56.8
Northeast	8339	47662	14456	4485	17957	9315	70458	31756	102214	68.9
East	16259	99056	20667	10608	42295	18345	135982	71249	207231	65.6
Central	12158	64331	12141	11722	46619	17321	88630	75662	164292	54.0
South	19617	119285	13994	11733	37904	9864	152895	59501	212396	72.0
Southwest	16504	81782	14072	21758	75759	24470	112359	121987	234346	48.0
Plateau	793	3429	442	1215	3411	663	4664	5289	9952	46.9
Northwest	9682	50578	8228	10215	38446	11414	68488	60075	128563	53.3

Integrated livestock planning and nutrients balances model

Date: 2011-03-31
Edition: Version 2 (latest update: 2011.10.15)
Presentation form: Executable under MS Windows operating system

Spatial representation

Extent: China
Source of data: China statistical year books, China agricultural census, China agricultural yearbook, CHINAGRO model projections, individual research
Resolution: County administrative units (2844), provinces (31), sub-national regions (8)

Temporal extent

Time period: 5-year time steps for period 1995 -2030

Abstract

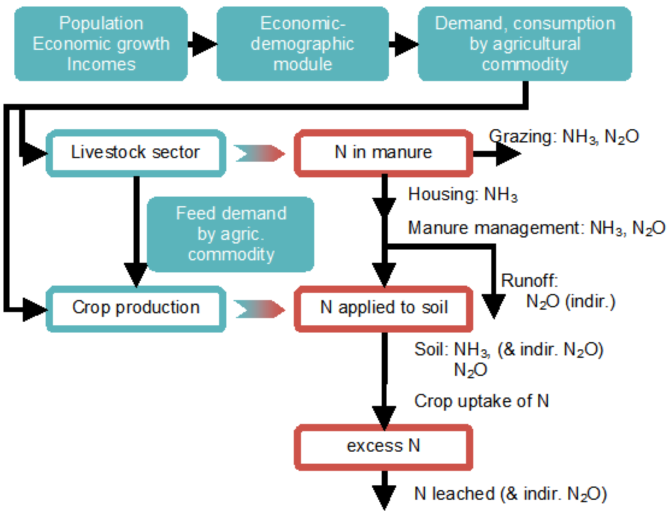
Over the past 30 years, China's demand and production of livestock products has intensified remarkably due to rapid development of the national economy and thereby induced rising living standards, urbanization and changing food preferences, and population growth. To meet a fast-growing demand for agricultural products, in a situation of limited land resources, China has been following a trend of agricultural production intensification characterized by high nitrogen fertilization rates and rapid introduction of industrial livestock production units in the vicinity of urbanized areas, causing negative ecological impacts through pollution and degradation of land and water, and increasing the risks of livestock diseases. There is much more livestock concentrated in rural areas near cities than land can support for proper manure and waste recycling. When coinciding with intensive crop cultivation, the problem of excess nutrients is further exacerbated by imbalanced fertilizer application. Apart from excess nutrients, the manure may contain harmful substances such as heavy metals, remains of livestock medicine and detergents.

Purpose

Initially, the integrated livestock planning and nutrients balance model has been developed with financial and technical support of the Food and Agriculture Organization (FAO) to investigate the risks of livestock epidemics outbreaks due to concentration of confined livestock production. In further development, the model has been substantially revised and applied in the CATSEI and INMIC projects with the aim to investigate the impacts of China’s rapid economic transition on the development of the agricultural sector, in particular the livestock sector and associated nutrients imbalances and GHG emissions. The model estimates the impacts of agricultural production intensification on the environment for studying alternative pathways of agricultural developments and to identify robust sustainable strategies mitigating agricultural pollution. The model thus explores how China could manage the required livestock expansion and its nitrogen use for agricultural activities in the coming decades in such a way that demands for agricultural products are satisfied while pressures on the environment are minimized.

Methodology/ How the model works/ Data generation

The main drivers and trends of agricultural intensification, including economic growth, population change and urbanization, are used to estimate spatially detailed activity levels of crop and livestock production. The model uses available data and projections (CATSEI project) on fertilizer consumption and livestock numbers to estimate input of reactive nitrogen to soils. Agricultural production is projected in a spatially detailed manner by main crops, which allows estimates of uptake/removal of nitrogen by plants. Using regionalized information on soil properties, climate conditions, and cropping habits, the model simulates the respective fractions of nitrogen compounds leaving the soil. Combining the information on nitrogen input and its removal by crops, nitrogen fluxes are estimated, which are used as indicators to highlight the magnitude of environmental loads and human exposure under alternative scenarios. The model assesses the effectiveness of various measures to modify agricultural practices in order to mitigate nitrogen spills into the environment: Business-as-usual allocation scenario; Sustainable reallocation scenario; Optimizing fertilizer use scenario; Minimized ammonia scenario based on advanced technology options. The model incorporates decision-support tools (stochastic optimization procedures) addressing the goals of sustainable livestock and crop production planning and allocation. A scheme of the model is presented in the figure below.



Nitrogen cascading: Schematic structure of the model

Descriptive keywords

Sustainable agriculture, livestock and crop production, agricultural pollution, GHG emissions, integrated modeling, robust production allocation, environmental indicators, nitrogen fluxes

Model and Data access

http://www.iiasa.ac.at/Research/LUC/
The model is available on request

Applications

Risk of livestock epidemics outbreak: FAO, Letter of Agreement PR 26922, 2005.
Further development work has been conducted within EU FP7 project on “Chinese Agricultural Transition: Trade, Social and Environmental Impacts” (CATSEI), “Atmospheric Composition Change, the European Network of Excellence” (ACCENT), and “Integrated Nitrogen Management in China” (INMIC, an activity of IIASA’s Greenhouse Gas Initiative).

Key references:

Ermolieva, T., Winiwarter, W., Fischer, G., Cao, G.-Y., Klimont, Z., Schöpp, W., Li, Y., Asman, W.A.H., 2009. Integrated nitrogen management in China. IIASA Interim Report, IR-09-005. IIASA, Laxenburg, Austria.

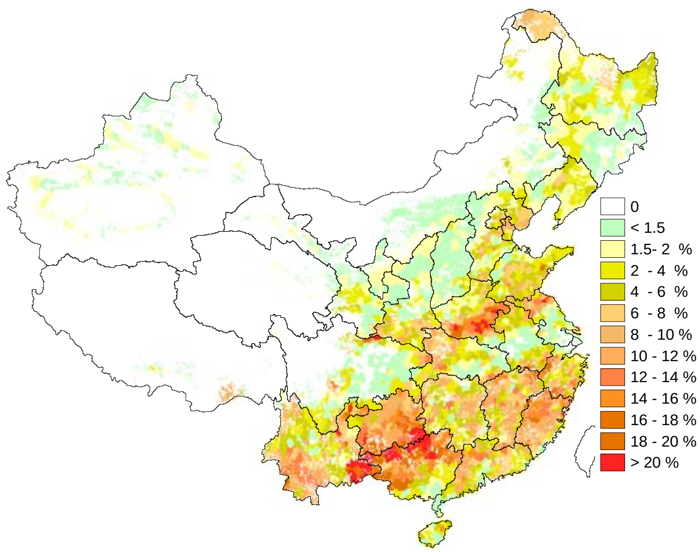
Fischer, G., Winiwarter, W., Ermolieva,T., Cao, GY., Qui, H., Klimont, Z., Wiberg, D., Wagner, F., 2010. Integrated modeling framework for assessment and mitigation of nitrogen pollution from agriculture: Concept and case study for China. Agriculture, Ecosystems and Environment, 136(1-2):116-124.

Velthof, G.L., Oudendag, D., Witzke, H.P., Asman, W.A.H., Klimont, Z., and Oenema, O., 2009. Integrated assessment of nitrogen emissions from agriculture in EU-27 using MITERRA EUROPE. Journal of Environmental Quality, 38:402–417, doi:10.2134/jeq2008.0108

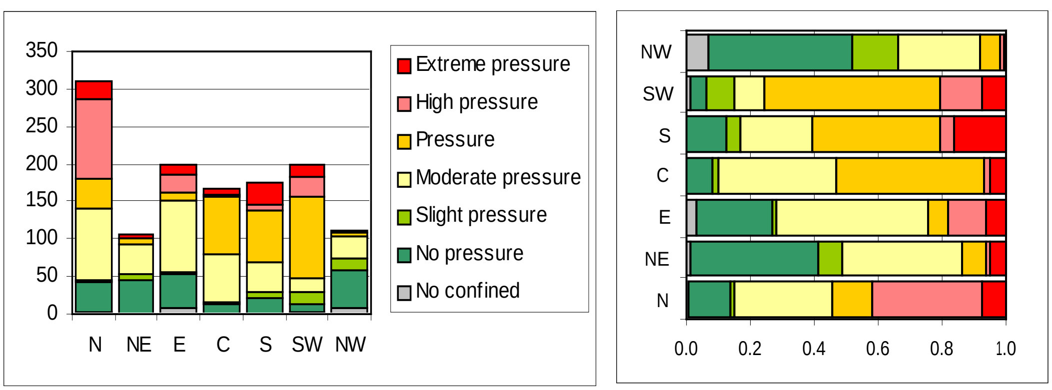
Use limitation

Citation: Integrated livestock planning and nutrients balance model, IIASA, Laxenburg, Austria.

Selected figures:



Nitrogen leaching fraction, by China counties



Absolute (million people) and relative (share of total population) distribution of population according to classes of severity of environmental pressure, 2000. The label on the horizontal axis indicate China regions: N, NE, E, C, S, SW, NW stand for North, North-East, East, Center, South, South-West, North-West, respectively.

INSTREAM

INSTREAM - Indicators Database

Date: 2012-03-31
Edition: Version 1 (latest update: 2011.01.15)
Presentation form: Data tables, MS Excel workbook

Spatial representation

Extent: Europe (EU27 and some closely related countries)
Type: Tabular
Resolution: country level

Temporal extent

Time period: 1990 – 2008

Abstract

The INSTREAM (Integration of Mainstream Economic Indicators with Sustainable Development Objectives) project undertook both qualitative and quantitative analysis to examine the connections among mainstream economic indicators and sustainable development indicators, mainly in the EU policy context. As part of the quantitative analysis a dataset of baseline indicators was compiled and a statistical analysis was conducted, mostly for countries belonging to the European Union. The dataset includes most of the 21 baseline indicators identified for the quantitative analysis by the INSTREAM project, as well as selected indices from the ”beyond GDP” initiative and some other sustainability indices. Statistical analysis was conducted.

Purpose

To establish a database to explore quantitative relationships among the INSTREAM indicators, as well as between these indicators versus selected "beyond GDP" and other indices.

Methodology/Data generation

The work of IN-STREAM focused on the links between mainstream indicators and sustainability measures and the links between the economic, social and environmental pillars of sustainability. As part of the quantitative analysis a dataset was compiled for countries of the European Union and a few other European countries for the period 1990-2008. The bulk of the original data for this analysis was taken from the official EuroStat online database and from a diversity of other sources for the rest of the indicators. An extensive correlation analysis was conducted. Results of the statistical analysis show patterns of correlations across countries and between indicator pairs.

Application

The database was used in the project 'Integration of Mainstream Economic Indicators with Sustainable Development Objectives' (INSTREAM) project funded by the European Commission DG Research.

Descriptive keywords

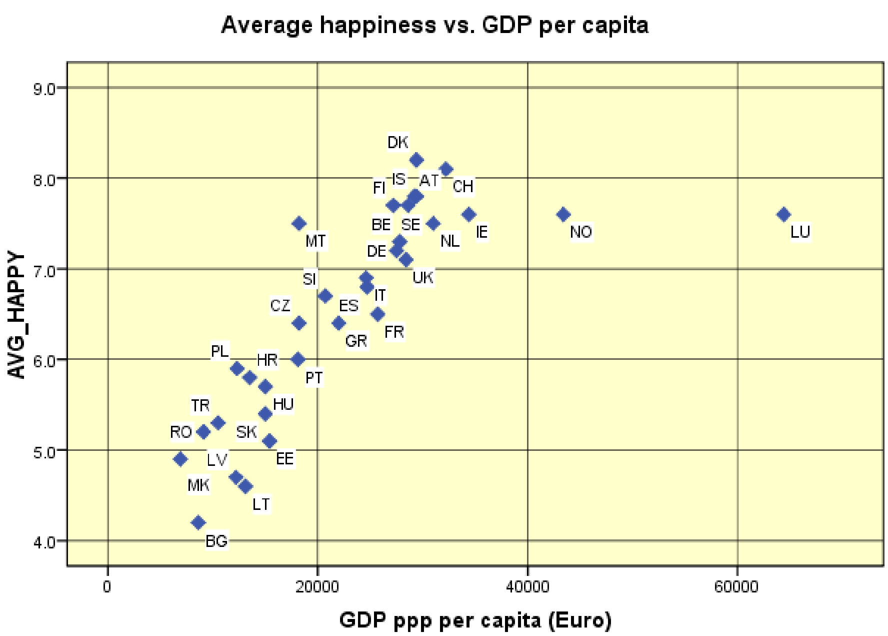
Sustainability indicators, GDP, beyond GDP, sustainable development, EU27, European Union, policy advice

Data access

Deliverable 3.2: 'Quantitative analysis of mainstream economic indicators and selected alternative measures', http://www.in-stream.eu/docs.html;
Excel Workbook: INSTREAM_IIASA_indicatorsDB.xlsx

			102	103	104	201	202	203	301	302	303	305	401	402	601	701
AT			gdp-perca	ppp-pe	p-gr-ra	e-perc	t-incom	sposab	loym-r	nploym	mploy-l	aged 1	prod pe	per h	ovt-deb	npPrice
	gdp-percap	102	1.00													
	gdp-ppp-pe	103	0.98	1.00												
	gdp-gr-rate	104	-0.04	0.07	1.00											
	hhold-incom	201	1.00	0.98	0.03	1.00										
	net-nat-incon	202	0.98	1.00	0.08	0.98	1.00									
	net-nat-dispc	203	0.98	1.00	0.08	0.98	1.00	1.00								
	employm-rat	301	0.87	0.82	0.11	0.70	0.80	0.81	1.00							
	unemploym-	302	0.32	0.27	0.25	0.52	0.29	0.29	-0.16	1.00						
	unemploy-lo	303	-0.03	0.00	0.43	0.26	0.02	0.02	-0.39	0.85	1.00					
	jobless hhol	305	-0.34	-0.26	0.36	0.05	-0.25	-0.26	-0.65	0.35	0.54	1.00				
	labour-prod	401	0.00	0.07	0.87	0.25	0.08	0.08	-0.10	0.41	0.59	0.45	1.00			
	labour-prod	402	0.99	1.00	0.10	0.99	1.00	1.00	0.85	0.25	-0.02	-0.27	0.08	1.00		
	govt-debt	601	0.37	-0.79	-0.25	-0.68	-0.79	-0.80	-0.71	-0.27	-0.27	0.21	-0.22	-0.80	1.00	
	compPriceL	701	-0.61	-0.75	-0.15	-0.74	-0.74	-0.73	-0.25	-0.26	-0.20	-0.13	-0.35	-0.72	0.57	1.00
	business-inv	801	-0.28	-0.41	0.13	-0.42	-0.43	-0.43	-0.49	-0.37	-0.11	0.38	-0.14	-0.43	0.11	-0.10
	fixed-invest-	802	-0.62	-0.74	0.14	-0.73	-0.73	-0.72	-0.17	-0.21	-0.09	-0.02	0.03	-0.71	0.53	0.94
	fixed-invest-	803	-0.78	-0.87	0.06	-0.82	-0.87	-0.86	-0.57	-0.24	-0.06	0.06	-0.01	-0.85	0.65	0.93
	energy-inten	901	-0.34	-0.40	-0.13	-0.15	-0.38	-0.38	-0.52	0.47	0.37	0.10	-0.42	-0.43	-0.07	0.46
	healthy-life-F	1001	-0.78	-0.80	-0.60	-0.84	-0.82	-0.81	-0.31	-0.81	-0.86	-0.49	-0.61	-0.78	0.72	0.45
	healthy-life-M	1002	-0.48	-0.39	-0.43	-0.40	-0.41	-0.42	-0.36	-0.66	-0.56	-0.18	-0.44	-0.41	0.55	-0.01
	life-exp-fema	1003	0.99	0.98	0.01	0.96	0.98	0.98	0.85	0.35	0.03	-0.24	0.04	0.99	0.35	-0.70
	life-exp-male	1004	0.99	1.00	-0.01	0.98	0.99	0.99	0.81	0.36	0.03	-0.24	0.02	0.99	0.33	-0.74
	common-bird	1201	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	ghg-emissio	1301	0.80	0.76	-0.02	0.82	0.78	0.77	0.29	0.72	0.41	-0.13	-0.09	0.73	0.26	-0.55
	freightTransp	1601	0.59	0.68	-0.36	0.71	0.67	0.66	0.12	0.02	-0.14	-0.16	-0.19	0.64	-0.18	-0.75
	gini-coeff.	1801	0.15	0.07	-0.22	-0.01	0.08	0.09	0.33	0.20	0.03	-0.48	-0.17	0.08	0.01	0.35
	youthEdu-se	1901	0.58	0.71	0.08	0.78	0.71	0.69	0.04	0.25	0.16	0.26	0.30	0.69	-0.42	-0.93
	TotalEdu-sec	1902	0.88	0.95	-0.07	0.92	0.95	0.94	0.61	0.33	0.07	-0.12	0.00	0.93	-0.68	-0.86
	early-school	1904	-0.55	-0.68	0.18	-0.76	-0.68	-0.66	0.18	-0.37	-0.22	-0.14	0.00	-0.63	0.41	0.90
	gerd%	2001	0.98	0.99	-0.02	0.97	0.99	0.99	0.79	0.38	0.02	-0.27	-0.02	0.99	0.25	-0.72
	gerd-percap	2002	0.98	0.99	0.00	0.98	0.99	0.99	0.83	0.35	0.00	-0.29	-0.01	0.99	0.22	-0.70

			801	802	803	901	1001	1002	1003	1004	1201	1301	1601	1801	1901	1902	1904	2001	2002
AT			stment	-invest-	vest-g	gy-inter	male (	Male (ye	at age l	age le	on-bird	-emiss	ghtTran	ni-coef	du-sec	du-sec	ed 18-2	gerd%	rd-perc
	business-inv	801	1.00																
	fixed-invest-	802	-0.06	1.00															
	fixed-invest-	803	0.09	0.97	1.00														
	energy-inten	901	-0.10	0.35	0.39	1.00													
	healthy-life-F	1001	0.57	0.08	0.71	-0.07	1.00												
	healthy-life-M	1002	0.56	-0.03	0.09	-0.02	1.00	1.00											
	life-exp-fema	1003	-0.21	-0.72	-0.85	-0.33	-0.79	-0.45	1.00										
	life-exp-male	1004	-0.23	-0.76	-0.89	-0.31	-0.81	-0.39	0.99	1.00									
	common-bird	1201	..	..	..	..	..	..	..	..	1.00								
	ghg-emissio	1301	-0.26	-0.61	-0.68	0.22	-0.50	-0.36	0.80	0.84	..	1.00							
	freightTransp	1601	-0.09	-0.85	-0.83	-0.24	0.59	0.23	0.62	0.70	..	0.60	1.00						
	gini-coeff.	1801	-0.72	0.30	0.19	0.39	-0.27	-0.26	-0.01	0.05	..	0.31	-0.12	1.00					
	youthEdu-se	1901	0.03	-0.92	-0.91	-0.38	-0.45	-0.02	0.68	0.73	..	0.54	0.80	-0.37	1.00				
	TotalEdu-sec	1902	-0.30	-0.89	-0.97	-0.28	-0.81	-0.24	0.92	0.96	..	0.81	0.81	-0.02	0.85	1.00			
	early-school	1904	-0.02	0.92	0.89	0.07	-0.04	-0.12	-0.61	-0.69	..	-0.73	-0.83	0.22	-0.89	-0.86	1.00		
	gerd%	2001	-0.28	-0.74	-0.88	-0.27	-0.76	-0.38	0.98	0.99	..	0.87	0.69	0.13	0.70	0.95	-0.70	1.00	
	gerd-percap	2002	-0.28	-0.72	-0.86	-0.29	-0.78	-0.40	0.98	0.99	..	0.86	0.67	0.11	0.68	0.94	-0.66	1.00	1.00



REFUEL

Land use scenarios assessing available land for energy crop production Europe

Date: 2012-03-31
Edition: Version 1 (latest update: 2009)
Presentation form: Data Tables
Data source: IIASA, REFUEL project

Spatial representation

Extent: Europe
Type: Tabular
Resolution: Country level

Temporal extent

Time period: 2000 – 2030

Abstract

Scenario-based estimates apply a "food first" paradigm and assess by individual countries up to 2030 the extents of cultivated land and grassland that could potentially be available for production of energy feedstocks including biofuels. Crop residues that may provide additional sources of bioenergy feedstock have been estimated as well.

Purpose

The purpose of the REFUEL project was to develop and assess ambitious yet realistic scenarios of potential land availability for biofuel feedstock production. The Renewable Energy Directive sets a target for 2020 of achieving a 20% share of renewable energy and a biofuels usage of 10% in transport. Full development of the biomass option requires a thorough analysis of possible consequences of a major shift in land use. While forests today provide the bulk of biomass energy used for heat and electricity, a still small but growing fraction of agricultural land is dedicated to the production of biofuel feedstocks. In the future food, feed and energy crops may compete for agricultural land causing food security, environmental, nature protection concerns.

Methodology/Data generation

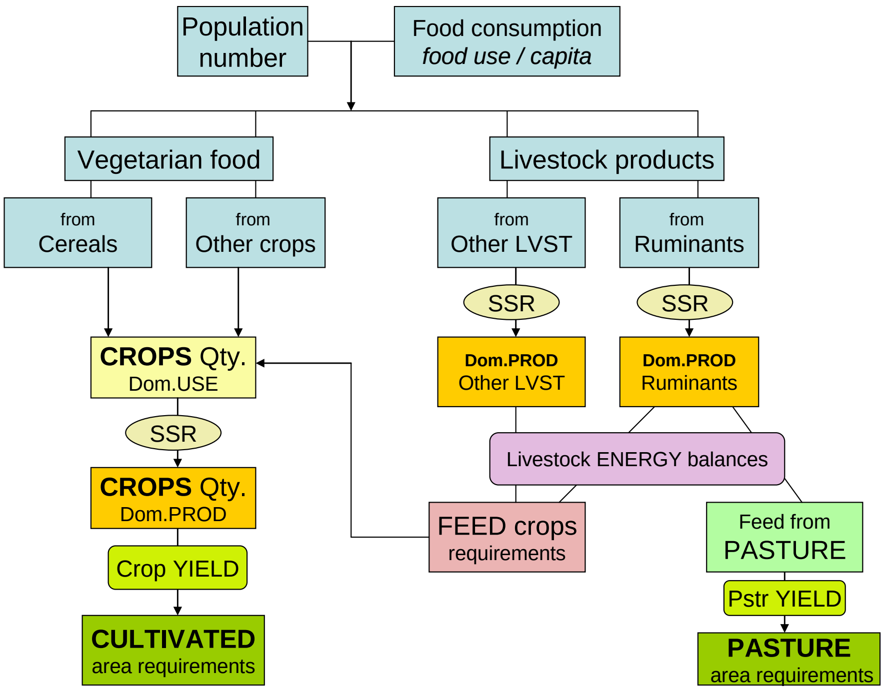
Input data:
Input data are derived from the project "Modelling Opportunities and Limits for Restructuring Europe Towards Sustainability (MOSUS)", when IIASA has created a comprehensive database: "Agricultural and forestry products trade balance database including production volumes and land use – a country-specific database from 1980 to 2002". It utilizes the large harmonized statistical data sources of the FAO to provide a full accounting of a country's produced, processed and traded agricultural products.

Methodology
The land use scenario database assesses available land for bioenergy production for three different scenarios for the period 2000 to 2030 covering the countries of EU27, Norway, Switzerland and Ukraine including:

A base scenario, that reflects developments under current policy settings and respects current trends in nature conservation and organic farming practices, by assuming moderate overall yield increases;
An environment oriented scenario with greater emphasis on sustainable farming practices and maintenance of biodiversity; and

An energy oriented scenario considering more substantial land use conversions including the use of same pasture land.

Land that may be freed up for alternative uses has been estimated for various scenarios representing conditions where projected food and feed demand from domestic production are satisfied ("food first" paradigm) while maintaining European self-reliance for agricultural products at current aggregate levels. Future land requirements for food and feed production were estimated following procedures outlined in the figure below.



Flow chart for food and feed area requirements calculation procedures

Future food demand, derived as a function of population number and per capita food consumption levels, was converted to domestic production levels using self-sufficiency ratios (SSR) with separate treatment of crop and livestock products. SSR has been calculated using production and trade data from the national statistics of FAOSTAT. Livestock production is associated with land via feed requirements of the livestock herd (livestock energy balances). Requirements of ruminants, being fed from pastures and from cultivated fodder and feed crops, have been considered separately from 'other livestock' (mainly monogastric animals). Aggregate livestock production intensity changes over time were implemented by modifying a technical coefficient, which describes the ratio of feed energy intake per unit of aggregate livestock production. Feed crop requirements and crops used for direct food consumption add up to domestic crop use (CROPS Qty. Dom.USE). Self-sufficiency ratios estimate the required levels of domestic crop production (CROPS Qty. Dom.PROD). Yields determine cultivated land area requirements of domestically produced food and feed crops. Pasture area requirements were calculated by estimating grassland production and comparing to ruminant feed requirements (net of feed and fodder from cultivated land and imports).

Output files:

Three land use scenario results describe until 2030 country level agricultural land use including: i) Cultivated land for food and feed production; ii) Cultivated land potentially available for biofuel feedstock production; iii) Pastures for livestock grazing; iv) Pastures for nature conservation; v) Pastures

for lignocellulosic bioenergy feedstock production; vi) Conversion of cultivated and pasture land to built-up areas required for urban expansion and infrastructure development.
In addition agricultural residues of food and feed crops for current and future conditions have been estimated for each country.

Application

The database has been developed and applied in the REFUEL project (www.refuel.eu) funded by the European Commission under the Intelligent Energy Program. REFUEL developed a biofuels road map, consistent with EU biofuel policies and supported by stakeholders involved in the biofuels field.

Descriptive keywords

Biofuels, land use scenarios, land resources, agriculture, crop residues, Europe

Data access

http://www.iiasa.ac.at/Research/LUC/External-Refuel/index.html

Supplemental information

Key references: Fischer G., Prieler S., van Velthuizen H., Berndes G., Faaij A., Londo M., de Wit M. Biofuel production potentials in Europe: Sustainable use of cultivated land and pastures Part II: Land Use Scenarios. Biomass and Bioenergy 34(2010)173-187.

Land productivity potentials for biofuel feedstock production in Europe

Date: 2012-03-31
Edition: Version 1, 2009
Presentation form: Digital Map, Tables
Data source: AEZ Europe

Spatial representation

Extent: Europe
Type: Raster Map
Resolution: 1x1 km grid-cell

Temporal extent

Time period: Productivity estimates based on current climate (1961-90)

Abstract

Spatial distributions of suitabilities of biofuel feedstocks in Europe were generated for each individual feedstock as well as for five main feedstock groups covering a wide range of agronomic conditions and energy production pathways. Potential biomass productivity and associated energy yields were calculated for each 1km grid cell throughout Europe. Estimated agronomically attainable yields, both in terms of biomass (kg ha-1) as well as biofuel energy equivalent (GJ ha-1), were mapped and tabulated by agriculture and pasture land cover classes as derived from the CORINE land cover database and results were aggregated by administrative units at NUTS 2 level.

Purpose

The Renewable Energy Directive sets a target for 2020 of achieving a 10% biofuels usage in transport. Second-generation biofuels produced from waste, or non-food cellulosic and lignocellulosic biomass will be double credited towards the 10% target. Europe's variability in spatial characteristics of biophysical conditions combined with management, land availability and efficiency of conversion technolgies determine a country's technical domestic biofuel energy potentials. The biofuel land productivity database presents a spatially detailed feedstock suitability and productivity assessment for a wide range of land utilization types, including feedstocks for first and second-generation biofuels, and provides a regional specification of Europe's biofuel production potential.

Methodology:

Input data:

An AEZ Europe database has been compiled using: CRU Climate data sets of the University of East Anglia; NASA Shuttle Radar Topographic Mission (SRTM) elevation models; Soil data from the European Soil Bureau Network; Land cover data from CORINE Version 1990 and JRC GLC2000; Protected areas from IUCN-WCMC inventory. An administrative layer map has been included in the GIS representing NUTS 2 of the member states of EU27, province/state in other countries of Western, Central and Southern Europe, and oblasts in the Ukraine.

Methodology

For the suitability and productivity assessments with the AEZ modelling framework, five main groups of land utilization types (LUT) with specific biofuel production pathways are distinguished, namely:

1) Woody lignocellulosic plants – (2nd generation biofuels) include short rotation forestry management systems. Tree species considered include poplars, willows and eucalypts. The selected tree species cover a wide range of ecological regions of Europe;

2) Herbaceous lignocellulosic plants - (2nd generation biofuels) include miscanthus, switch grass and reed canary grass;
3) Oil crops – (1st generation biofuel for production of biodiesel). The two selected oil crops are widely grown in respectively southern and central, and northern and central Europe including sunflower Rand rapeseed;
4) Starch crops - (1st generation biofuel for production of bioethanol). Selected cereals are wheat, maize, rye and triticale. Wheat and maize are widely grown, rye and triticale are (currently) much less grown but have similar potential for starch to energy conversion as wheat; and
5) Sugar crops - (1st generation biofuel for production of bioethanol). Sugar beet is a widely grown crop in Europe, while sweet sorghum is regarded as a potential energy crop for the sugar to energy production pathway.

Suitability and productivity assessments were carried out by matching climate characteristics with plant requirements, calculating annual biomass increments or yields including consideration of soil and terrain characteristics of each grid-cell (details of the AEZ methodology are described elsewhere). Potential biomass productivity and associated energy yields were calculated for each grid cell and feedstock biomass yields were converted to biofuel energy equivalents using published conversion factors. For the tabulation of biofuel feedstock potentials for respective land use categories, a uniform Pan-European land resources database was compiled at the spatial resolution of 1 km2.

Output files:
GIS map at the spatial resolution of 1 by 1 km.
Tabulation of results at land cover and administrative unit level.

Application

The database has been developed in the REFUEL project (www.refuel.eu) funded by the European Commission under the Intelligent Energy Program. It developed a biofuels road map, consistent with EU biofuel policies and supported by stakeholders involved in the biofuels field.

Descriptive keywords

Biofuels, biofuel feedstock potential, land resources, agriculture, Europe

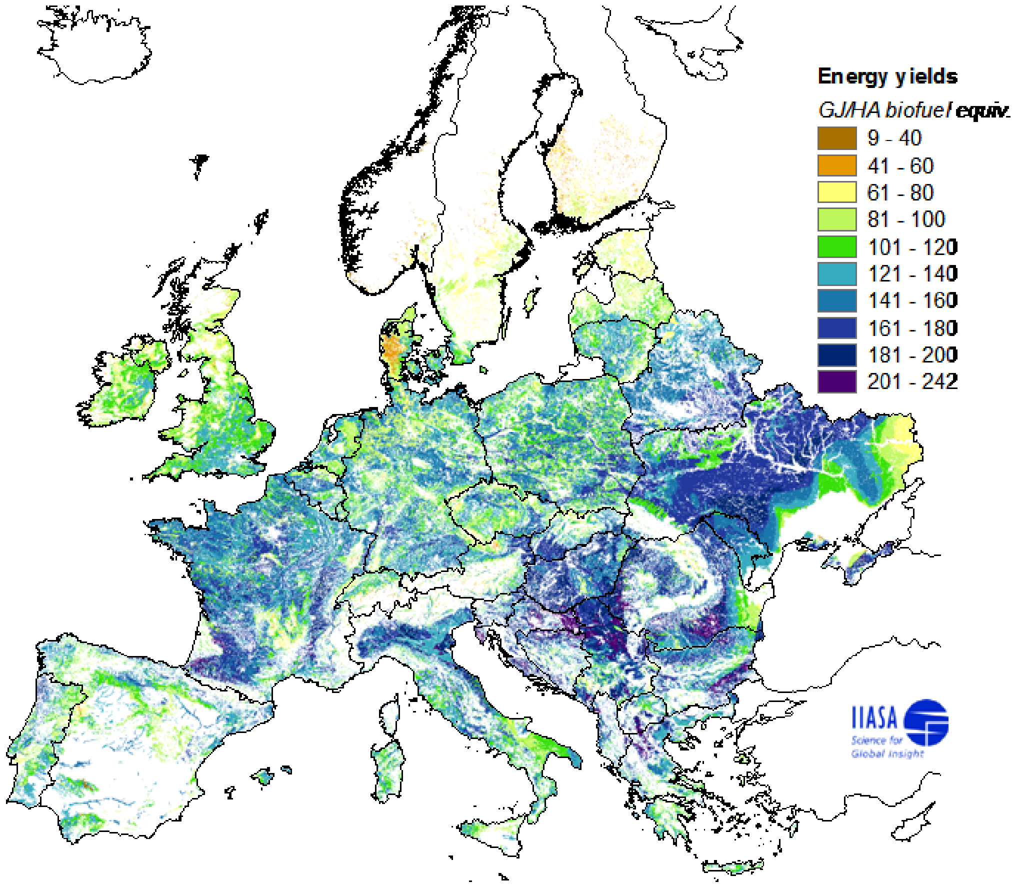
Supplemental Information

Key references: Fischer G., Prieler S., van Velthuizen H., Lensik S.M, Londo M., de Wit M. Biofuel production potentials in Europe: Sustainable use of cultivated land and pastures Part I: Land Productivity Potentials. Biomass and Bioenergy 34(2010)173-187.

Use limitation

Citation: IIASA AEZ Europe, IIASA, Laxenburg, Austria.

Selected figure:



Potential energy yields of second-generation biofuel feedstocks on agricultural land

SAT

Rainfed Agriculture and Water Harvesting Potential in the Semi-Arid Tropics

Date: 2012-02-22
Edition: Version 1.0 (latest update: 2009)
Presentation form: Raster Maps and tables

Spatial representation

Extent: Global
Type: Grid data is used to represent geographic data with country tables for socio-economic data.
Resolution: 5 minutes

Temporal extent

Time period: annual Begin: 1961 End: 2000, 2020

Abstract

One of the critical regions concerning hunger, rising population, inadequate land and water resources, and lack of institutions and access to markets is the semi-arid tropics (SAT), where poor small-holder farmers make their living from the land, which lie primarily within developing countries with rapid population growth and serious land degradation problems, and which also can be seen as one of the regions with the highest potential for increasing rainfed agricultural production.

This database provides spatial data on potential production, the standard deviation and coefficient of variation of production, number of failure years, soil water balance showing deficits and surplus water, and impact of water harvesting and soil moisture management techniques and climate change on five important crops in the semi-arid tropics and 16 types of those crops. Tabular information is available by country, region, and climatic zone on cultivated area and yields, population, moisture index, net primary production, livestock production, and other socio-economic indexes used to assess vulnerability.

CROPS	CROP TYPES	CLIMATE ZONES
Cereals	***(10)***	
Maize	4	Tropics
Sorghum	4	Tropics
Pearl millet	2	Tropics
Legumes	***(6)***	
Soybean	3	Tropics
Groundnut	3	Tropics
Total	***16***	

Purpose

The purpose of this database is to assess the vulnerability and potential of the countries in the semi-arid tropics to improve their rainfed agriculture and increase agricultural output to feed their own growing populations and also reduce world hunger and poverty.

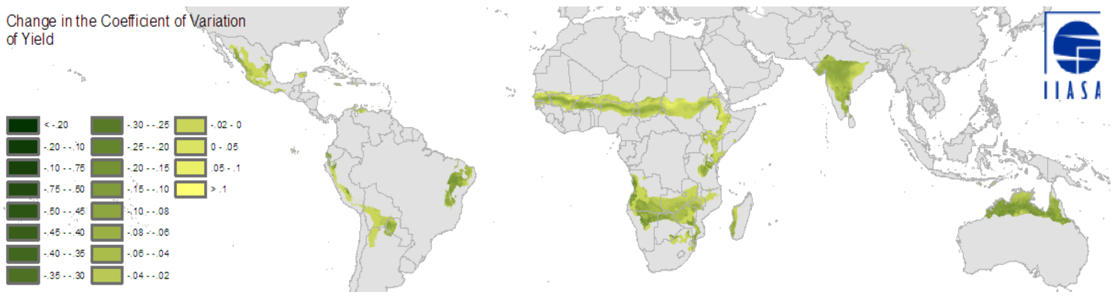
Methodology/Data generation

The potential production data was generated using a version of the IIASA and FAO Global Agro-Ecological Zones methodology adapted for assessing water harvesting and soil moisture management techniques.

Water harvesting potential was modeled by increasing the soil water storage capacity, while other dryland management practices to reduce evaporation were modeled primarily by adjusting crop coefficients (Kc values) throughout the year.

Application

The modeling methodologies and database were developed as part of the "Comprehensive Assessment of Water Scarcity and Food Security in Tropical Rain-fed Water Scarcity System: A multi-level Assessment of Existing Conditions, Response Options and Future Potentials" funded by the Comprehensive Assessment of Water Management in Agriculture (CA) through a grant from the Government of Netherlands to the IWMI. The database is available for further assessments of agriculture in the semi-arid tropics.



Change in the coefficient of variation of attainable yield for lowland sorghum with a 135-day growing period when dryland management practices are implemented.

Descriptive keywords

Semi-arid tropics, agricultural potential, water harvesting, dry land management, soil moisture, yield gap

Data access

Available upon request

Use limitation

Citation: Gunther Fischer, Harrij Van Velthuizen, Eva Hizsnyik, and David Wiberg. 2009. Potentially Obtainable Yields in the Semi-Arid Tropics. Global Theme on Agroecosystems Report no. 54 Patancheru 502 324, Andhra Pradesh, India; International Crops Research Institute for the Semi-Arid Tropics. 68 pp.

SCENES

SCENES Population Scenario Projector

Date: 2012-03-22
Edition: Version 1 (latest update: 2009)
Presentation form: Microsoft Excel Workbook

Abstract

The SCENES Population Scenario Projector is written in Microsoft Excel's Visual Basic and was developed out of the need for a population model that can provide immediate feedback to stakeholders and decision makers in the process of developing scenarios of the future. The population projector allows users to vary population growth rates or set a desired final total population at an endpoint in the future. The model varies fertility, mortality, and migration rates within plausible limits and rates of change set by experts to come as close as possible to the desired growth rates and timeline set by users. The users gain immediate feedback on the population trajectory in comparison with other projections and can modify rates accordingly to achieve a plausible and rapid quantified scenario of population development into the future.

Purpose

The Population Scenario Projector was developed in the European Union Framework Program 6 project "Water Scenarios for Europe and Neighbouring States (SCENES)" to help stakeholder groups understand population dynamics and build plausible quantified scenarios of population, one of the drivers of water demand. The tool can be used for rapid visualization of population development over time and can therefore be adapted to be used in any stakeholder setting in which population scenarios are needed or as a capacity building tool in other settings.

Methodology/Data generation

The model is based on cohort component population projection model. Separate modules apply annual data for countries within the EU and UN data at 5-year time steps for countries outside the EU. The modules are harmonized to produce aggregated output data at 5-year time steps, while maintaining country data at the time resolution of the input data. Fertility, mortality, and migration rates are allowed to adjust linearly over time within limits set by experts and extreme scenarios published by Eurostat and the UN. Excel's Solver is used as the optimizer to vary the rates in order to achieve a population trajectory that fits the scenario of the user, and results are displayed in graphical form for instant feedback.

Application

The model was developed and applied for the SCENES project as part of an integrated modeling framework for quantifying scenarios of water futures for Europe.

Descriptive keywords

Population scenario development, decision support tool, demographic modeling, SCENES

Model access

Available upon request

Supplemental information

The Population Scenario Projector is part of an integrated scenario quantification framework including models for the projection and downscaling to national level of GDP, energy, agriculture output and livestock numbers.

Thermal electricity production projections were done with a two variable model. The two variables were: 1. total electricity production per unit GDP as a measure of energy efficiency in the economy, and 2. the share of electricity produced by thermal power plants. Both variables were adjusted according to scenario storylines and past trends in each country, and results immediately available for the user graphically and checked against existing scenario quantifications.

Scenario quantifications of agricultural output and livestock number were done with IIASA's GAEZ, WFS, and downscaling methodologies and GDP was estimated by stakeholders at regional level and downscaled to national level using a modified version of the methodology employed by IIASA in its integrated assessment of greenhouse gas emissions and their mitigation.

Use limitation

Citation: Wiberg, D., Fischer, G., K.C., S. 2010. Projecting European Population, GDP, Energy, and Agricultural Land Use Based on a Participatory Scenario Development Process. EC GOCE 036822, Brussels.

SCENES European Population Scenario Projections

Date: 2012-03-31
Edition: Version 1 (latest update: 2010.03.12)
Presentation form: Data tables

Spatial representation

Extent: Europe and Northern Africa
Type: Tabular
Resolution: Country level

Temporal extent

Time period: 5-year intervals, 2000 – 2050

Abstract

The SCENES Population Scenario Projections are country-scale projections of total population for four different scenarios and 54 countries in Europe, parts of Central Asia, Northern Africa, and the Middle East. The population projections are part of a set of consistent, pan-European projections of the drivers of changes in water availability and use, developed as part of a stakeholder and expert driven scenario development process. Four scenario storylines, entitled Economy First, Fortress Europe, Policy Rules, and Sustainability Eventually, were created in SCENES by a group of stakeholders and experts. Based on these storylines, IIASA developed a consistent set of projections for population, GDP, thermal electricity production, agriculture and livestock production.

Purpose

The SCENES Population Scenario Projections form part of a set of consistent projections of the drivers of changes in water availability and use, enabling planners and managers to assess the impacts of alternative futures and find solutions that are robust across a set of these futures. They have been used in SCENES to investigate potential changes in water supply and demand based on changes in population and the other driving forces. The projections add to the limited number of consistent, interdisciplinary, country-scale scenario projections available and can be used for a variety of studies to assess the implications of possible futures and what actions are required now to ameliorate negative effects.

Methodology/Data generation

The projections were produced with the SCENES Population Projector, a population projection model developed to provide rapid and detailed feedback in a stakeholder setting. The model is based on a standard cohort component population projection model, with an optimizer added to balance fertility, mortality, and migration rates to be consistent and as close as possible with scenario storylines and population growth estimates provided by stakeholders, as well as within parameter bounds set by experts.

Historic data and assumptions regarding fertility, mortality and international migration by age and sex were obtained from Eurostat within EU countries and UNPD elsewhere. Because Eurostat data is available annually for the EU27 countries and UN projection data is available only at five-year time steps, two separate models were produced to make use of all available information. The models were then harmonized to run concurrently.

Application

The primary application for the population projections was for the EU-funded Water Scenarios for Europe and for Neighbouring States (SCENES) project. The dataset can be used anywhere that European population projections or a consistent set of scenario driver projections are desired.

Descriptive keywords

SCENES, cohort component, population, projection, scenario, Europe, international, inter-sectoral, stakeholder, drivers

Data access

Deliverable 1.7: Projecting European Population, GDP, Energy, and Agricultural Land Use Based on a Participatory Scenario Development Process and Excel Workbook (SCENES_IIASA_pop_story_logic.xlsx)

SCENES European GDP Scenario Projections

Date: 2012-03-31
Edition: Version 1 (latest update: 2010.03.12)
Presentation form: Data Tables

Spatial representation

Extent: Europe and Northern Africa
Type: Tabular
Resolution: Country level

Temporal extent

Time period: 5-year intervals, 2000 – 2050

Abstract

The SCENES GDP Projections are country-scale projections of gross domestic product for four different scenarios and 54 countries in Europe, parts of Central Asia, Northern Africa, and the Middle East. The projections are part of a set of consistent, pan-European projections of the drivers of changes in water availability and use, developed as part of a stakeholder and expert driven scenario development process. Four scenarios storylines, entitled Economy First, Fortress Europe, Policy Rules, and Sustainability Eventually, were created in SCENES by a group of stakeholders and experts. Based on these storylines, IIASA developed a consistent set of projections for population, GDP, thermal electricity production, agriculture and livestock production.

Purpose

The SCENES GDP Projections form part of a set of consistent projections of the drivers of changes in water availability and use, enabling planners and managers to assess the impacts of alternative futures and find solutions that are robust across a set of these futures. They have been used in SCENES to investigate potential changes in water supply and demand based on changes in the driving forces. The projections add to the limited number of consistent, interdisciplinary, country-scale scenario projections available and can be used for a variety of studies to assess the implications of possible futures and what actions are required now to ameliorate negative effects.

Methodology/Data generation

The projections were produced by applying stakeholder estimates for GDP growth for seven regions, four scenarios and two time periods. Stakeholder estimates were checked and, in a few cases, modified for feasibility and consistency. The regional GDP estimates were then downscaled to national scale and harmonized using the methodology IIASA developed as part of its integrated assessment of greenhouse gas emissions and their mitigation, using parameters that were altered to be consistent with each scenario.

Application

The primary application for the gdp projections was for the EU-funded Water Scenarios for Europe and for Neighbouring States (SCENES) project. The dataset can be used anywhere that European a consistent set of scenario driver projections are desired.

Descriptive keywords

SCENES, gdp, projection, scenario, Europe, international, inter-sectoral, stakeholder, drivers

Data access

Deliverable 1.7: Projecting European Population, GDP, Energy, and Agricultural Land Use Based on a Participatory Scenario Development Process and Excel Workbook (SCENES_GDP_PEP3_12_03_10.xlsx)

SCENES European Thermal Electricity Scenario Projections

Date: 2012-03-31
Edition: Version 1 (latest update: 2010.03.12)
Presentation form: Data Tables

Spatial representation

Extent: Europe and Northern Africa
Type: Tabular
Resolution: Country level

Temporal extent

Time period: 5-year intervals, 2000 – 2050

Abstract

The SCENES Thermal Electricity Projections are country-scale projections of thermal electricity production for four different scenarios and 54 countries in Europe, parts of Central Asia, Northern Africa, and the Middle East. The projections are part of a set of consistent, pan-European projections of the drivers of changes in water availability and use, developed as part of a stakeholder and expert driven scenario development process. Four scenarios storylines, entitled Economy First, Fortress Europe, Policy Rules, and Sustainability Eventually, were created in SCENES by a group of stakeholders and experts. Based on these storylines, IIASA developed a consistent set of projections for population, GDP, thermal electricity production, agriculture and livestock production.

Purpose

The SCENES Thermal Electricity Scenario Projections form part of a set of consistent projections of the drivers of changes in water availability and use, enabling planners and managers to assess the impacts of alternative futures and find solutions that are robust across a set of these futures. They have been used in SCENES to investigate potential changes in water supply and demand based on changes in the driving forces. The projections add to the limited number of consistent, interdisciplinary, country-scale scenario projections available and can be used for a variety of studies to assess the implications of possible futures and what actions are required now to ameliorate negative effects.

Methodology/Data generation

The projections were produced with the SCENES Thermal Electricity Projector, a projection tool developed to provide rapid, yet consistent and detailed feedback in a stakeholder setting. Past trends in total electricity production and thermal shares were assessed based on national data from the International Energy Agency (IEA). Thermal electricity generation was then projected to fit scenario storylines by making changes to two parameters, the electrical energy efficiency of the economy expressed as total electricity generation per unit GDP, and the change in the share of thermal electricity production to total electricity production over time. Comparisons were made with historic data and other existing projections to ensure feasibility.

Application

The primary application of the thermal electricity projections was for the EU-funded Water Scenarios for Europe and for Neighbouring States (SCENES) project. The dataset can be used anywhere that European a consistent set of scenario driver projections are desired.

Descriptive keywords

SCENES, thermal electricity, production, projection, scenario, Europe, international, inter-sectoral, stakeholder, drivers

Data access

Deliverable 1.7: Projecting European Population, GDP, Energy, and Agricultural Land Use Based on a Participatory Scenario Development Process and Excel Workbook (IIASA_SCENES_Energy_PEP3_12_03_10.xlsx)

SCENES Agriculture and Livestock Scenario Projections

Date: 2012-03-31
Edition: 2010-03-12
Presentation form: Data Tables

Spatial representation

Extent: 54 countries in Europe, Central Asia, Northern Africa and Middle East
Type: Tabular data
Resolution: Country level

Temporal extent

Time period: 5-year intervals for 2000 - 2050

Abstract

The SCENES Agriculture Projections are country-scale projections for four different scenarios and 54 countries in Europe, parts of Central Asia, Northern Africa, and the Middle East. IIASA created consistent projections for broader categories of crop and livestock production: cereals, other crops, fodder crops, ruminants, and other livestock and disaggregated these into projections of the production of wheat, rice, maize, other cereals, root crops, sugar crops, pulses, oil seeds/crops, fruit, vegetables, stimulants, fibres and tobacco, cattle and buffalo, sheep and goat, other large animals, pigs, and poulty. The projections are part of a set of consistent, pan-European projections of the drivers of changes in water availability and use, developed as part of a stakeholder and expert driven scenario development process. Four scenarios storylines, entitled Economy First, Fortress Europe, Policy Rules, and Sustainability Eventually, were created in SCENES by a group of stakeholders and experts. Based on these storylines, IIASA developed a consistent set of projections for population, GDP, thermal electricity production, agriculture and livestock production.

Purpose

The SCENES Agriculture and Livestock Projections are part of a set of consistent projections of the drivers of changes in water availability and use, enabling planners and managers to assess the impacts of alternative futures and find solutions that are robust across a set of these futures. They have been used in SCENES to investigate potential changes in water supply and demand based on changes in the driving forces. The projections add to the limited number of consistent, interdisciplinary, country-scale scenario projections available and can be used for a variety of studies to assess the implications of possible futures and what actions are required now to ameliorate negative effects.

Methodology/Data generation

To numerically project agricultural changes in the SCENES scenarios, we used empirical parameters characterizing current demand levels and patterns in combination with the SCENES population and GDP projections to estimate future demand. Demand included both direct human consumption as well as projected feed and industrial demand. Future supply trends were then estimated in response to anticipated demand changes, consistent with historical trends, and falling within the limits of assessed land resources availability. To achieve robust alternative scenario projections, a nested approach was used for supply estimation. At the first level, demand and supply were balanced for broad aggregate commodity groups (such as cereals, oil crops, etc.) and in a second step these aggregate supply estimates were attributed to individual commodities taking into account historical trends of individual shares within commodity groups.

Application

The primary application of the Agriculture and Livestock projections was for the EU-funded Water Scenarios for Europe and for Neighbouring States (SCENES) project. The dataset can be used anywhere that a consistent set of European agriculture and livestock scenario driver projections are desired.

Descriptive keywords

SCENES, agriculture, livestock, projection, scenario, Europe, international, inter-sectoral, stakeholder, drivers

Data access

Deliverable 1.7: Projecting European Population, GDP, Energy, and Agricultural Land Use Based on a Participatory Scenario Development Process and Excel Workbook (SCENES_AGR_PEP3_12_03_10.xlsx)

Use limitation

Citation: SCENES Agriculture and Livestock Scenarios, IIASA, Laxenburg, Austria.

SOLAW

Scarcity and abundance of land resources

Date: 2012-03-31
Edition: Version 1 (latest update: 2010.12.02)
Presentation form: Research report

Spatial representation

Extent: Global
Type: Maps: Grid data is used to represent geographic data; Other: Tabular.
Resolution: Maps: 5 arc-minute grid cells; Tabular: Global, regional, country

Temporal extent

Time period: 2000, 2050

Abstract

For an estimated world population of about 9 billion in 2050, agricultural production has to increase above year-2000 levels by about 70% globally and by 100% in developing countries. This has been leading to growing competition for land and water resources. The report analyses the current status of land and water resources together with trends. It assesses the biophysical and technical aspects of the resources and their use, and presents projections for the year 2050.

Purpose

The study was prepared as a thematic report for ‘The State of Land and Water Resources’ (SOLAW), FAO's first flagship publication on the global status of land and water resources. It is an 'advocacy' report, to be published every 3 to 5 years, and targeted at senior level decision makers in agriculture as well as in other sectors.

Methodology/Data generation

FAO, in collaboration with IIASA, has developed an assessment framework that enables rational land-use planning based on an inventory of land resources, and evaluation of biophysical limitations and production potentials. The Agro-Ecological Zones (AEZ) approach is based on robust principles of land evaluation. The current Global AEZ (GAEZv3.0) offers a standardized framework for the characterization of climate, soil and terrain conditions relevant to agricultural production, which can be applied at global to sub-national levels.
This framework was used to analyze the current status of land and water resources together with trends. Themes covered include:

- land resources: historical trends, degradation
- availability of suitable land resources,
- constraints of land: soil and terrain, water scarcity, accessibility

The report contains several maps and tables.

Application

SOLAW Report by FAO (2011)

Descriptive keywords

GAEZ, land use, land resources, land suitability, soil constraints, agricultural water use, SOLAW

Data access

Report: http://www.fao.org/fileadmin/templates/solaw/files/thematic_reports/TR_02_light.pdf
http://www.fao.org/nr/solaw/solaw-home/en/
Maps: http://www.iiasa.ac.at/Research/LUC/GAEZv3.0/

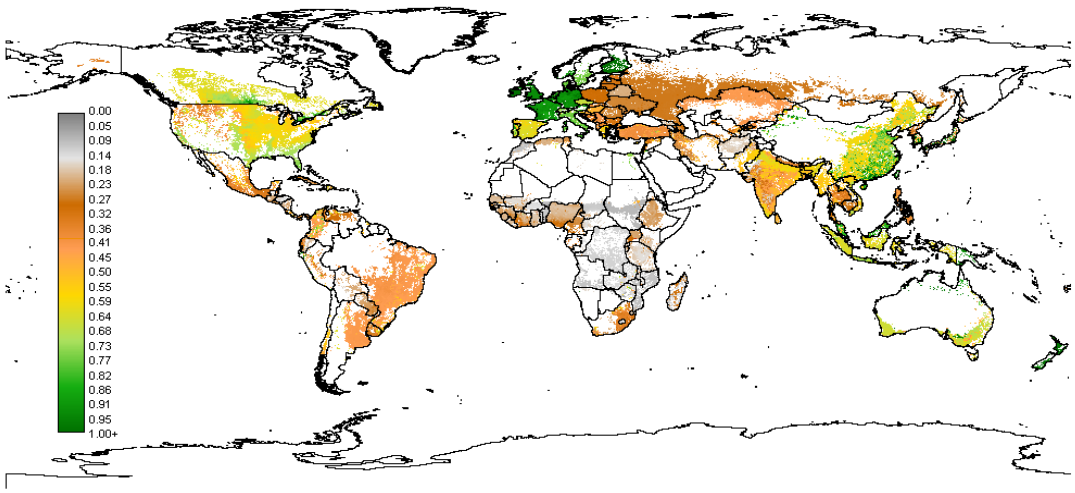
Supplemental information

Key references:

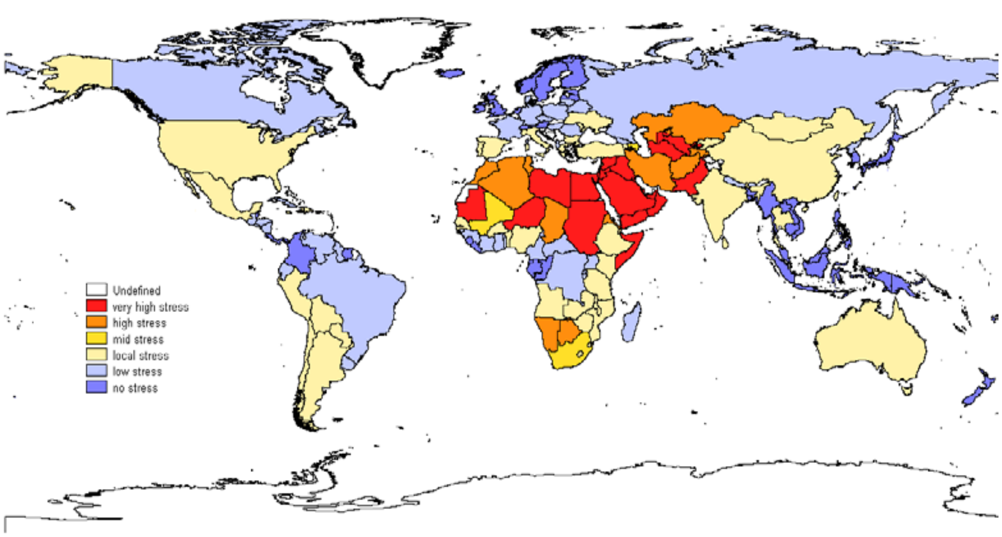
FAO (2011) The state of the world's land and water resources for food and agriculture (SOLAW) - Managing systems at risk. Food and Agriculture Organization of the UN, Rome and Earthscan, London.

G. Fischer, E. Hizsnyik, S. Prieler & D. Wiberg (2011) Scarcity and abundance of land resources: competing uses and the shrinking land resource base. SOLAW Background Thematic Report - TR02.

Use limitation



Yield gap ratios comparing actual crop production of year 2000 with potentials achievable in current cultivated land with advanced farming



Global distribution of water scarcity for agriculture

OTHER APPLICATIONS

Brazil Land Balances

Date: 2012-03-31
Edition: Version 1 (latest update: 2011.06.01)
Presentation form: GIS layers, Data Tables
Data source: AEZ BRAZIL

Spatial representation

Extent: Brazil
Type: GIS raster
Resolution: GIS layer: 30 arc-second; Data Tables: for states, micro regions (group of municipios)

Temporal extent

Time period: 2006

Abstract

Statistically recorded extents of agricultural and forest land uses were allocated to a spatial grid of 30 arc-second resolution in accordance with remotely sensed land cover information. The allocation also accounts for built-up land, water bodies and barren/sparsely vegetated areas. The remainder of this land balance is allocated to 'residual land'.
The resulting land balances describe for each 30 arc-second grid cell shares of seven main land use categories: i) Cropland; ii) Pasture; iii) Forest; iv) Built-up land; v) Barren and sparsely vegetated; vi) Water; vii) Residual land. Cropland and pasture areas are consistent with statistical information reported for 559 micro-regions in Brazil's latest Agricultural Census of the year 2006. Forest extents comply with area statistics for six biomes reported in the Brazil national report of FAO's Forest Resource Assessment 2010. Residual land was further categorized according to its i) legal protection status; ii) biodiversity value and iii) agricultural quality.

Purpose

Global studies on future agricultural land availability indicate considerable potential for agricultural expansion in Brazil both for the production of food and feed crops as well as for bioenergy crops. At the same time agricultural expansion has been identified as a main driver of deforestation in the Brazilian Amazon. Assuming the potential for expanding bioenergy crop production necessitates a careful analysis of potential environmental, social, and economic impacts, such as competition with food and risks of reducing biodiversity, or impacts on water quality and availability. Regional land balances based on most recent available data are a crucial input for quantifying Brazil's land resource potentials.

Methodology/Data generation

Input Data:
Statistical data sources: i) Brazil Agricultural Census of 2006; ii) FAO Forest Resource Assessment 2010.
Spatial data sources: i) Regional classification for South America of the Global 2000 Land Cover characteristics dataset (JRC, 2006); ii) Global Map of Irrigation Areas version 4.0.1 (Siebert et.al, 2007).

Methodology:
An iterative sequential downscaling procedure has been implemented to estimate land cover shares for major land use categories in individual 30 arc-second longitude/latitude grid cells. First built-up land intensities required for urban and infrastructure land calculated based on an estimated relationship of per capita land requirements applied to a spatially detailed population layer at 30 arc-second (about 1 km2) for the year 2000 developed at FAO and based on the Landscan global population. Second, land cover data and additional soil data from the Harmonized World Soil Database were used to delineate inland water bodies. After excluding built-up land shares and water bodies, agricultural land and forest area were allocated and calibrated in accordance with statistical data and geographic land cover distributions.
For this step the regional classification for South America of the GLC2000 dataset was the prime geographic data source. In addition, land coded in GLC2000 as barren or sparsely vegetated was delineated as category 'barren land'. These ranges were defined first, by using information contained in GLC2000 land cover class descriptions and second, by expert judgment of possible intensities.
An iterative spatial allocation procedure is used to estimate set of weight factors for land cover classes representing the content of each class in terms of farmland (separately for crop and pasture) and forest that result in observed statistical extents of these land uses. Estimated weight factors are limited to fall within class-specific range. Finally, any unallocated share of a grid-cell was then interpreted as being 'unused' residual land. Shares in each grid cell sum up to 1, i.e., there is consistency without double-counting or leakage.
Output variables:
GIS raster (30 arc-second) of seven land cover shares
Tabulation of area extents (hectares) for Brazil state and micro-regions (Excel) for seven land cover categories

Application

The database was created for the collaborative project of Daimler and IIASA on: 'Biofuel Potentials of Residual Land in Brazil'.

Descriptive keywords

Brazil land use, residual land, land balances

Data access

Available on request

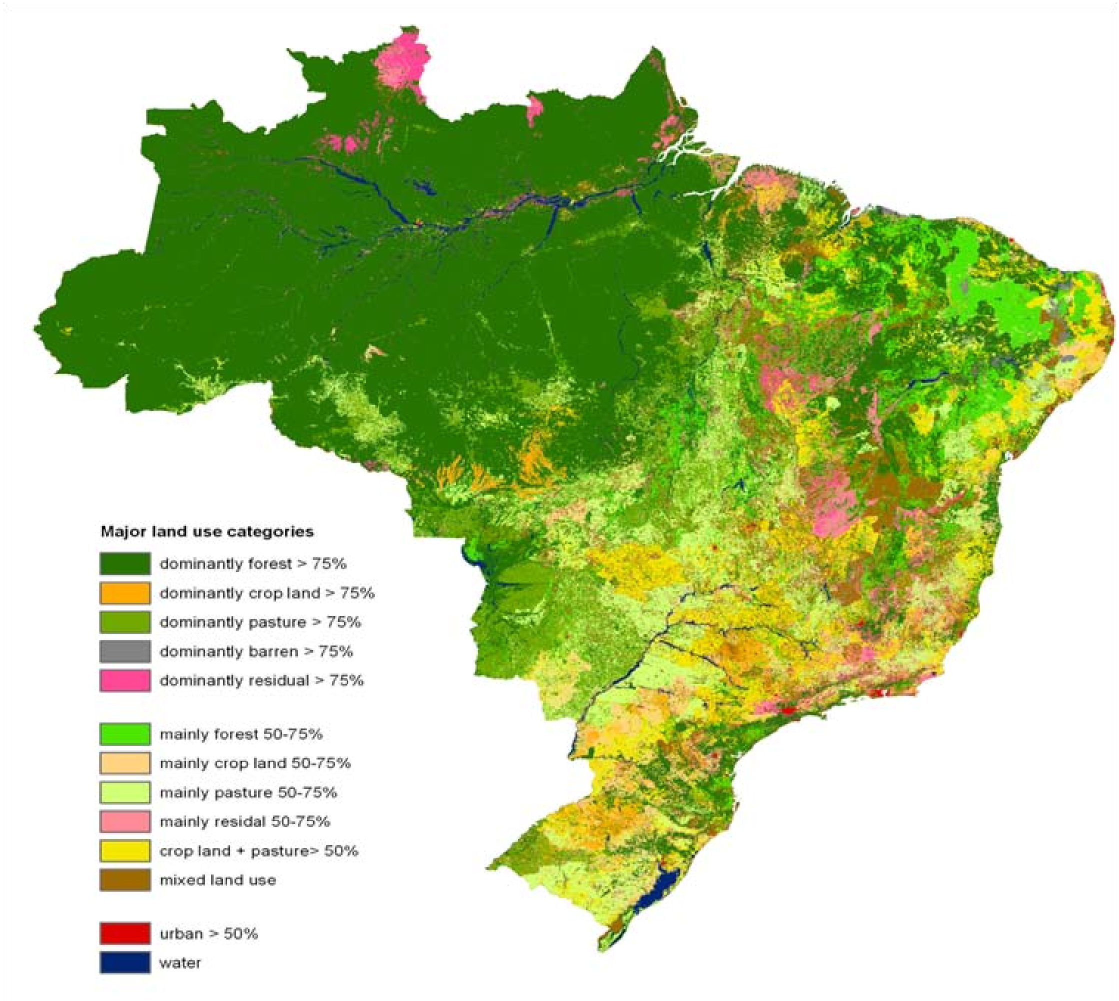
Supplemental information

Key references: Ulusoy S., Holder E., Fischer G., Prieler S., van Velthuizen H., Schomaecker R., Kleinschmit B. Biofuel Potentials of Residual Land in Brazil; Part I: Land Balance, *forthcoming*

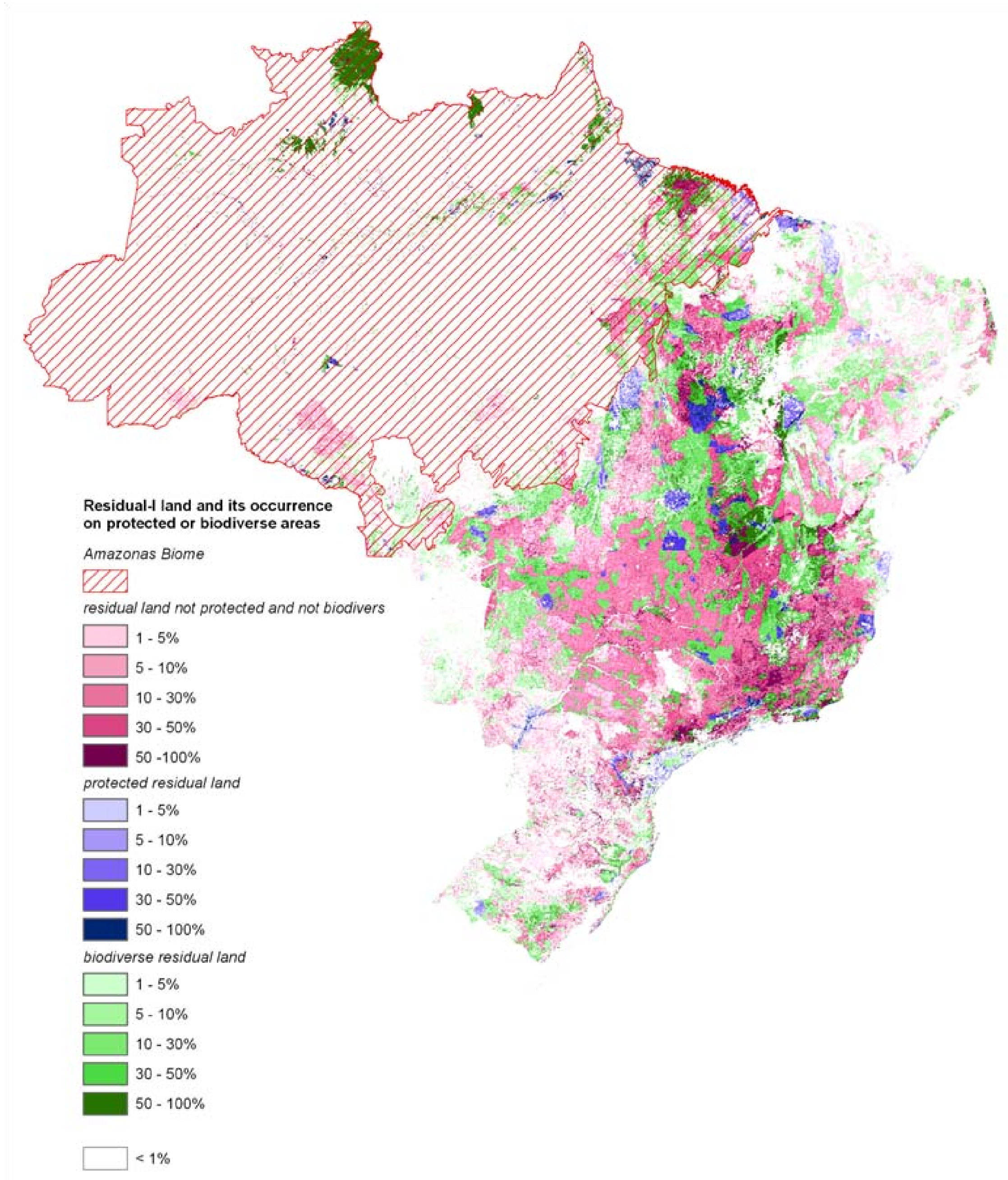
Use limitation

Use restrictions until publication Ulusoy et.al.

Selected figures:



Brazilian land resources database with land intensities at 30-arc second grid cell resolution



Distribution and intensity of residual land and its occurrence on protected or biodiverse areas

Global Land Use Scenario Projections

Date: 2012-02-22
Edition: Version 1.0 (latest update: 2010)
Presentation form: Raster Maps

Spatial representation

Extent: Global
Type: Raster
Resolution: 0.5 degree and 5 arc minutes

Temporal extent

Time period: 10-year time steps for period 2000 – 2100

Abstract

Food security, water resource availability and demand, climate change, forestry, energy and economic development are all interlinked with land use and land cover. Scenario-based land use and land cover projections are required for assessments and planning in any of these topic areas. The Global Land Use Scenario Projections provide scenario-based projections of eight categories of land use and cover future decades up to 2100 for the SRES A2r and B1 scenarios.

Purpose

This database provides spatially detailed land use and cover projections for the SRES A2r and B1 scenarios for use in global assessments applying the A2 and B1 IPCC SRES scenarios.

Methodology/Data generation

Land cover interpretations have been used for the base year 2000 together with statistical data from the FAO to derive a consistent spatial characterization of each land unit (at 5′ by 5′ latitude/longitude grid-cells) in terms of area shares for seven main land use/land cover classes. Six geographic datasets were used for the compilation of an inventory of major land cover/land use categories at 5 arc-minute resolution. The datasets used are:

(1) GLC2000 land cover database at 30 arc-sec (http://www-gvm.jrc.it/glc2000), using regional and global legends;
(2) an IFPRI global land cover categorization providing 17 land cover classes at 30 arc-sec. (IFPRI, 2002), based on a reinterpretation of the Global Land Cover Characteristics Database (GLCC ver. 2.0), EROS Data Centre (EDC, 2000);
(3) FAO's Global Forest Resources Assessment 2000 (FAO, 2001) at 30 arc-second resolution;
(4) digital Global Map of Irrigated Areas (GMIA) version 4.0 of (FAO/University of Frankfurt) at 5 arc-minute by 5 arc-minute latitude/longitude resolution, providing by grid-cell the percentage land area equipped with irrigation infrastructure;
(5) IUCN-WCMC protected areas inventory at 30-arc-second (http://www.unep-wcmc.org/wdpa/index.htm); and
(6) a spatial population density inventory (30-arc seconds) for year 2000 developed by FAO-SDRN, based on spatial data of LANDSCAN 2003, with calibration to UN 2000 population figures.

An iterative calculation procedure has been implemented to estimate land cover class weights, consistent with aggregate FAO land statistics and spatial land cover patterns obtained from (the above mentioned) remotely sensed data, allowing the quantification of major land use/land cover shares in individual 5' by 5' latitude/longitude grid cells. The estimated class weights define for each land cover class the presence of respectively cultivated land and forest. Starting values of class weights used in the iterative procedure were obtained by cross-country regression of statistical data of cultivated and forest land against land cover class distributions obtained from GIS, aggregated to national level. The percentage of urban/built-up land in a grid-cell was estimated based on presence of respective land cover classes as well as regression equations relating built-up land with number of people and population density.

The resulting seven land use land cover categories shares are:

(i) Rain-fed cultivated land;
(ii) Irrigated cultivated land;
(iii) Forest;
(iv) Pastures and other vegetated land;
(v) Barren and very sparsely vegetated land;
(vi) Water; and
(vii) Urban land and land required for housing and infrastructure.

Land conversion of future scenarios in the integrated AEZ-WFS assessment framework is explicitly modeled to maintain full consistency between the spatial agro-ecological zones approach used for appraising land resources and land productivity and the expansion of cultivated land as determined in the world food system model. The conversion of agricultural land is allocated to the spatial grid in 10-year time steps by solving a series of multi-criteria optimization problems for each of the countries/regions of the world food system model.

The criteria used in the land conversion module depend on whether there is a projected net decrease or increase of cultivated land in the region of consideration. In the case of a decrease the main criteria and drivers include demand for built-up land and abandonment of marginally productive cultivated land. In case of increases of cultivated land the land conversion algorithm takes land demand from the world food system equilibrium and applies several constraints and criteria, including: (i) the total amount of land converted from and to agriculture in each region of the world food system model, (ii) the productivity, availability and current use of land resources in each country/region of the world food system model, (iii) suitability of land for conversion to crop production, (iv) legal land use limitation, i.e. protection status, (v) spatial suitability/propensity of ecosystems to be converted to agricultural land expressed as a priority ranking of ecosystems with regard to land conversion, and (vi) land accessibility, i.e. in particular a grid-cell's distance from existing crop production activities.

Application

These scenario-based land use projections were developed and have been used for IIASA 's Integrated assessment of uncertainties in greenhouse gas emissions and their mitigation (GGI project) and for the European Union Framework Program 6 project "Water and Global Change (WATCH)". The scenarios were also provided as an input to climate modeling of representative greenhouse emission pathways in AR5.

Descriptive keywords

Land use scenarios, downscaling, integrated assessment, SRES, AEZ, WFS, sequential rebalancing

Data access

http://www.iiasa.ac.at/Research/LUC/External-Watch/WATCHInternal/WATCHData.html

Supplemental Information

Spatially detailed land use/cover projections for scenarios were also developed for SRES B2 socio-economic dynamics. These scenarios, focusing on land cover implication of biofuel expansion, have a time frame up to 2050 and have been published in Fischer et al., 2009 and Fischer et al., 2010.

Key *references:*

Fischer, G., E. Hizsnyik, S. Prieler, M. Shah, and H. van Velthuizen (2009). Biofuels and Food Security. The OPEC Fund for International Development (OFID) and International Institute of Applied Systems Analysis (IIASA), Vienna, Austria, 228 pp.

Fischer G. and Prieler S. (2010). Impacts of biofuel expansion on world food systems and the environment. A global agricultural ecological-economic modelling framework for scenario analysis. ELOBIO Deliverable 5.2 and 5.3. Intelligent Energy Europe. Available at: http://www.elobio.eu/fileadmin/elobio/user/docs/D5.2_5.3.pdf

Use limitation

Citation: Global Land Use Scenario Projections, IIASA, Laxenburg, Austria.

Global grass- and woodland characterization for ligno-cellulosic energy crop production

Date: 2012-03-20
Edition: Version 1 (latest update: 2012.01.30)
Presentation form: 30 arc-second map and country level tabulation
Data source: GAEZ

Spatial representation

Extent: Global
Type: GIS raster
Resolution: 30 arc-second

Temporal extent

Time period: Year 2000

Abstract

Available under-utilized grass- and woodland may provide land resources suitable for food, feed and energy crop production, while causing limited impacts on biodiversity and terrestrial carbon stock depletion. Land balances consistent with statistical information and available remotely sensed land cover information provide an estimation of the spatial distribution of global grass- and woodland areas. These have been characterized in terms of productivity and biomass potential for ligno-cellulosic energy crop production. In addition, the GAEZ databases have been used to provide a qualification of land in terms of spatial grass/woodland concentration, its accessibility, and presence of ruminant livestock.

Purpose

Today some 1.6 billion hectares of cropland are used for crop production concentrated on the world's most fertile areas. With considerable population and economic growth, food production will result in cropland expansion of an estimated 200 million hectares by 2050. At the same time ambitious bioenergy production targets e.g., such as described in the IEA 'Blue Map' Scenario will result in significant demand for biomass feedstocks including dedicated ligno-cellulosic energy crops grown on surplus land.
Forest preservation is key for maintaining terrestrial carbon stocks and securing biodiversity. Underutilized grassland/woodland areas may provide an acceptable and sustainable land use option for agricultural expansion. Compared to cropland, global statistics on grassland area extents are less certain and detailed. A spatially explicit quantification of grass- and woodland areas and their current land use and quality for potential crop production is urgently required for rational land use planning to meet future demand for food, feed and energy crops.

Methodology/Data generation

Input Data: The main input is derived from GAEZ land resources data layers (GAEZv3.0, 2011). Additional data sets include GIS maps on accessibility and current use in terms of livestock grazing: a) Accessibility is defined as the travel time to the nearest city of 50,000 or more people by land (road/off road) or water (navigable river, lake, ocean) in the year 2000 (Nelson, 2008); b) Ruminant livestock densities are based on FAOs gridded livestock of the world (Wint and Robinson, 2007); c) Protected areas (GAEZ, 2011).

Methodology: The grass- and woodland areas of the GAEZ major land use categories represent the remainder of the spatial downscaling of i) best available downscaled agricultural and forest statistical data together with remotely sensed derived land cover information (RS LC); ii) built-up areas for urban and infrastructure allocated from available population data (and RS LC); iii) barren or very sparsely vegetated areas allocated from GAEZ land productivity and RS LC ; and iv) water bodies based on RS LC.

Such estimated occurrence of grass- and woodland areas for 5 arc-minute grids throughout the globe were spatially combined with information on protection status, accessibility and ruminant livestock density.
The suitability profile, assessed in GAEZ, for rain-fed ligno-cellulosic energy crop production was tabulated for each country for combinations of the following classes:

Grass and woodland occurrence (in 5 arc-minute grid cell)
*) Grass, scrub and woodland (i.e. all grid cells with grass- and woodland occurring)
*) "large area" grassland/woodland (i.e. grass- and woodland share in grid cell > 30%)
*) "very large area" grassland/woodland (i.e. grass- and woodland share in grid cell > 50%)
Protection class: Area under national or international protection scheme
*) not protected
*) protected
*) total land
Ruminant livestock density classes
*) very low < 10 RLU / km2 (RLU = reference livestock unit)
*) low 10-25 RLU/km2
*) intermediate 25-50 RLU/km2
*) high > 50 RLU/km2
Accessibility: Travel time to closest market of 50,000 people or more
*) < 3 hours
*) 3-6 hours
*) 6-12 hours
*) > 12 hours
Suitability class
*) VS very suitable
*) S suitable
*) MS moderately suitable
*) mS marginally suitable
*) vmS very marginally suitable
*) NS not suitable

The resulting table with over 40 thousand records describes for each country the occurrence of land extents (hectares) and potential biomass production (tons) for rain-fed ligno-cellulosic energy crop production for the above described classes.

Output variables: Excel table for all countries with variables described above.

Application

Analysis included in invited article on: 'Land and the Food-Fuel Debate: Insights of Modelling' for the section 'grassland availability for biofuel feedstock production'.

Descriptive keywords

Global grassland, grassland suitability, ligno-cellulosic energy crops

Data access

Excel file: npp_CrAv6190Lr.xls

Supplemental information

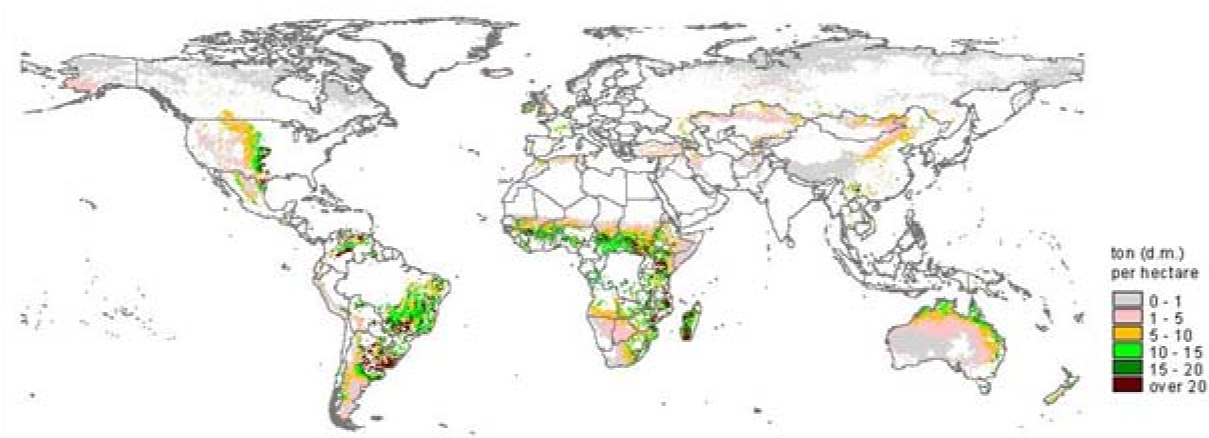
Further expansion Improved analysis of grassland connectivity for identification of potential areas for large-scale energy crop plantations

Key references: Prieler S., Fischer G. Land and the food-fuel debate: Insights from Modelling. Wiley Interdisciplinary Review: Energy and Environment. *Submitted* .

Use limitation

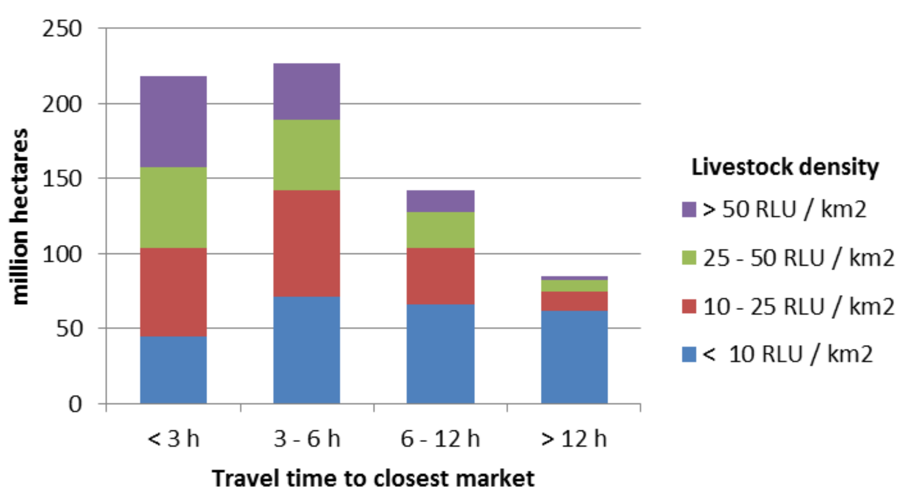
None

Selected figures:



Potential rain-fed yield of ligno-cellulosic feedstocks in current areas with dominantly grass- and woodland*

*Dominantly includes 5 minutes longitude/latitude grid-cells with over 50% grass- and woodland.



Accessibility and livestock density in unprotected Grass/Woodland suitable for production of ligno-cellulosic feedstocks in grid cells with GRWL share exceeding 50%

*Suitable here includes the suitability classes Very Suitable (80-100% of maximum attainable yield), Suitable (60-80%) and Moderately Suitable (40-60%);

Accessibility is defined as travel time to nearest city of 50 thousand or more people in year 2000; Reference Livestock Unit (RLU).

Ukrainian Resource Data Base

Date: 2012-03-31
Edition: Version 1.4 (latest update: 2012.03.10)
Presentation form: Tabular data in Excel spreadsheets

Spatial representation

Type: Version 1.2 contains the data on agricultural activities, natural resources, demographic, socio-economic and environmental indicators at the national level and at the level of districts and regions in Ukraine (496 and 25, respectively)

Temporal extent

Time period: Annual time series data for period 2000 - 2010

Abstract

Agriculture is one of the major economic sectors of Ukraine. Improving agricultural practices is of critical importance for the economy, environment, and society in Ukraine. The harmonized Ukrainian database has been developed as a collaborative activity between IIASA and NMO institutes in Ukraine (Institute of Economics and Forecasting (IEF), Scientific Centre for Aerospace Research of the Earth Institute of Geological Sciences, Institute of Cybernetics, National Academy of Sciences, Ukraine) in the framework of *IIASA – Ukrainian NMO project on "Integrated modeling of food, energy and water security for sustainable social, economic and environmental developments"* to support decision making regarding sustainable developments in Ukraine to fulfill food, water, energy security goals under scarcity of and competition for natural resources, inherent natural and anthropogenic uncertainties, economic and market instabilities, weather variability.

Purpose

The database provides inputs into the model-based investigation (e.g. APPA model) of robust pathways increasing resource use efficiency in Ukrainian agriculture by planning agrifood systems that fulfill food security goals and reduce stress on natural resources (e.g., water, soil).
In particular, the database permits to compute key indicators needed as inputs into the decision-making framework: production costs, environmental (resource) constraints, rural-urban socio-economic and demographic indicators, etc. The spatial resolution of the data allows delineation of geographical diversity among producers and consumers while the temporal resolution permits analysis of inherent uncertainties in demand, production, weather variability, market conditions.
The DB is being complied to fulfill the following requirements:

1. To systematize available data and improve data quality
2. To validate downscaling procedures developed at IIASA
3. To allow analyses of driving forces of threats to food-energy-water security in Ukraine
4. To be used as database for scenario analysis with a multi-objective stochastic optimization model.

Methodology/ Data generation

Data has been collected from various sources and harmonized at the level of Ukrainian districts and regions (496 and 25, respectively) to support geographically detailed model-based analyses of sustainable rural development paths.
Source of data: The data are collected from many sources. The data on demographic situation of the country, balances and consumption of the main food commodities by population of Ukraine, crop statistics of Ukraine for 2000-2010, mineral and organic fertilizers by agrarian enterprises for 2000-2010,

volumes of sales and prices of basic agricultural products in the markets were derived from State Statistical Committee of Ukraine. Economic and social indicators were obtained from the Ukrainian database “Main Economic Indicators of Agricultural Enterprises”, 2000-2010. Data on land resources and land use were assembled using information from State Agency of Land Resources of Ukraine. Various other data were integrated and harmonized from available GIS data sets, data of Ministry of Agrarian Policies of Ukraine, Ministry of Finance of Ukraine, FAO, USDA, World Bank, OECD and HEIFER.

Application

The DB has been used in recent studies of mechanisms for land pricing in Ukraine (Yarovyy et al. 2008), in the analysis of food security and rural-urban interactions (Borodina et al. 2010); for estimating the role of agricultural trade quotas (Kyryzyuk 2010; Kyryzyuk et al. 2011); for the analysis of agricultural land market policies (Frayer 2011).

Descriptive keywords

Ukrainian agriculture; sustainable development; food-water-energy security; sub-national statistics

Data access

http://www.iiasa.ac.at/Research/LUC/
Available on request

Supplemental information

Key references:

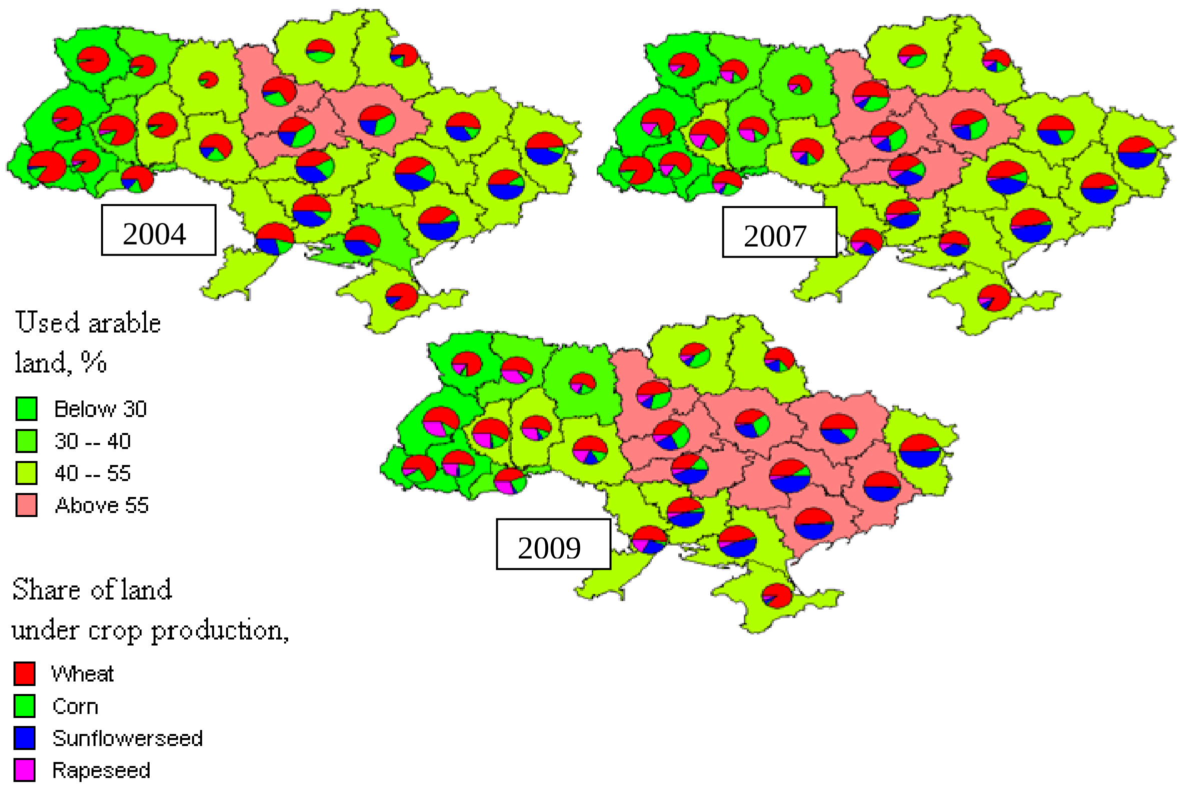
Borodina, O., Borodina, E., Ermolieva, T., Ermoliev, Y., Fischer, G., Makowski, M., van Velthuizen, H. (2010): Integrated modeling approach to the analysis of food security and sustainable rural developments: Ukrainian case study. IIASA Interim Report IR-10-017, Int. Inst, for Applied Systems Analysis, Laxenbburg, Austria.

Frayer, A. (2011) Agricultural production intensification in Ukraine: Decision support of agricultural policies based on the assessment of ecological and social impacts in rural areas. IIASA Interim Report IR-11-033, Int. Inst, for Applied Systems Analysis, Laxenburg, Austria.

Kyryzyuk, S., Ermolieva, T., Ermoliev, Y. (2011) Planning sustainable agroproduction for food security under risks, Economics of Agriculture, 9, 145-151 (in Ukrainian).

Yarovyy V, Fischer G, Ermolieva T (2008). Land pricing mechanisms for sustainable agricultural land use planning in Ukraine. EUROPA XXI: New Functions of Rural and Industrial Space in Central and Eastern Europe, 17:109-119 [2008].

Selected figures:



The dynamics of arable land expansion and main production commodities by Ukrainian regions, 2004-2009. Source: database "Main Economic Indicators of Agricultural Enterprises", 2004-2009.

MODELS

Stochastic Agriculture production planning and allocation (APPA) model

Date: 2012-03-31
Edition: Version 2.2 (latest update: 2011.12.12)
Presentation form: Executable under MS Windows operating system

Spatial representation

The model operates at national, subnational, regional, district levels. It uses country-specific statistics at the resolution of administrative units e.g. villages, districts, counties, municipalities, provinces, regions, to represent local agricultural activities and socio-economic, demographic, environmental conditions and limitations. In the absence of required data, the model implies adequate down- and upscaling procedures to fill the gaps and to harmonize the data and the results across scales.

Temporal extent

APPA is a dynamic model with embedded stochastic optimization procedures enabling to plan production expansion and resource use under natural and anthropogenic uncertainties before the information on uncertainties becomes available.

Abstract

The APPA model is a geographically detailed stochastic and dynamic model for spatio-temporal planning of agricultural activities to meet food security goals under natural and anthropogenic risks, resource constraints, and social targets. The model illustrates that explicit treatment of risks and uncertainties in agricultural production planning may considerably alter strategies for achieving robust outcomes with regard to sustainable agricultural development.

Purpose

APPA is a stochastic model for long term and geographically explicit planning of agricultural activities under resource constraints. Physical production potentials of land are incorporated in the model together with demographic and socio-economic variables and behavioral drivers. The model is designed to study in a systemic way robust pathways for increasing resource use efficiency agricultural systems to fulfill food security goals, reduce pollution (e.g., non-point source pollution) and stress on natural resource systems (e.g., water, soil).

Methodology/How the model works/Data generation

The model incorporates economic growth scenarios and population projections to simulate alternative pathways of agricultural demand increases. In some locations, the indicators characterizing status of the environment and socio-economic conditions, may exceed acceptable thresholds, signaling that further production growth in these locations should not take place. The question then becomes how and where to plan expansion of production facilities to meet demand without exacerbating problems. For this, the model uses indicators defined by various interdependent factors including the spatial distribution of people and incomes; the current levels and costs of crop and livestock production and intensification; the availability, conditions and current use of land resources. These indicators are used to discount production locations by the degree of their diverse risks and production suitability. The risk-based preference structure is then used in production allocation algorithms to derive solutions regarding sustainable and robust production expansion, allocation and intensification.

Application

The APPA model has been applied for the analysis of agricultural developments in China in the context of EU FP7 project on “Chinese Agricultural Transition: Trade, Social and Environmental Impacts” (CATSEI), the “Integrated Nitrogen Management in China” (INMIC) project, an activity of IIASA’s Greenhouse Gas Initiative (Ermolieva et al. 2009; Fischer et al. 2006, 2009, 2010). In Ukraine, the model has been revised and applied for the analysis of recent rural-urban migration caused by rapid agriculture intensification and biofuel production trends in Ukraine (Borodina et al. 2010); for investigating optimal land pricing mechanisms (Yarovyy et al. 2008); for identifying the role of agricultural quotas (Kyryzyuk 2010; Kyryzyuk et al. 2011); for estimating optimal investments into expansion of agricultural activities and rural services to employ potential workers migrating between Ukrainian regions as a result of job losses or financial/production instabilities (Borodina et al. 2010); for the analysis of food-water-energy security issues (Borodina et al. 2010; Kyryzyuk 2010; Kyryzyuk et al. 2011); etc. Currently, the APPA model serves as a basis for the analysis of food, water, energy security issues in Ukraine within a collaborative *IIASA – Ukrainian NMO project on “Integrated modeling of food, energy and water security for sustainable social, economic and environmental developments”*. The Ukrainian resource data base is being harmonized and compiled to support the APPA-based research.

Descriptive keywords

Food, water, energy, environment security; sustainable agriculture and rural developments planning; resource allocation; uncertainties and risks; two-stage stochastic optimization; conditional value-at-risk; sustainability indicators

Model and Data access

http://www.iiasa.ac.at/Research/LUC/
The model is available on request.

Supplemental information

There exist different approaches to the analyses of optimal production structure and resources allocation in agriculture. The APPA model follows general ideas of economic modeling outlined in Nobel Memorial Lecture by Tjalling C. Koopmans (Koopmans 1975). In the presence of uncertainties and resource (financial, land, water) constraints, the model employs stochastic optimization algorithms for production allocation in a multi-producers environment under environmental safety and food security constraints in the form of multidimensional risk measures having direct connections with Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR or expected shortfalls) type indicators (Ermoliev and Wets 1998; Rockafellar and Uryasev 2000; Ermoliev and von Winterfeldt 2012).

Key references:

Borodina, O., Borodina, E., Ermolieva, T., Ermoliev, Y., Fischer, G., Makowski, M., van Velthuizen, H. (2010): Integrated modeling approach to the analysis of food security and sustainable rural developments: Ukrainian case study. IIASA Interim Report IR-10-017, Int. Inst, for Applied Systems Analysis, Laxenbburg, Austria.

Kyryzyuk, S., Ermolieva, T., Ermoliev, Y. (2011) Planning sustainable agroproduction for food security under risks, Economics of Agriculture, 9, 145-151 (in Ukrainian).

Kyryzyuk S. (2010). Model-based risk-adjusted planning for sustainable agriculture under agricultural trade liberalization: Ukrainian case study.. Interim Report IR-10-016, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Use limitation

Citation: Stochastic Agriculture production planning and allocation (APPA) model, IIASA, Laxenburg, Austria

Climate and Human Activities – sensitive Runoff Model (CHARM)

Date: 2012-03-22
Edition: Version 2 (latest update: 2003)
Presentation form: Windows executable

Abstract

Charm is a flexible distributed hydrologic model written in C++ and designed to calculate the runoff produced from rainfall at the grid-cell resolution. The flexible design enables it to be applied at any grid-cell resolution, or alternatively to model a river basin as a single unit or a collection of hydrologic units. The model includes an optimizer so that it can be automatically calibrated to average annual watershed runoff values. CHARM can supply currently available surface water runoff for entire regions and supply runoff and runoff variability inter-annually and intra-annually for any area desired. Furthermore, it can be used to assess the impacts of land use and climate change on water resources.

Purpose

CHARM was originally developed for rapid analysis of the impacts of land use and climate change on water resource availability and variability over large regions where data is limited. However, its flexibility allows it to be used at any scale.

Methodology/Data generation

CHARM employs a water balance consisting of five main components:

1. Precipitation, which is input to the model
2. Direct surface runoff, governed by the USDA curve-number method
3. Evapotranspiration, calculated with the Penman-Monteith methodology recommended by FAO (FAO, 1998) and used in the Agro-Ecological Zoning Methodology (Fischer et al., 2000)
4. Sub-surface runoff, calculated using a power function of relative soil water storage similar to that used by Kaczmarek (1991), Yates (1996), Bowling (1997)

Additional components to the water balance can be added as needed.

The model was designed to be used for rapid assessments in areas where little data is available other than global data sets. Input requirements include: daily precipitation, daily average temperature and temperature range, daily radiation (sunshine hours), latitude, longitude, altitude, land use, soil texture, soil available water content, soil depth, and optionally actual basin runoff for calibration. When daily data is not available, monthly input data can be used and daily values will be generated using spline interpolations. Monthly runoff is output.

Application

The CHARM model was originally developed to assess the impacts of climate and land use changes on water availability and variability and on the existing water infrastructure throughout China. It has since been used for a variety of studies at different scales, including a basin scale water quality study in the Huang He and a climate variation and land cover change study in the Suomo basin.

Descriptive keywords

Hydrology, hydrologic modeling, CHARM, climate, land use, impact assessments, rapid assessment

Model access

Available upon request

Supplemental information

Key references:

Wiberg D, Strzepek KM (2005). Development of Regional Economic Supply Curves for Surface Water Resources and Climate Change Assessments: A Case Study of China. IIASA Research Report RR-05-001. IIASA, Laxenburg, Austria.

Wiberg D, Strzepek KM (2000). CHARM: A Hydrologic Model for Land Use and Climate Change Studies in China. IIASA Interim Report IR-00-072. IIASA, Laxenburg, Austria.

Use limitation

Citation: Wiberg D, Strzepek KM (2000). CHARM: A Hydrologic Model for Land Use and Climate Change Studies in China. IIASA Interim Report IR-00-072. IIASA, Laxenburg, Austria.

CRIM: Integrated catastrophe risk management (CRIM) model

Date: 2012-03-31
Edition: Version 2.2 (latest update: 2012.01.15)
Presentation form: Executable under MS Windows operating system

Spatial representation

Type: Version 2.2 uses country and regional level statistics
Source of data: National and regional statistics, local and international insurance companies (e.g. Munich Re), national and local legislation authorities, expert opinion, modeling, literature reviews, etc
Resolution: national, regional

Abstract

Losses from human made and natural catastrophes are rapidly increasing (Munich Re 2009, 2011). The main reason for this is the clustering of people and capital in hazard-prone areas as well as the creation of new hazard-prone areas. Also warming climate is projected to be a driver (IPCC) affecting the frequency of some extreme events, such as wildfires and flash floods, as well as the intensity of hurricanes. The increasing vulnerability of the society calls for new integrated approaches to economic developments and risk management. The integrated Catastrophe Risk Management model (CRIM) has been developed at IIASA for spatial and temporal analysis of various catastrophic risks, e.g., floods, earthquakes, livestock epidemics, windstorms, security management.

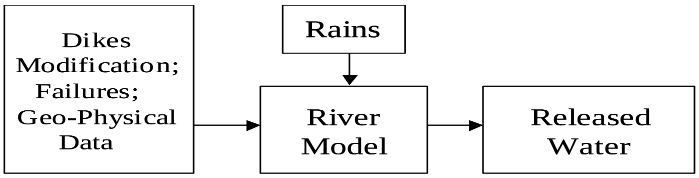
Purpose

The purpose of the model is to conduct a quantitative and spatially detailed analysis of structural and financial measures for reducing the impacts of natural catastrophes. Identification and proper planning of land use policies for dealing with extremes may substantially decrease regional vulnerability and catastrophic losses which otherwise produce dramatic and long-term consequences for societies. The model comprises four main GIS-based modules: hazard simulation, vulnerability estimation, a multi-agent accounting system, and a decision-making stochastic optimization procedure. For example, the scheme of the catastrophe flood management model applied in the project on Tisza river, in Hungary and Ukraine, is presented in the figure below. The model addresses the specifics of catastrophic risks: highly mutually dependent and spatially distributed endogenous risks, the lack of historical location-specific observations (unknown risks), the need for long-term perspectives and robust strategies, and explicit treatment of spatial and temporal heterogeneities of involved agents such as farmers, producers, households, local and central governments, land use planners, water authorities, insurers, and investors.

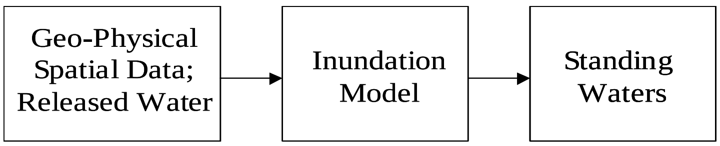
Methodology/How the model works/Data generation

This is a GIS-based model which explicitly accounts for the interplay between national and local ex-ante measures, e.g., investment in prevention/mitigation measures (on the part of the public authorities, the citizens and the insurance industry) and ex-post policies for sharing the financial costs after the disaster.

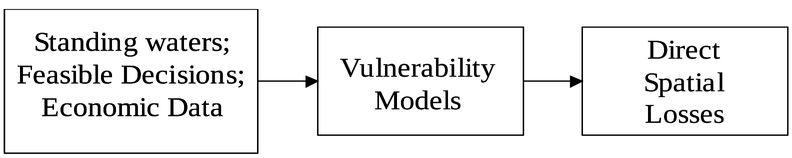
A case study region is subdivided into grid cells or sub-regions with “homogenous” properties, i.e., the spatial units (not necessarily of strict geometrical form) may correspond to a collection of buildings, a collection of land plots with similar land use practices (e.g. agricultural land), a segment of a pipe line, urban area, rural settlement. Each grid is characterized by a property value and exposure to catastrophic event. The hazard module in a Monte Carlo fashion simulates the occurrence of catastrophes. The vulnerability module estimates losses to property values according to vulnerability curves. The multi-agent accounting system derives histograms of gains and losses to the agents exposed to and involved in land use planning and catastrophe management. The losses depend on past and current decisions. To minimize the losses and achieve robust stable economic performance of the region, a spatially explicit decision-making stochastic optimization procedure tracks the gains and losses and adjusts the decision variables towards fulfillment of goals and constraints of the agents.



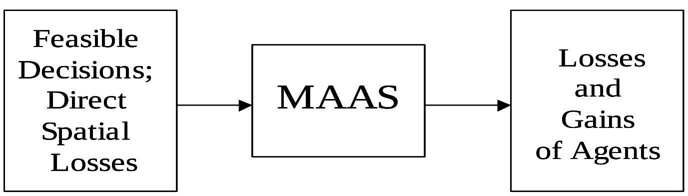
River Module



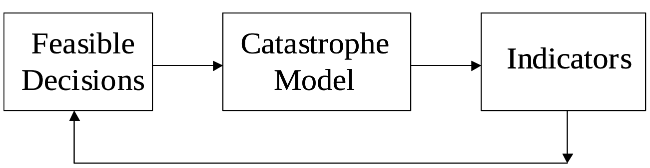
Spatial Inundation Module



Vulnerability Module



Multi - Agent Accounting System (MAAS)



The Adaptive Monte Carlo Optimization Model

Integrated catastrophic flood management model scheme

Application

Since its first creation in 1997 the model has been developed and applied to various case studies of catastrophic risks, e.g., earthquakes, floods, livestock epidemics, windstorms, etc., jointly with researchers from Italy (Amendola et al. 2000b), Russia (Amendola et al. 2000a), US (Linnerooth-Bayer et al), Austria (Compton et al), Japan, Hungary (Ermolieva et al.), Ukraine, Sweden (Ekenberg et al.), Poland (Nowak et al.), China (Liu et al.). The approach enables simultaneous analysis of complex interdependencies among damages at different locations and robust prevention, mitigation, and adaptation (both structural and financial) measures. Among the first case studies, the model was used for designing earthquake insurance policies in Russia and Italy by integrating an earthquake hazard module and GIS-based maps of seismic intensities and vulnerabilities (Amendola et al. 2000 a,b; Ermoliev et al. 2000, 2011). On Tisza river, in Hungary and Ukraine, the model helped evaluating robust public-private insurance schemes against flood losses (Ekenberg et al. 2003; Ermolieva et al. 2001, 2003, 2008). There, the model incorporated spatially explicit river, inundation, and vulnerability modules to account for the specifics of flood risks and losses. Since then, the approach has been extended for applications of other types of natural and anthropogenic hazards, such as urban flash floods (Compton et al. 2009), windstorms, livestock epidemics, security management (Ermoliev and von Winterfeldt 2012).

Descriptive keywords

Catastrophic risks, catastrophe modeling, integrated modeling and management, discount factors, stochastic optimization, multi-agent decision making, safety constraints, robust decisions

Model and Data access

http://www.iiasa.ac.at/Research/LUC/
The model is available on request.

Supplemental information

The model has won a Kjell Gunnarson's Risk Management Prize of the Swedish Insurance Society, 1997 (Ermolieva 1997; Ermolieva et al. 1997b,c).

The model uses economically sound risk indicators leading to convex stochastic optimization problems strongly connected with non-convex insolvency constraint and Conditional Value-at-Risk (CVaR).
The model permits to analyze the implications of extreme events on the proper choice of discounting (Ermolieva et al. 2010) for evaluation of policies with long-term perspectives, e.g. climate change and catastrophe management projects such as construction and maintenance of dikes. The misperception of discounting may dramatically contribute to the alarming increase of regional vulnerability. The model has been used for designing optimal portfolios of financial instruments in catastrophe management, e.g. such as a composition of a multi-pillar flood loss-spreading program involving partial compensation to flood victims by the central government, a mandatory public-private insurance on the basis of location-specific exposures, a contingent ex-ante credit to reinsure the insurance liabilities, a catastrophe bond.

Key references:

Ermolieva T, Ermoliev Y, Fischer G, Galambos I (2003) The role of financial instruments in integrated catastrophic flood management. Multinational Finance Journal 7(3&4): 207–230.

Ermolieva T, Ermoliev Y (2005) Catastrophic risk management: Flood and seismic risks case studies. In: Wallace SW, Ziemba WT (eds.) Applications of stochastic programming. MPS-SIAM Series on Optimization, Philadelphia, PA, USA.

Use limitation

Citation: Integrated catastrophe risk management model (CRIM), IIASA, Laxenburg, Austria

Sequential downscaling methods for spatial estimation from aggregate data

Date: 2012-03-31

Edition: Version 3 (latest update for global production downscaling: December 2011)

Presentation form: Executable under MS Windows operating system

Abstract

The estimation of global processes consistently with local data and, conversely, local implications emerging from global tendencies challenge the traditional statistical estimation methods. Traditional statistical estimation methods are based on the ability to obtain observations from unknown true probability distributions. For the new estimation problems, which can be termed downscaling and upscaling problems, often there may be only very restricted samples of real observations. In particular, the downscaling procedures permit to address the problem of data scarcity and incompleteness, and provide the required spatio-temporal resolutions and heterogeneities of agricultural production and flows data. For example, agricultural production statistics are available at national scale from FAO, but these data do not include the spatial heterogeneity of agricultural production at finer resolutions, e.g. grid cells within country boundaries. In this case, downscaling procedures can be applied to represent information in locations relying on appropriate optimization principles, e.g. cross-entropy maximization. Procedures combine the aggregate statistics and available samples of real observations in the locations with other "prior" hard and soft data (expert opinion, scenarios) and relationships on the related variables that exist among observable, partially or indirectly observable and non-observable variables on multiple scales.

Purpose

The development of sequential (rebalancing) downscaling procedures for spatial estimation from aggregate data was motivated by the needs of various practical projects. For example, initially a flexible sequential downscaling method, based on iterative rebalancing, was developed and implemented for use in connection with GAEZ v3.0 (Fischer et al. 2012) to estimate the spatial distribution of national statistical crop production (of year 2000) and implied apparent yield gaps. Generic sequential downscaling and up-scaling procedures were also developed in CATSEI and INMIC projects (Ermolieva et al. 2009; Fischer et al. 2010) to address problems of data harmonization, and to deal with location-specific heterogeneities of data and agricultural production planning processes at required spatio-temporal scales. Similar rebalancing procedures were implemented in the EU Water and Global Change project (WATCH) project to produce from aggregate projections harmonized spatial databases of future land use and related agricultural variables at required resolutions (WATCH 2011).

Methodology

Downscaling is, in essence, an attribution of known aggregate statistics, e.g. on economic activities, agricultural production, land use, population, etc., to finer locations such as regular grid cells. For example, aggregate regional annual concentrations of pollutants may be well within norms, whereas concentrations in some locations may exceed critical levels for a short time and cause irreversible damages. The downscaling methods permit to derive local estimates by using appropriate optimization principles, e.g. cross-entropy, relying on available data and knowledge to form a so-called "prior" distribution specifying a plausible spatial distribution of the given aggregate values. For practical applications, the choice of appropriate priors, their inherent uncertainties and imprecision are among the major challenges of the downscaling methodology, ultimately determining the success of the spatial attribution. The sequential downscaling procedures developed by the LUC group are based on methods for iterative rebalancing estimates to satisfy general balance equations with unobservable and observable variables. A prove of the convergence of this method to the solution maximizing a cross-entropy function is given in Fischer et al. (2006).

Descriptive keywords

Aggregate statistics, spatial estimation, local-global balances, “prior” information, rebalancing procedures, cross-entropy, maximum likelihood estimates

Model and Data access

http://www.iiasa.ac.at/Research/LUC/
The model is available on request.

Supplemental information

Specific downscaling applications developed in GAEZ v3.0 and CATSEI/INMIC projects.

Key references:

Fischer, G., Ermolieva, T., Ermoliev, Y., and van Velthuizen, H., 2006. Sequential downscaling methods for estimation from aggregate data. In: Marti, K., Ermoliev, Y., Makowski, M., Pflug, G. (Eds.), Coping with Uncertainty: Modeling and Policy Issue. Springer Verlag, Berlin, New York, 155-169.

Fischer G, Ermoliev Y, Ermoliev Y, van Velthuizen HT (2006). Sequential Downscaling Methods for Estimation from Aggregate Data. IIASA Interim Report IR-06-002 [January 2006, 12 pp].

Fischer G, Ermolieva T, Ermoliev Y, van Velthuizen HT (2006). Spatial recovering of agricultural values from aggregate information: Sequential downscaling methods. International Journal of Knowledge and Systems Sciences, 3(1): [2006].

Use limitation

Citation: Sequential downscaling methods for spatial estimation from aggregate data. IIASA, Laxenburg, Austria

Induced discounting and catastrophic risks management

Date: 2012-03-31
Edition: Version 1 (latest update: December 2011)
Presentation form: Executable under MS Windows operating system

Abstract

A novel approach to discounting has been developed at IIASA in relation to economic evaluation of long-term projects, e.g., such as catastrophic floods management (construction of dams and dikes) and climate change mitigation projects. Debates on proper discount rates have a long-standing history. Indeed, how can we justify investments into mitigation efforts, which may possibly turn into benefits over long and uncertain time horizons in the future? Misperception of discounting may provoke catastrophes. Most traditional models assume the discount rate is the same as the rate of return in capital market. Such choice of discounting rate equal to market return rate is linked with the assets having a lifespan of only a few decades. This may substantially reduce the impacts that investments may have beyond these intervals. For example, market interest rates of 3.5% corresponds to approximately 30 years, which may have no correspondence with expected, say, 300-year extreme events. The IIASA approach links discount factors with the occurrences of "stopping time" random events (e.g. catastrophes) determining a discount-related evaluation horizon. Conversely, any stopping time associated with the first occurrence of a random event induces a discounting. A set of random events, e.g., 1000-, 500-, 250-, and 100- year floods, induces discounting with time-declining discount rates.

Purpose

The methodology has been developed for addressing food, water, energy, social security issues. It has been applied in numerous studies on catastrophic risks management; for planning social security and health provision under risks; sustainable agriculture planning; for the development of a prototype model of robust emission trading markets; in model-based planning for secure energy provision; in water pricing methodology; etc.

Methodology

Long-term and uncertain horizons of catastrophic events pose new challenges for the choice of proper discount rates. Catastrophes often create so-called endogenous, unknown (with the lack and even absence of adequate observations) and interdependent systemic risks (Arrow, 1996; Arrow et al., 1996; Ermolieva and Ermoliev, 2005; Ermolieva et al., 2003; Heal and Kristrom, 2002). Evaluation and management of catastrophic risks require development of spatially explicit catastrophe models (Ermolieva, 1997; Ermolieva and Ermoliev, 2005; Ermoliev et al., 2000; Weitzman, 1999). In these models, catastrophes are characterized by a random "stopping time" moment associated with the first occurrence of a catastrophic ("killing") or "stopping time" event. The concept of random stopping time criterion in catastrophe management models induces social discounting that focuses on occurrence time of catastrophic events rather than the lifetime of market products. Since risk management decisions affect the occurrence of disasters in time and space, the induced discounting may depend on spatio-temporal distributions of extreme events and feasible sets of decisions. This endogeneity of induced spatio-temporal discounting calls for the use of stochastic optimization methods, which allow also to address the variability of discounted criteria.

Application

The methodology is applied in integrated catastrophe management analysis; in planning agricultural production in the presence of risks and uncertainties; for planning social security and health provision under risks; in modeling of robust carbon trading markets; in models for planning secure energy provision, etc.

Descriptive keywords

Extreme events, stopping time, catastrophic (systemic) risks, induced discounting, investments, stochastic optimisation, risk measures

Model and Data access

The model is available on request.

Supplemental information

Key references:

Ermoliev Y, Ermolieva T, Fischer G, Makowski M, Nilsson S, Obersteiner M (2008). Discounting, catastrophic risks management and vulnerability modeling. Mathematics and Computers in Simulation, Vol 79(4), pp. 917-924.

Ermolieva T, Makowski M, Fischer G, Ermoliev Y (2009). Economic evaluation of dams for flood protection: An integrated safety approach. In: Dam-break Problems, Solutions and Case Studies, D. de Wrachien, S. Mambretti (eds), WIT Press, Southampton, UK, pp. 241-272.

Ermoliev Y, Ermolieva T, Fischer G, Makowski M (2010). Extreme events, discounting and stochastic optimization. Annals of Operations Research, 177(1), pp. 9-19.

Integrated emission trading and abatement (ETA) model

Date: 2012-03-31
Edition: Version 1.2 (latest update: 2012.01.15)
Presentation form: Executable under MS Windows operating system

Spatial representation

Extent: The model operates at the level of emitting entities, countries, aggregate world regions
Type: Multi-agent integrated stochastic model
Resolution: country-level, aggregate regions

Temporal extent

Time period: 1990 – 2020

Abstract and background

Environment is a global public good, which requires proper regulations for environmental security. A prominent example of adopted economic instruments is emissions trading schemes. These schemes play an important role in climate change policy negotiations. However, existing carbon markets are volatile and operate at disequilibrium prices, which do not ensure cost-efficient and environmentally safe outcomes. The current market-based emission trading, therefore, does not necessarily minimize abatement costs and achieve emission reduction goals. The integrated emissions trading and abatement model (ETA) has been developed in the framework of a joint GGI project at IIASA. The model allows to find a robust trade-off between abatement and trading of emissions to fulfill environmental targets under asymmetric information and other multiple anthropogenic and natural uncertainties. For example, the model studies if and by how much the uncertainties about emissions and abatement costs may affect portfolios of technological and trade policies or structure of the market, and how uncertainty characteristics may affect market prices and change the market structure (Ermolieva et al. 2010, 2012). The model includes countries such as Australia, Canada, China, EU27, Japan, Russia, Ukraine, US.

Purpose

The model is an exploratory market environment for carbon emissions trading. It allows trading parties (countries or emitting entities) to investigate the conditions of their cost-efficient trades. The model suggests cost efficient and environmentally safe equilibrium solution that can be implemented in reality. The model addresses the following key questions:

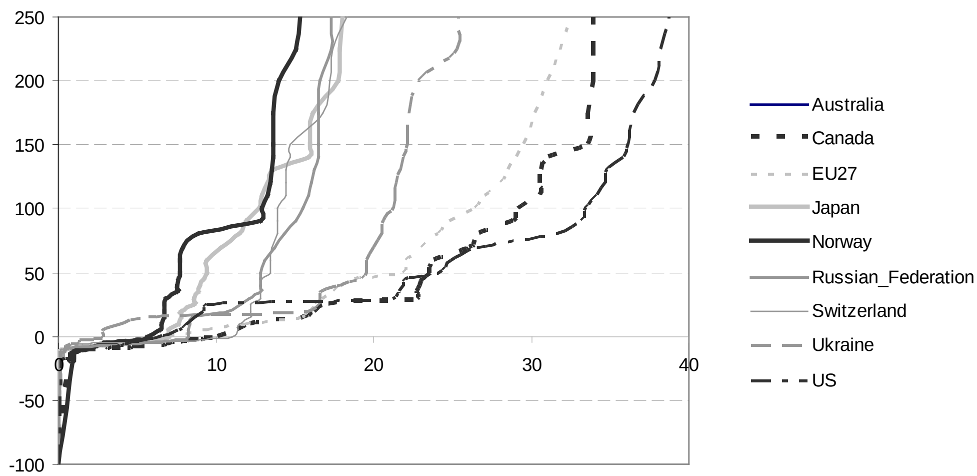
- Under which conditions is carbon trading environmentally safe (i.e. to actually achieve the emission reductions with a certain probability) and cost-effective in the long-term, if considered in the context of a stochastic market?
- How the knowledge about uncertainties may affect portfolios of technological and trade policies of the parties?
- By how much differ marginal abatement costs calculated from technology parameters and the spot carbon price in the existing stochastic market?
- By how much trading parties may decrease the chances of lock-in solutions and "irreversible" trades at spot market?

Methodology/ How the model works/ Data generation

The multi-agent integrated stochastic model of emissions trades/exchanges is a modeling environment that connects computers of trading "parties" with the computer of a "central agency". In an anonymous manner it stores information on the "parties", e.g. their cost functions and other characteristics of the underlying optimization model including specific characteristics or models (Ermolieva et al. 2010; Hudz et al. 2003; Winiwarter and Muik 2010) of uncertainties. The procedure for deriving an equilibrium solution is the following: two parties “meet” (e.g. picked at random) and exchange emission permits in a mutually beneficial way accounting for actual costs. At the next step, a new pair is picked and the procedure is repeated. At each step of the bilateral trades, the actual costs will differ between the sequential trades, but finally the trading system converges to an equilibrium with marginal costs of all parties equal to an equilibrium price. The model derives the solution in a decentralized manner without revealing information of the parties.

Version 1.2 uses country-level statistics and projections of GHG emissions, emissions uncertainties, emission reduction targets, cost functions of emissions abatement, etc.

Source of data: models (e.g GAINS, POLES), literature reviews (e.g. IPCC reports), own research



Marginal cost of emissions reduction as percent of pledge targets, € per tC (source: GAINS; Wagner and Amann, 2009).

Descriptive keywords

Emissions trading, uncertainties, asymmetric information, robust economic mechanisms, environmental safety, cost-efficiency, stochastic equilibrium

Model and Data access

http://www.iiasa.ac.at/Research/LUC/
The model is available on request

Supplemental information

The model supports decisions regarding a trade-off between technological and economic mitigation and adaptation measures in the presence of inherent uncertainties to reduce GHG emissions and combat climate change without compromising economic development goals.
The integrated emission trading and abatement model has been developed within a framework of a GGI project “A prototype model of robust emissions trading market under uncertainties”, a collaborative activity of IIASA’s Greenhouse Gas Initiative between MAGG (former APD), ESM (former LUC and FOR), ASA (former IME) programs.

Key references:

Ermolieva T., Ermoliev Y., Fischer G., Jonas M., Makowski M., Wagner F., Winiwarter, W. Uncertainty, cost-effectiveness and environmental safety of carbon trading: integrated approach (submitted to Climatic Change, 2012)

Ermolieva T., Ermoliev Y., Fischer G., Jonas M., Makowski M., Wagner F. (2010). Carbon emission trading and carbon taxes under uncertainties. Climatic Change, 103(1-2).

Use limitation

Citation: Integrated emission trading model, IIASA, Laxenburg, Austria

Decentralized water pricing and water pollution taxation model (WAP)

Date: 2012-03-31
Edition: (latest update: 2012.01.15)
Presentation form: Executable program under MS Windows operating system

Spatial representation

The model can operate at national, subnational, regional, district, households levels.

Abstract

Water pricing is an example of financial measures to control or reduce water consumption by different users and systems. In the water framework directive (WFD), it is required that Member States, by 2010, introduce water-pricing policies that create incentives for efficient use of water resources. The water pricing should recover the true costs of water and water services. There are major challenges associated with the development of fair water pricing mechanisms. Inadequate water pricing may lead to imbalanced production in different sectors of national economies. Some industries are very sensitive to water supply and treatment costs. Agriculture, which is still widely subsidized, often pays much lower prices than other sectors. The difficulties with water pricing foremost concern the lack of exact knowledge about the utility functions of the water users and the incomplete information about the amounts of water required. The proposed approach to determine the price of water is based on a decentralized water pricing methodology which does not require water users/systems to reveal their private information.

Purpose

The decentralized water pricing methodology addresses main challenges of sharing a common resource – water – among competing users/sectors in an efficient and fair way, including the objective to preserve water quality.

Methodology/How the model works/Data generation

The model describes the market price formation process for a common resource – water. Formally, if all information about the water users is available, e.g. the utility functions, demands, uncertainties, etc., the water price may be derived by a central planner as the shadow price (the dual value) of the optimal water-use program. In the absence of full information, it is impossible for a central planner to find such shadow prices. The water users may not want to reveal their utility functions, demands, and uncertainties associated with the use of water. The proposed approach determines the water prices in a decentralized manner without requiring water users to reveal or exchange their private information. The water pricing methodology is augmented with a water quality constraint to determine implying an optimal level of a water pollution tax. The methodology of water pricing in the presence of uncertainties and incomplete information is a rather general scheme which, in fact, has analogues with Walras law describing the dynamics of prices under specific market conditions, which finally converge to the optimal (equilibrium) prices.

Application

The model has been applied to the agricultural region around the Aral Sea to determine how water policies may affect agricultural production and improve environmental conditions (Ermoliev et al. 1995). Then, the model has been advanced and applied for the analysis of pollution abatement strategies (Ermoliev et al. 1996, 2000; Godal et al. 2003). In a recent development, the underlying methodology of decentralized pricing under uncertainties, incomplete and asymmetric information has been used for the development of a prototype emission trading model in the framework of a project under IIASA's GGI initiative (Ermolieva et al. 2010, Ermolieva et al. 2012).

Descriptive keywords

Water resources, efficient water use, water pollution constraints, decentralized water pricing schemes, fair and robust water prices

Model and Data access

http://www.iiasa.ac.at/Research/LUC/

Key references:

Ermoliev Y, Michalevich M, Uteuliev N (1995) Economic modelling of international water use: the case of the Aral sea basin. IIASA RR-95-5.

Ermoliev Y, Michalevich M, Nentjes A (2000) Markets for tradable emission and ambient permits: A dynamic approach. Environ Res Econ 15:39–56.

Ermolieva T., Ermoliev Y., Fischer G., Jonas M., Makowski M., Wagner F. (2010). Carbon emission trading and carbon taxes under uncertainties. Climatic Change, 103(1-2).

Godal O, Ermoliev Y, Klassen G, Obersteiner M (2003) Carbon trading with imperfectly observable emissions. Environ Res Econ 25:151–169.

Use limitation

The model is available on request.

Citation: Decentralized water pricing and water pollution taxation model in the presence of uncertainties, incomplete and asymmetric information (WAP), IIASA, Laxenburg, Austria

World of Water (WOW!!)

Date: 2012-03-31
Edition: Version 2 (latest update: 2002)
Presentation form: Windows executable

Abstract

WOW!! is an object-oriented integrated river basin management model written in C++ that can be used on a pc in the field. It allows the user to interactively select and place components of a managed river basin on the screen and draw the connections between these nodes. Once the river basin arrangement is complete and demand and inflow information has been input for each node, WOW!! calculates flow through the basin and tries to meet demand based on rules selected by the user. The model then produces results for each node, showing when, where, and how water demands can or cannot be met.

Purpose

WOW!! was designed as a portable, pc-based integrated river basin management model for the Bureau of Reclamation, United States Department of Interior. It can be used to assess water supply and demand balances throughout complex managed basins, the reliability and robustness of these managed systems, and the impacts of changing conditions on the existing basin infrastructure.

Methodology/Data generation

The WOW!! user interface allows the user provides the user with a palette of node classes, including inflow, reservoir, hydropower, irrigation, municipal and industrial, instream flow, diversion, and confluence nodes. Nodes can be placed on a canvas and connected by the user by drawing lines in the direction of flow with the connector tool. Each node has input data requirements, options, and calculation methods that depend on its class. With the exception of the inflow node, though, each node has allows the user to set a target flow, or demand, for that node. The model adds up these demands from the end of the basin to the source, and then tries to meet all the demands based on options set by the user. The flow through each node is the output of the model. Additional classes of nodes and functionality are easy to add programmatically thanks to the object-oriented nature of the model.

Application

The model has been applied by the Bureau of Reclamation, United States Department of Interior to assess and manage water in the Western United States of America and has been applied to study the impacts of climate change and changes in variability in the Nile River and the High Aswan Dam.

Descriptive keywords

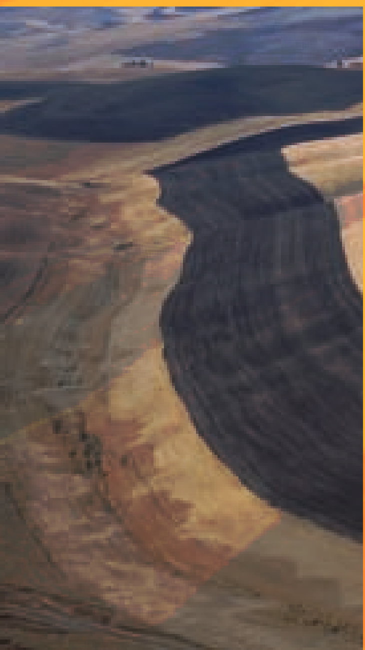
Integrated river basin management, river basin modeling, impact assessment, water accounting, water infrastructure, dam management

Model access

Available upon request

Use limitation

Citation: Wiberg, D, 1998. Climate change impacts on reservoir operation: the effect of changing mean and variance of inflow time series. M.S. Thesis. University of Colorado.



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