Monitoring land-use change assignment

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This hands-on session makes you familiar with different datasets that can be used to assess land-use change. Most of these datasets are freely available from internet sources. They each have a different focus as far as level of detail and covered time period are concerned. Please read the introductory text and instructions below.

A symbol (A) is placed in the left margin to indicate when specific computer operations are required.

FAOSTAT

The Food and Agriculture Organisation of the United Nations (FAO) is responsible for the FAOSTAT database. This on-line and multilingual database currently contains over 3 million time-series records covering international statistics in many areas.

Open the FAOSTAT global database at http://faostat.fao.org. Go to "all databases", the domain "Land" and the data collection "Land Use". This dataset contains country-level statistics of land use of different years. It allows for the comparison of land-use characteristics between countries, but also opens the possibility to study land-use conversion rates in individual countries. Information on the available countries and land-use types can be obtained by clicking on the "country" and "element" field at the top of the page.

Select your country of interest (e.g your home-country, or another nation that you know from research or holidays) , the item "land use", the elements "land area", "arable land", "permanent crops", "permanent pasture", "forest and woodland", "all other land" and the years 2001, 1991, 1981, 1971, 1961. Submit this query to the database and save the provided table as a Comma Separated Value (.CSV) file to your local hard disk. Repeat this operation until all members of your group have selected a different country.

The CSV files can be imported in for example MS Excel (through Data- >Import External Data) or a similar spreadsheet program to allow for data-processing. In order to better understand your data you are advised to calculate the percentage of the total land area covered by each land-use type. Making a line-chart will further help interpreting your dataset.

Question 1:
After having studied the land-use time-series of the countries of your choice please answer the following questions:
What is the most important land use in the different countries?
    a) Which land-use change trends can you discern for each country over the past 40 years?
    b) Can you explain which driving forces have caused the observed trends?
    c) Compare the answers to the above question for all selected countries.
    d) What are the similarities and differences in most important land use, observed trends and explanations?

Question 2:
The FAOSTAT database is mostly based on country level census data and surveys. Identify some possible problems of using these data when comparing countries and time-series.

SAGE and HYDE

Scientists now recognise that land use is an important driver of world-wide environmental change. But we still do not know exactly how the use of land has changed, or why. As a first step, several attempts have been made to document the current land-use practices across the globe, and estimate how these patterns have changed through recent history. While landscapes are now routinely monitored from space, satellite images have only been available for the last three decades. To describe land cover change in the last few centuries, we must also rely on other historical records such as census and tax records. In this part of the exercises we will look at two global databases of historic land-use change: SAGE and HYDE.

SAGE DATABASE

The SAGE database was made in the Climate, People and Environment Program of the Institute for Environmental studies, University of Wisconsin, Madison. Goal of the study is to derive geographically explicit changes in global croplands from 1700 to 1992. Human activities over the last three centuries have significantly transformed the earth's environment, primarily through the conversion of natural ecosystems to agriculture (Ramankutty and Foley, 1999). To understand the impacts on land cover change on climate it is necessary to quantify the nature and extent of anthropogenic changes of land cover at a global scale. The SAGE database focuses on the conversion of natural vegetation into croplands, because this is the primary mode of historical land use.

The SAGE database was developed by blending spatial information from satellite images with historical cropland inventory data from a variety of sources. A simple land cover change model was used to convert the available data in a global 30 minute (half a latitude/longitude degree) resolution dataset on the presence of permanent croplands from 1992 back to 1700. Using these techniques a high-resolution version of the distribution of croplands was made. By overlaying the historical cropland data set with a potential vegetation data set, the extent to which natural vegetation types have been converted for agriculture can be visualized.

(A) Open the cropland_sage movie that is distributed to you. This .MOV file can be viewed with Quicktime software version 6.5.1 or higher. The newest Quicktime software can be downloaded from: http://www.apple.com/quicktime/download/. The movie shows the changes in global cropland distribution for the past centuries.

Question 3:
Identify the 'hot-spots' of agricultural expansion and the time period in which the highest rate of agricultural expansion occurred in these 'hot-spots'. Can you explain the main driving factor of the agricultural expansion in these regions?

HYDE DATABASE
The HYDE database also offers an interesting overview on historic land-use changes since 1700. It has a 30 minute resolution and contains information on land use and population density. The database is developed by RIVM (the Dutch National Institute of Public Health and the Environment). It is based on a variety of data, including data from the FAOSTAT database, statistical population data from the UN and data from other RIVM projects. HYDE was originally designed to test the IMAGE-2 model, see Klein Goldewijk (2001). Goal of IMAGE-2 is to provide a disciplinary and geographical overview of the society-climate-biosphere system. The model simulates greenhouse emissions stemming from various industrial activities, energy use and land use. The historic land-use data from the HYDE database are amongst others used to initialise the carbon cycle and climate system in the IMAGE-2 model. The HYDE time-series can thus be used to calibrate the IMAGE-2 model and can also help to validate other global change models.

This exercise focuses on the land-use data of the HYDE database that is available on the internet. For those who have access to the GIS-package IDRISI we also provide the data in IDRISI format

DATA access through the internet:
Open the HYDE database on the internet mapserver of RIVM at: http://milntj34.rivm.nl/website/intdata/intdata_hyde/viewer.htm This webmapping application gives access to the datasets, without requiring specific locally installed GIS-software. It also offers the historic population density data.

Alternative option using IDRISI:
The HYDE database is also available in IDRISI raster format in the zipped data-file. You can access the unzipped data from this file in the following steps:
- Start Idrisi
- Go to Display, display launcher
- Select Map Composition File
- Browse to your data directory
- Select the "Land use" map
Use the composer (the red V symbol on the left of each layer) to view the maps of the different years. Notice that the lowermost layer is the visible one.
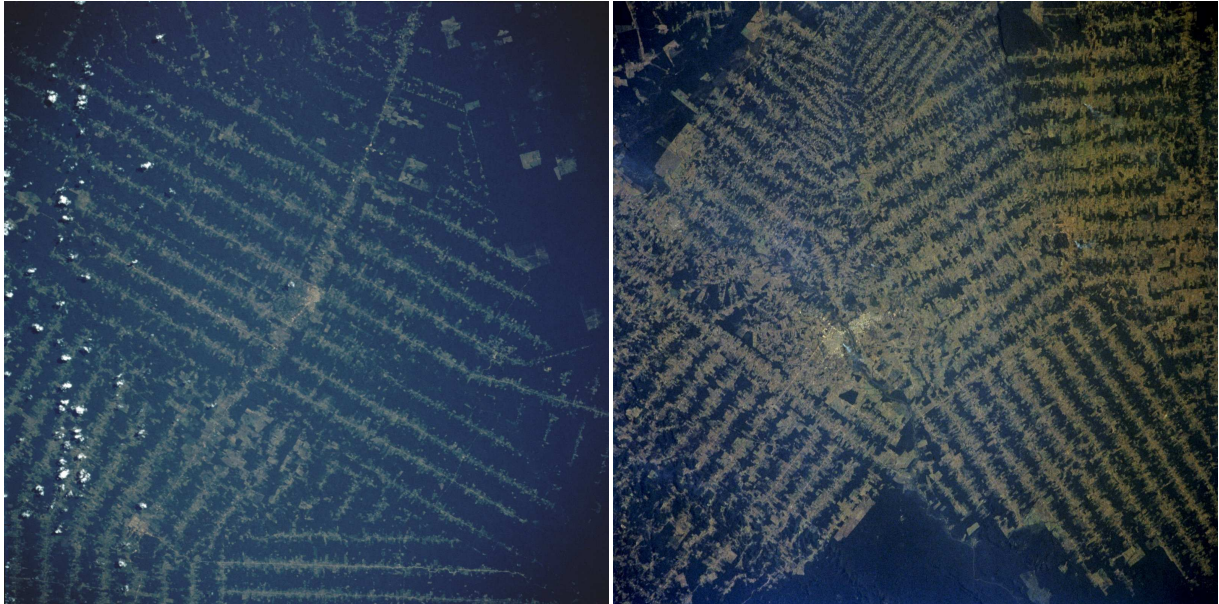
Question 4:
    a) What are the main differences in data representation/format between the SAGE and the HYDE database?
    b) Focus on the countries that you studied in question 1. What is the prevailing land-use trend in your countries
    c) Can you explain this development?
    d) Are the long-term changes in land use different from the short-term changes?
    e) Can you think of a reason why urban area is not included in the HYDE database?

Question 5:
Mention a number of applications of these historic land-use databases for global environmental change research.

Remote Sensing images

Remote sensing can provide valuable insight in land-use conversions at a very fine resolution. Recently launched satellites (e.g. IKONOS, QuickBird) offer an astonishing spatial detail with 1x1 meter pixels. As an example of the use of remote sensing two images are included here of part of the Amazon River Basin. They date back to 1985 and 1992. The images have only a small area in common, but are representative for the land cover over vast areas in the Amazon basin. The dark (green) colours represent original forest, whereas the lighter colours denote bare soil. The images are also available as jpg-files in the zip-file that was distributed. These can be viewed in any image-processing package.

Ron1985   *Ron1992*

Question 6:
Compare the general pattern of the clear-cut areas in both images above.
   a) What will have caused the major difference that you see between the two pictures?
   b) Can you explain the regular patterns that are visible?
After giving the images a brief thought, read the explanatory descriptions on the next page.

Description of the images
Ron1985: Rondônia, Brazil June 1985.
Worldwide destruction of tropical rain forests has been under way for several decades. Nowhere has this destruction surpassed the deforestation of parts of the southern Amazon River Basin. The Brazilian state of Rondonia, which borders Bolivia, has been especially hit hard. This photograph shows the unique Brazilian pattern of clearing land only along transportation routes. Land clearings in the southern Amazon Basin usually radiate out in a perpendicular pattern from streams or roads. The clearings usually have a "herringbone" appearance. While the spacing of the perpendicular roads or tracts can vary, most of the intervals between these roads are 2 to 3 miles (4 to 5 kilometers). Photographs of the same geographic area collected on different dates provide information on changes that have occurred; for example, road clearings, slash and burn activities, and field pattern sizes.

Ron1992: Rondônia, Brazil August 1992.
This photograph, showing the destruction of tropical rain forests, provides a visual indication of the rate of deforestation that is taking place in the state of Rondônia, which has been especially hard hit by deforestation. The solid dark green areas show the remaining tropical rain forest canopy. The lighter colours denote the clear-cut areas that are beginning to coalesce. Their total area now exceeds the area of remaining rain forest timber stands. Two urban areas separated by a small river can be seen near the centre of the photograph. This photograph and the one taken 7 years earlier, are representative of much larger areas where tropical rain forests are being decimated to permit farming and grazing in Brazil, Central America, Africa, Asia, and Australia.

Question 7:
Land cover changes can be observed in great detail by remote sensing images.
   a) Can remote sensing also be used for *land-use* changes?
   b) What are the limitations of the remote sensing approach and what other monitoring techniques can be used to obtain data on land-use change?

References:

Klein Goldewijk, K., 2001. *Estimating global land use change over the past 300 years: The HYDE database.* In: Global biogeochemical cycles, vol. 15, no 2.

Ramankutty, N., and J.A. Foley, 1999. *Estimating historical changes in global land cover: Croplands from 1700 to 1992*. In: Global biogeochemical cycles, vol. 13, no 4.