Ministry of Planning, Budget and Management
Brazilian Institute of Geography and Statistics - IBGE
Directorate of Geosciences
Department of Natural Resources and Environmental Studies

LAND-COVER AND LAND-USE CHANGES IN BRAZIL
2000 – 2010 – 2012

Rio de Janeiro
2015

Introduction

The IBGE is proud to present to the society the first results of the work on Land-Cover and Land-Use Changes in Brazil. This study is an important tool to support and lead management actions and decision-making, particularly when Brazil is striving to identify the indicators to maintain and monitor Earth's environmental quality and sustainability, following international conceptual frameworks.

Under the scope of the World Conferences on the Environment, the System of Environmental-Economic Accounts and the Sustainable Development Objectives, the Directorate of Geosciences, through the Coordination of Natural Resources and Environmental Studies and the Sector of Natural Resources of Santa Catarina, makes an important contribution to the underlying objectives of this matter.

The access to these results allows detecting changes in the dynamics of the patterns of occupation and the organization of the space, in terms of its use along a two-year period. Likewise, these results provide important inputs to the studies of the ecosystem accounts, recommended by the United Nations, in which inventories and flows of natural resources are estimated.

At the same time that the IBGE makes these results available to decision makers, research groups, academic and technical communities and society as a whole, it thanks everybody that helped to accomplish this task.

Wadih Joao Scandar Neto
Director of Geosciences

CONTENTS

Land-Cover and Land-Use Changes and the Environment

The changes that occur in land cover and land use are intrinsically related to the activities of human beings, who take hold of natural resources transforming them for their own benefit. This process, most often, results in some kind of impact that can decisively influence the natural environment.

Since the Industrial Revolution, the planet has witnessed significant transformations directly associated to demographic growth, to technological development and to the need for agricultural modernization. More recently, population concentrations in urban centers, the expansion of the agricultural frontiers over the vegetation cover and the increasing complexity of the communication and transportation networks have generated massive changes in land cover and use. These changes, on their turn, generate several impacts on the environment.

Globally, great changes in land cover and use exert influence, directly or indirectly, on the climate dynamics, on the changes of the sea level, on the ozone layer and on the loss of biodiversity. Regionally, impacts are related to air, water and soil pollution, erosion, desertification, destruction of ecosystems, among others. All these events somehow affect the quality of life of the populations.

The expansion of croplands and pastures can, on the one hand, increase the availability of food and generate economic profit, but it can also reduce biodiversity and destroy habitats due to the removal of native vegetation and to the intensity of agrochemical use. If such removal happens as a result of fire, the carbon dioxide emission will contribute to global warming, which can provoke the melting of glaciers and sea level rise. The use of inadequate agricultural techniques, besides polluting the water and reducing its availability, can degrade the soils and, in extreme cases, lead to desertification.

The urban expansion, associated with the industrial development and with the supply of services, can totally eliminate some ecosystems, if measures are not taken in order to reduce the impacts generated. Air and water pollution which result mainly from the major urban centers and the great industrial plants contribute significantly to global warming and to changes in the ozone layer.

In short, there is a close relationship between socioeconomic aspects, land-cover and land-use changes and global and local environmental issues. One of the ways of assessing this interrelationship is by systematically keeping an account of the changes occurred in land cover and use, providing information to land-use planning and to the sustained development of human activities.

Why Keeping an Account of Land-Cover and Land-Use Changes?

Global Scenario and Environmental Accounting

Technological advances, both in the rural and in the urban areas, favor the expansion of food production and the supply of material goods, but they also generate a number of negative impacts on the environment. These impacts are denominated loss of environmental assets, and are more significant in terms of water, forests, energy, among others. However, these losses are not considered in the calculation of the wealth produced by countries (GDP), reported in the National Accounts. Such calculations account for the total of goods and services generated by the producing units, but still do not include the use and, often, the degradation of natural resources. In the last decades, these issues have begun to gain more and more room in international discussion forums, such as the United Nations Conference on Environment and Development (UNCED, 1992) and the subsequent Conferences in Johannesburg and in Rio de Janeiro (Rio +10 and Rio +20). Gradually, environmental topics have been interfering in the budgets of governments and populations. Health problems resulting from pollution, biodiversity reduction caused by deforestation and uncertainties generated by climate action are some examples of this new issue.

Most recently, this theme was also highlighted in the elaboration of the Sustainable Development Goals - SDG (UN, 2015), whose proposal contains 17 goals and 169 targets, encompassing different topics, as the eradication of hunger, food security and agriculture, health, education, gender equity, inequality reduction, energy, water and sanitation, sustainable consumption and production patterns, climate action, sustainable cities and sustainable use of oceans and of terrestrial ecosystems, inclusive economic growth, infrastructure and industrialization, governance and means of implementation, in order to build a new development agenda to be followed by the United Nations.

In this context, land cover and use studies represent an important instrument to support and guide the management and decision-making processes, for their results allow the monitoring of the changes in the patterns of land occupation and organization, making it possible to detect the changes in the dynamics of land use throughout a certain period and also providing important information to the studies of environmental accounting, in which the inventories and use flows of natural resources are estimated.

Land-cover and land-use changes mean changes in the proportion of their classes and, as one measures these changes through time and space, it is possible to obtain composite indicators, since they aggregate several biotic and abiotic aspects. Turner II et al. (2007) state that measuring these changes can be a means to analyze the environmental assets and liabilities, for as they modify the landscape, there will be changes in terms of environmental impacts and services. These changes must be monitored and getting to know such effects can help not only to draw an overview of the human action on the environment, but also to guide the development processes. Adequate measurement, analysis and management of these changes can help to understand and decide upon matters related to sustainability. It is recommended that the assessment of the land-cover and land-use changes be spatially explicit (BRIASSOULIS, 2000).

Brazilian Scenario for Environmental Accounting

Throughout the years, the discussions around environmental statistics and indicators have been getting more and more space before the technical-scientific community, but have not led to more consistent results in terms of projects to provide the government with information for planning. However, the evidence of the increasing environmental degradation, affecting several populations, and the latest international debates about the necessity of keeping an account not only of the impacts, but also of the services that the ecosystems offer, have influenced the discussions on environmental accounting. This new level of discussions have been gaining ground inside some institutions in Brazil, pointing out to an increasing need for partnerships and for the creation of an information system capable of providing the manager with data for policy-making and programs directed to the reduction of impacts, to adaptation (for climate actions) and to monitoring. Besides these advances, today there is a conceptual framework provided by the United Nations guiding studies on environmental topics, the *Central Framework* of the *System of Environmental-Economic Accounting 2012* (SEEA, 2014).

Having as an institutional milestone the *International Seminar on Environment Statistic and Environmental-Economic Accounting*, held on September 21 and 22 of 2009 in Rio de Janeiro, the IBGE has been in line with the guidelines of the United Nations for the accounting of ecosystems, having then taken an important step towards the production of information that can contribute to The Satellite Accounts of the Environment for the System of National Accounts. The event aimed at raising awareness of Brazil and Latin American countries to the importance of integrating environmental and economic statistics with the implementation of a common reference framework: *Sistema de Contabilidade Economico-Ambiental* - SCEA (IBGE, Sala de Imprensa).

The first action was to carry out a study of water bills, in partnership with the National Water Agency and the Ministry of Environment, which includes Land-Cover and Land-Use Changes. Since that Seminar, which had the participation of representatives of institutions of several countries, the IBGE kicked off a series of activities towards the implementation of environmental accounting, among which is the project ***Land-Cover and Land-Use Changes,*** designed by the Directorate of Geosciences. Based on an international methodological framework (GONG;WEBER, 2009), which allows the identification of changes in the terrestrial ecosystems, this activity aims at monitoring the changes in land cover and land use all over the national territory, in regular periods, based on systematic topographic mapping. This piece of information can be associated with other spatial and statistical data in order to produce new information and support different activities. Among these activities are the Physical Accounts of Land-Cover and Land-Use Changes, which keep an account of the great transformations occurred in the Brazilian territory, being capable of giving support as well to the value of the environmental changes in economic terms. This study can also be included, contextually, in the attempt made by FAO (Food and Agriculture Organization of the United Nations) to establish a world system of land cover classification, as a support to environmental accounting, as recommended by JAFFRAIN, 2012.

How to Keep an Account of Land-Cover and Land-Use Changes?

Class Definition

The classes of land cover and land use, as well as the Land-Cover and Land-Use Changes in this study were developed based on the correspondence with the System of Land-Cover and Land-Use Classification of the IBGE-SCUT, in the levels II and III (IBGE, 2013), because those levels are the closest ones to the SEEA proposal of Central Framework (2012, op. Cit). This system, in its design, was made compatible with the National Classification of Economic Activities – CNAE/AGRO (IBGE, 2013).

Aiming at the study of the Land-Cover and Land-Use Changes, the definition of the classes, besides being based on the IBGE classification system, was also made compatible with the nomenclature of the *System of Environmental-Economic Accounting* – SEEA-LC (cover) and SEEA-LU (use) (SEEA, 2014), bringing up as a benefit the possibility of using the international codification of these classifications in future developments of this kind of studies. The correspondence between the classes of the IBGE and of the SEEA took into consideration the objectives and the scale adopted (see tables 1 and 2). It is important to highlight that both classifications were conceived for regional-scale topographic mappings and consider the current terminology in several surveys, national and international. For such reasons, one should be very careful when interpreting the results.

As already mentioned, this study can be included, contextually, in the discussion coordinated by FAO to establish a world system of land cover classification, as a support to environmental accounting. Thus, an adjustment was also implemented between the classes used in this study "Land-Cover and Land-Use Changes" and the classes proposed in *Land Cover Functional Unit* - LCFU (JAFFRAIN, 2012), in the light of the descriptions in the work *System of*

Environmental-Economic Accounting (SEEA), edited by the European Commission and FAO (SEEA, 2014).

Table 1: Correspondence between the classifications of SEEA-LC and IBGE-LEVEL II

SEEA-LC CLASSIFICATION		**IBGE CLASSIFICATION – Level II**	
CLASS	DESCRIPTION	CLASS	DESCRIPTION
LC01	Artificial surfaces (including urban and associated areas)	1.1	Urbanized area
		1.2	Mining and quarrying area
LC02	Herbaceous crops	2.1	Temporary crops
LC03	Woody crops		
LC04	Multiple or layered crops	2.2	Permanent or temporary crops associated or not
LC05	Grassland croplands	2.3	Pastures
LC06	Tree-covered areas	3.1	Forests (including mangroves)
LC07	Mangroves	3.1	Forests ------------------------
LC08	Shrub-covered areas	3.2	Shrub-covered areas
LC09	Shrubland, and/or herbaceous vegetation, aquatic or regularly flooded	3.2	Shrubland, and/or herbaceous vegetation, aquatic or regularly flooded
LC10	Sparsely natural vegetated areas	3.2	Sparsely natural vegetated areas
LC11	Terrestrial barren land	5.1	Other areas
LC12	Permanent snow and glaciers	-	--------------------------------
LC13	Inland water bodies	4.1	Continental water bodies
LC14	Coastal water bodies	4.1	Continental water bodies (when in coastal plains)
		4.2	Coastal water bodies

Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

Table 2: Correspondence between SEEA-LU and IBGE-LEVEL II and III

<table>
<tr><th colspan="2">SEEA-LU CLASSIFICATION</th><th colspan="2">IBGE - Level II and III CLASSIFICATION</th></tr>
<tr><td>CLASS</td><td>DESCRIPTION</td><td>CLASS</td><td>DESCRIPTION</td></tr>
<tr><td>D</td><td>Land used for extractive industry and civil construction</td><td>1.2</td><td>Mining and quarrying areas</td></tr>
<tr><td>E</td><td>Land used for industry</td><td rowspan="7">1.1</td><td>Urban-industrial areas or Industrial complexes or Other urban areas</td></tr>
<tr><td>F</td><td>Land used for infrastructure</td><td>Same as above</td></tr>
<tr><td>G</td><td>Land used for transportation and storage</td><td>Same as above</td></tr>
<tr><td>H</td><td>Land used for services, trade, financial system and public areas</td><td>Village or Town</td></tr>
<tr><td>I</td><td>Urbanized lots for recreational purposes</td><td>----</td></tr>
<tr><td>J</td><td>Residential areas</td><td>Village or Town</td></tr>
<tr><td>A1</td><td>Land under temporary crops</td><td>2.1</td><td>Temporary crops</td></tr>
<tr><td>A4</td><td>Land under permanent crops</td><td>2.2</td><td>Permanent crops</td></tr>
<tr><td rowspan="2">A</td><td rowspan="2">Agricultural land</td><td>2.1</td><td>Temporary crops</td></tr>
<tr><td>2.2</td><td>Permanent crops</td></tr>
<tr><td>A2</td><td>Temporary meadows and pastures</td><td>2.3</td><td>Pastures</td></tr>
<tr><td>A3</td><td>Land temporarily fallow</td><td>2.1</td><td>Temporary crops</td></tr>
<tr><td>A5</td><td>Permanent meadows and pastures</td><td>2.3</td><td>Pastures</td></tr>
<tr><td>A6</td><td>Bare soil</td><td>5.1</td><td>Barren land</td></tr>
<tr><td>K2</td><td>Herbaceous vegetation</td><td>3.2</td><td>Grassland</td></tr>
<tr><td>B1</td><td>Land with naturally regenerated forests</td><td>3.1</td><td>Forest</td></tr>
<tr><td>B2</td><td>Planted forest</td><td>2.4</td><td>Silviculture</td></tr>
<tr><td>K1</td><td>Shrubland</td><td>3.2</td><td>Grassland</td></tr>
<tr><td>L1</td><td>Arid land and sandy land</td><td>5.1</td><td>Barren land</td></tr>
<tr><td>L2</td><td>Glaciers</td><td>5.1</td><td>Barren land</td></tr>
<tr><td>M</td><td>Open land</td><td>5.1</td><td>Barren land</td></tr>
<tr><td>C</td><td>Land with aquaculture facilities</td><td>-</td><td>Not available for these scales</td></tr>
<tr><td>N</td><td>Other</td><td>-</td><td>Depends on which category</td></tr>
<tr><td rowspan="2">-</td><td rowspan="2">-</td><td>4.1</td><td>Inland water body</td></tr>
<tr><td>4.2</td><td>Coastal water body</td></tr>
</table>

Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

This way it was possible to adjust the aforementioned classifications, as presented in tables 1 and 2, which resulted in 14 major classes, considerably aggregated, but which allow, due to their composition, even more disaggregated evaluations at wider scales in the future. That includes the possible feedback to the System of Land-Use Classification of the IBGE-SCUT. Table 3 describes the previously mentioned classes, guiding the map interpreter in their identification.

Table 3: Land-Cover and Land-Use Classes

LAND-COVER AND LAND-USE CLASSES	
1 - Artificial Surfaces	More than 75% of the polygon occupied by urban fabric, structured by buildings and road systems, where nonfarm artificial surfaces predominate. Metropolises, cities, villages, road areas, services and transportation, energy and communication networks, industrial and commercial complexes are included in this category. Native villages and mining areas are also included. Urban fabric can be continuous or discontinuous.
2 - Cropland	More than 75% of the polygon occupied by annual crops and/or permanent crops, irrigated or not, aimed at the production of food, fiber and agribusiness commodities. Fallow croplands and inundated crops are included. It can be represented by different cultivation patterns, such as heterogeneous zones or extended plantation areas.
3 - Managed Pasture	Area predominantly occupied by cultivated herbaceous vegetation (perennial forage), used for grazing of cattle and other animals. High intensity human interference, such as the removal of stumps and rocks.
4 - Cropland and Remaining Forest Mosaics	More than 50% and less than 75% of the polygon occupied by cropland. In the other areas there may be remaining forest tree cover, forest regeneration, pastures or silviculture. Other vegetation types, such as herbaceous and shrubby, can appear in a smaller proportion.
5 - Silviculture	Planted forests with cultivation of exotic species. In this case, more than 75% of the polygon needs to be occupied by silviculture.

LAND-COVER AND LAND-USE CLASSES	
6 - Forest Tree Cover	More than 75% of the polygon occupied by forests (arboreal formations higher than 5 meters tall). It includes Dense forests, Open forests, Seasonal forests (characterized by the loss of leaves during the dry season) and Mixed forests (forest structures that encompasses the natural distribution area of the *Araucaria angustifolia*, whose upper stratum usually forms a continuous coverage). It also includes other features whose tree structure is more than five meters high, like the forested savannah, forested *Campinarana* and mangroves.
7 - Forest and Farming Activities Mosaics	More than 50% and less than 75% of the polygon occupied by forest vegetation. In the other areas there may be seasonal crops, irrigated or not, permanent crops, pastures and/or silviculture.
8 - Savannah, Shrubland, Grassland	More than 75% of the polygon occupied by non-tree formations. Diverse categories of physiognomic vegetation very different from the forest type, featured by a predominant shrub stratum, largely distributed over a grassy-woody carpet. Savannas, steppes, pioneer formations and ecological refuges are included in this category. These formations can occur in different phytogeographic regions, such as plateaus, rocky outcrops in coastal mountains and sandbanks.
9 - Wetlands	Natural herbaceous formation (covering 10% or more) permanently or periodically inundated by fresh or brackish water. Includes estuaries, marshes, swamps and others. Inundation period must be at least of 2 months per year. Shrub or tree vegetation may occur, but these formations must not occupy more than 10% of the total area.
10 - Natural Pasture	Natural grassland used for grazing and other low intensity human interferences.
11 - Cropland and Savannah/Shrub /Grassland Mosaics	More than 50% and less than 75% occupied by savannas, shrubs, steppes and pioneer formations. In the other areas there may be seasonal crops, irrigated or not, permanent crops, pastures and/or silviculture.
12 - Inland Water Bodies	It includes all interior waters, as rivers, streams and linear water bodies, natural lakes and artificial reservoirs.

LAND-COVER AND LAND-USE CLASSES	
13 - Coastal Water Bodies	It includes all coastal waters, lagoons, estuaries, bays and waters within the 12 nautical miles, according to the law no 8,617, of January 4th, 1993.
14 - Barren land	Rocky outcrops, cliffs, reefs, land with active erosion processes and abandoned extraction areas with no remaining vegetation, where 75% of the surface is covered by rocks, blocks and debris. It also includes coastal and inland dunes and accumulation of gravel along the rivers.

Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

The elaboration of the Change Classes considered all the possible combinations among the 13 classes of land cover and use; the class *Coastal water body* was not used, because it is inserted in the final mapping as an element originated in the cartographic base. The methodology is described in the item Detection of Changes and presented in detail in annex I.

Work Steps

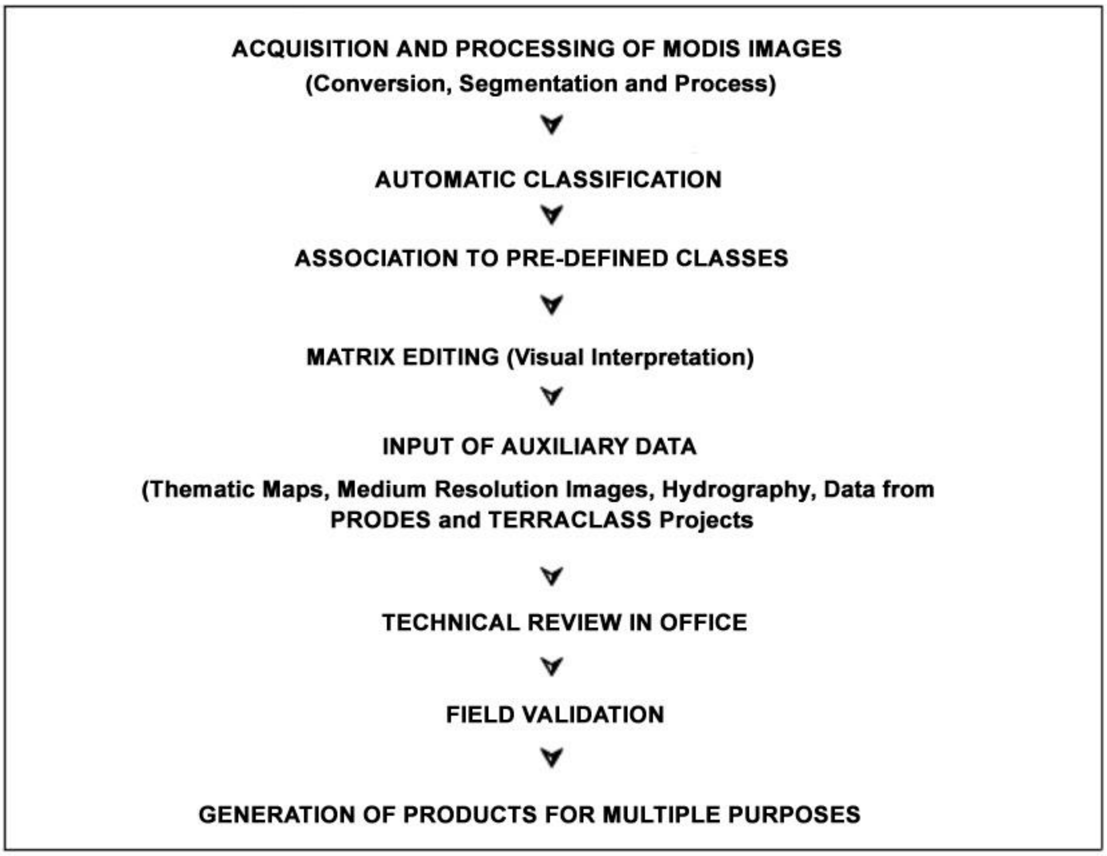
Digital Processing

The work steps operating procedures are summarized in the flowchart presented in Figure 1. These procedures start with the acquisition, conversion, enhancement, segmentation and classification of MODIS images from TERRA and AQUA satellites. The acquisition of MODIS (Moderate Resolution Imaging Spectroradiometer) images, with spatial resolution of approximate 250m is done freely on the Internet by the US Geological Survey (USGS). The MODIS images are originally available in hdf format, and need to be converted into tif to be imported and processed by the SPRING program developed by the Brazilian Institute of Spatial Research (INPE).

This conversion is conducted with the help of program MRT Tools (TAAHERI; COHEN, 2011). The most commonly used MODIS bands are NIR (near infrared), MIR (middle infrared), Red Reflectance and NDVI (Normalized Difference Vegetation Index). In the selection of images, in order to avoid scenes with a high percentage of clouds, the rainfall characteristics of each Brazilian region and also the national agricultural calendar are taken into consideration, with priority given to images showing well developed crops and, thus, obtaining a good spectral response from these targets. The information is obtained, respectively, from the website of the Weather Forecast and Climate Studies Center - CPTEC and from the IBGE's Agricultural Department.

Once converted, the images are enhanced (contrast adjustment), segmented and automatically classified by the SPRING tool. Then the classes generated by this classification and the previously defined classes are associated, according to procedures in the SPRING tool. It is important to highlight that the entire classification process was conducted only for the first period studied (year 2000). In the following periods, since the only observed changes referred to the starting point, there was no need of new classifications. This procedure optimizes the of a national-coverage work.

Figure 1: Work Steps



Source: IBGE, Diretoria de Geociências, Levantamento e Classificação de Uso da Terra

Editing

Editing is subdivided into two steps: matrix editing and data input. Matrix editing is a non-automatic process, conducted in order to correct possible imperfections generated by the automatic classification system and by the association process. In this step it is also necessary to use additional information such as thematic maps and statistical data produced by the IBGE, thematic maps produced by state governments or by any other entities. Additional support includes images from medium resolution satellite such as CBERS, SPOT and LANDSAT TM 5, 7 and 8, and high resolution ones such as RAPIDEYE, Google Earth and the Time Series elaborated by the INPE's Lab of Remote Sensing Applied to Agriculture and Forest.

In the following step, data from the IBGE and other Institutions on detection of deforested areas, agricultural and managed pastures, mainly in the Legal

Amazon, are inserted. The IBGE data included information from the enumeration areas (smallest area for data collection in the IBGE surveys) of the latest Census of Agriculture, previously spatialized and converted into the shapefile *format* and exported to the SPRING tool. For rural enumeration areas it is possible to identify the existence of areas representing managed pastures, according to the scale. Regarding other institutions, the data refer to those produced by the project Amazon Monitoring Program - PRODES and by the TERRACLASS project, made available by INPE and EMBRAPA, in shapefile format. The polygons of the different classes defined by the projects are compared to polygons from the interpretation previously elaborated by the working team. In case of incompatibility among the data from the Census, from PRODES, from TERRACLASS and from the prior interpretation, other sources are consulted, for example, medium resolution images, Google Earth and Time Series - INPE.

Besides the procedures mentioned above, there was a series of tests with the objective of checking the viability of the systematic separation of grazing areas in the scale adopted in this project. The test consisted in evaluating the viability of MODIS images 13A1 Normalized Difference Vegetation Index - NDVI (INPE, 2003) multi-temporal product, in the detection of grazing areas. The methodology used several applications of the MODIS sensor according to Rudorff et al, 2007. The selection of 250m resolution NDVI images was associated with the agricultural calendar and also with the rainfall (Brazil Monitoring - CPTEC/INPE). This way, images from at least three different dates in the same year were used. The procedure of multi-temporal analysis allowed croplands, which notably present changes in the vegetation index throughout the year, to be separated from areas which hold more stable indexes in the same period. The values of pixels between images were subtracted. In this process the pixels that present little or no change between the dates have a value equal to or close to zero. On the other extreme, the pixels which presented a big difference between the dates get close to 255 (gray shade value). So, the areas with little or no change were represented in shades of black and very dark gray and those areas with a big difference among the dates were represented in white or very light gray. In the following step, the polygons presenting little variation in values were vectored and overlapped with images used for the analysis of points in the sample through the "MODIS time series viewer for the analysis of Land Cover and Use."

Then the hydrography polygons, officially made available by the Cartography Department of the IBGE are incorporated into the mapping. The editing step ends with a technical revision which includes verification of possible inconsistencies, edge matching, elimination of polygons with an area below 625,000 m² and geometric adjustment. This adjustment is necessary to correct dislocations generated by the SPRING tool.

Validating Information

In order to clarify any doubts and set standards for the satellite images used in the interpretation, field campaigns are conducted in representative areas selected throughout the work, in an attempt to encompass the several existing biomes of the Brazilian territory: Atlantic Forest, *Cerrado*, *Caatinga*, the Amazon, *Pampa* and *Pantanal*. Besides these field works, the project counts on the assistance of civil servants from all the IBGE State Branches. In order to reach this objective, it makes use of the big chain of branches of the Institution and acknowledges the experience and knowledge of all these professionals.

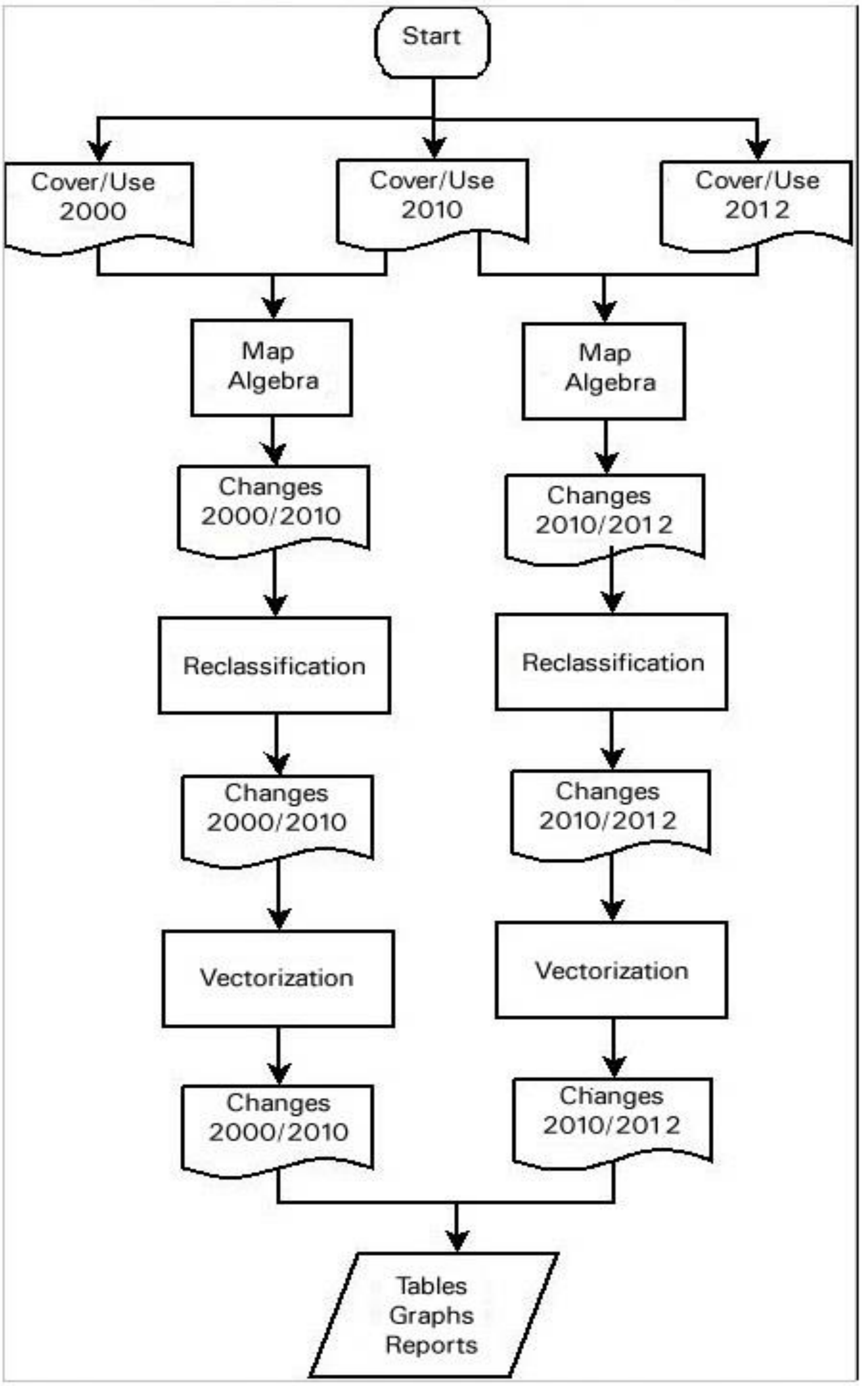
For the final validation of the classifications, a comparative work was carried out among a set of 379 points obtained from field works and from office materials, aiming at generating the Kappa coefficient – statistical measure which adjusts the random effect in the proportion of agreement observed for the elements/classes. Distributed all over the national territory, these points were collected between the years 2011 and 2012, both by technicians of the Land Cover and Land Use Changes Project and by technicians of the Land Use project, whose products have a more detailed scale (1:250,000) and are published by Federation Unit. As a final result of this procedure, a Kappa index of 0.70815 was obtained (*strong* agreement).

Detection of Changes

In order to identify the changes along the periods under consideration (2000, 2010 and 2012), combinatorial analysis among the classes of Land Cover and Use of the mappings was adopted, resulting in 169 possible change classes (13 x 13). To assess the types of changes that take place in these periods, a new simplified classification is needed to aggregate and better reflect what takes place in spatial terms. To do this and address the objective of this work, some criteria were adopted to define the final classes from possible Changes Level I and II (annex I).

Some geoprocessing methods to extract the change classes, described in figure 2, were used to develop products to disseminate information on the dynamics of the land cover and use along 2000, 2010 and 2012. The initial and final maps (2000-2010 and 2010-2012) were co-registered. To assess these maps, a confusion matrix was generated, and the *Kappa* index calculated, using the coordinates obtained in the field. In matrix format, these maps are analyzed *pixel* per *pixel* (local operation) through the map algebra. In this operation, the values from each *pixel* (labels) are concatenated to define a change code. After the cross tabulation, a re-classification was carried out to fit in the change classes defined in the previous section. Having classified the map in matrix format, then the outputs were prepared for dissemination, including the vectoring and the standardization of the associated attributes.

Figure 2: Steps of the extraction of the change classes



Source: IBGE, Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

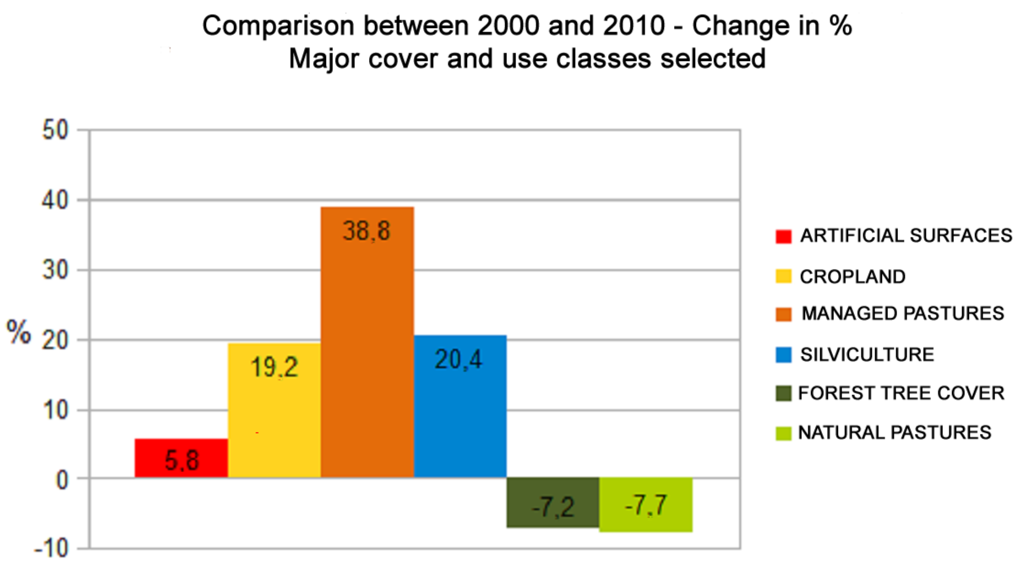
The continental water bodies were not changed in the two periods surveyed (2000-2010 and 2010-2012), since the criterion of the official polygons of water bodies, published by the IBGE itself, was adopted. Only the areas that impound water to generate energy, which were not included in the cartographic base, were added to this class. They were added to the mappings based on the Continuous Cartographic Base 1: 250,000 (IBGE, 2013) and only new reservoirs were added to the mapping. As a result, changes related to water bodies are not detected.

Analysis of the Results

The results obtained in this work comprise three maps of Land Cover and Use in Brazil, years 2000, 2010 and 2012, as well as the Change Classes, by crossing these maps. The maps of land cover and use are available in *PDF* and *shapefile* (link to PDF/SHAPE files) formats, whereas the Changes for the 2000-2010 and 2010-2012 periods are only in shapefile format (link to SHAPE files).

The analysis of the **land cover and use** data allows detecting the change, in percentage, of a period when compared with the previous period. It is noticed between 2000 and 2010 that the managed pastures increased significantly more than the croplands. It could be also noticed that the decrease of the forest area was equivalent to the natural pastures as demonstrated on graph 1.

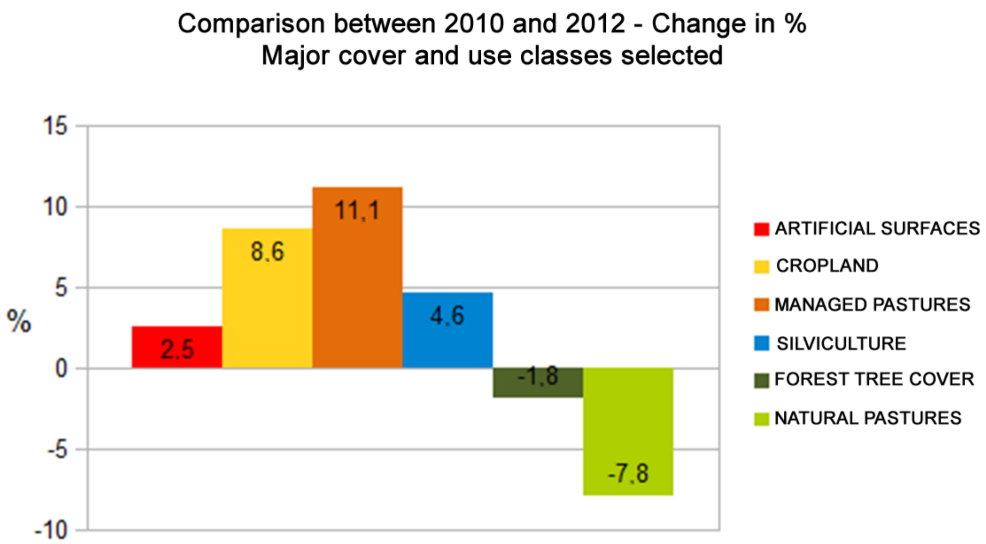
Graph 1: Comparison between the 2000 and 2010 periods



Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

The comparison of the major classes of land cover and use between 2010 and 2012 showed the significant increase of the croplands when compared with the managed pastures, though the latter still shows a higher percentage. Unlike the previous comparison period, the 2010-2012 period showed that the loss of the natural pastures was four times that of the forest tree cover, according to graph 2. These areas were particularly absorbed by the productive process of the agricultural expansion.

Graph 2: Comparison between the 2010 and 2012 periods



Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

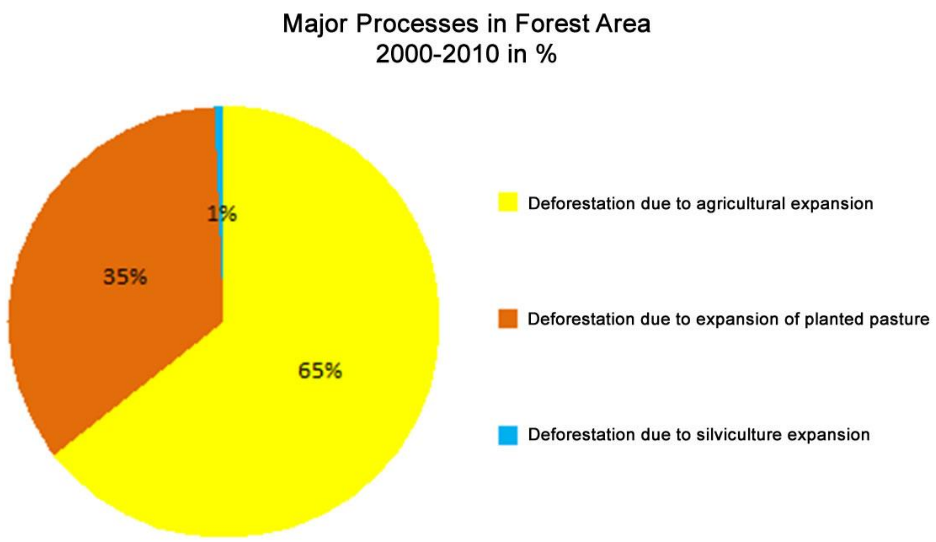
Some comments can be drawn on the **changes** that took place in all the Brazilian territory based on the information obtained when crossing the 2000-2010 and 2010-2012 periods. The statistical data of these crossings are represented in annex II as Physical Accounts of the Earth, according to SEEA, 2012. This table can be interpreted through the observation of the land cover and use classes in the columns, according to their total areas in 2000, 2010 and 2012, and the additions or reductions of inventories in the lines, corresponding to the same classes. In the periods surveyed, each line discriminates the increase or reduction of inventories, in km², of each class in relation to the classes showed in the columns.

For the purpose of analysis, the major processes that contributed to changes in the land cover and use were split between the two major vegetation covers:

forest areas and non-forest areas, dominated by natural pastures. It is important to remember that the largest part of the natural pastures use areas of the *Cerrado*, *Caatinga* and *Pampas* biomes, in their different physiognomies.

The changes in the 2000-2010 period took place in about 7% of the Brazilian territory, according to the change detection procedure. In the forest environment, the agricultural expansion was a highlight, responsible for more than half of the deforestation in the period, as showed on graph 3.

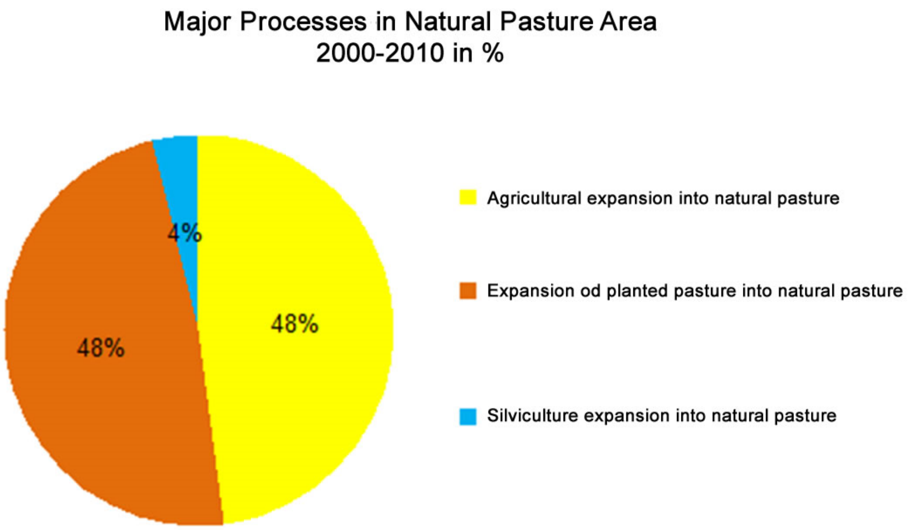
Graph 3: Major processes in forest areas, 2000 and 2010



Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

Between 2000 and 2010, the agricultural expansion and the managed pastures equally advanced into natural pastures. It can be seen on graph 4 that the silviculture expansion is more present in these areas.

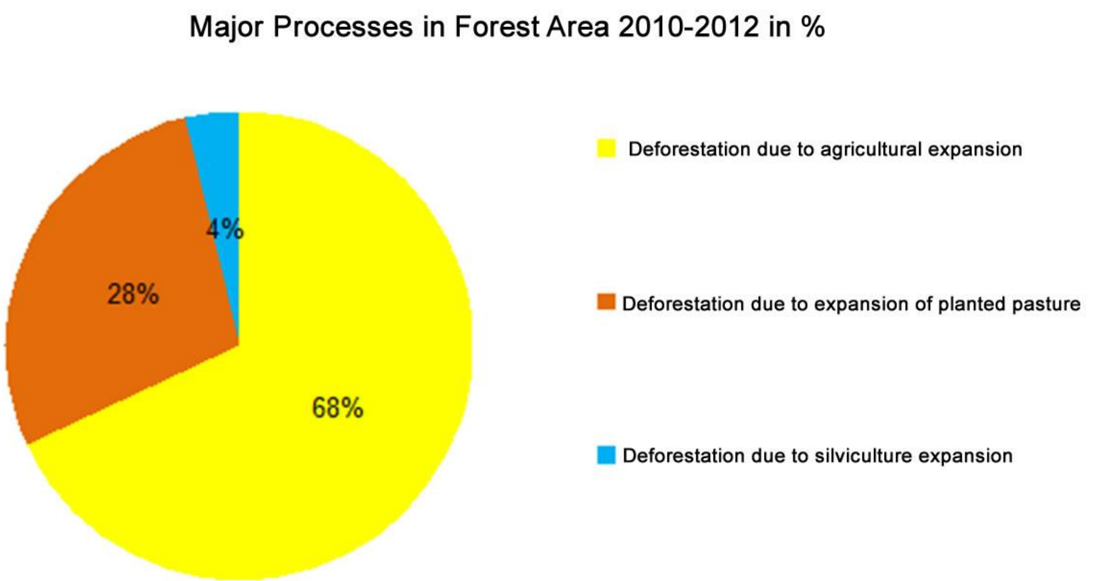
Graph 4: Major processes in natural pastures, 2000 and 2010



Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

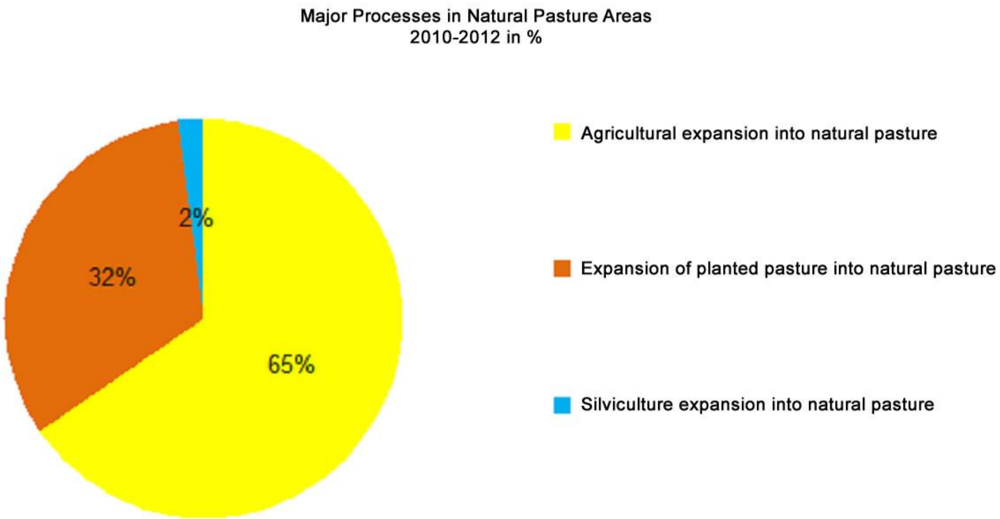
In the 2010-2012 period, about 96.5% of the areas did not change, and the classes of *agricultural expansion* and *expansion of managed pastures* once again changed more significantly. When compared with the previous period, *agricultural expansions* were larger in percentage terms, both in the forest environment and in the natural pastures, particularly in the latter as seen on graphs 5 and 6.

Graph 5: Major processes in forest areas, 2010 and 2012



Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

Graph 6: Major processes in natural pastures, 2010 and 2012



Source: IBGE. Diretoria de Geociencias. Levantamento e Classificacao de Uso da Terra

It is important to remember that the mapping of changes in land cover and use was conceived to contribute to the understanding of what are the major changes and where they occur in widespread scale, provided that the calculation of areas follows the recommendations and limitations of the main input used, MODIS.

References

BRIASSOULIS, H. Analysis of land use change: theoretical and modeling approaches. 2000. Doctoral Dissertation (Geography) - University of the Aegean. Lesvos, Greece. 2000. Available from: <http://www.rri.wvu.edu/WebBook/Briassoulis/contents.htm>. Cited: Jan. 2012.

CENTRO DE PREVISAO DO TEMPO E ESTUDOS CLIMATICOS/INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (CPTEC). **Monitoramento Brasil**. Available from: <http://clima1.cptec.inpe.br/monitoramentobrasil/pt>. Cited: July 15 2014.

COHEN, Jacob, 1960 A coefficient of agreement for nominal scales. Educational and Psychological Measurement 20 (1):37-46.

CORINE land cover changes 1975-1990, vector data, polygon. European Environment Agency, 1990. Available from: <http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-1990-clc1990-and-corine-land-cover-changes-1975-1990-in-a-10-km-zone-around-the-coast-of-europe>. Cited: August 4 2011.

DI GREGORIO, A.; JANSEN, L. J. M. *Land cover classification system (LCCS):* classification concepts and user manual: for software, version 1.0. FAO Land and Water Development Division, 2000. Available from: <http://www.fao.org/docrep/003/x0596e/x0596e00.htm>. Cited: May 11 2011.

FREITAS, R.M.; ARAI, E.; ADAMI, M.; SOUZA, A.F.; SATO, F.Y.; SHIMABUKURO, Y.E.; ROSA, R.R.; ANDERSON, L.O.; RUDORFF, B.F.T. Virtual laboratory of remote sensing series: visualization of MODIS EVI2 data set over South America. Journal of Computational Interdisciplinary Sciences, 2:57-64. 2011. Available from: <http://www.dsr.inpe.br/laf/series/artigos/Freitas_Ramon_M_et_al_2011_JCIS_Virtual_laboratory_of_remote_sensing_time_series.pdf>. Cited: Jan 8 2011.

GONG, X.; WEBER, J. L. *Land cover and land use classifications in the SEEA Revision: paper prepared by the European Environment Agency and FAO*, for discussion. *In*: MEETING OF THE UN COMMITTEE OF EXPERTS ON ENVIRONMENTAL-ECONOMIC ACCOUNTING, 4., 2009, New York. European Environment Agency, 2009. Available from:<http://unstats.un.org/unsd/envaccounting/ceea/meetings/UNCEEA-4-11.pdf>. Cited: May 9 2011.

INDICADORES de desenvolvimento sustentavel: Brasil 2004. Rio de Janeiro: IBGE, 20012. 395p. (Serie Estudos e Pesquisas, n.4) Available from: <http://www.ibge.gov.br/home/geociencias/recursosnaturais/ids/ids_2004.shtm>. Cited: May 2 2012.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATISTICA (IBGE). **Base Cartografica Cont nua do Brasil na escala 1:250.000 (versao 1.0).** Available from: <http://mapas.ibge.gov.br/pt/bases-e-referenciais/bases-cartograficas/cartas>.

Cited: Jan 25 2014.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATISTICA (IBGE). Sala de imprensa. **IBGE promove Seminario Internacional sobre Estat sticas Ambientais.** Available from: <http://saladeimprensa.ibge.gov.br/noticias?idnoticia=1459&t=ibge-promove-seminario-internacional-sobre-estatisticas-ambientais&view=noticia>. Cited: July 23 2014.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATISTICA (IBGE). Diretoria de Pesquisas. **Classificacao Nacional de Atividades Economicas (CNAE).** Rio de Janeiro, 2007. Available from: <http://www.ibge.gov.br/home/estatistica/economia/classificacoes/cnae2.0/cnae2.0.pdf>. Cited: August 8 2014.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATISTICA (IBGE). **Indicadores IBGE.** Estat stica da Producao Agr cola. Available from: <ftp://ftp.ibge.gov.br/Producao_Agricola/Fasciculo_Indicadores_IBGE/estProdAgr_201504.pdf>. Cited: April 30 2015.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATISTICA (IBGE). Censo Demografico 2010. Available from: <http://www.ibge.gov.br/home/estatistica/populacao/censo2010/default.shtm>. Cited: August 21 2015

INSTITUTO BRASILEITO DE GEOGRAFIA E ESTATISTICA (IBGE). **Manual Tecnico de Uso da Terra.** 3. ed., Rio de Janeiro: IBGE, 2013.

INSTITUTO BRASILEITO DE GEOGRAFIA E ESTATISTICA (IBGE). Sistema de Classificacao de Uso da Terra – SCUT. Available from: <http://portalextranet.ibge.gov.br/qa/geociencias/recursosnaturais/usodaterra/app_indice/index.shtm>.

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (INPE). Diretoria de Pesquisas. **Projeto Prodes.** Monitoramento da Floresta Amazonica Brasileira por Satelite. Available from: <http://www.obt.inpe.br/prodes/index.php>. Cited: June 30, 2014.

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (INPE). **Projeto TerraClass.** Available from: <http://www.inpe.br/cra/projetos_pesquisas/terraclass2010.php>. Cited: July 03 2014.

INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS (INPE). **Sensor Modis: Uma abordagem geral.** Sao Jose dos Campos/SP: INPE, 2003.

INPE. Metodologia para o Calculo da Taxa Anual de Desmatamento na Amazonia Legal. INPE, 2006.

PROGRAMA DAS NACOES UNIDAS PARA O DESENVOLVIMENTO. **Introducao a Proposta do Grupo de Trabalho Aberto para os Objetivos do Desenvolvimento Sustentavel**. Rio +. World Centre For Sustainable Development. T tulo Original: *Introduction to the Proposal of The Open Working Group for Sustainable Development Goals*.

JAFFRAIN, G; 2012. *Proposal of Land Cover System Classification for Ecosystem Accounting*. Working document. Final report. European Topic Centre Spatial Information and Analysis – November 2012

JENSEN, John R. Sensoriamento remoto do ambiente: uma perspectiva em recursos terrestres. Remote sensing of the environment: an earth resource perspective. Traducao e coordenacao de Jose Carlos Neves Epiphanio. et. al. 2. ed. Sao Jose dos Campos, SP: Parentese, 2011. 598 p. ISBN 978-85-60507-06-1.

LABORATORIO DE SENSORIAMENTO REMOTO APLICADO A AGRICULTURA E FLORESTA. Series Temporais. Available from: <https://www.dsr.inpe.br/laf/series/ ndex.php>. Cited: Jun 25 2014.

RUDORFF, B.F.T.; SHIMABUKURO, Y.E.; CEBALLOS, J.C. (Coord.). Sensor MODIS e suas Aplicacoes Ambientais no Brasil. 1.ed. Sao Jose dos Campos: Ed. Parentese, 2007. 425 p.

SEEA - System of Environmental-Economic Accounting. Central Framework. White Cover Publication: 2012. 306 pag.

_____. System of Environmental-Economic Accounting. Central Framework: 2014. 346 pag.

SPRING: Integrating remote sensing and GIS by object-oriented data modelling. Camara G, Souza RCM, FreitasM, Garrido J Computers & Graphics, 20: (3) 395-403, May-Jun 1996.

Taaheri A, Cohen A. HDF-EOS to GeoTIFF Conversion Tool (HEG) Stand-alone User's Guide. Available from: <ftp://edhs1.gsfc.nasa.gov/edhs/HEG_Tool/Version2.11/516eed001_HEG_UsersGuide_v2.11.pdf>. Cited: July 2013.

TURNER II, B. L.; LAMBIN, E. F.; REENBERG, A. The emergence of land change science for global environmental change and sustainability. **PNAS** (Land Change Science Special Feature – Perspective), v. 104, n. 52, p. 20666-20671. 2007.

USGS Global Visualization Viewer (GloVis). **MODIS**. Available from: <http://glovis.usgs.gov/>. Cited: August 11 2014.

WEBER, J. L. Globcorine. In: GLOBCOVER THIRD USER CONSULTATION, 2008, Copenhagen. *Copenhagen:* European Environment Agency, 2008. Available from: http://www.esa.int/esaCP/index.html

Available from: <http://due.esrin.esa.int/prjs/Results/131-176-149-30_2008912104639.pdf>. Cited: May 10 2011.

_____. Implementation of land and ecosystem accounts at the European Environment Agency. *Ecological Economics,* v.61, n.4, p.695–707, Mar.2007. Available from: <http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%235995%232007%23999389995%23646497%23FLA%23&_cdi=5995&_pubType=J&_auth=y&_acct=C000049831&_version=1&_urlVersion=0&_userid=1035497&md5=fbc2687bc8972ffa78f4f95c4311ba05>. Cited: May 5, 2011.

_____. Land cover classification for land cover accounting*. In:* MEETING OF THE LONDON GROUP ON ENVIRONMENTAL ACCOUNTING, 14., 2009, Canberra. Canberra :European Environment Agency, 2009. Available from: <http://unstats.un.org/unsd/envaccounting/londongroup/meeting14/LG14_9a.pdf>. Cited: May 12 2011.

ANNEX I – LAND-COVER AND LAND-USE CHANGE CLASSES

<table>
<tr><th>LAND-COVER AND LAND-USE CLASS
INITIAL</th><th>LAND-COVER AND LAND-USE CLASS
FINAL</th><th>CHANGE CLASS
LEVEL I</th><th>CHANGE CLASS
LEVEL II</th></tr>
<tr><td>Savannah, Shrubland, Grassland</td><td>Natural Pasture</td><td rowspan="4">Grassland Degradation</td><td rowspan="4">Grassland Degradation</td></tr>
<tr><td>Savannah, Shrubland, Grassland</td><td>Cropland and Savannah/Shrub/Grassland Mosaics</td></tr>
<tr><td>Wetlands</td><td>Natural Pasture</td></tr>
<tr><td>Wetlands</td><td>Cropland and Savannah/Shrub/Grassland Mosaics</td></tr>
<tr><td>Forest Tree Cover</td><td>Barren land</td><td rowspan="2">Deforestation</td><td rowspan="8">Deforestation</td></tr>
<tr><td>Forest and Farming Activities Mosaics</td><td>Barren land</td></tr>
<tr><td>Cropland and Remaining Forest Mosaics</td><td>Cropland</td><td rowspan="6">Deforestation
due to Agricultural Expansion</td></tr>
<tr><td>Forest Tree Cover</td><td>Cropland</td></tr>
<tr><td>Forest Tree Cover</td><td>Cropland and Remaining Forest Mosaics</td></tr>
<tr><td>Forest Tree Cover</td><td>Forest and Farming Activities Mosaics</td></tr>
<tr><td>Forest and Farming Activities Mosaics</td><td>Cropland</td></tr>
<tr><td>Forest and Farming Activities Mosaics</td><td>Cropland and Remaining Forest Mosaics</td></tr>
</table>

to be continued

ANNEX I – LAND-COVER AND LAND-USE CHANGE CLASSES

LAND-COVER AND LAND-USE CLASS INITIAL	LAND-COVER AND LAND-USE CLASS FINAL	CHANGE CLASS LEVEL I	CHANGE CLASS LEVEL II
Forest Tree Cover	Artificial Surfaces	Deforestation due to Expansion of Artificial Area	Deforestation
Forest and Farming Activities Mosaics	Artificial Surfaces		
Forest Tree Cover	Managed Pasture	Deforestation due to Expansion of Managed Pastures	
Forest and Farming Activities Mosaics	Managed Pasture		
Forest Tree Cover	Silviculture	Deforestation due to Expansion of Silviculture	
Forest and Farming Activities Mosaics	Silviculture		
Silviculture	Cropland	Agricultural Expansion into Silviculture Area	Agricultural Expansion
Silviculture	Cropland and Remaining Forest Mosaics		
Barren land	Cropland	Agricultural Expansion into Barren Land	
Barren land	Cropland and Remaining Forest Mosaics		
Natural Pasture	Cropland	Agricultural Expansion into Natural Pastures	
Natural Pasture	Cropland and Savannah/Shrub/Grassland Mosaics		
Managed Pasture	Cropland	Agricultural expansion into Managed Pastures	
Managed Pasture	Cropland and Remaining Forest Mosaics		

to be continued

ANNEX I - CHANGE CLASSES IN LAND COVER AND USE

CLASS OF LAND COVER AND USE INITIAL	CLASS OF LAND COVER AND USE FINAL	CHANGE CLASS LEVEL I	CHANGE CLASS LEVEL II
Cropland	Artificial Surfaces	Expansion of Artificial Area into Cropland	Expansion of Artificial Area
Cropland and Remaining Forest Mosaics	Artificial Surfaces		
Silviculture	Artificial Surfaces	Expansion of Artificial Area into Silviculture Area	
Barren land	Artificial Surfaces	Expansion of Artificial Area into Barren Land	
Managed Pasture	Artificial Surfaces	Expansion of Artificial Area into Managed Pastures	
Cropland	Managed Pasture	Expansion of Managed Pastures into Cropland	Expansion of Managed Pastures
Cropland and Remaining Forest Mosaics	Managed Pasture		
Silviculture	Managed Pasture	Expansion of Managed Pastures into Silviculture Area	
Barren land	Managed Pasture	Expansion of Managed Pastures into Barren Land	
Natural Pasture	Managed Pasture	Expansion of Managed Pastures into Natural Pastures	
Cropland	Silviculture	Expansion of Silviculture into Cropland	Expansion of Silviculture
Cropland and Remaining Forest Mosaics	Silviculture		
Barren land	Silviculture	Expansion of Silviculture into Barren Land	
Natural Pasture	Silviculture	Expansion of Silviculture into Natural Pastures	
Managed Pasture	Silviculture	Expansion of Silviculture into Managed Pastures	

to be continued

ANNEX I - CHANGE CLASSES IN LAND COVER AND USE

LAND-COVER AND LAND-USE CLASS INITIAL	LAND-COVER AND LAND-USE CLASS FINAL	CHANGE CLASS LEVEL I	CHANGE CLASS LEVEL II
Cropland	Savannah, Shrubland, Grassland	Grassland Recovery from Cropland	Grassland Recovery
Cropland	Wetlands		
Cropland	Natural Pasture		
Cropland	Cropland and Savannah/Shrub/Grassland Mosaics		
Cropland and Savannah/Shrub/Grassland Mosaics	Savannah, Shrubland, Grassland		
Cropland and Savannah/Shrub/Grassland Mosaics	Wetlands		
Silviculture	Savannah, Shrubland, Grassland	Grassland Recovery from Silviculture Area	
Silviculture	Wetlands		
Silviculture	Natural Pasture		
Silviculture	Cropland and Savannah/Shrub/Grassland Mosaics		
Barren land	Savannah, Shrubland, Grassland	Grassland Recovery from Barren Land	
Barren land	Wetlands		
Barren land	Natural Pasture		
Barren land	Cropland and Savannah/Shrub/Grassland Mosaics		
Natural Pasture	Savannah, Shrubland, Grassland	Grassland Recovery from Natural Pastures	Grassland Recovery
Natural Pasture	Wetland		
Managed Pasture	Savannah, Shrubland, Grassland	Grassland Recovery from Managed Pastures	
Managed Pasture	Wetland		
Managed Pasture	Natural Pasture		
Managed Pasture	Cropland and Savannah/Shrub/Grassland Mosaics		

to be continued

ANNEX I - CHANGE CLASSES IN LAND COVER AND USE

CLASS OF LAND COVER AND USE INITIAL	CLASS OF LAND COVER AND USE FINAL	CHANGE CLASS LEVEL I	CHANGE CLASS LEVEL II
Cropland	Cropland and Remaining Forest Mosaics	Forest Recovery from Cropland	Forest Recovery
Cropland	Forest Tree Cover		
Cropland	Forest and Farming Activities Mosaics		
Cropland and Remaining Forest Mosaics	Forest Tree Cover		
Cropland and Remaining Forest Mosaics	Forest and Farming Activities Mosaics		
Forest and Farming Activities Mosaics	Forest Tree Cover		
Silviculture	Forest Tree Cover	Forest Recovery from Silviculture Area	
Silviculture	Forest and Farming Activities Mosaics		
Barren land	Forest Tree Cover	Forest Recovery from Barren Land	
Barren land	Forest and Farming Activities Mosaics		
Managed Pasture	Forest Tree Cover	Forest Recovery from Managed Pastures	
Managed Pasture	Forest and Farming Activities Mosaics		
Natural Pasture	Barren land	Reduction of Natural Pastures	Reduction of Natural Pastures

to be continued

conclusion

ANNEX I - CHANGE CLASSES IN LAND COVER AND USE

CLASS OF LAND COVER AND USE INITIAL	CLASS OF LAND COVER AND USE FINAL	CHANGE CLASS LEVEL I	CHANGE CLASS LEVEL II
Savannah, Shrubland, Grassland	Barren land	Reduction of Grassland	Reduction of Grassland
Wetland	Barren land		
Cropland and Savannah/Shrub/Grassland Mosaics	Barren land		
Cropland and Savannah/Shrub/Grassland Mosaics	Cropland	Reduction of Grassland due to Agricultural Expansion	
Savannah, Shrubland, Grassland	Cropland		
Savannah, Shrubland, Grassland	Artificial Surfaces	Reduction of Grassland due to Expansion of Artificial Area	
Wetland	Artificial Surfaces		
Natural Pasture	Artificial Surfaces		
Cropland and Savannah/Shrub/Grassland Mosaics	Artificial Surfaces		
Savannah, Shrubland, Grassland	Managed Pasture	Reduction of Grassland due to Expansion of Managed Pastures	
Cropland and Savannah/Shrub/Grassland Mosaics	Managed Pasture		
Savannah, Shrubland, Grassland	Silviculture	Reduction of Grassland due to Silviculture Expansion	
Cropland and Savannah/Shrub/Grassland Mosaics	Silviculture		
Cropland and Remaining Forest Mosaics	Barren land	Retraction of Cropland	Retraction of Cropland
Managed Pasture	Barren land	Retraction of Managed Pastures	Retraction of Managed Pastures
Silviculture	Barren land	Retraction of Silviculture	Retraction of Silviculture

Source: IBGE. Diretoria de Geociencias. Survey and Classification of Land Use

Technical staff

Directorate of Geosciences

Department of Natural Resources and Environmental Studies

Celso Jose Monteiro Filho

Technical Staff of Land Use

Eloisa Domingues
Fernando Peres Dias
Fernando Yutaka Yamaguchi
Mauricio Zacharias Moreira

State Branch of Santa Catarina

Alceu Vanzella
Jose Marcos Moser

Geoprocessing Staff at UE-SC

Luiz Roberto de Campos Jacintho
Rodrigo de Campos Macedo

Trainees

2012

Daniela Pra S. de Sousa
Elton Hollanda dos Santos
Isabelle Fernandes
Marco Aurelio Virtuoso
Maria Luiza Silva Garcia
Marina Coelho Rosa e Silva
Natalia Cristina Wiederkehr
Rafael Cardao Augusto
Thiago Ribeiro Alves

2012-2013

Ana Carolina de Pinho
Ana Paula Esnidei Pereira
Barbara Ferreira
Laura Dias Prestes
Nara Ribeiro Menezes Mariano

2013

Daniel Andrjio Malandrin
Daniel Rosick da Silva
Debora Rodrigues de Souza
Priscila Domingues Colturato

2013-2014

Alexandre Lopes da Silva

Ana Paula Oliveira
Ariane da Silva Paim
Caroline Regina Silva
Gisella Maria da Luz
Maria Ely Goulart Boing
Raquel Martins

2014

Heloisa Helena Pereira
Raquel Gouvea Lucio Bittencourt
Suellen Maur cio