

ICONE Brazilian Land Use Model and its application for ethanol impacts

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Outline

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- Supply and demand projections for Brazil.
- Area allocation at regional level.
- Improvements under development

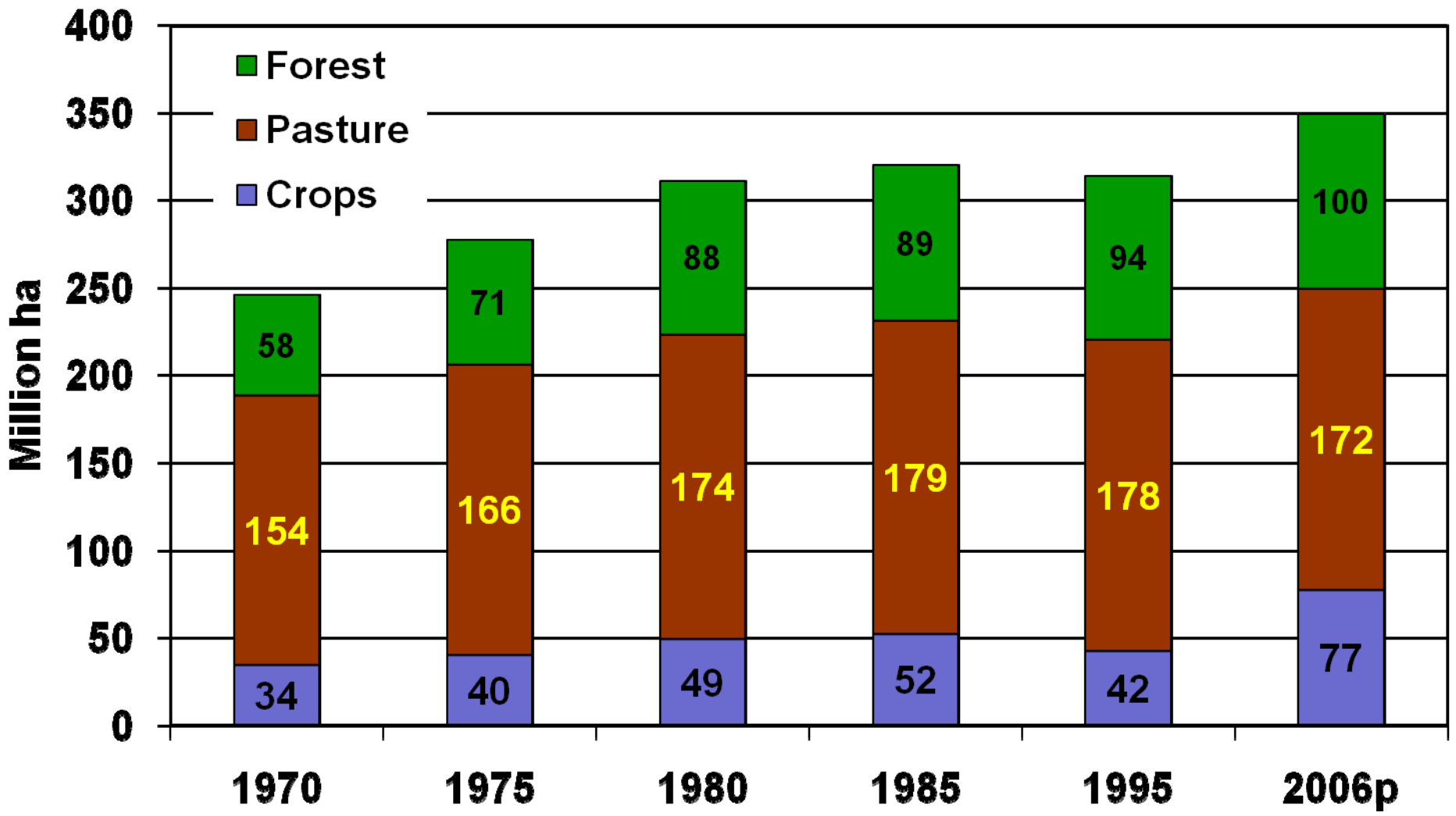
3. Applications

Introduction

- There are many concerns worldwide about the **social and environmental impacts** of biofuels productions and expansion.
- **Land Use Change (LUC)**, as well as **Indirect Land Use Change (ILUC)**, are now being taking into account in many policies aiming to promote biofuels.
- ICONE started to work on an Agriculture Projection Model in the beginning of 2008 in a joint effort with the Food and Agricultural Policy Research Institute (**FAPRI**), from Iowa State University, which is part of the Center for Agriculture and Rural Development (CARD).
- Although the Brazilian model follows the same structure of the FAPRI Models, it was **adapted to the specific conditions and situations of the Brazilian agricultural sector.**
- The Model aims to capture the **Brazilian land use dynamics** observed in the past and to forecast new dynamics



Agricultural Land use in Brazil

(Agricultural census)



P = Preliminary
Source: IBGE

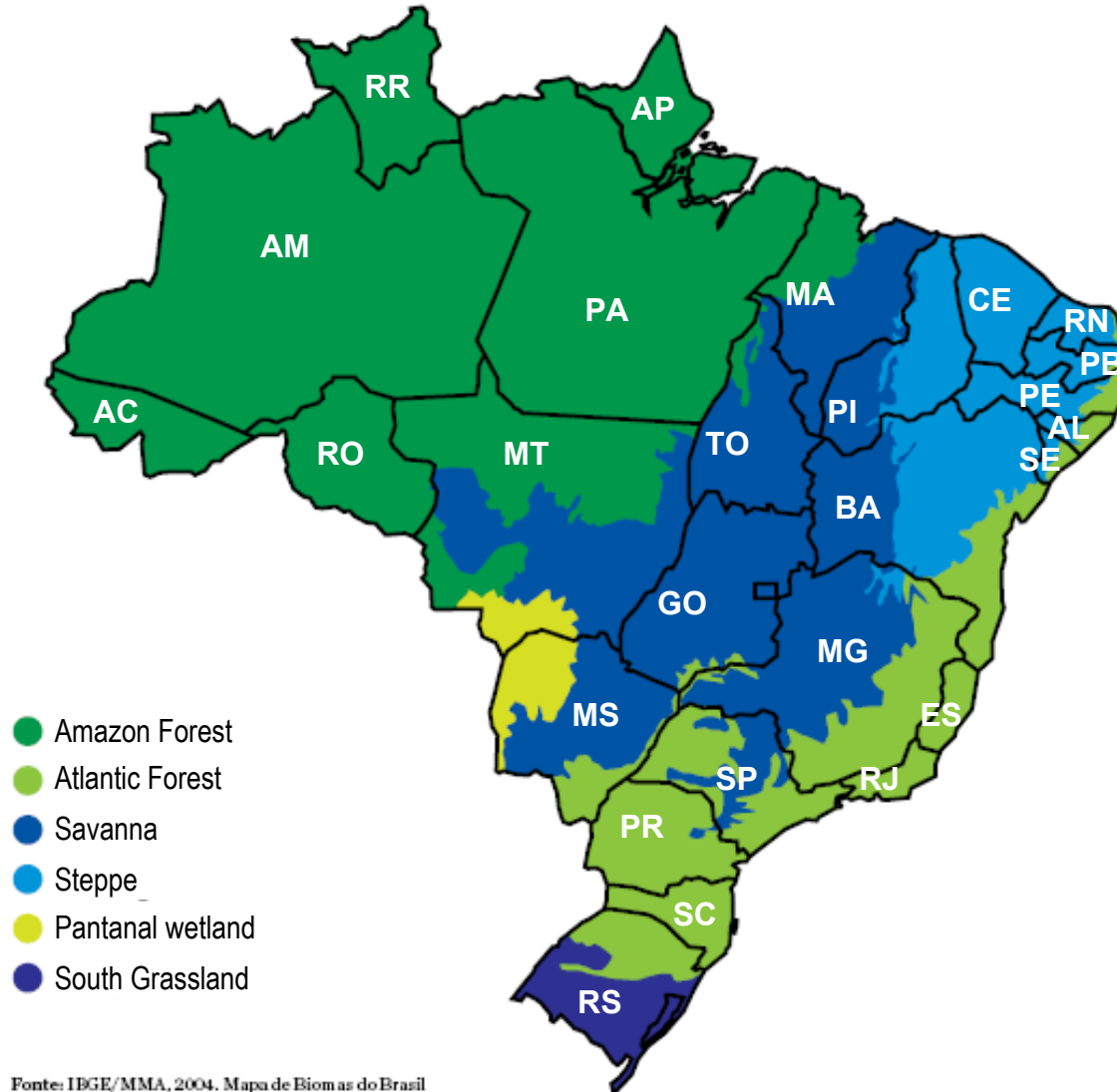
General structure of the land use model

- The model comprises two general sections: **supply and demand** and **land allocation**.
- Supply and demand, for a given year, is calculated at a national level. Supply includes production and initial stocks (in the case of crops), and demand includes domestic consumption, net trade and final stocks.
- Supply (regional) = Demands (national)
- Land allocation calculations are integrated to the supply side. Area is calculated at a regional level, as a function of the expected market profitability of the product and of the competing products.
- The amount of land allocated for a given crop, in a given region, depends on the response to expected market profitability, which means that regions with higher market returns will have higher planted area.
- Allocation of land across regions  Brazilian production  national supply
- The calculation of the expected planted area is also calibrated with the lagged area (area of the previous year) in order to avoid strong oscillations in the planted area.

General structure of the land use model

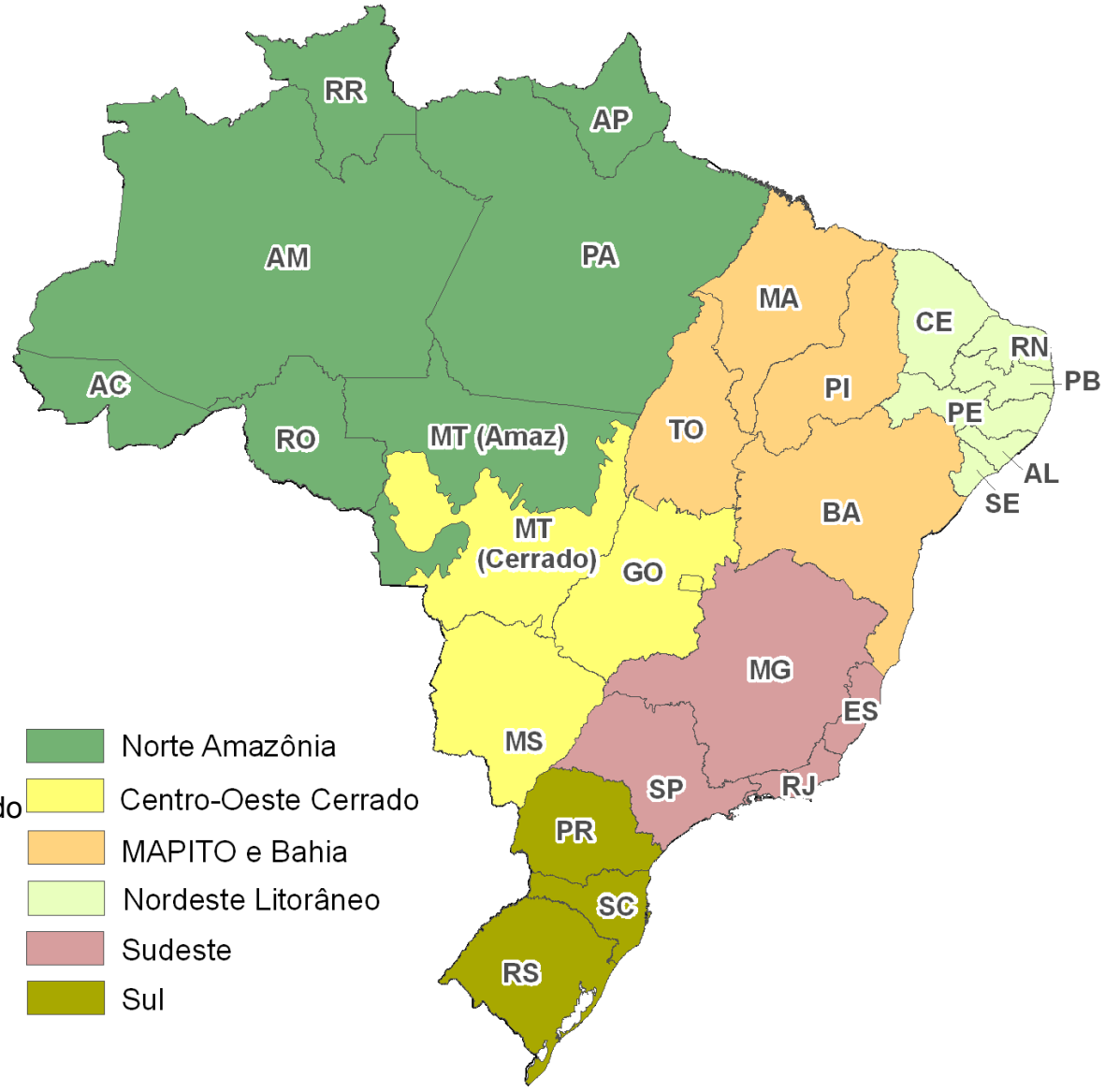
- Planted forests are also included in the area allocation section of the model. For the version we are using now, projections of land allocation for planted forest are exogenous.
- The model comprises 6 macro-regions in Brazil:
 - Region 1: South (States of Rio Grande do Sul, Santa Catarina e Parana);
 - Region 2: Southeast (States of Sao Paulo, Minas Gerais, Espirito Santo e Rio de Janeiro);
 - Region 3: Center-West Cerrado (States of Goias and Mato Grosso do Sul and the Cerrado area in Mato Grosso);
 - Region 4: Amazon North (States of Amazonas, Para, Amapa, Acre, Rondonia, Roraima and the Amazon area in Mato Grosso);
 - Region 5: Coastal Northeast (States of Ceara, Alagoas, Sergipe, Pernambuco, Rio Grande do Norte and Paraiba);
 - Region 6: Mapito e Bahia (States of Maranhao, Piaui, Tocantins e Bahia).
- The regions are independent in the model in the sense that land allocation equations for each crop are different among regions. However, given that the total production must be equal to the demand, if a given crop loses area in a certain region, for a given regional yield, other region will offset it with an increase in area.

Fig. 1 Brazilian Biomes and States



Fonte: IBGE/MMA, 2004. Mapa de Biomas do Brasil

Fig. 2 Macro-regions used in the Land Use Model



- North Amazonia Norte Amazônia
- Center West Cerrado Centro-Oeste Cerrado
- MAPITO and Bahia MAPITO e Bahia
- Northeast coast Nordeste Litorâneo
- Southeast Sudeste
- South Sul

Figure 3. Land Use Model: Interactions Among Sectors

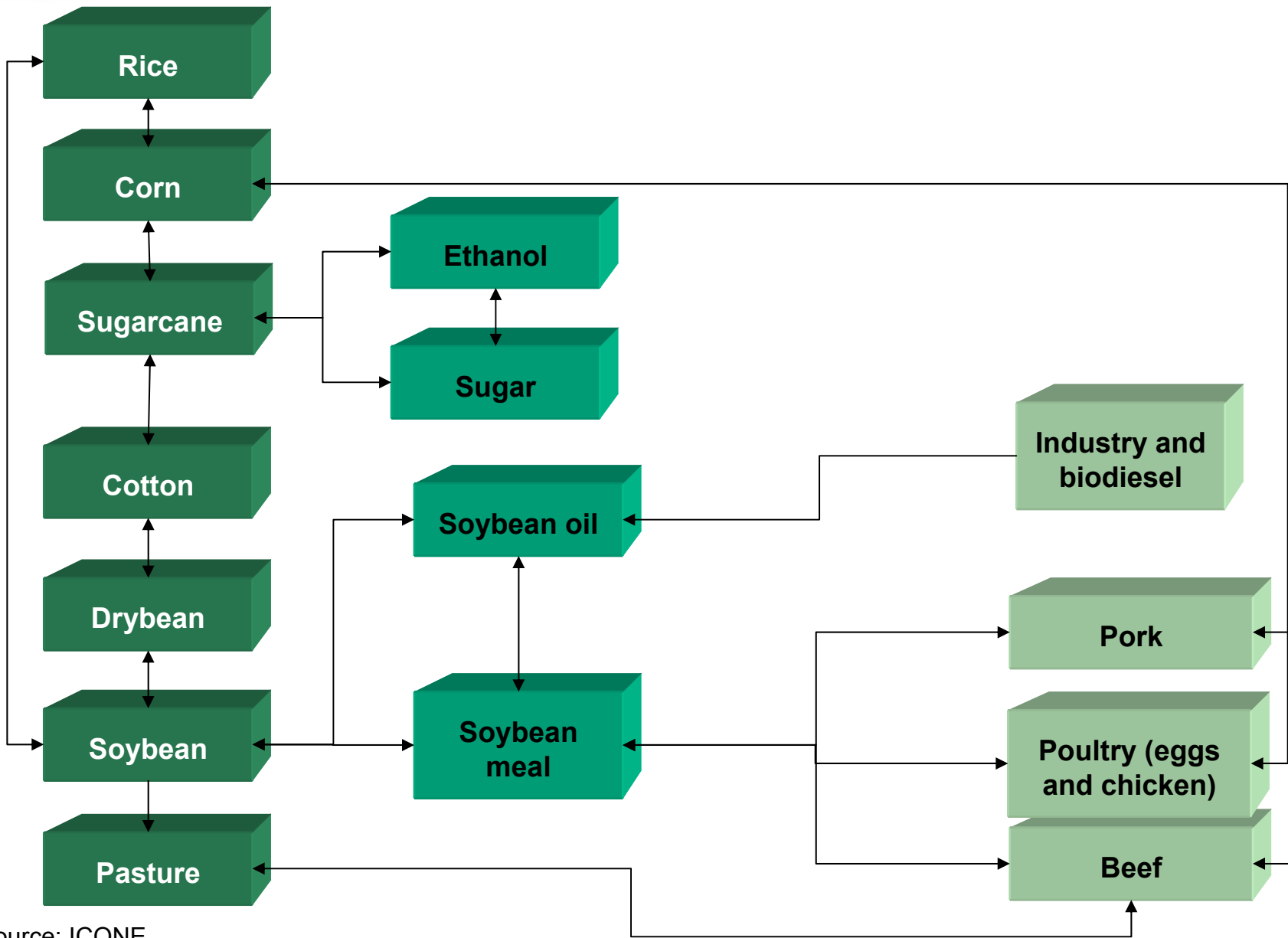
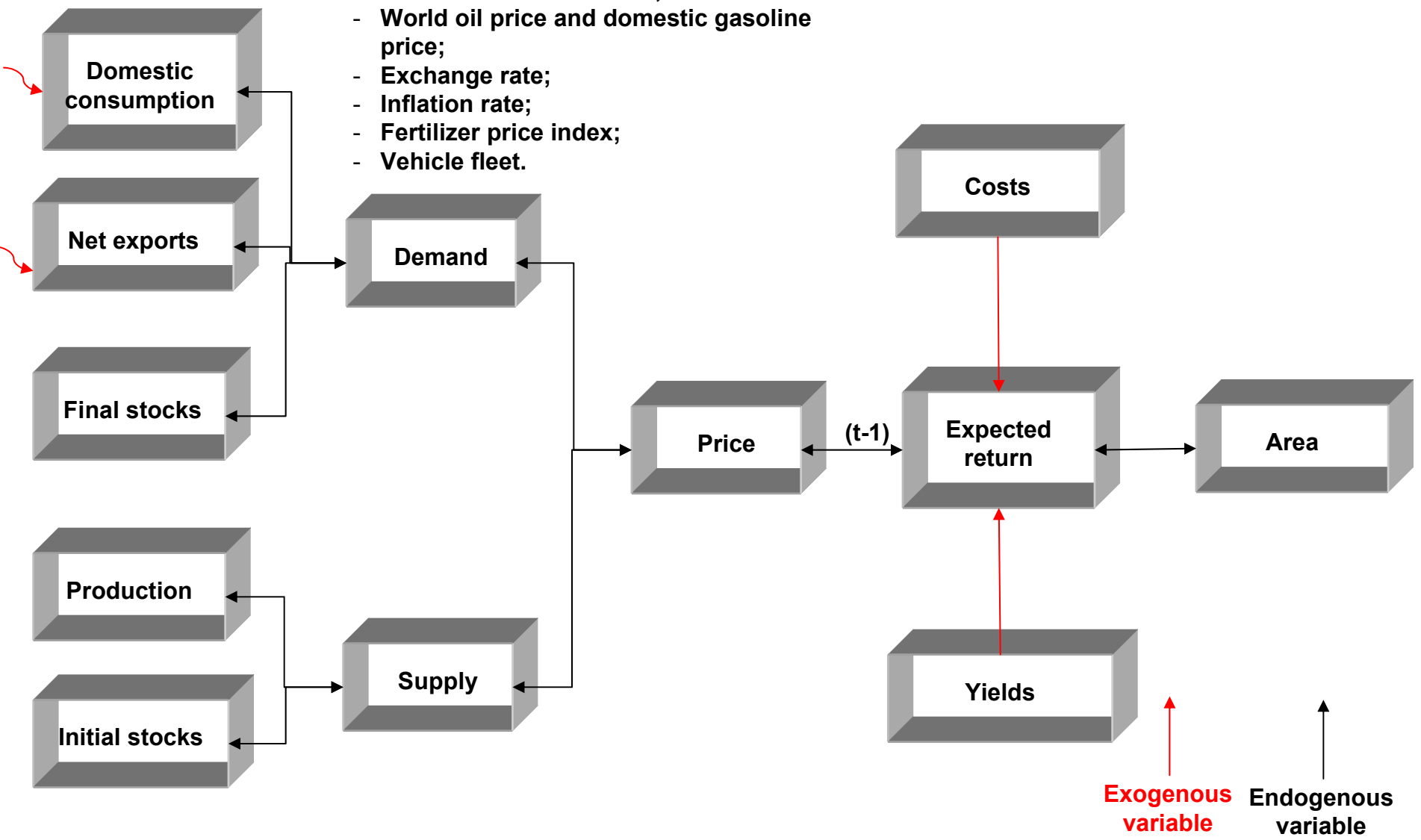


Figure 4. General Structure of the Land Use Model

Institute for International Trade Negotiations

Exogenous macroeconomic data

- Population;
- World and national GDP;
- World oil price and domestic gasoline price;
- Exchange rate;
- Inflation rate;
- Fertilizer price index;
- Vehicle fleet.



General structure of the land use model

- One key output of the model is the **total land allocated for agriculture and pastures**. If this total, plus the exogenous planted forest area, is increasing over time, more natural land is brought for production purposes. This excess allocation of land can be explained by the combination of two factors:
 - Increase of cattle herd in regions with agricultural frontiers (regions 4 and 6 of the model), with a simultaneous reduction or stabilization of cattle herd in the traditional areas. This can be interpreted as an indirect effect due to crops expansion;
 - Expansion of crops in the frontier, which is a direct effect.

In order to measure the indirect effect it is necessary to isolate these two causes of crops and pasture expansion in the frontier regions.

Data Gathering and Preparation

- In order to run the regressions and to calculate the parameters (elasticities and coefficients) used for the projections, a 13 year database was organized, from 1996 to 2008. Due to the lack of information with respect to prices and costs of production, data from 1997 and 2007 were used for the estimations.
- With respect to the variables that are solved endogenously in the model, the following variables are included in the database:
 - Supply and demand balance sheets for Brazil;
 - Regional information on production, planted area, yields, prices received by farmers, costs of production, cattle herd structure, animal production (beef, chicken, eggs, pork and milk).
- The model requires a set of exogenous macroeconomic variables (presented in the figure 2). We are using exogenous macroeconomic variables supplied by FAPRI.
- The model is prepared to project ethanol exports and domestic demand endogenously, but can also work with exogenous scenarios, such as different countries' mandates. ICONE is ready also to create exogenous scenarios of ethanol world trade, calculating supply and demand for the main producers and consumers (Unites States, European union, Japan, etc.).

Assumptions

- Equilibrium price is obtained when supply is equal to demand, in a given year, for a given activity (crops or animal products).
- Area allocated to a given crop, in a given year, is a result of the market equilibrium. Producers respond, in terms of planted area, according to the expected market return (costs of production of the current year and prices received in the previous year).
- Prices received by farmers and prices paid by consumers follow the same trend over time.
- The model assumes full availability of capital for investments and credit for working capital, which means that it does not capture negative effects of low availability of credit in the market.
- Crops yields and total recoverable sugar factors, although regional, are projected as a time series trends.
- Prices are solved at a national level and are transmitted to the regions using transmissions coefficients estimated by regressions. Improvements in infrastructure, which would may lead to increase prices and to reduce costs of production can be simulated as scenarios.

The two model's versions

➤ First Version

- Results are ready and have already been used for some projects. Results validation among analyzed sectors will be carry out soon.
- The first version doesn't considered land availability, so that total agricultural land use can expand indefinitely.
- Equations for Allocation Area are independent in each Region. Historical planted areas are considered as an explanatory variable.

➤ Improved Version

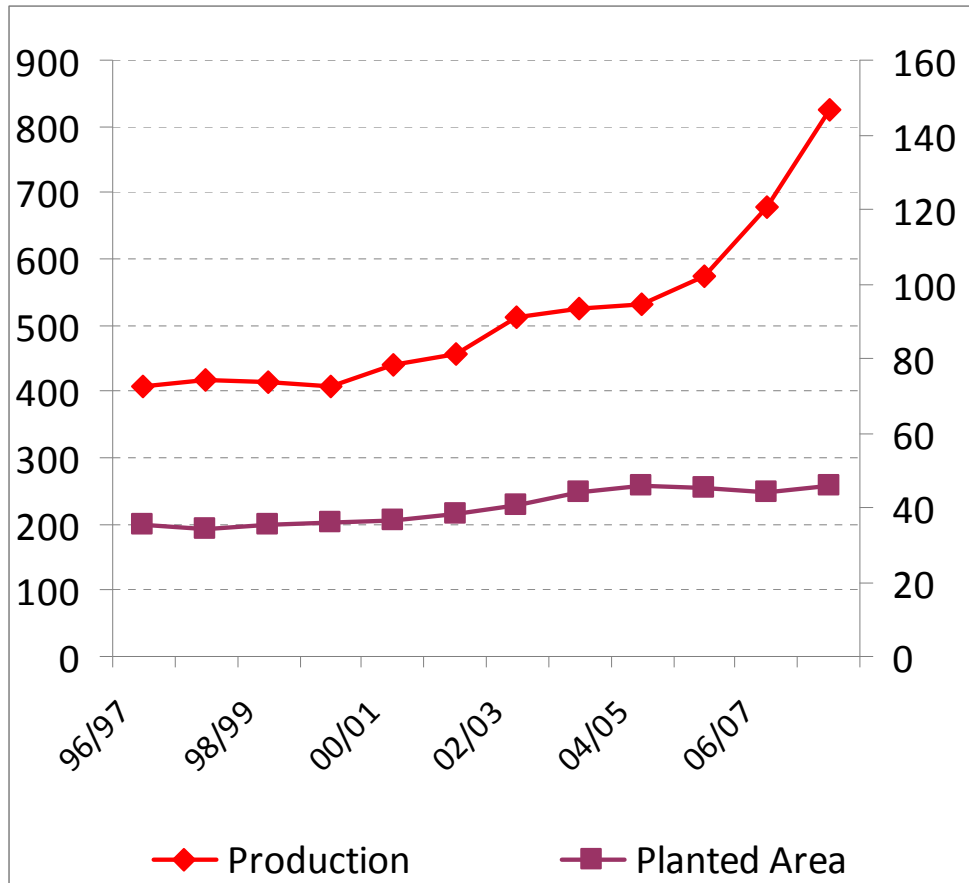
- Area allocated for each crop and pasture will be defined by two equations
 1. Expansion Equation: it will define total agricultural area and it is subject to land availability.
 2. Shares Equation: for each crop and pasture, its share on the total agricultural area is the dependent variable. Returns of all crops are used as explanatory variables.
- Equations for Allocation Area are simultaneously in each Region.

Net Growth of Agricultural Land Uses Area and Cattle Herd, 2002-06 (1,000 ha and heads)

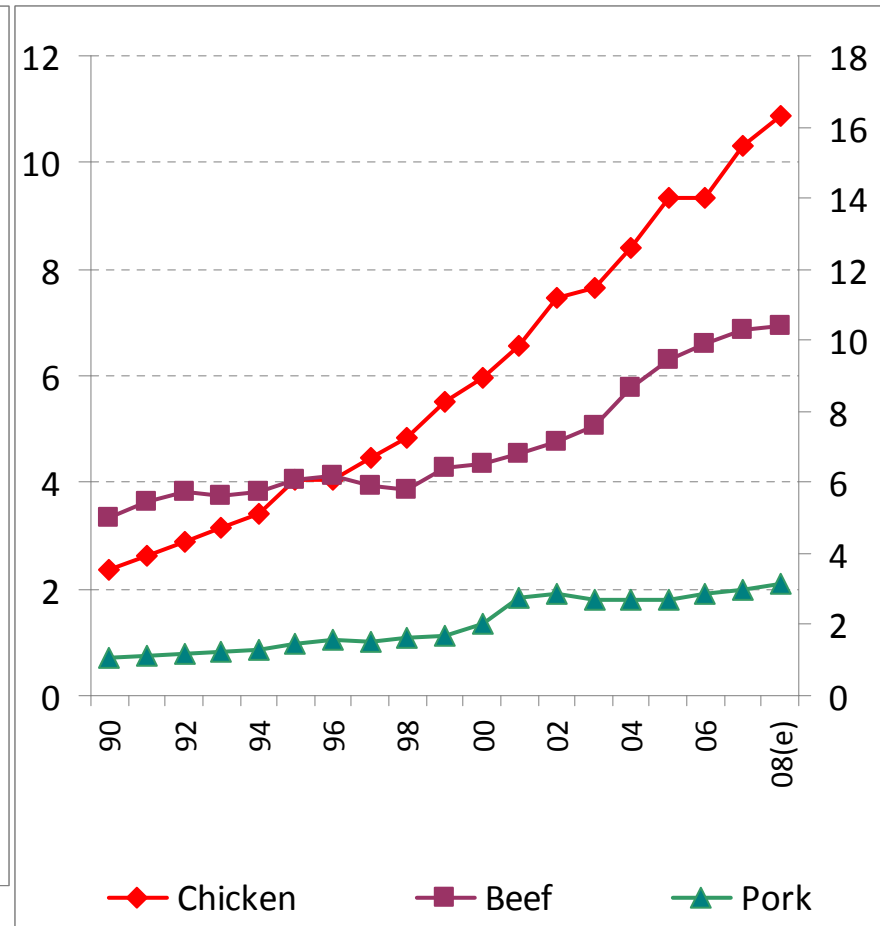
State	Sugarcane (ha)	Other crops (ha)	Pasture (ha)	Total used area (ha)	Cattle Herd (hd)
São Paulo	622	-224	-882	-484	-909
Minas Gerais	153	389	-625	-82	1,644
Paraná	74	850	-1	287	-284
Mato Grosso do Sul	41	1	-985	-210	558
Goiás	34	576	-2,041	-1,431	545
Bahia	26	492	143	661	912
Mato Grosso	25	1,634	-1,437	0	3,881
Maranhão	16	298	-463	-148	1,835
Pará	3	115	2,502	2,620	5,311
South-Centre	949	3,226	-5,971	-1,920	5,435
Total	1,000	5,446	-5,385	1,061	18,383

Brazil: Crops Area (excluding 2nd crop) and Production and Meat Production Performance

Crops Area and Production
(million tons and million ha)

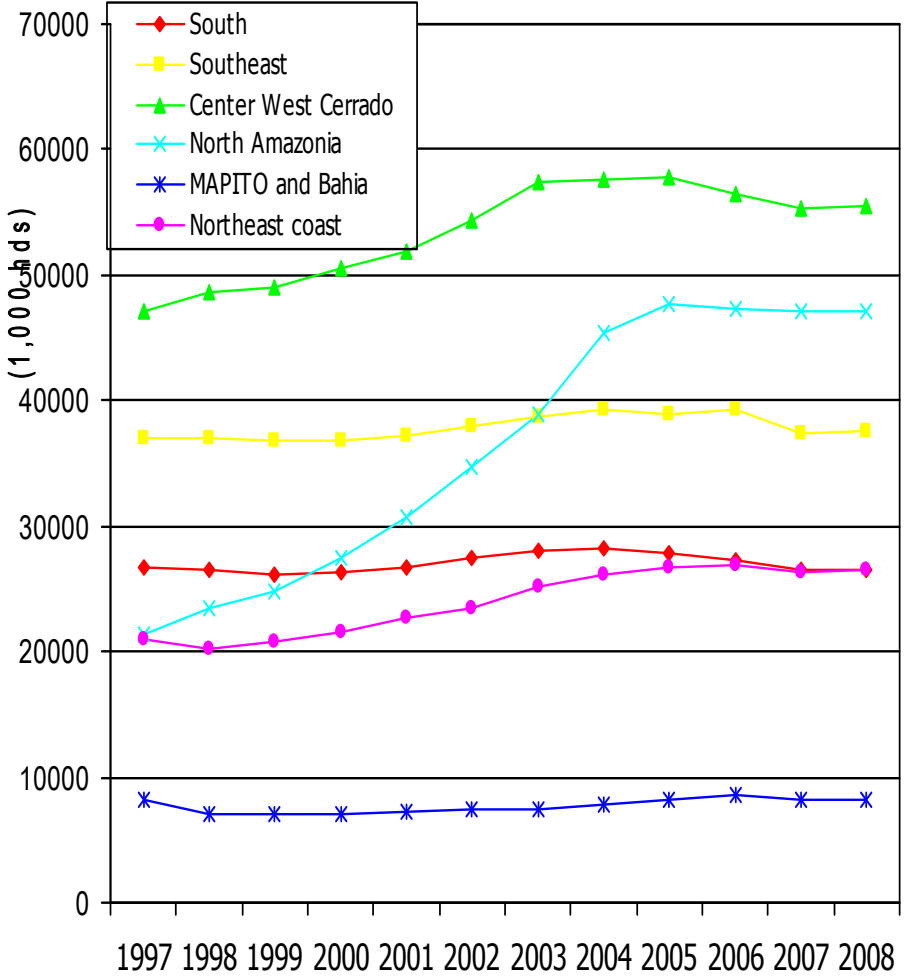


Meat (million tons)

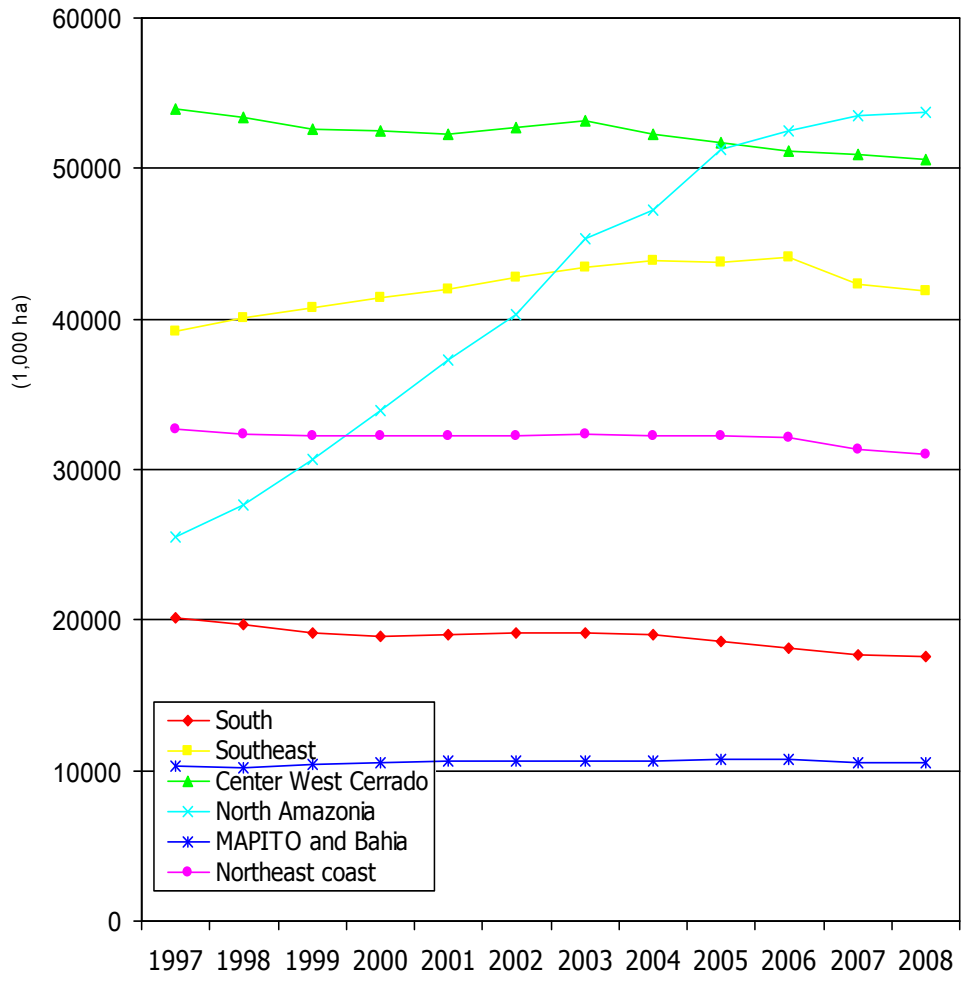


Brazil: Livestock dynamics

Cattle Herd in the Model's Regions

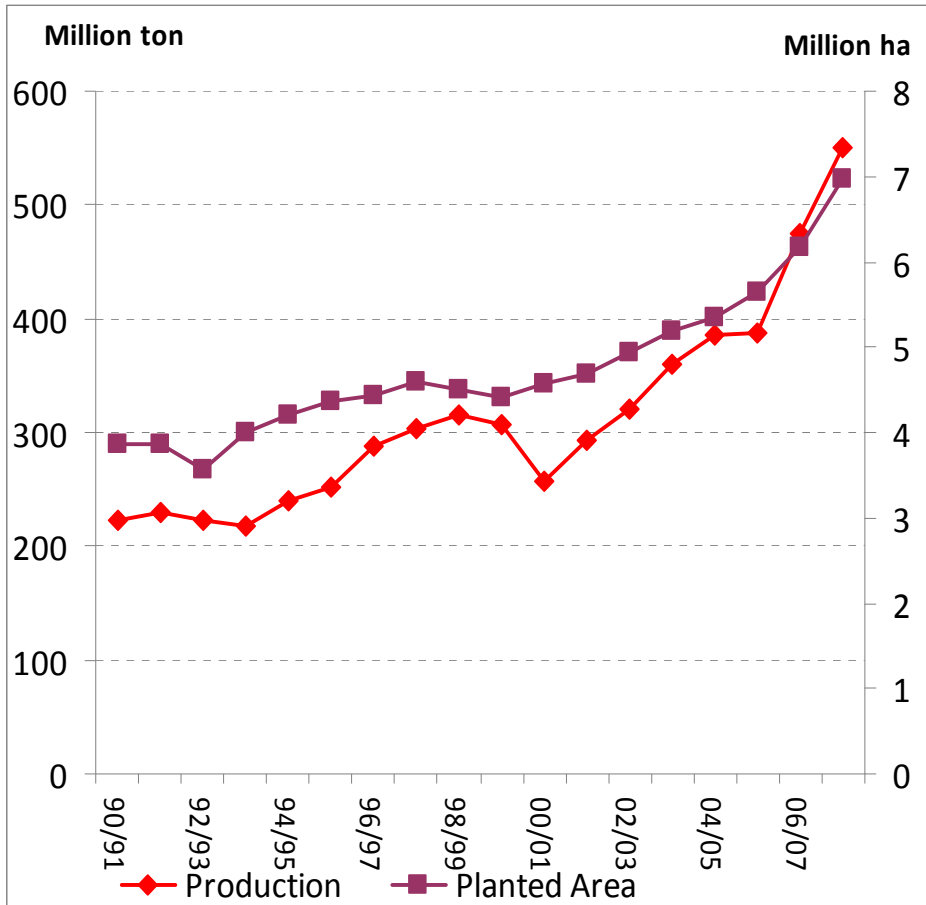


Pasture Area in the Model's Regions

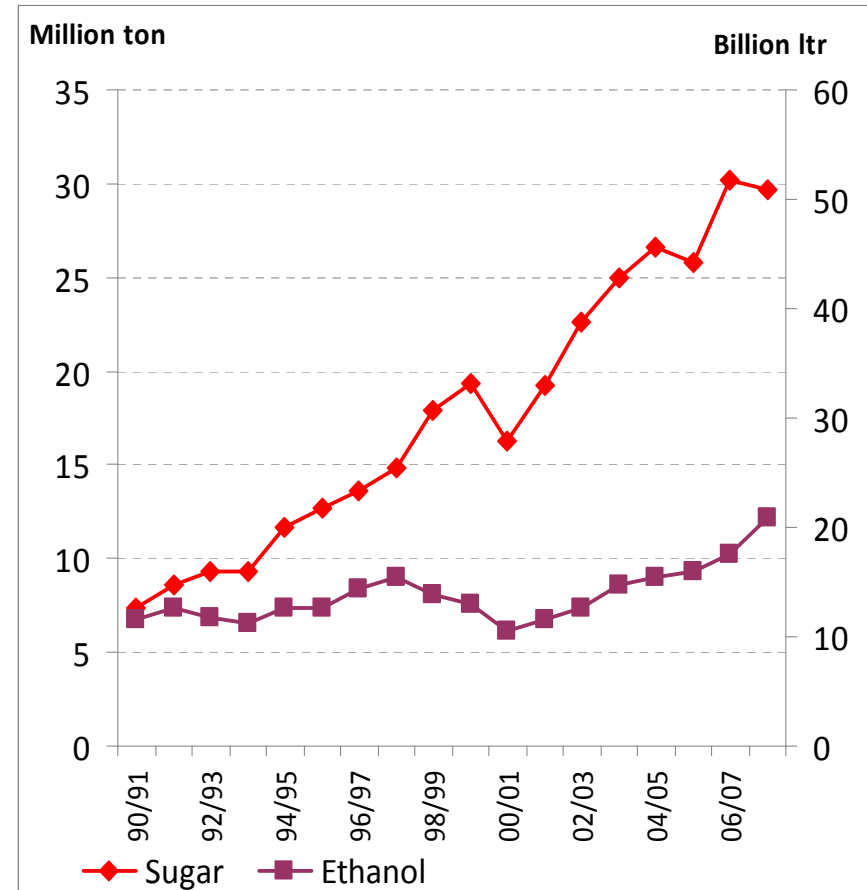


Brazil: Sugarcane, Sugar and Ethanol Production

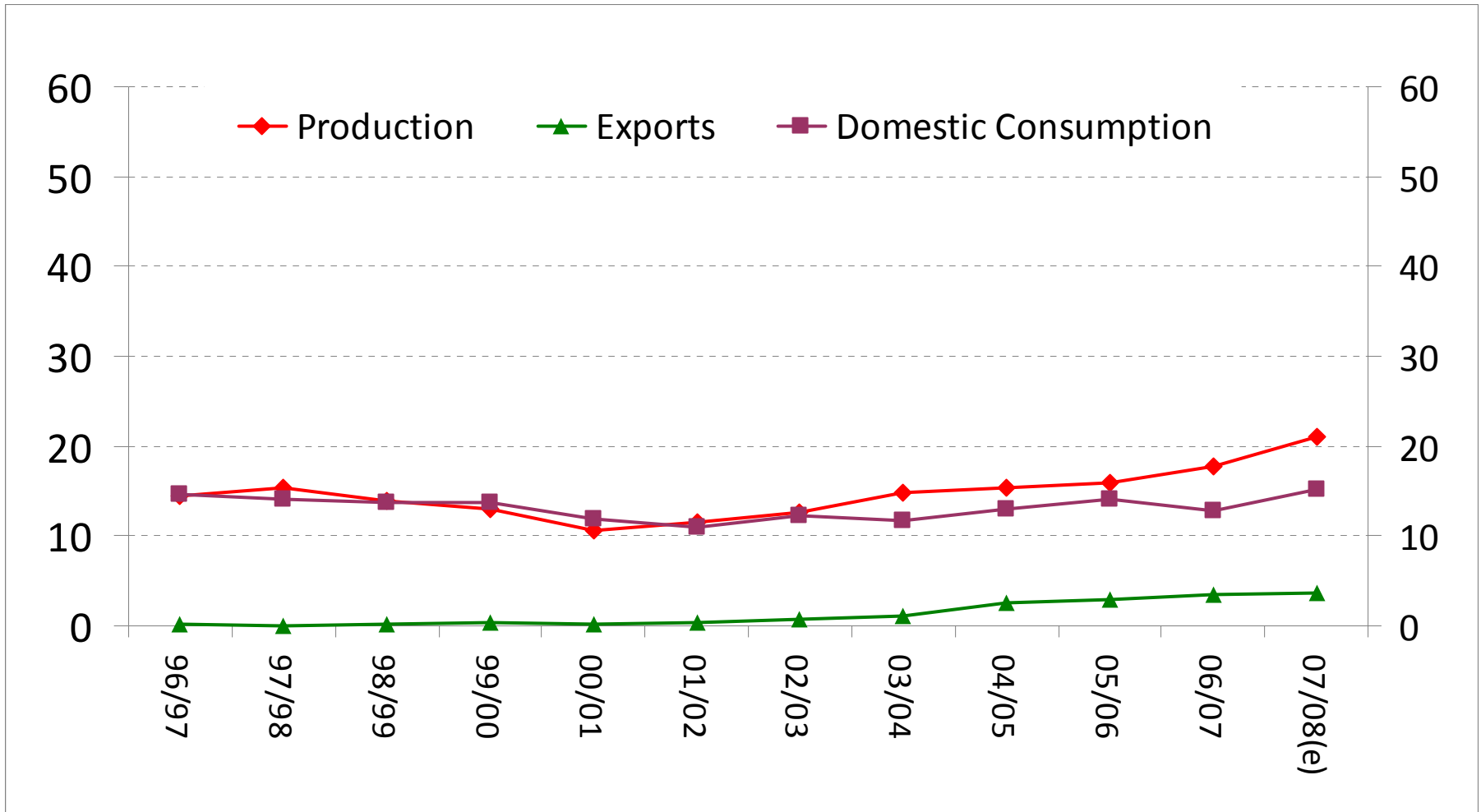
Sugarcane Production and Area



Sugar and Ethanol Production

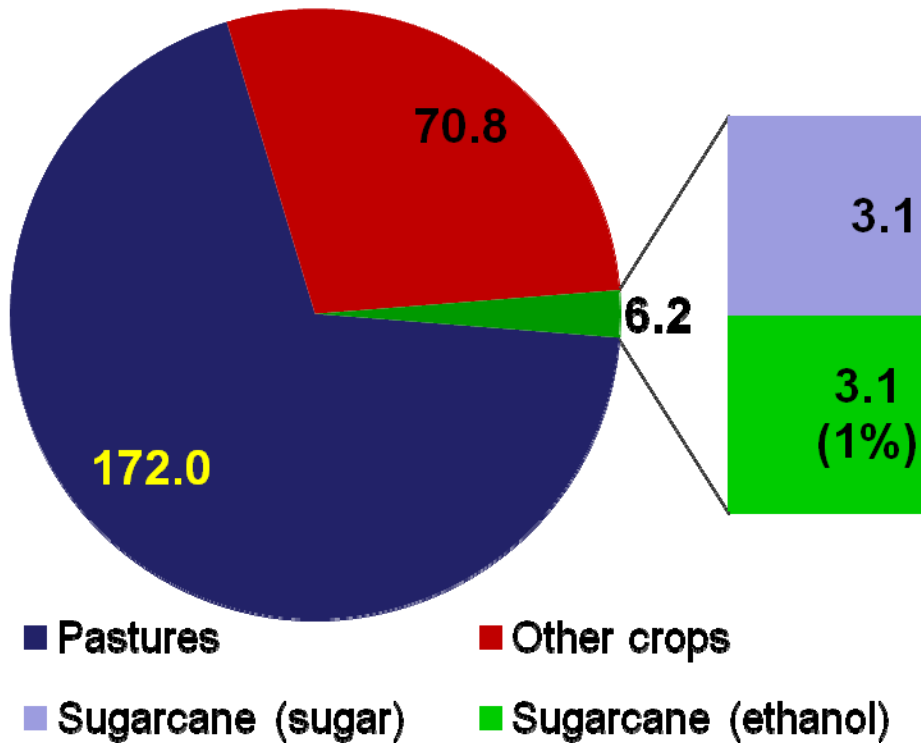


Brazil: Ethanol Supply & Demand (billion liters)

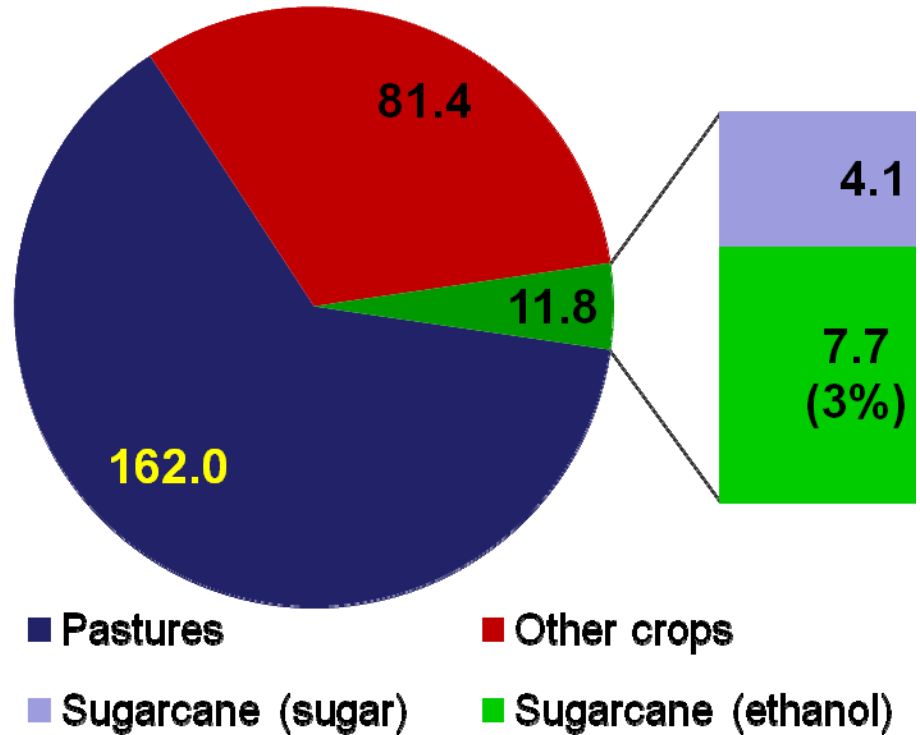


Overview of Sugarcane in Brazil

**Land Allocated in 2006
 (million ha)**



**Land Allocated 2018(p)
 (million ha)**



Applications

- The model is very **flexible** and can be used for different types of **simulations and scenarios**.
- The model is also prepared to simulate **impacts of variables** that are not explicit in the model, such as improvements in transportation infrastructure (construction of an ethanol pipeline, for example), costs reduction due to the adoption of new technologies (second generation ethanol and GMOs adoption), among others applications.
- Useful for specific sector analysis
- Regional land use results can be disaggregate for smaller scales (World Bank's Brazil Low Carbon Study)
- Land use changes can be converted into **carbon emissions**.
- It is possible to connect the Brazilian Model with world models.
- It is used to compare land use results from other models (**GTAP- CARB**)