



Brazilian agriculture has been historically known for its extensification – which is the increase of agriculture output through expansion of agriculture area over natural vegetation – first over the Atlantic Forest, then the Cerrado and finally over the Amazon.

An alternative to increase production is to increase yield without increasing the area under agriculture or causing significant environmental degradation, which is known as sustainable intensification. However, implementation of sustainable intensification raises enormous political, technological, and social challenges in Brazil. Meeting these challenges will require, among other things, accurate information on the spatial and temporal patterns of agricultural land use and yield. It is only through the lens of history that the current geographic trends in land use can be fully understood and accurate future projections made. This study explains *how the patterns of agricultural land use, extensification, and intensification have changed in Brazil in the last 72 years*.

We investigate historical patterns of agricultural land use and productivity in Brazil using a new historical-spatial database for Brazilian agricultural land use at spatial resolution of 30'' (approximately 1 km x 1 km). This database was developed by merging agricultural census data and remote sensing data at 30 m resolution, and includes yearly data on

- cropland areas (total cropland areas from 1940 to 2012, and soybean, maize, and sugarcane from 1990 to 2012);
- soybean, maize, and sugarcane yield and yearly cattle stocking rate from 1990 to 2012;
- pasturelands (total, and split into natural and planted pastures from 1940 to 2012).

In addition, we contrast the productivity and agriculture area for soybean, maize, sugarcane and cattle to understand the extensification-intensification relationship. We also provide a basic yield gap analysis – the difference between average yields and the top yields (top 5%) in the main producing regions.

The analysis of our new historical database of agricultural land use area and productivity shows that, although the agriculture frontier is still expanding in the Amazon and Cerrado, rates are much lower than before, and throughout the eastern and southern part of the country, agricultural land use is actually decreasing. In contrast, agricultural productivity is quickly increasing in the entire country.

In other words, Brazil is moving slowly towards a more intensive and sustainable agriculture.

From this analysis, we also draw other conclusions:

- 1) The production of soybean and maize increased due to increase in area and yields, but the production of sugarcane increased predominantly due to extensification. The highest soybean and sugarcane yields (top 5%) are close to the average, which indicates a high use of technology by these producers;
- 2) Pasturelands have always been the most important contributor to total agriculture land use in Brazil, but natural pasturelands were gradually replaced by more profitable planted pastures, since 1975;
- 3) Pasturelands decreased in all regions analyzed, except in Amazonia, but the slow process of technology transference appears to be keeping the Brazilian stocking rate of cattle close to 1.0 head/ha, indicating an inefficient livestock system. The highest stocking rate of cattle (top 5%) were dramatically higher than the average in 2010.

Although a deeper analysis of the spatial and temporal variability of yields is necessary, our results clearly demonstrate that closing the yield gaps can increase the Brazilian agriculture production.

Our results provide the first comprehensive historical overview of agricultural land use and productivity in Brazil, providing clear insights to guide future territorial planning, sustainable agriculture, policy and decision-making.

To visualize the maps and download the 30'' database present in this work, please visit:

<http://www.biosfera.dea.ufv.br>

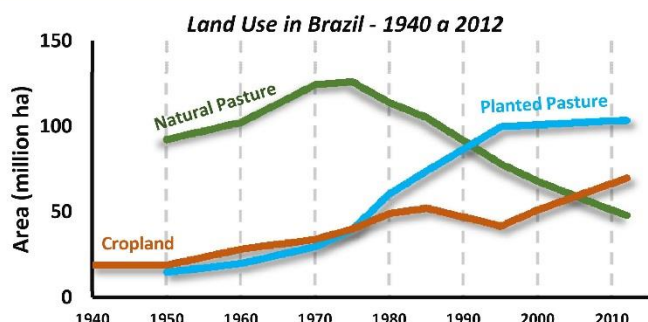
Contact:

Livia Dias, liviacrisdias@gmail.com
Marcos H. Costa, mhcosta@ufv.br

Dias et al. (2016). Patterns of land use, extensification and intensification of Brazilian agriculture. *Global Change Biology*, DOI:10.1111/gcb.13314
<http://onlinelibrary.wiley.com/doi/10.1111/gcb.13314/full>

AGRICULTURAL LAND USE CHANGE IN BRAZIL

AGRICULTURAL LAND USE



DECREASE IN THE AGRICULTURAL AREA IN THE SOUTH AND EAST OF THE COUNTRY.



INCREASE IN THE AGRICULTURAL AREA IN THE CERRADO AND AMAZON.

220
MILLIONS HA OF
AGRICULTURAL
LAND USE
(IN 2012)

70% OF THE AGRICULTURAL
LAND USE IS
PASTURELAND
(IN 2012)



55% OF **NEW**
AGRICULTURAL AREAS
WERE ESTABLISHED IN
AMAZONIA
(BETWEEN 2006 AND 2012)



EXTENSIFICATION

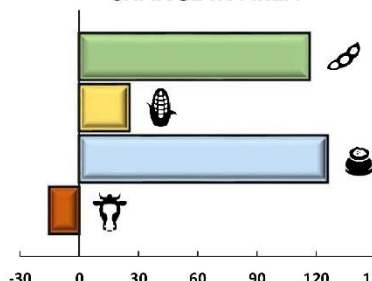
THE INCREASE PRODUCTION
THROUGH EXPANSION OF
AGRICULTURE AREA

INTENSIFICATION

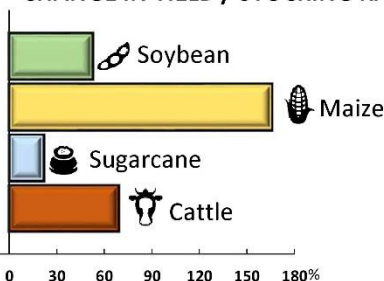
THE INCREASE IN PRODUCTIVITY
ON EXISTING AGRICULTURAL
LANDS



CHANGE IN AREA



CHANGE IN YIELD / STOCKING RATE



AREA AND PRODUCTIVITY INCREASE/DECREASE BETWEEN 1990 AND 2012 (IN %)



IN GENERAL,
**EXTENSIFICATION HAS
SLOWED DOWN, AND
WAS REPLACED BY A
STRONG TREND OF
INTENSIFICATION**

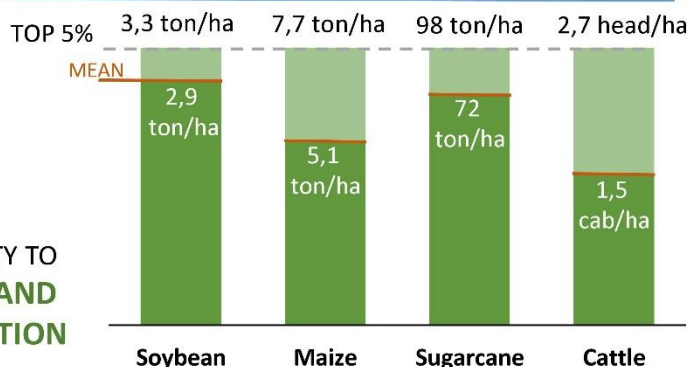
YIELD GAP

(the difference between the mean productivity and the top productivities)

WHY IS IMPORTANT TO CLOSE THE YIELD GAP?



BECAUSE IT IS THE OPORTUNITY TO
COMBINE **FOOD SECURITY AND
ENVIRONMENTAL PROTECTION**



(IN 2010. MEAN PRODUCTIVITIES OF
THE MAIN PRODUCING REGIONS)



To visualize the maps and download the data, visit:
Research Group on Atmosphere-Biosphere Interaction - UFV
www.biosfera.dea.ufv.br

TO KNOW MORE:
Dias et al. (2016). Patterns of land use, extensification and intensification of Brazilian agriculture. *Global Change Biology*, DOI:10.1111/gcb.13314