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Patterns of land use, extensification, and intensification of Brazilian agriculture

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Introduction

“To **guarantee global food security**, currrent production would need to be approximately **doubled** over the next 35 yr”

Dias et al 2016

Introduction

"To **guarantee global food security**, currrent production would need to be approximately **doubled** over the next 35 yr"

"This enormous challenge has led to a renewed focus on **agricultural production** in regions that have the capacity to meet this vastly increased demand."

Dias et al 2016

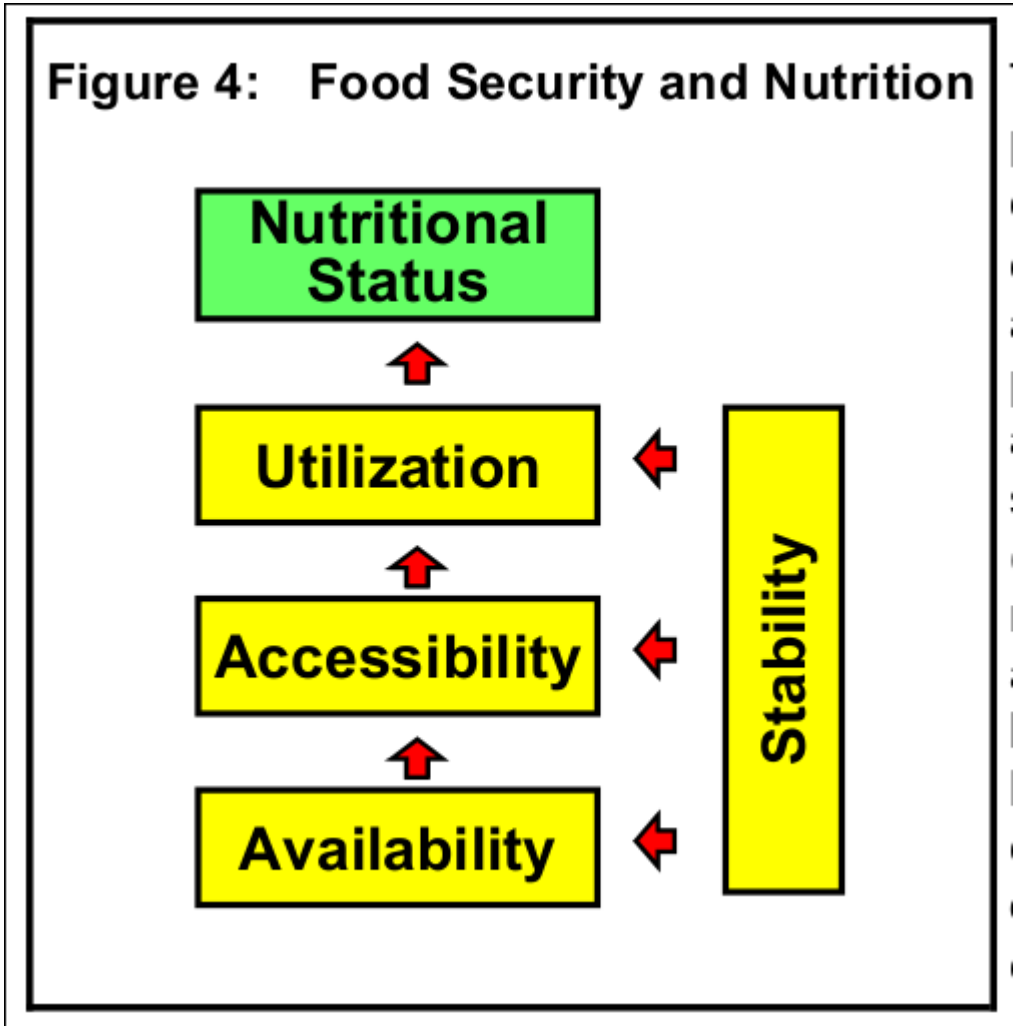
Introduction

Figure 3: Definition of Food and Nutrition Security

"Food security is achieved, if adequate food (quantity, quality, safety, socio-cultural acceptability) is available and accessible for and satisfactorily utilized by all individuals at all times to live a healthy and happy life."

Gross et al 2000

Introduction



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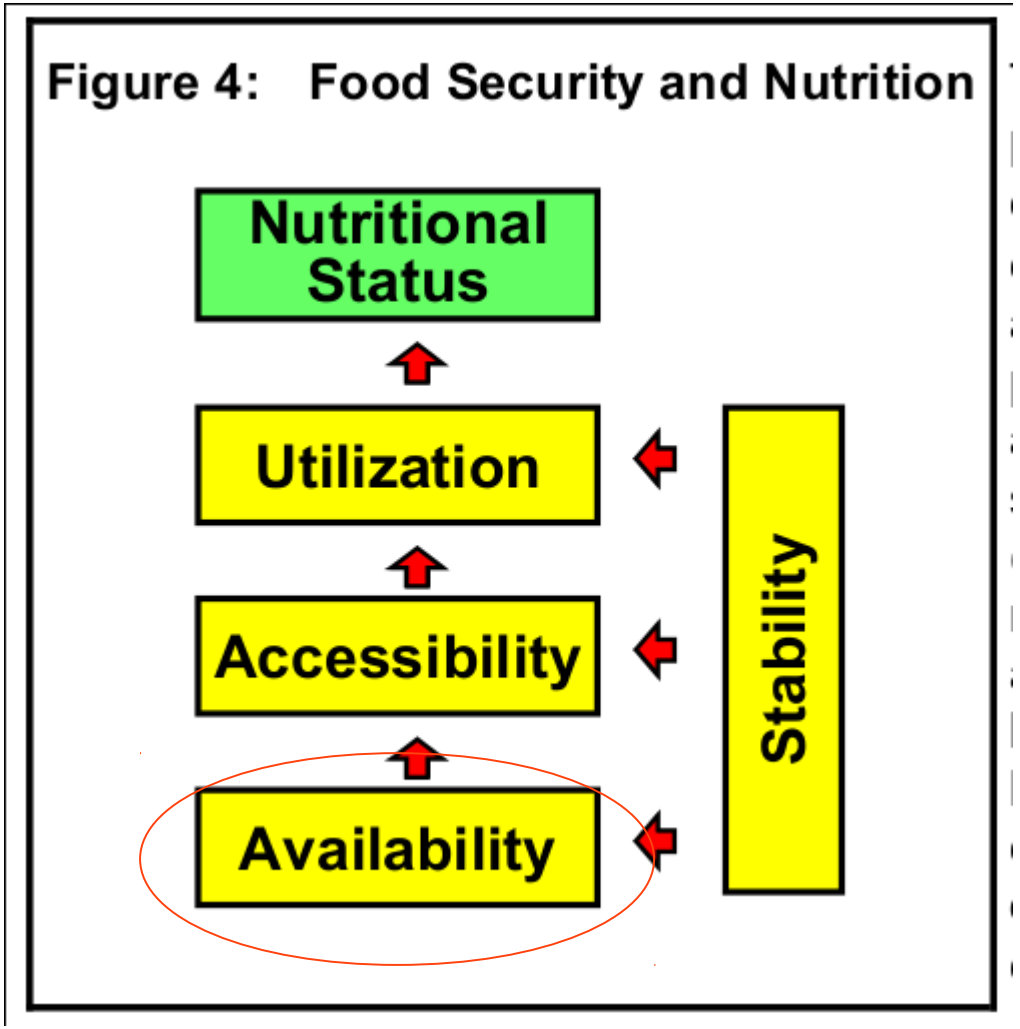

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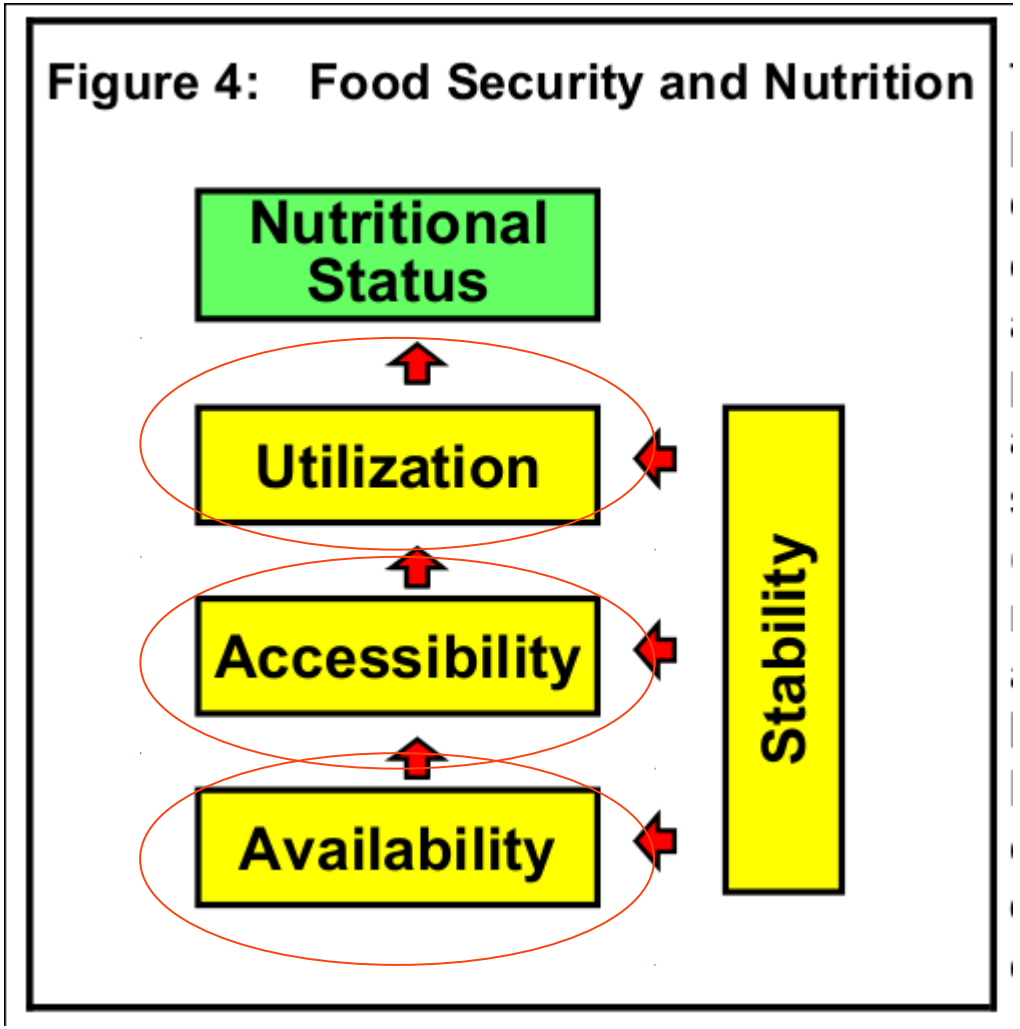

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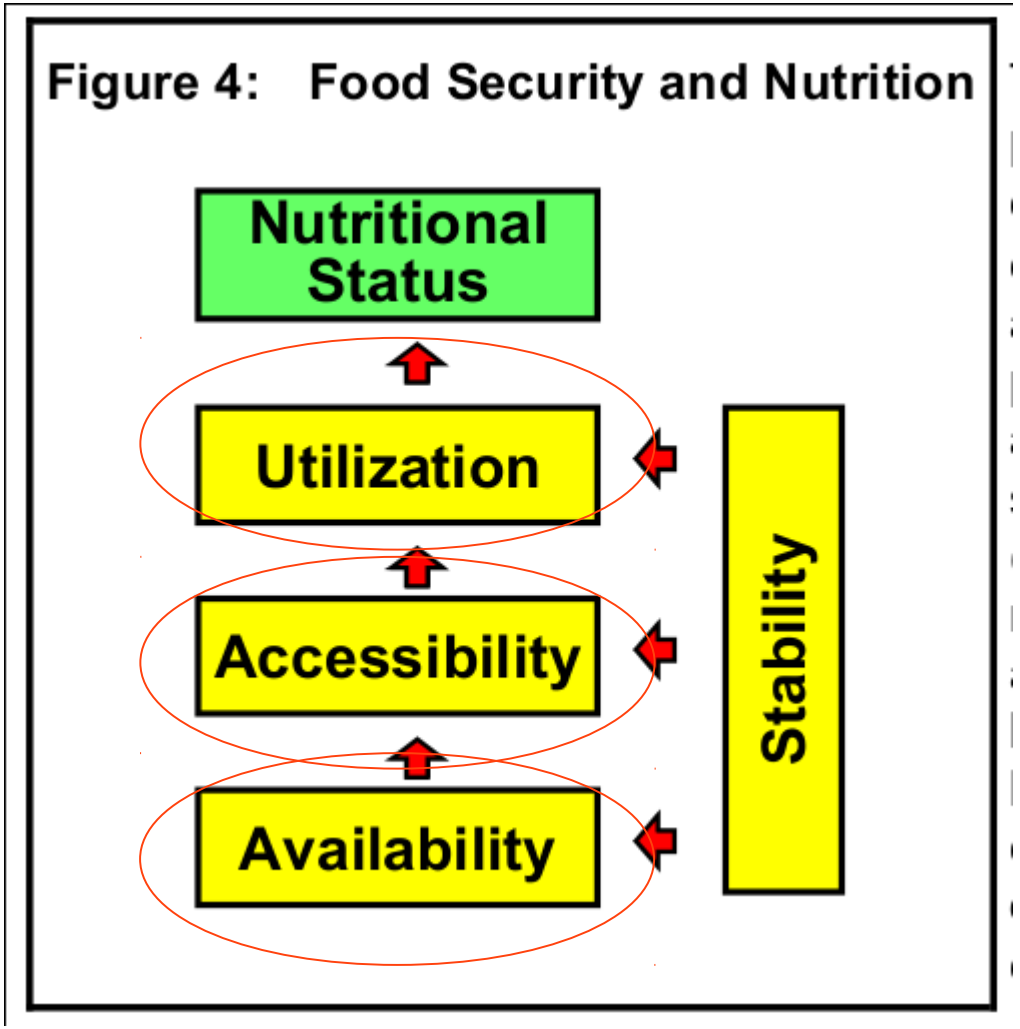

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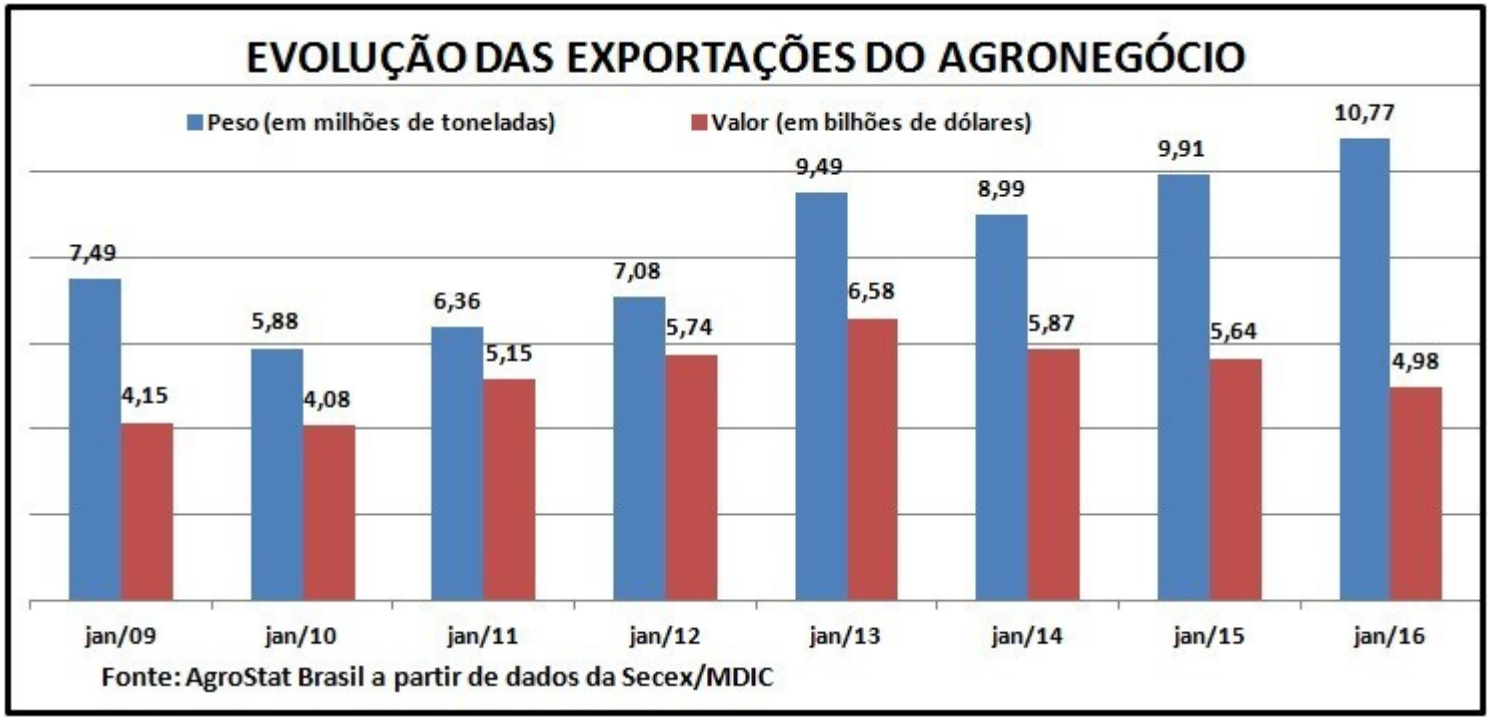
Introduction

"Brazil is one of these countries with high capacity to increase agricultural production"

> "Indeed, Brazil is already one of the ten major exporters of agricultural products in the world (FAO, 2015) and it is expected to continue to increase production and export."



http://revistagloborural.globo.com/Noticias/Economia-e-Negocios/noticia/2016/02/receita-da-exportacao-do-agronegocio-em-janeiro-cai-117.html
Acesso em 09/08/2016

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mercado

imposto

Desmatamos por uma das agriculturas mais produtivas, diz Kátia Abreu

Sérgio Lima/Folhapress

A ministra da Agricultura Kátia Abreu

Introduction

"Brazilian grain production has roughly doubled since 2005 **despite** reductions in deforestation rates during the same period."

"Such an increase in production coupled with enhanced environmental protection cautiously supports the view that **Brazil has the potential for large-scale sustainable development of its agriculture to meet global food security goals."**

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http://www1.folha.uol.com.br/mercado/2015/12/1714200-avanco-da-agricultura-no-matopiba-puxa-devastacao-do-cerrado.shtml
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Introduction

Sustainable intensification

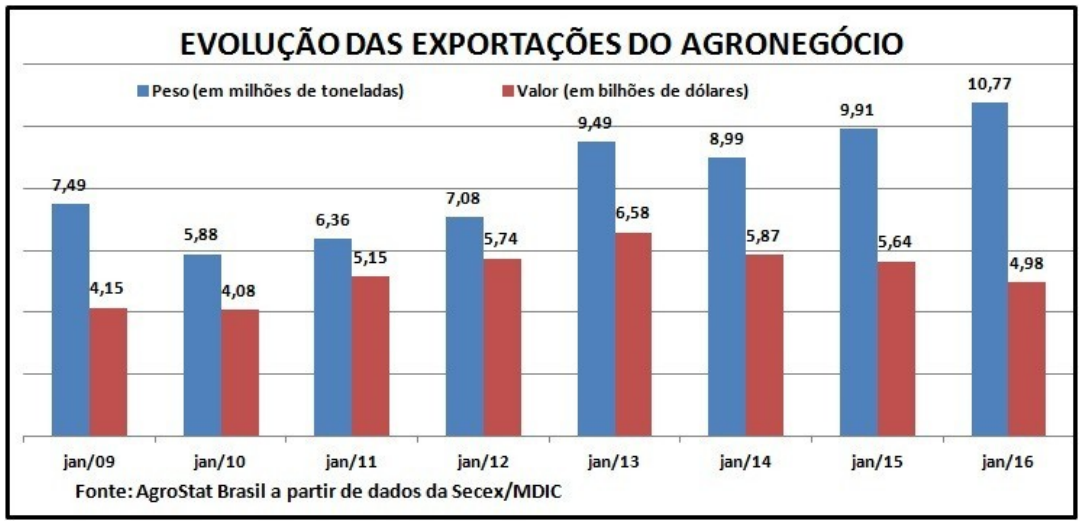
> “one of the main strategies to provide global food security”

“As a starting point for policy development, it is essential that decision-makers have accurate information on the spatial and temporal patterns of agricultural land use and yield in the Brazilian territory”

Introduction

Agricultural extensification x Intensification

“Increasing yields makes agriculture more profitable and therefore creates further financial incentives to increase the rate of conversion of natural habitat at agricultural frontiers”



Introduction

main objectives:
(i) characterize agricultural land use change in Brazil and the productivity of four agricultural products (soybean, maize, sugarcane, and cattle);

(ii) describe the patterns of yield of soybean, maize, and sugarcane, and the stocking rate of cattle for the entire country;

(iii) explore the productivity agriculture area relationship for the three crops and cattle to better understand the dynamics of extensification–intensification, especially in the Amazon and Cerrado agricultural frontiers.

Material

Tree cover (Hansen et al., 2013) → nonforest maps (1x1km) 2000 – 2012

Censos agropecuários → land use (cultivated, natural and planted pasture)
1940, 1950, 1960, 1970, 1975, 1980, 1985, 1995, 2006

PAM → soja, milho cana, gado (1990 - 2012)

Methods

Minimum Comparable Area (MCA)
Boundary stability through time

Agricultural land use area

1: increase or decrease rate between two census

$$\Delta U_{\mathrm{MCA}} = \frac{(U^{2006}_{\mathrm{MCA}} - U^{1995}_{\mathrm{MCA}})}{U^{1995}_{\mathrm{MCA}}}, \qquad (1)$$

2: all municipalities in an MCA converted land use at the same annual rate

$$U^{t}_{k} = U^{1995}_{k \in \mathrm{MCA}} \cdot \left[1 + (t - 1995) \cdot \frac{\Delta U_{\mathrm{MCA}}}{(2006 - 1995)}\right], \qquad (2)$$

Uk estimated total agricultural land use in a municipality k in the year t (km 2) for 2000 ≤ t ≤ 2012
Umca amount of total agricultural land use from 1995 census data in a municipality k

Methods

Land use data disaggregation

Agricultural land use maps (% area/pixel) → pre 2000 NONF_2000

$$\mathrm{ALU}_{i,j}^{t} = 100 \cdot \frac{\left(\mathrm{NONF}_{i,j \in k}^{t} \cdot \frac{U_{k}^{t}}{\sum_{i,j \in k} \mathrm{NONF}_{i,j}^{t}} \right)}{A_{i,j}}, \qquad (3)$$

Pixels with ALU > NONF were corrected (LU) = corrected map in year t:

$$\mathrm{LU}_{i,j}^{t} = 100 \cdot \frac{\left[1 - \exp\left(-0.01 \cdot F \cdot \mathrm{ALU}_{i,j}^{t} \right) \right]}{\left[1 - \exp\left(-0.01 \cdot F \cdot P_{\mathrm{MCAmax}}^{t} \right) \right]}, \qquad (4)$$

Methods

Land use data disaggregation

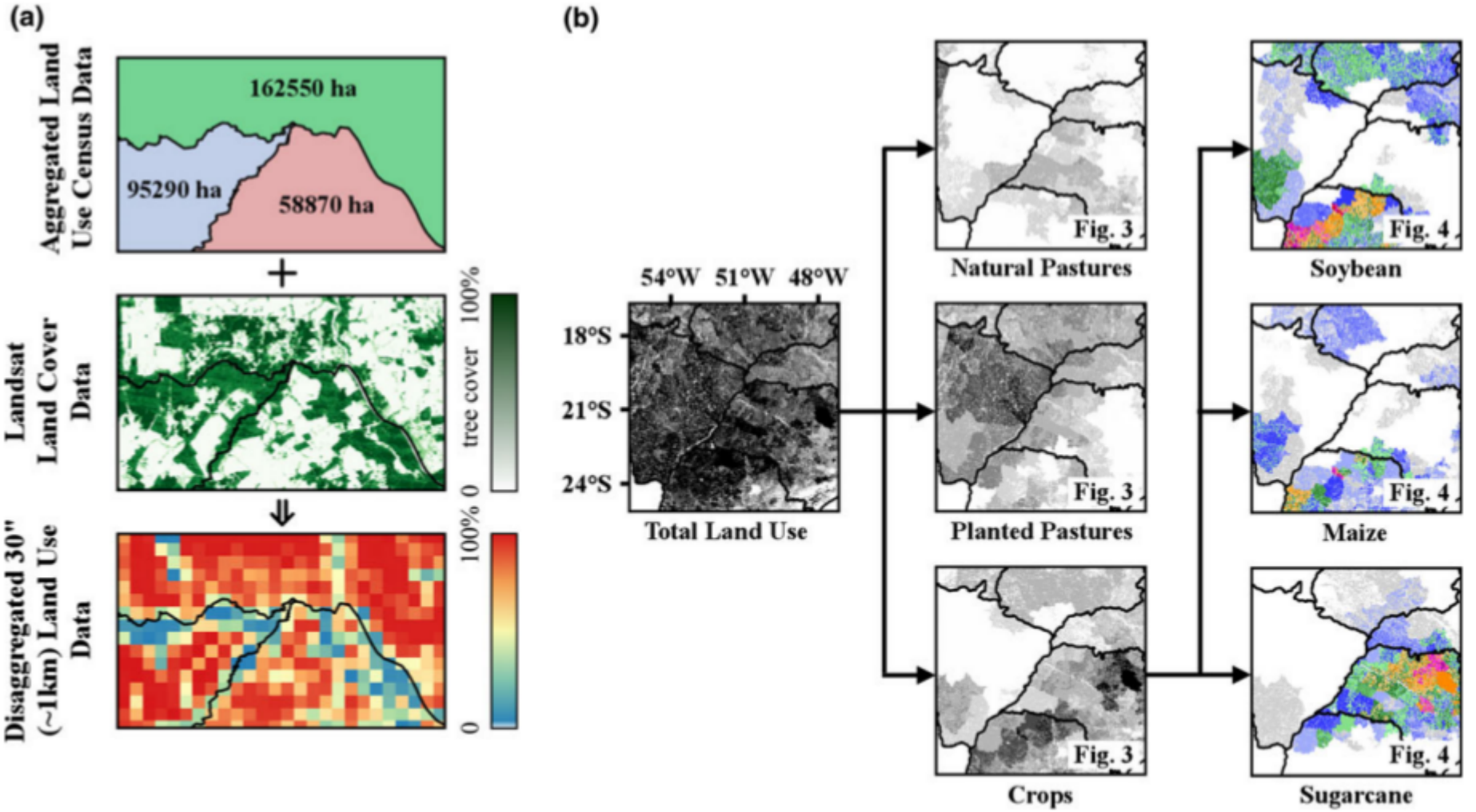
Croplands and pasturelands:

- proportion = cropland/pasturelands_k_t / total agricultural land use area_k_t
- Crop.pastMap = LU_t * proportion (grid cell)
- Specific_cropMap = Crop.pastMap * proportion of each crop_k_t

Productivity maps (1990 – 2012) = production (PAM) / Specific_cropMap

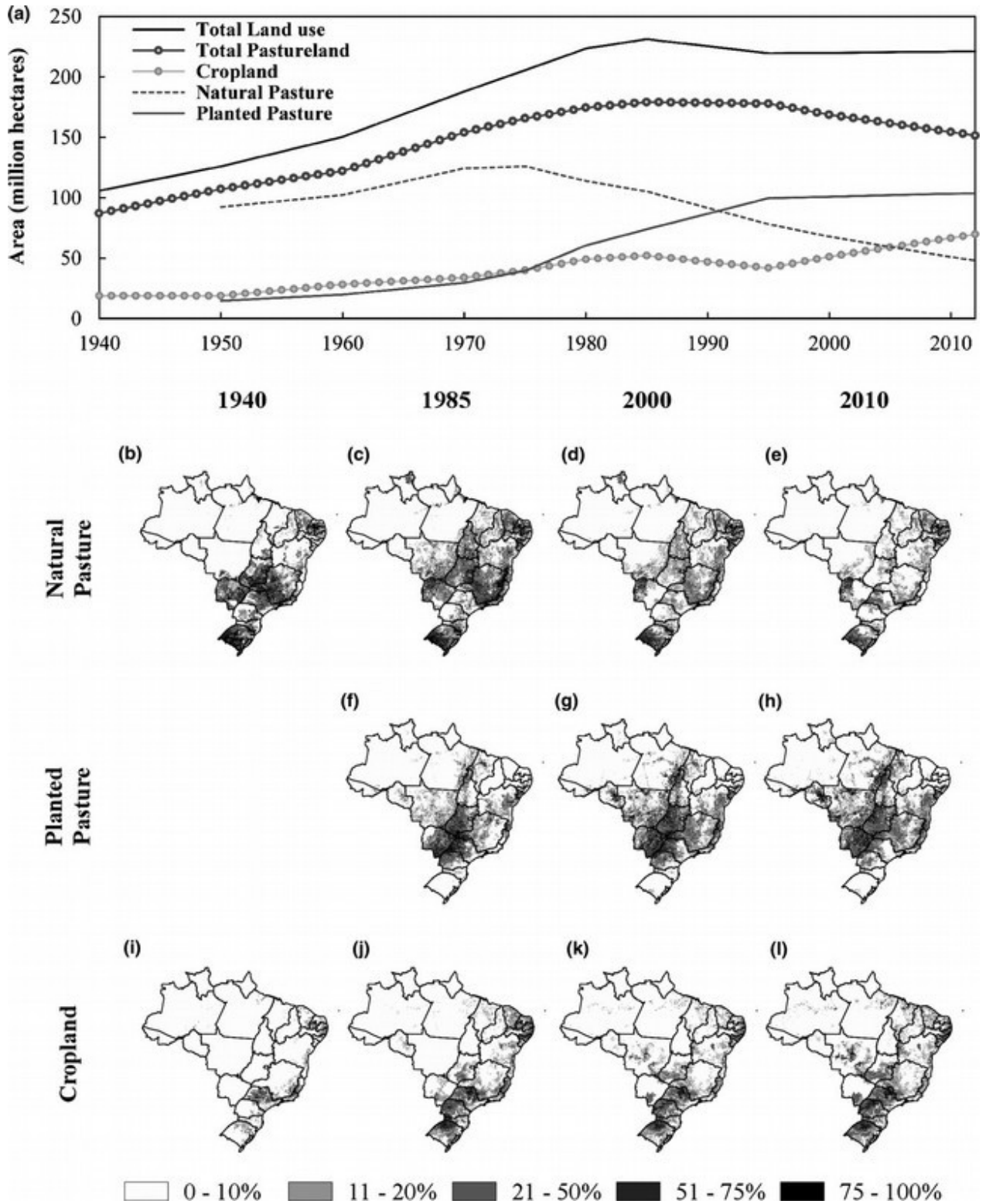
Methods

Land use data disaggregation



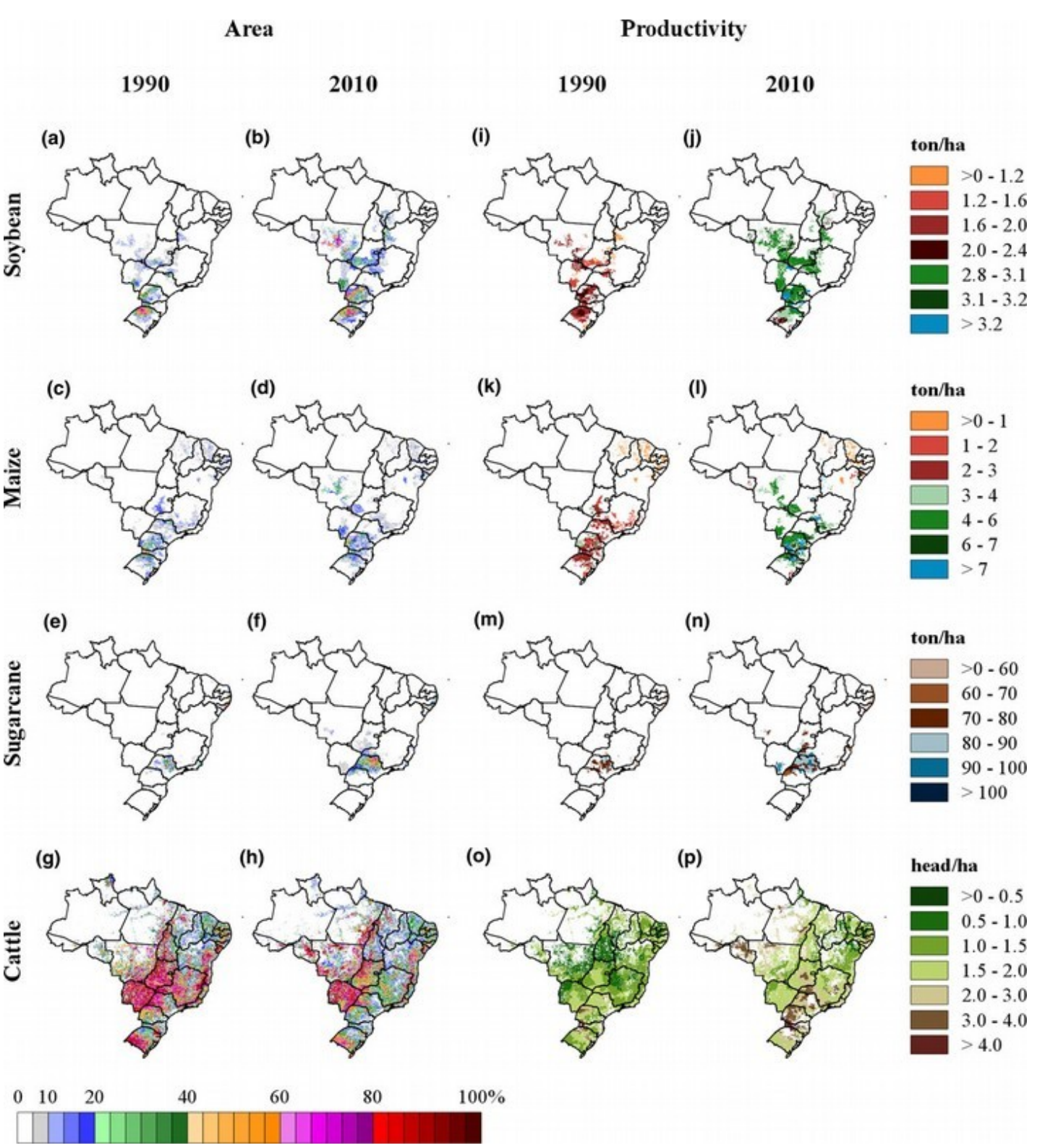
Results

Historical patterns of agriculture land use



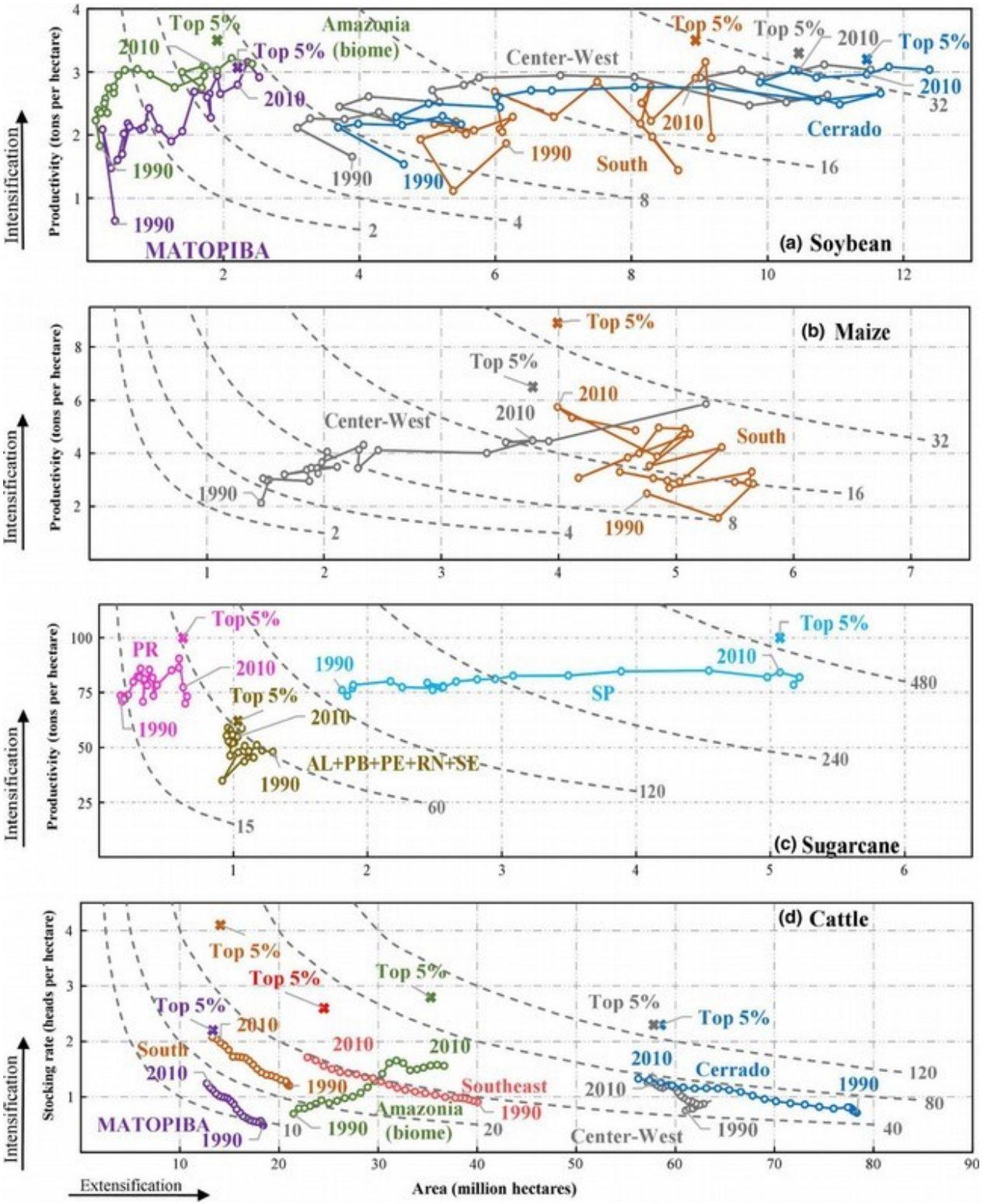
Results

Historical patterns of crop productivity and cattle density



Results

Productivity – agriculture area relationship



Discussion

General trends:

- gradual replacement of natural pasturelands with planted pasture in several parts of the country since the 1970s
- rapid expansion of croplands since the 1980s in almost all states

- Sugarcane areas are mainly concentrated in the center and northern São Paulo state

Discussion

"West et al. (2014) suggested reduction in natural vegetation conversion in Brazil as a strategy for **agricultural sustainability and food security.**"

Arroz 2003: 3,1 Mha → 2013: 2,3 Mha (LSPA/IBGE)
2015: 2,1 Mha → 2016: 1,9 Mha

Feijão
2015: 2,9 Mha → 2016 2,8 Mha

Mandioca
2015: 1,47 Mha → 2016: 1,49 Mha

Soja
2015 32,1 Mha → 33,1 Mha (mais de 1 Mha)

Discussion

“West et al. (2014) suggested reduction in natural vegetation conversion in Brazil as a strategy for **agricultural sustainability and food security.**”

“Despite public efforts against deforestation, we estimated that **13 million ha of new agricultural areas** was established between 2006 and 2012, of which 55% replaced Amazon rainforest and 24% replaced Cerrado.”

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“Despite public efforts against deforestation, we estimated that **13 million ha of new agricultural areas** was established between 2006 and 2012, of which 55% replaced Amazon rainforest and 24% replaced Cerrado.”

Although Brazilian agriculture has been historically known for extensification of agriculture at the expense natural vegetation (especially in the Amazonia and Cerrado), data from recent years indicate thatextensification has slowed and intensification is increasing.

Discussion

“São Paulo and Paraná states clearly experienced sugarcane **extensification**, characterized by increases in area and little increase in yield. Low increases in yield probably occurred because, in general, new sugarcane producers adopt adjacent practices allowing them to quickly reach sugarcane yields similar to consolidated areas.”

Limit for “closing yield gap?”

Discussion

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Limit for “closing yield gap?”

Yield gap analysis is a powerful tool to analyze deficits in agricultural technology and closing this gap could have a dramatic impact on food security (Godfray et al., 2010; Foley et al., 2011; Mueller et al., 2012).

Discussion

“We were able to generate high-quality land use and productivity maps for Brazil between 1940 and 2012.”

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“We were able to generate high-quality land use and productivity maps for Brazil between 1940 and 2012.”

“Nevertheless, some uncertainties and inaccuracies still need to be clarified.”

- tree cover (Hansen, 2013)
  Allocation of agriculture areas

- MCAs

- 1995 → 2006 trend for 2007 → 2012
  Need new census data (how accurate?)

-MODIS, Landsat-8 and Sentinel-2
  Robust crop mapping