HISTORY AND GEOGRAPHY OF LAND PRODUCTIVITY TO ASSESS THE CHALLENGES FOR FOOD SECURITY

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Motivations & Aims

- Population growth
- Increasing demand of calories and proteins
- Land and water resources are approaching their upper bound

KEY CHALLENGE: producing more nutrients with less resources, while preserving the natural ecosystem

Existing literature: *Nutritional yield* to link crop yield and # of people fed

- DeFries *et al*. (2015), DOI: 10.1126/science.aaa5766
- Kassidy *et al*. (2013), DOI: 10.1088/1748-9326/8/3/034015

Gaps: lack of a unique indicator merging all crops and accounting for their multi-variegate spectrum of nutrients; temporal and geographical evolution of the nutrient production in relation to the Malthusian trap with a data-driven approach

GOAL: monitoring the role of *intensification* vs *extensification* in boosting agricultural production of nutrients over 1961-2016 worldwide

Data & approach

NUTRITIONAL LAND PRODUCTIVITY(*LP*) measures the amount of calories (*c*), fats (*f*), and proteins (*p*) supplied by a hectare of harvested land.

$$LP_{c,f,p} = \frac{\sum_i P(i) \cdot k_{c,f,p}(i)}{\sum_i LF(i)}$$

P(i) is the annual production of crop *i* [ton]
source: FAOSTAT database (http://www.fao.org/faostat/en/#data)

$k_{c,f,p}(i)$ is the calorie [kcal/ton], fat [g/ton], and protein [g/ton] content
source: USDA database (https://fdc.nal.usda.gov/)

LF(i) is the crop-specific harvested area or Land Footprint [hectare]
source: FAOSTAT database

140 crops, period: 1961-2016, country to regional scale analysis

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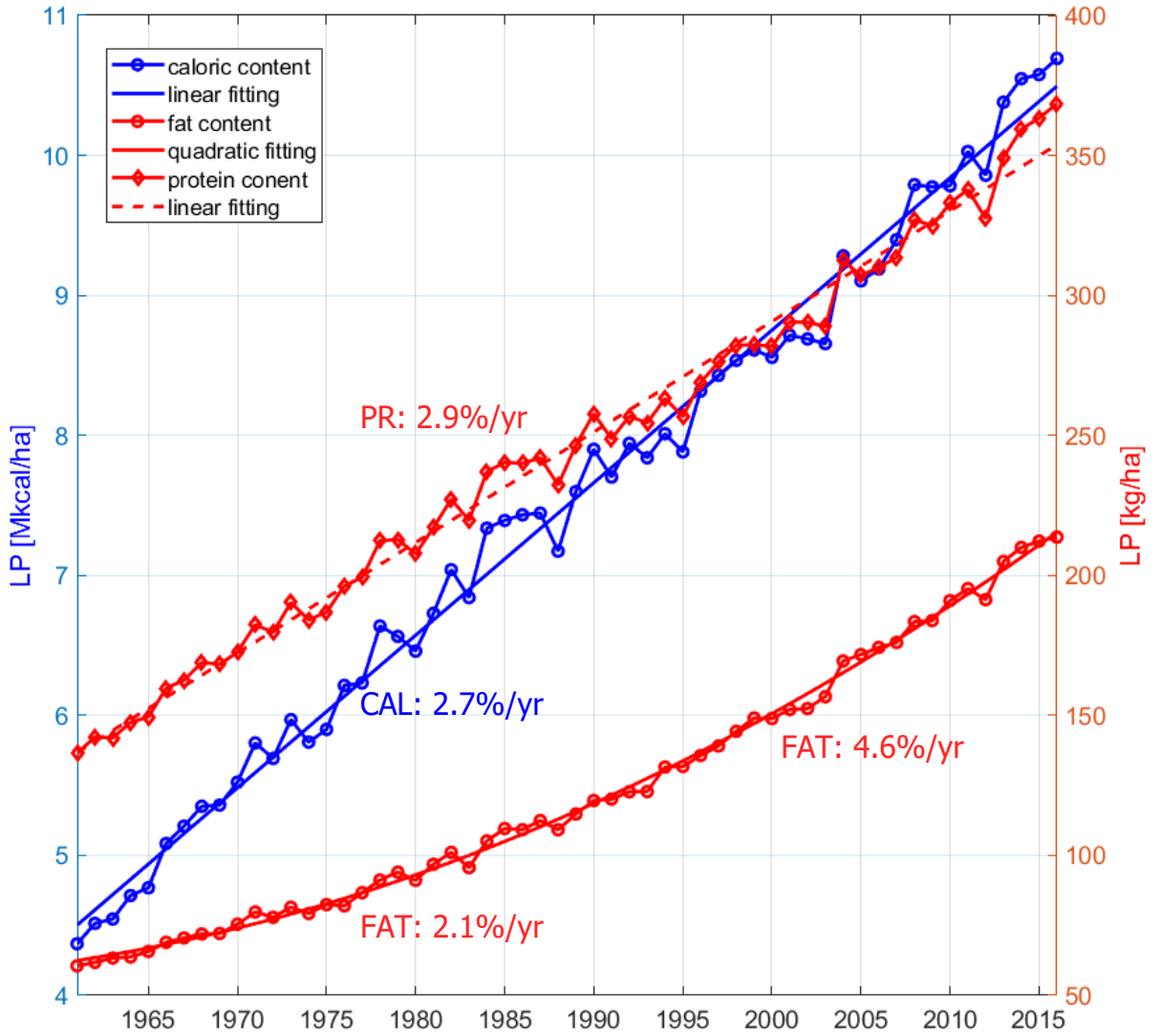
Global land productivity (*LP*) across the period 1961-2016.

- Calories & protein *LP*: LINEAR INCREASE
- Fats *LP*: SUPER-LINEAR INCREASE

We produce more fatty products (e.g., oil palm, rapeseed) than in 1960s.

- A kilogram of crop still provides an average of 1700 calories and 55 g of proteins, on global average, but it provides **60% more fats** than in the past



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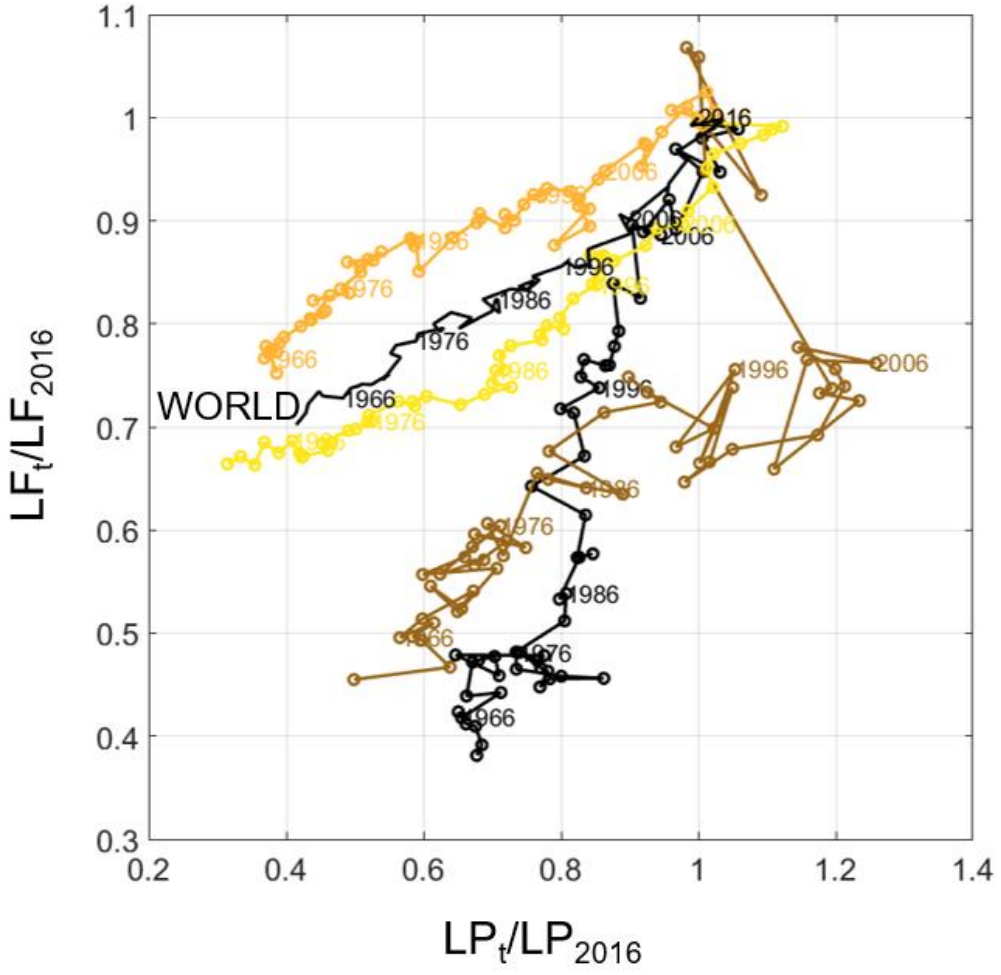
History and geography of agricultural production growth (1/2)



driven by

land productivity (*LP*)

- **South Asia**
- **Eastern Asia**
- **MENA region** (from 1990s)
- North America
- Europe (decreasing *LF*)

land footprint (*LF*)

- **Sub-Saharan Africa**
- **MENA region** (until 1990s)
- Oceania

- Latin American & Caribbean

INTENSIFICATION **EXTENSIFICATION**

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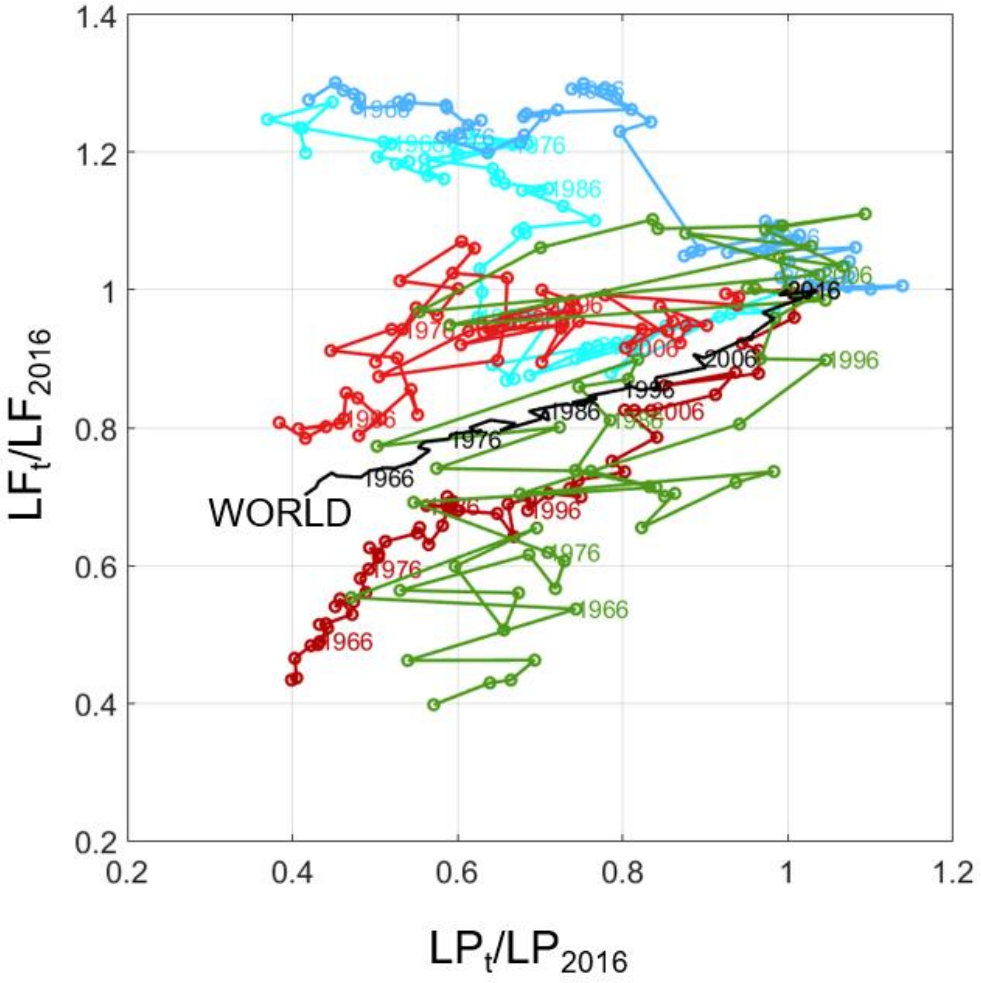
History and geography of agricultural production growth (2/2)



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INTENSIFICATION **EXTENSIFICATION**

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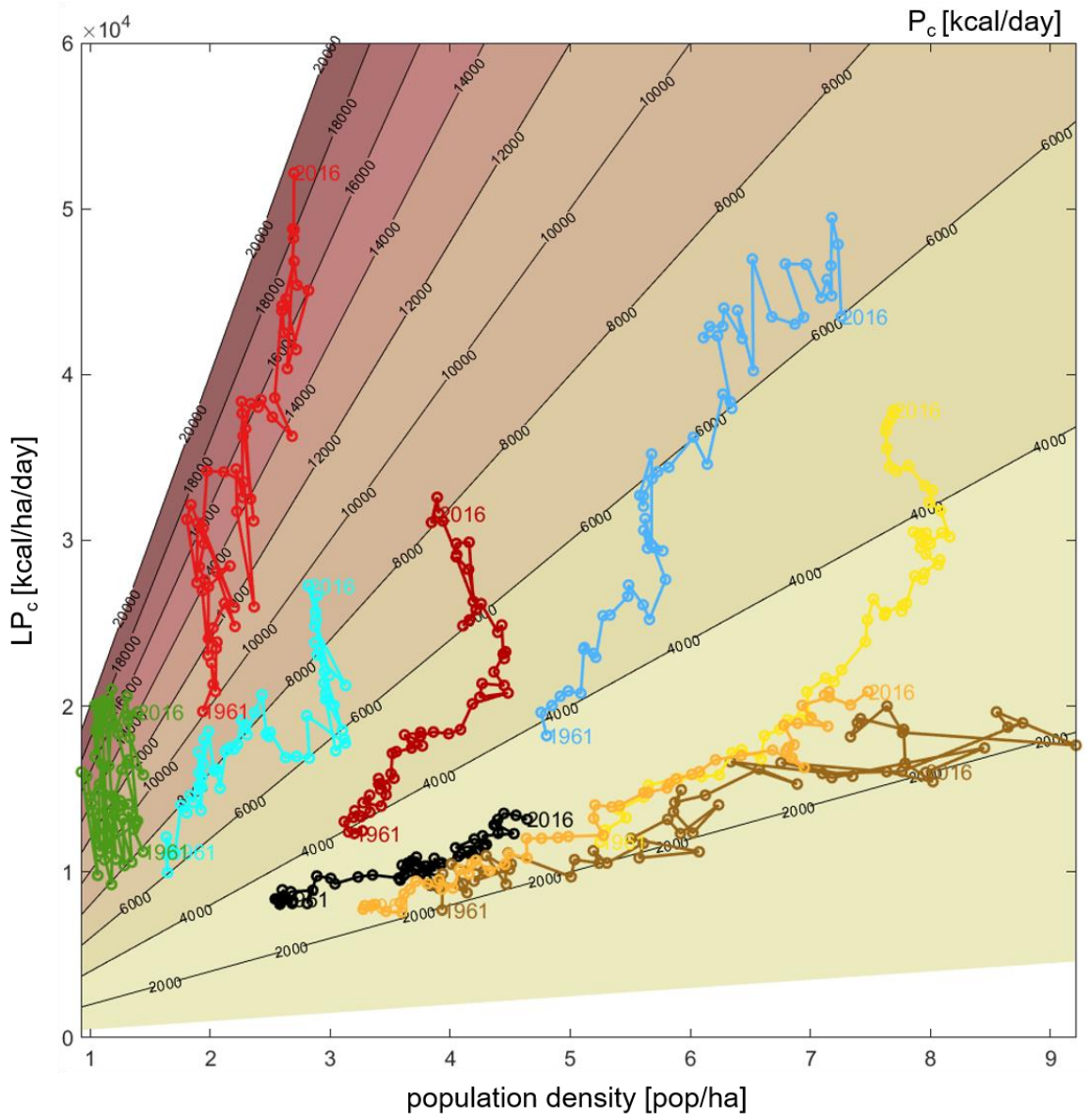
Did we escape the Malthusian trap?

- **GLOBAL SCALE**: production increased at faster rate than population growth→ increase of per-capita production

	1961		2016	
CAL:	3711	to	5351	kcal/day/cap
PROT:	115	to	184	g/day/cap
FAT:	51	to	106	g/day/cap

The transition of the production regime happens when production is not levelled-off by population growth

- **REGIONAL SCALE**:
- **Eastern Asia**: from 3000 to 5000 kcal/cap/day;
- **Latin America**: exceeds 8000 kcal/cap/day in 2016;
- **South Asia**, **Africa** and the **MENA** region still halted in the Malthusian trap.



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Key results

- The combined use of the land footprint and land productivity indicators allows one to monitor the role of agricultural *intensification* vs *extensification*
- These indicators synthetize the dynamics of 140 different crops, having different yield and nutrients content
- The *LP* indicator accounts at the same time for the crop yield and the nutrient content (as calories, fats, proteins), aiming at providing a *nutrition-sensitive yield*

ANSWER TO THE CHALLENGE: re-orienting the agricultural production basket toward those crops having the largest nutritional land productivity.

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