Total Factor Productivity in Agriculture: Taking Water Into Account

International Workshop on
"Going Beyond Agricultural Water Productivity"
December 8-9, 2014
World Bank, Washington DC

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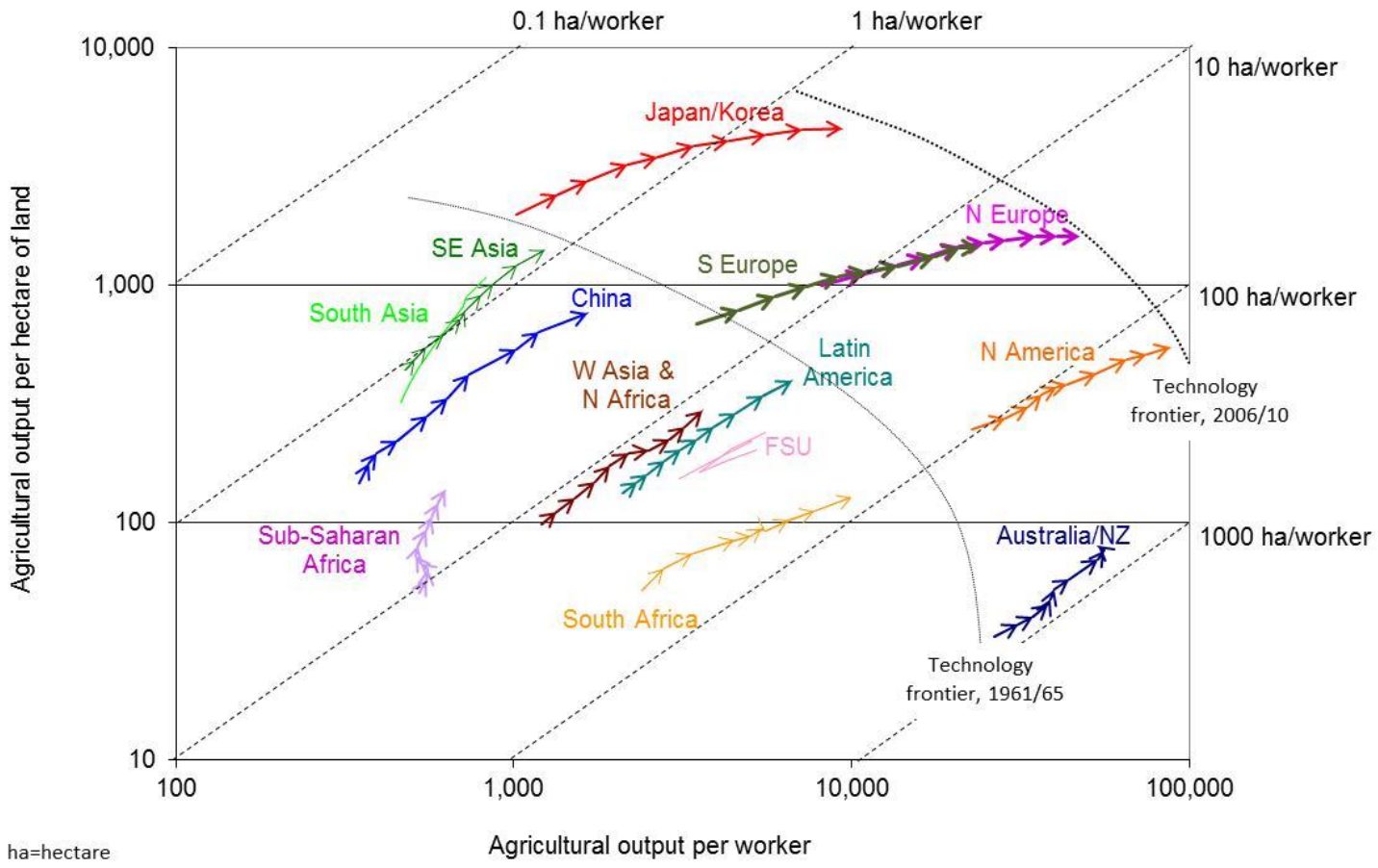
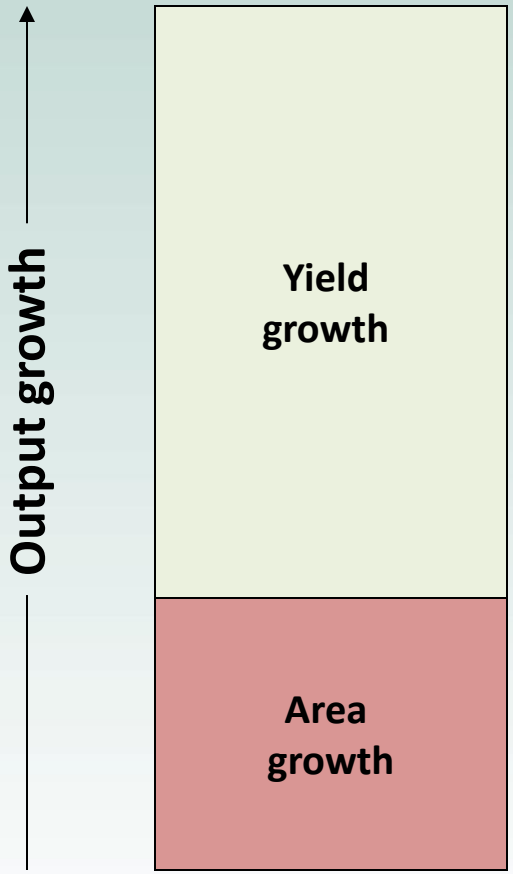
Agricultural productivity rising for most resources, but at uneven rates, depending on relative scarcity

Agricultural land and labor productivity for each 5-year intervals over 1961-2010, in constant US$

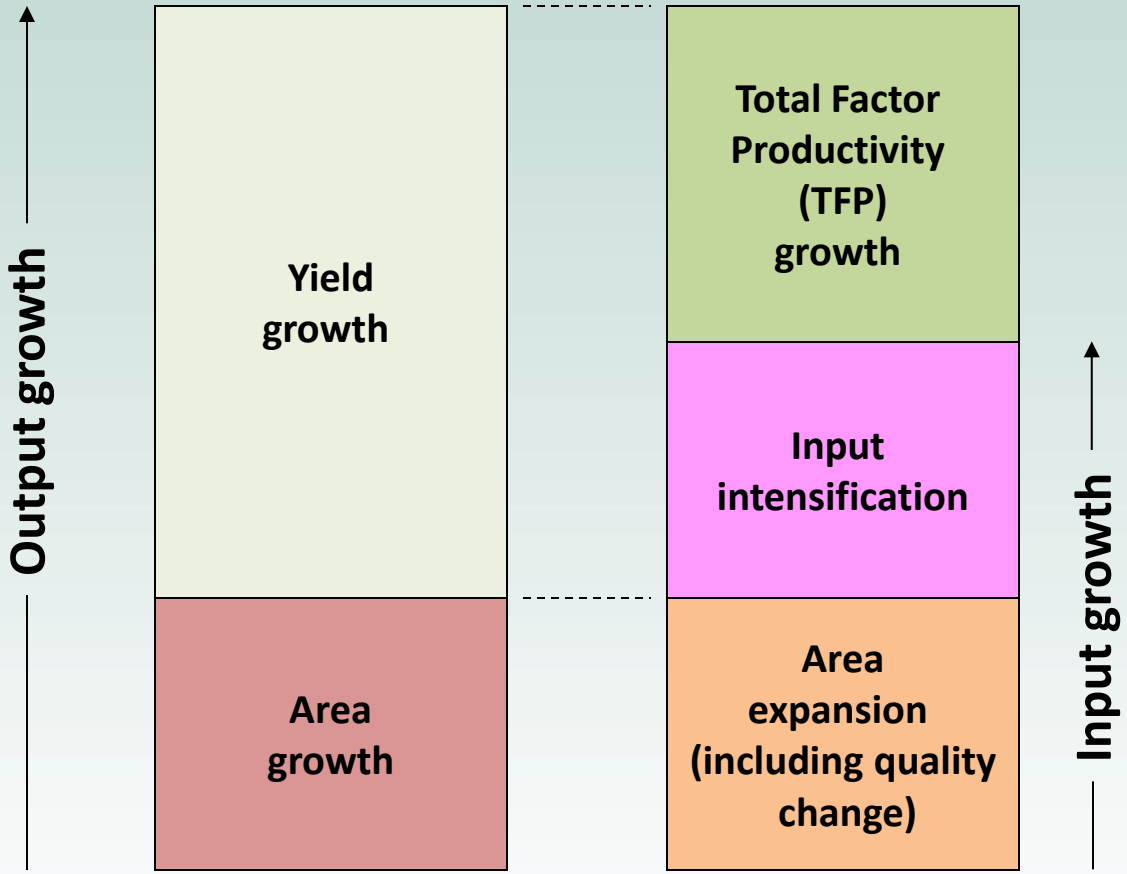


Source: Fuglie & Wang (2012)

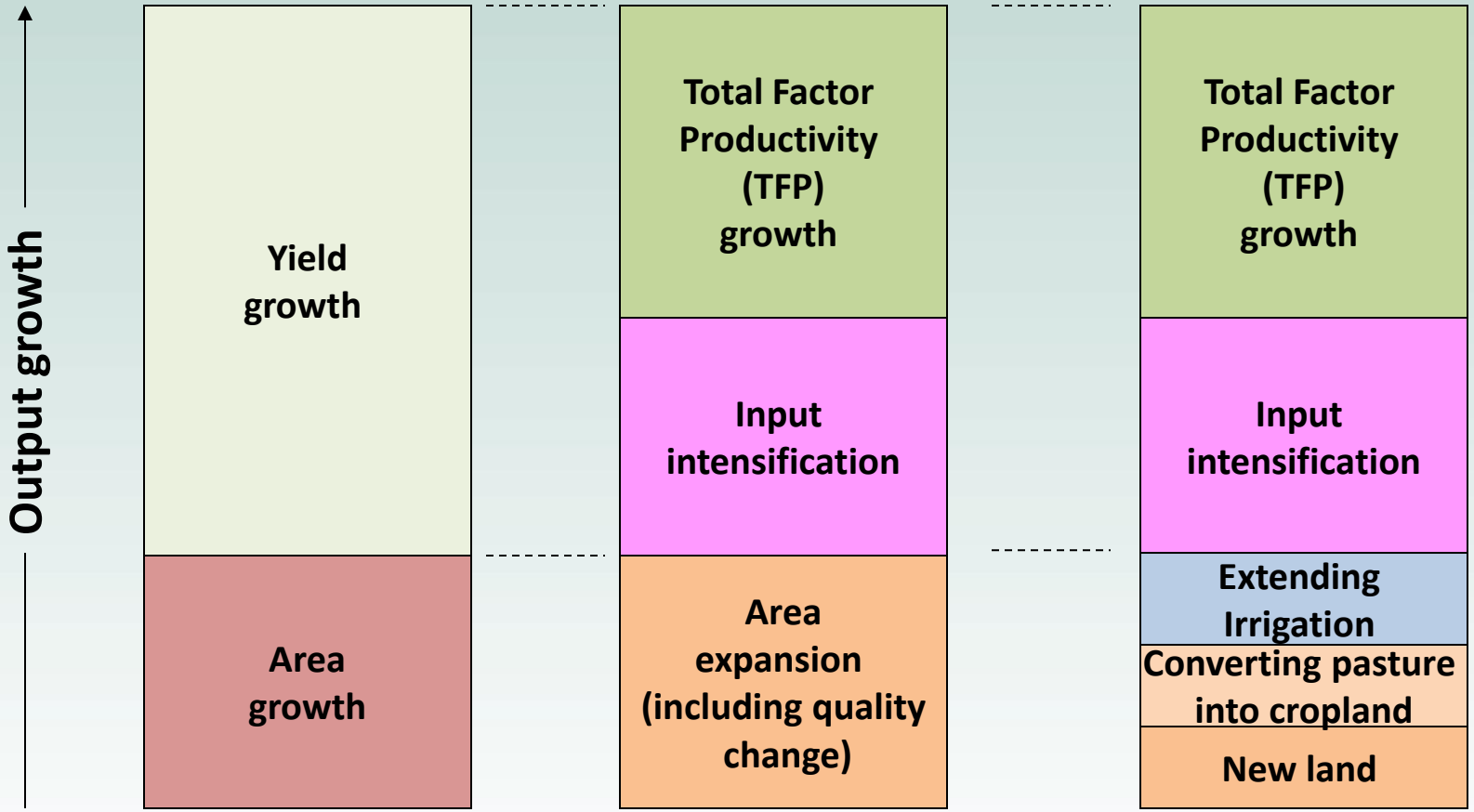
Future agricultural growth will rely more on raising yield rather than expanding resources



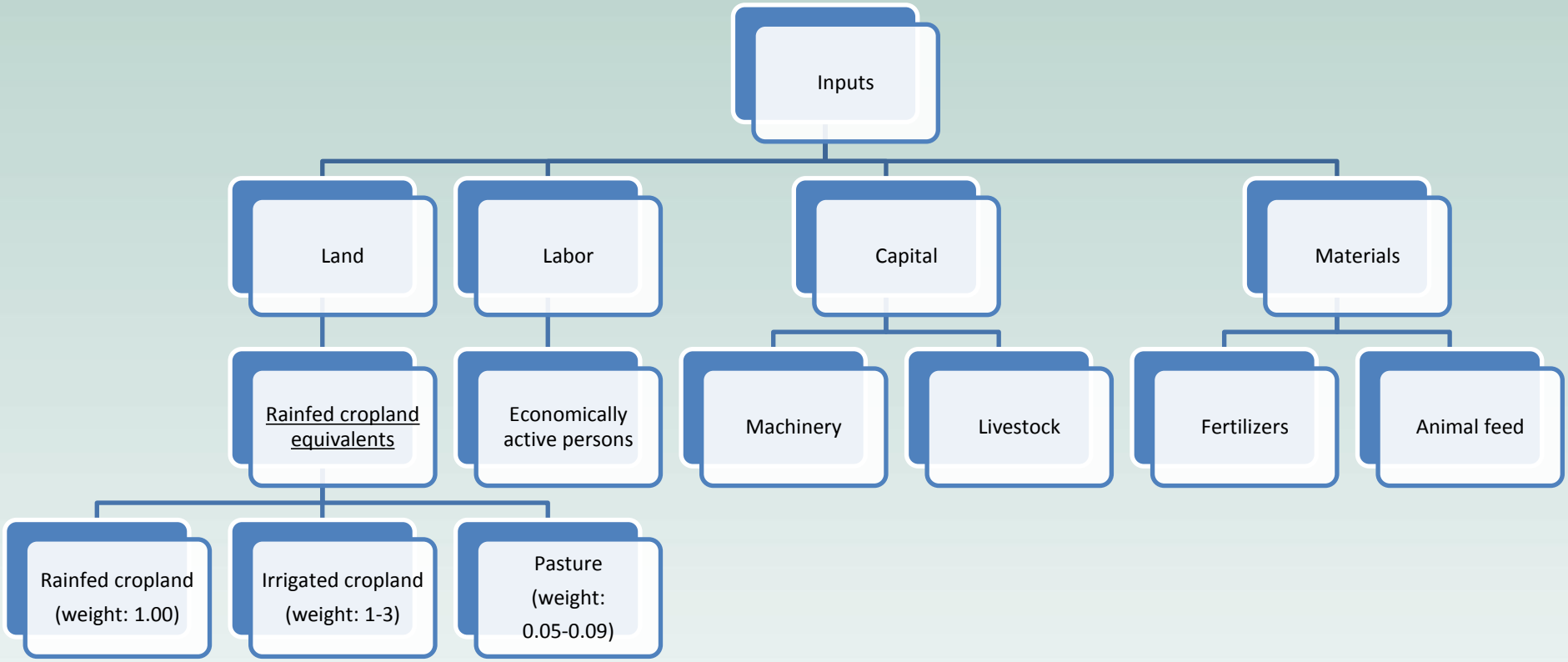
“Growth accounting” decomposes growth due to total input use and total factor productivity (TFP)



Irrigation can be treated as an improvement in land quality

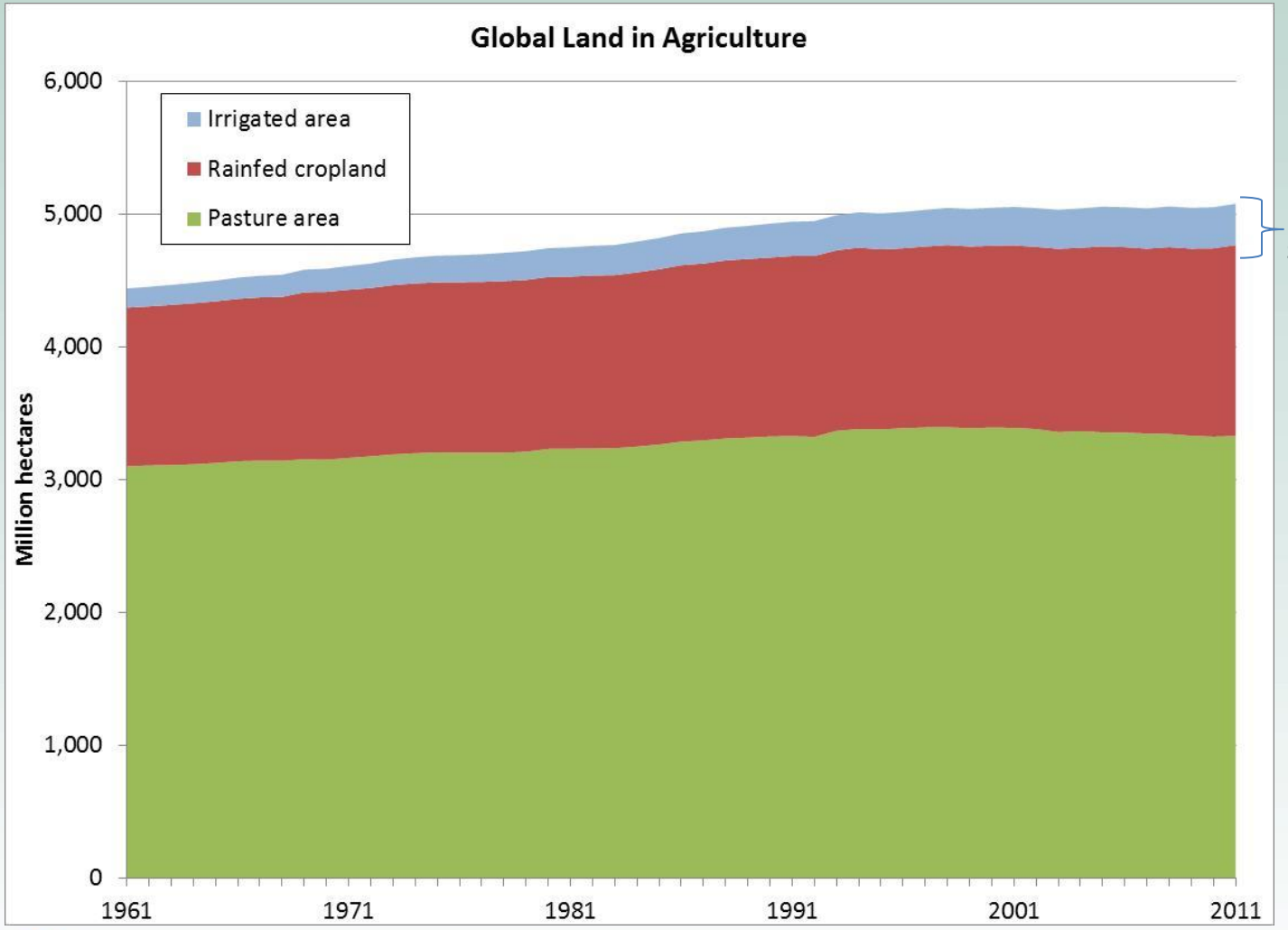


Measuring growth in inputs



- Growth in each input weighted by its cost share to get growth in aggregate inputs
- Land: adjusted for quality into “rainfed cropland equivalent” hectares

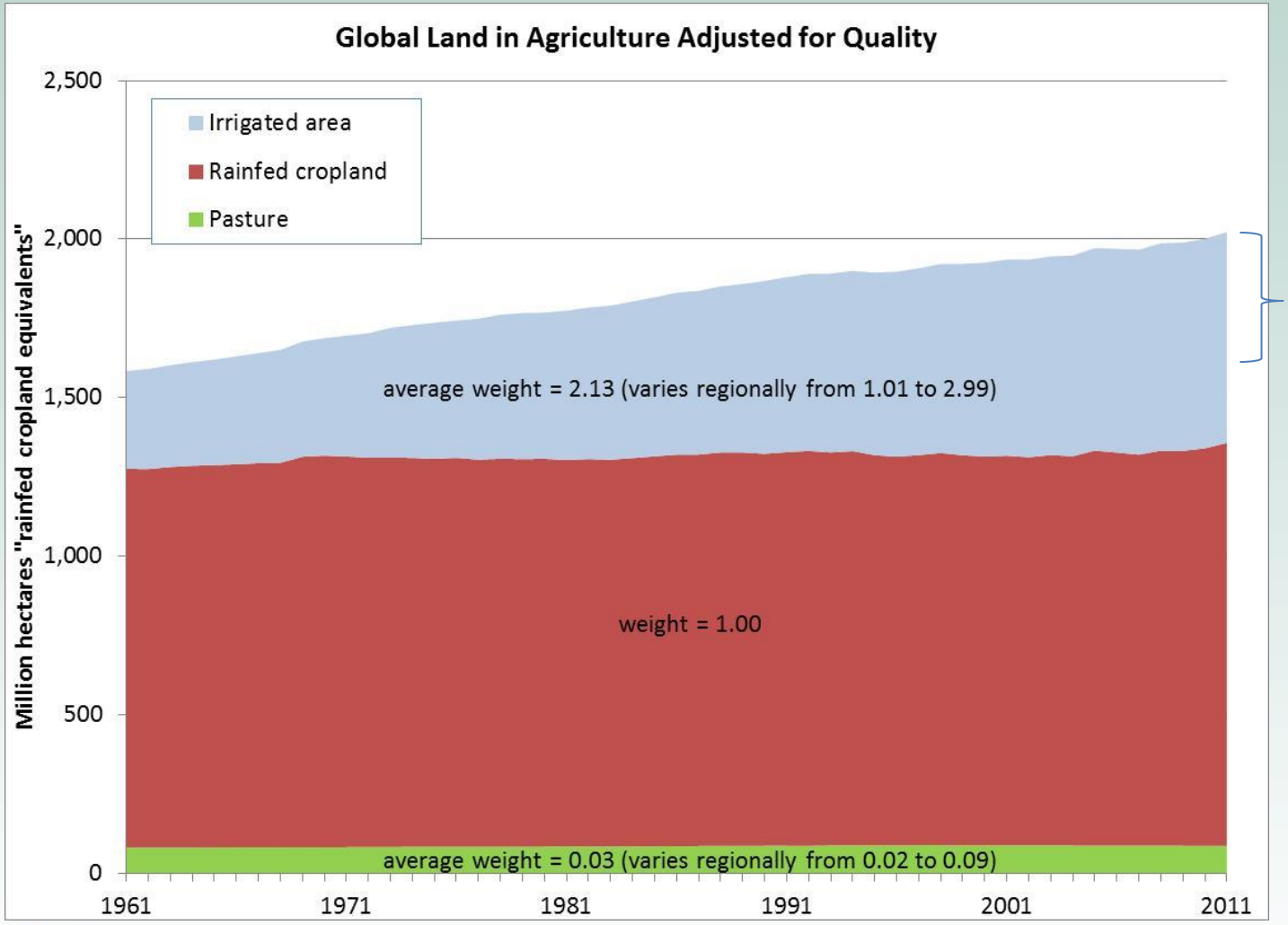
Extension of irrigation increases the effective land input



Increased by 500 mHa since 1961, or by about 10%

Source: FAO

Extension of irrigation increases the effective land input



Increased by about 30% since 1961

Source: ERS

Decomposing growth into TFP and input components

- Cobb-Douglas constant-returns-to-scale production function

$$Y = A \prod_{i=1}^{n} X^{\beta_i}$$

- Growth decomposition by input costs (β_i = cost share of input X_i)

$$\dot{Y} = \dot{A} + \sum_{i=1}^{n} \beta_i \dot{X}_i$$

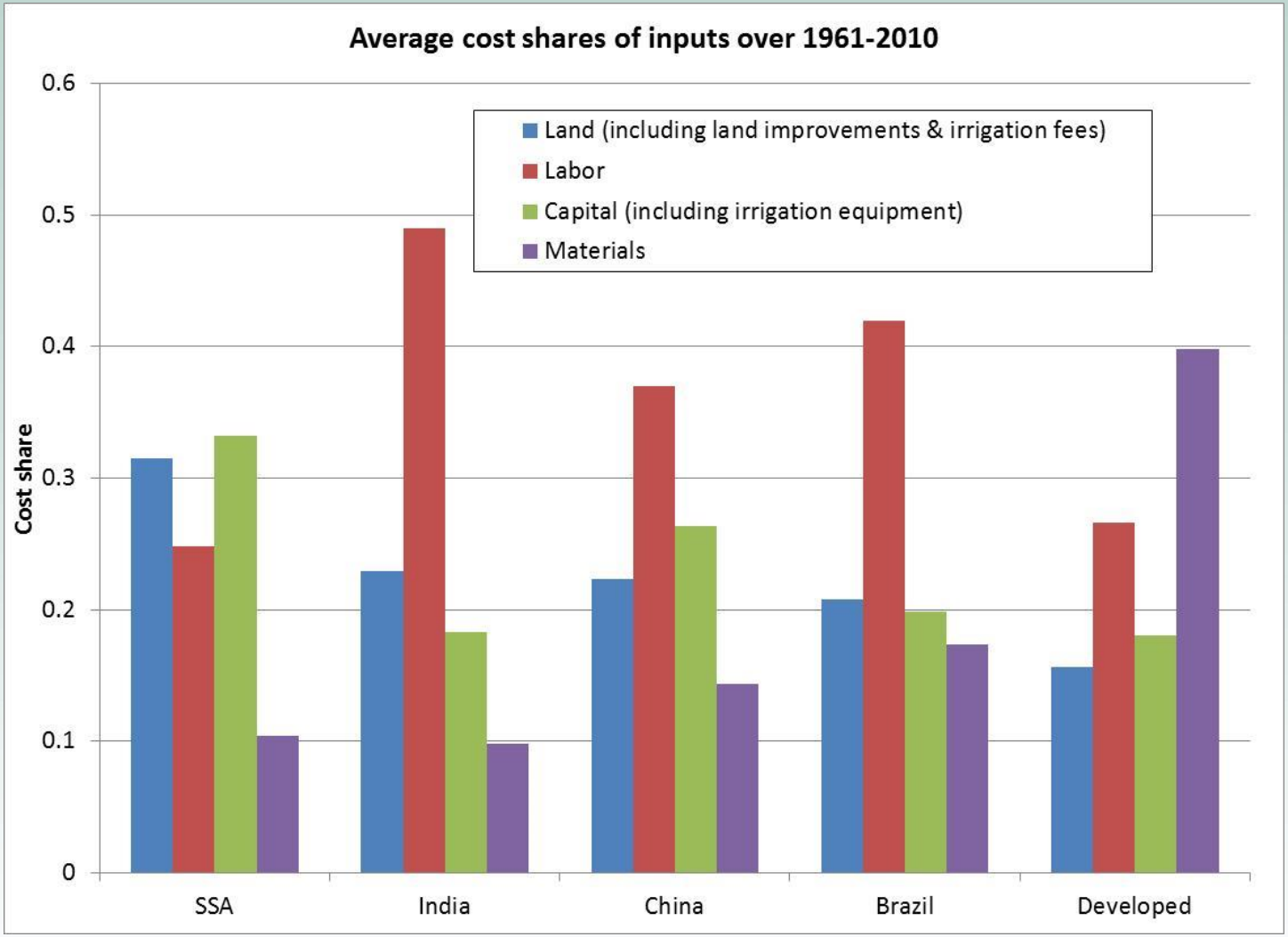
- Growth decomposition by resources (X_1 = land, including irrigated land)

$$\dot{Y} = \dot{X}_1 + \frac{\dot{Y}}{X_1}$$

$$\dot{Y} = \dot{X}_1 + \dot{A} + \sum_{i=2}^{n} \beta_i \left(\frac{\dot{X}_i}{X_1}\right)$$

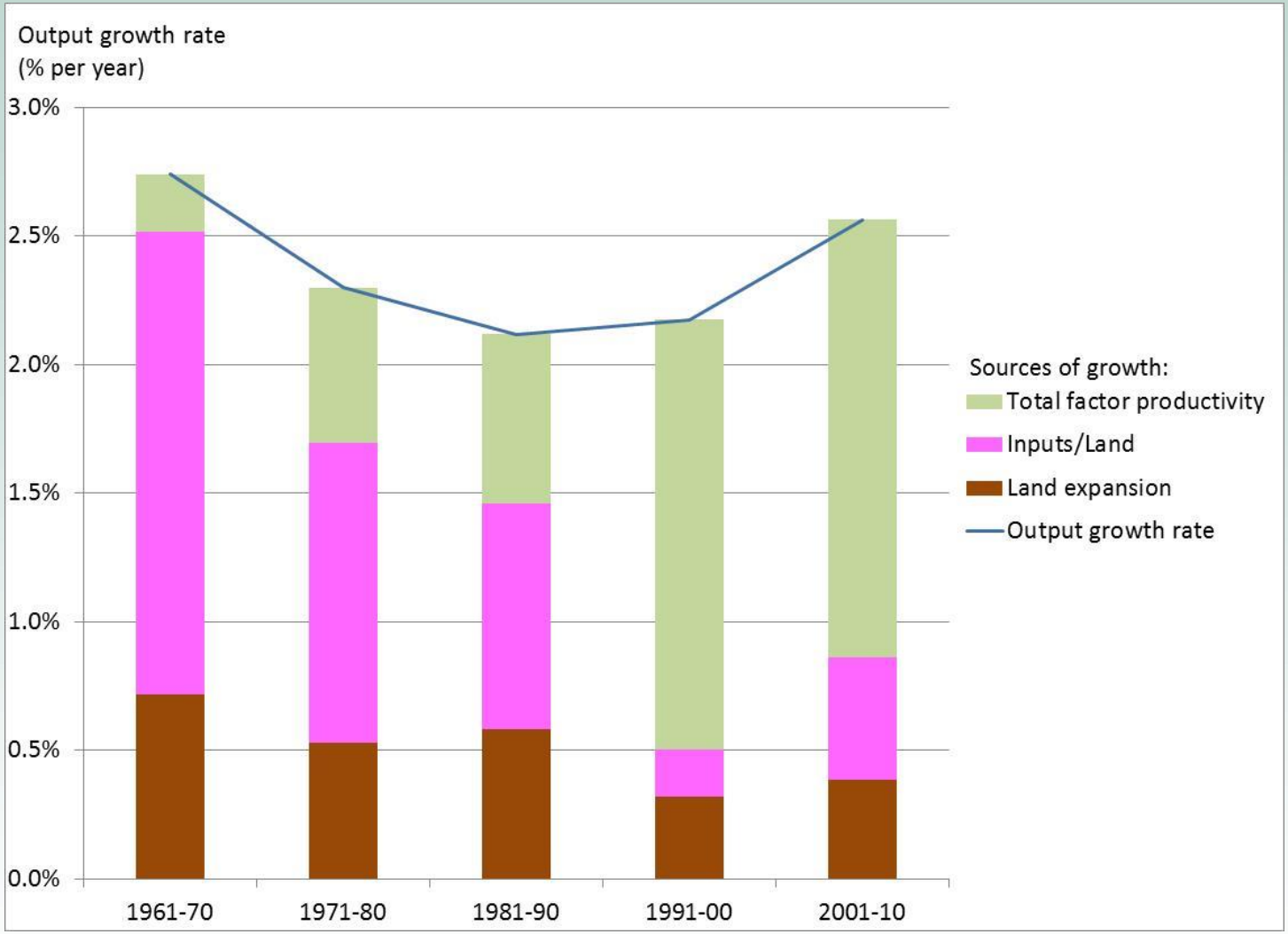
- Underlying this theory is the assumption that inputs are substitutable

Cost shares in international agriculture



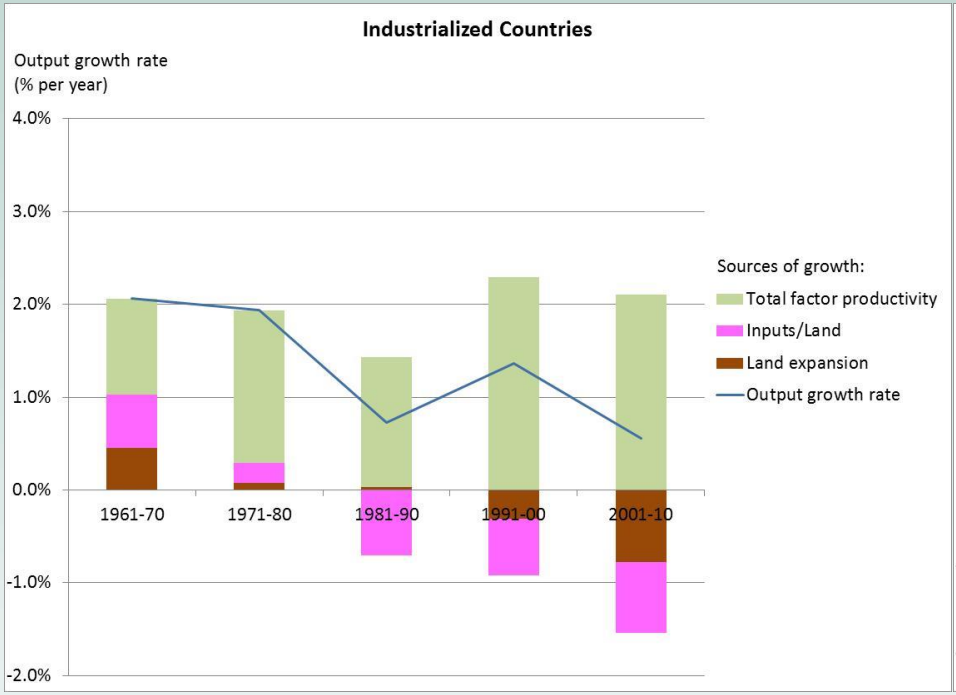
Source: Fuglie (2012)

Improvement in TFP accounts for a rising share of global agriculture growth

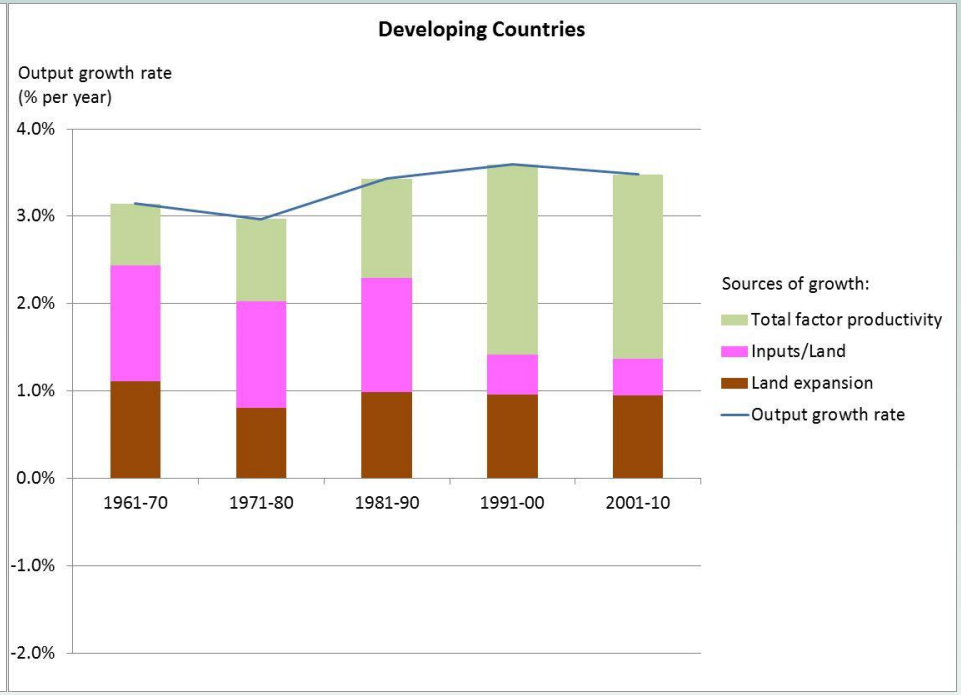


Source: ERS

Most of the global acceleration in agricultural TFP growth took place in developing countries



TFP enables output to grow even as resources leave sector



TFP has become the major source of growth

Source: ERS

Irrigation's contribution to agricultural growth

- Irrigation accounts for most of the 'effective' land area growth
- Land (and irrigation) are a declining share of total costs
- Growth in land (and irrigation) account for a declining share of agricultural growth
- Technological change (TFP) has become the primary agricultural growth driver world wide
- Future analysis
  - develop more refined estimates of irrigation's contribution to growth in specific countries and regions
  - consider social cost (versus private cost) of natural resource inputs in agriculture