Impact of Increasing World-Market Prices for Oilseeds on West African Agriculture

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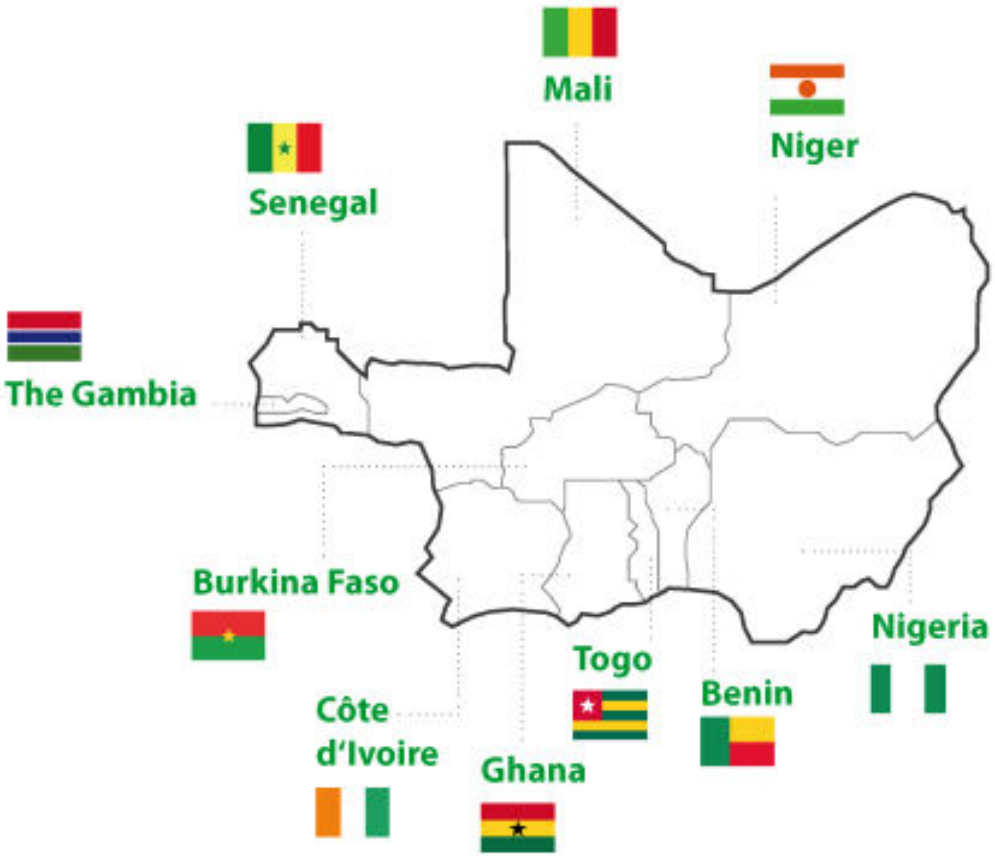
WASCAL

West African Science Service Center on
Climate Change and Adapted Land Use

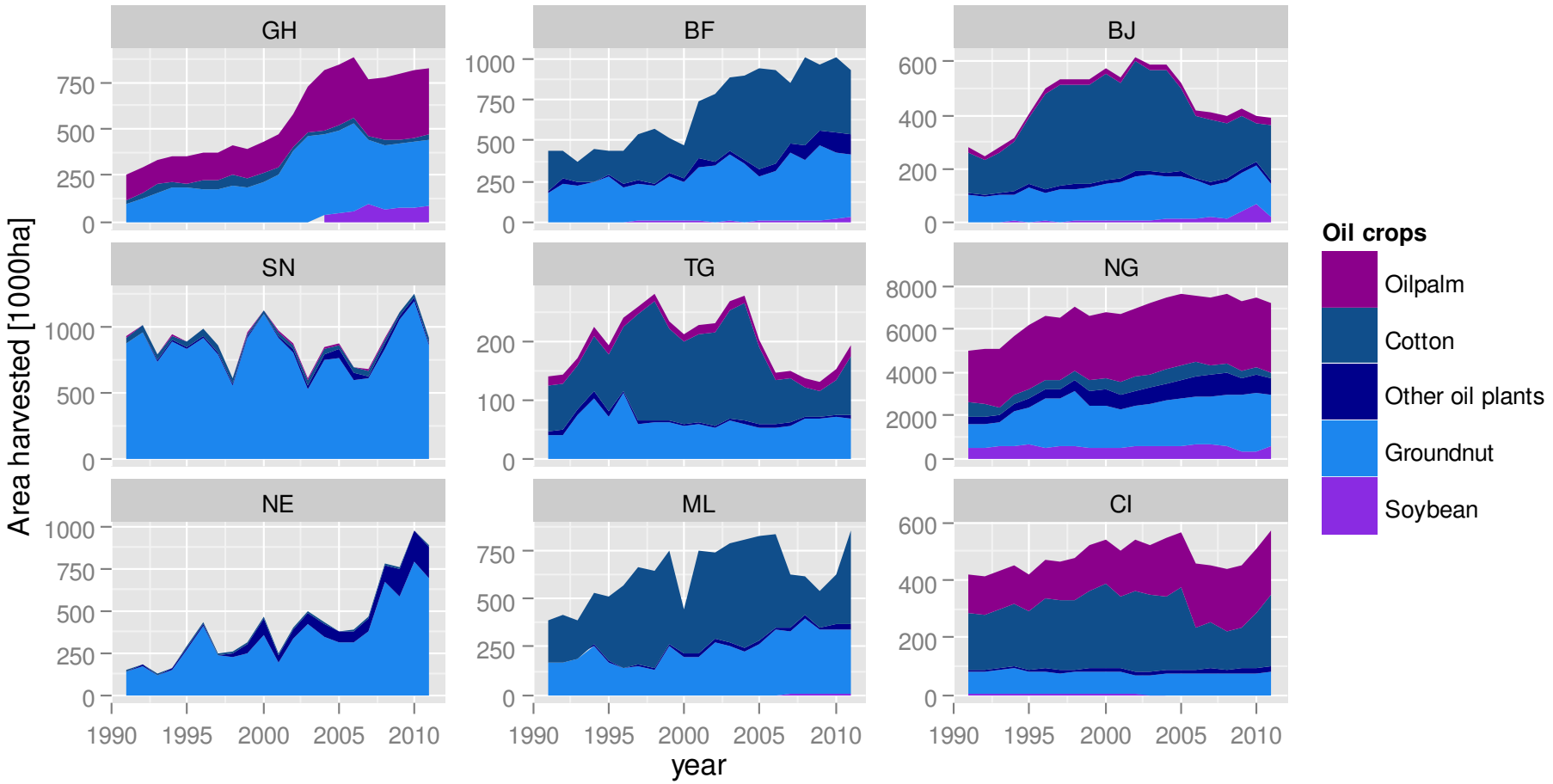
Bundesministerium
für Bildung
und Forschung



Oil crops in West Africa: Some data …

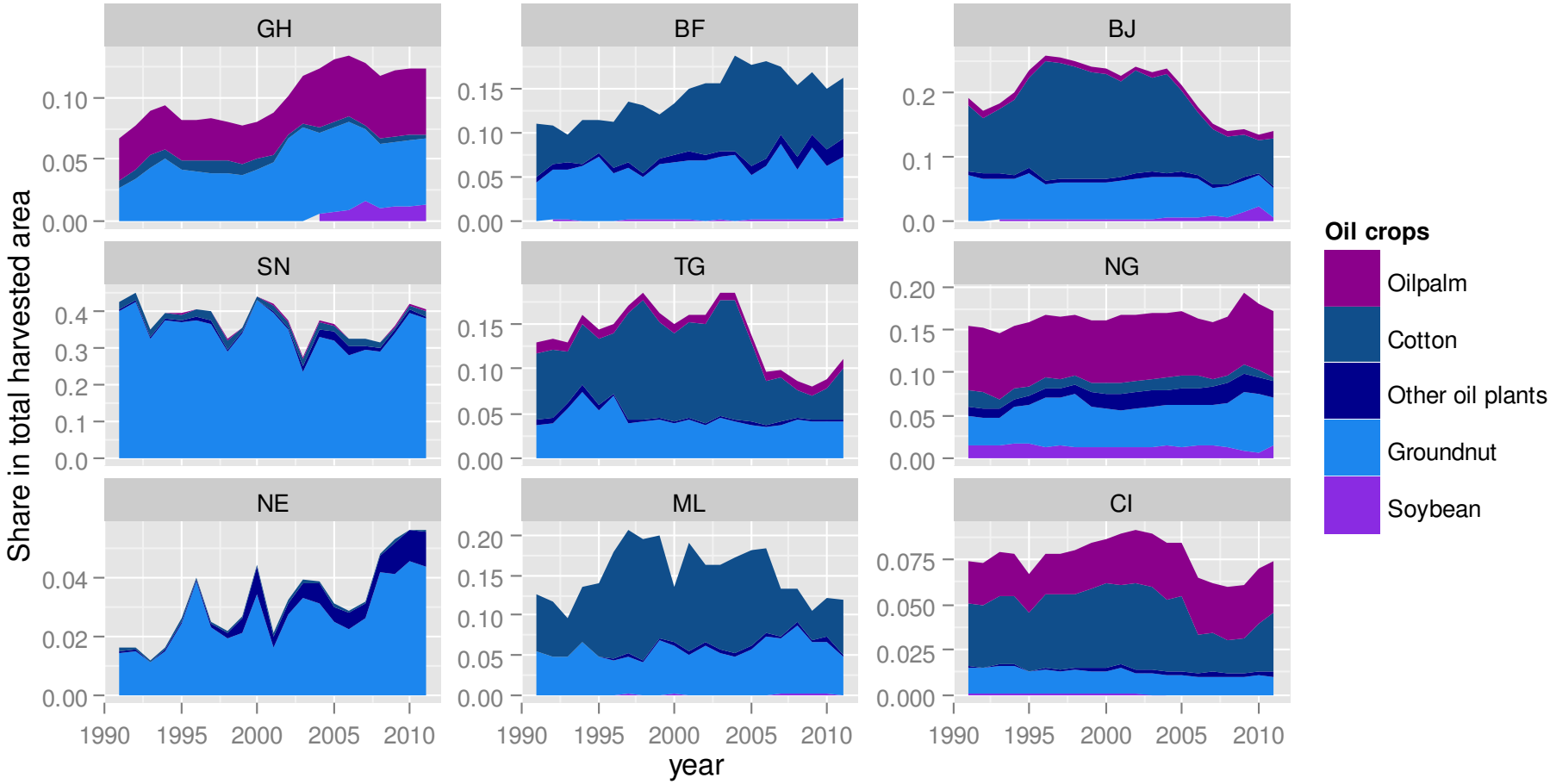
Background

Harvested Area of Oil Crops, WASCAL Partner Countries, 1990-2010



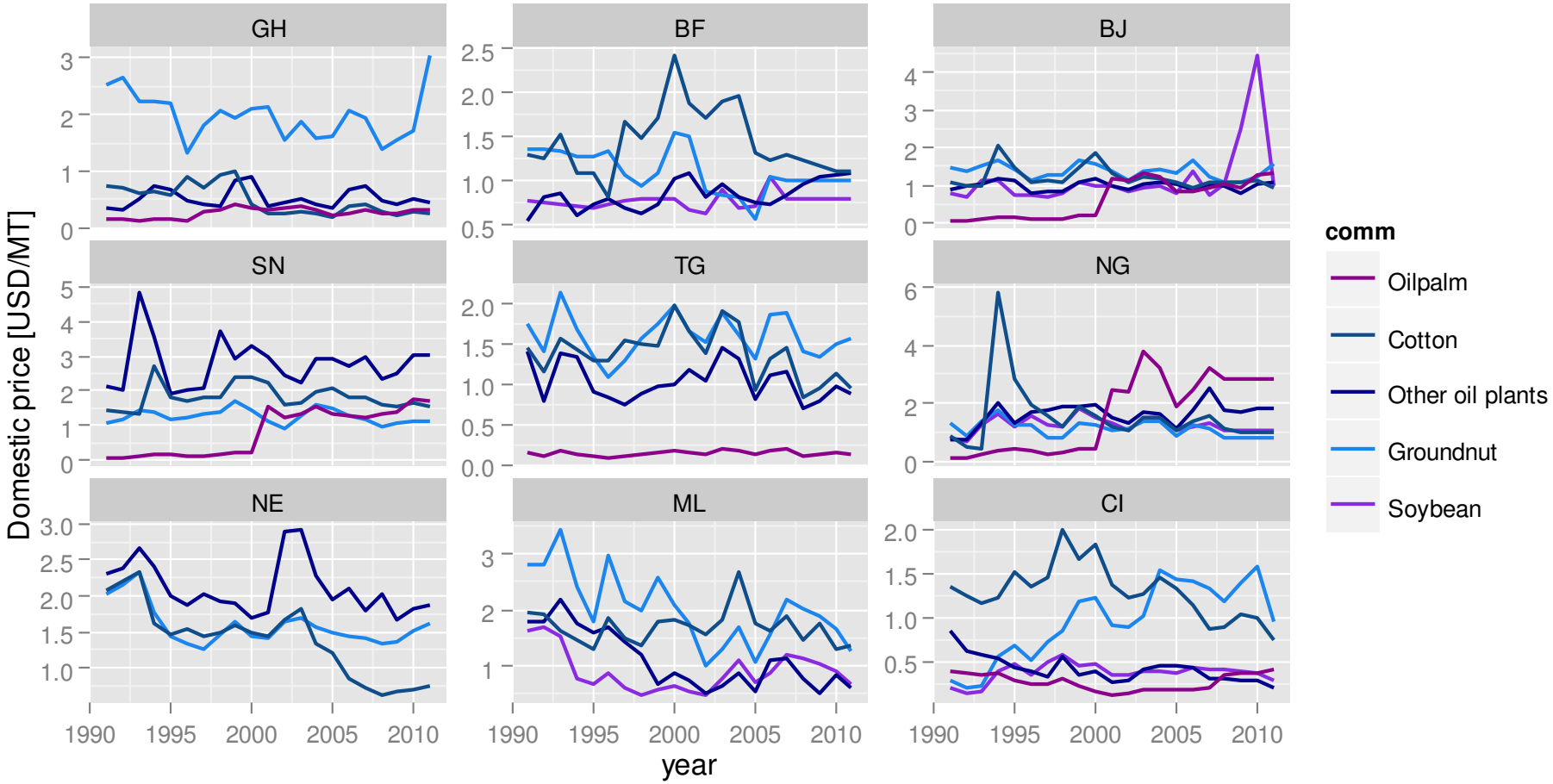
Source: FAOSTAT, own computations

Share of oil crops in total agricultural area, WASCAL Partner Countries, 1990-2010



Source: FAOSTAT, own computations

Relative domestic prices, oilseeds to cereals, WASCAL Partner Countries, 1990-2010



Source: FAOSTAT, own computations

Summary: Oilseed production in West Africa

Background

- Oilseed production accounts for ~15% of West Africa's harvested area
- Oil palm, groundnut, and cotton are dominant (depending on AEZ)
- Soybean has gained importance in some countries
- Oil palm area remained stable over the last two decades (in contrast to Indonesia and Malaysia)

Oilseed and vegetable oil consumption in West Africa

Background

- While oilseeds are mainly exported, vegetable oil is mainly imported
- Palm fruit (not kernels) and groundnut are mainly processed on farm (~80%)
- Import share of vegetable oil larger than 50%

State of debate

Motivation

- Increasing global energy prices may lead to increased demand for energy crops
- Increase of energy crop areas at expense of:
  - Food crop areas (soybeans, cotton)
  - Natural resources (conversion of forest into oil palm plantations)

- **Contribution of this study: Analysis of world-market price changes on West African production, consumption, and rural welfare**

-> General equilibrium analysis because income is not exogenous!

Social Accounting Matrices

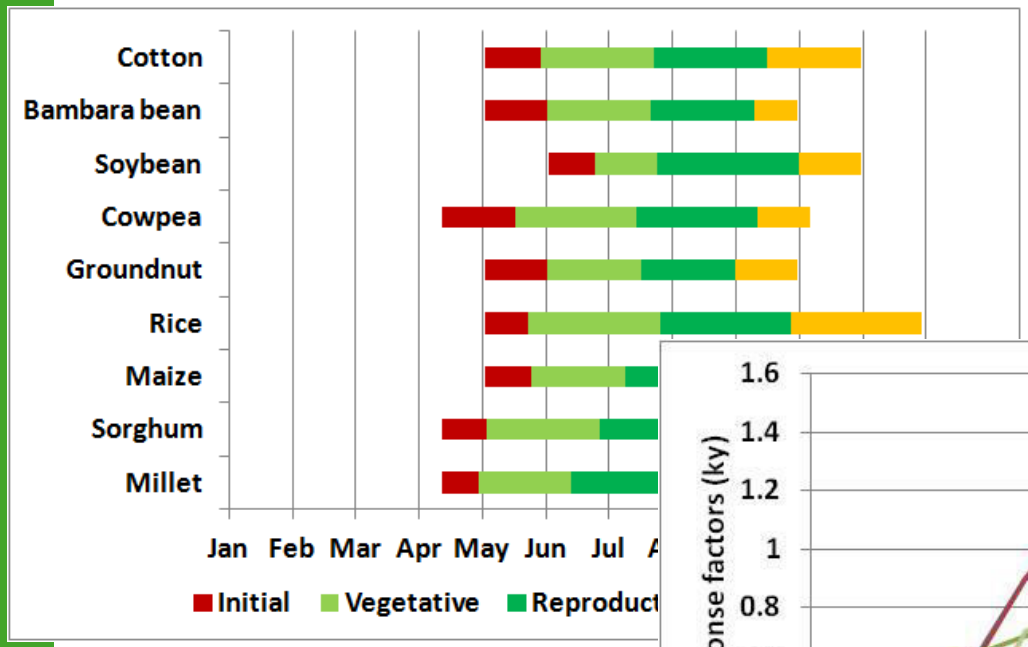
Database

- **GTAP-Africa database**
  - Base year 2007
  - 6 agric. sectors (incl. oilseeds)
- **World bank WDI**
  - Macro-indicators not represented in GTAP, e.g. remittances
  - Update to 2010
- **FAOSTAT**
  - Crop areas, yields, domestic prices, more detail (30 crops) …

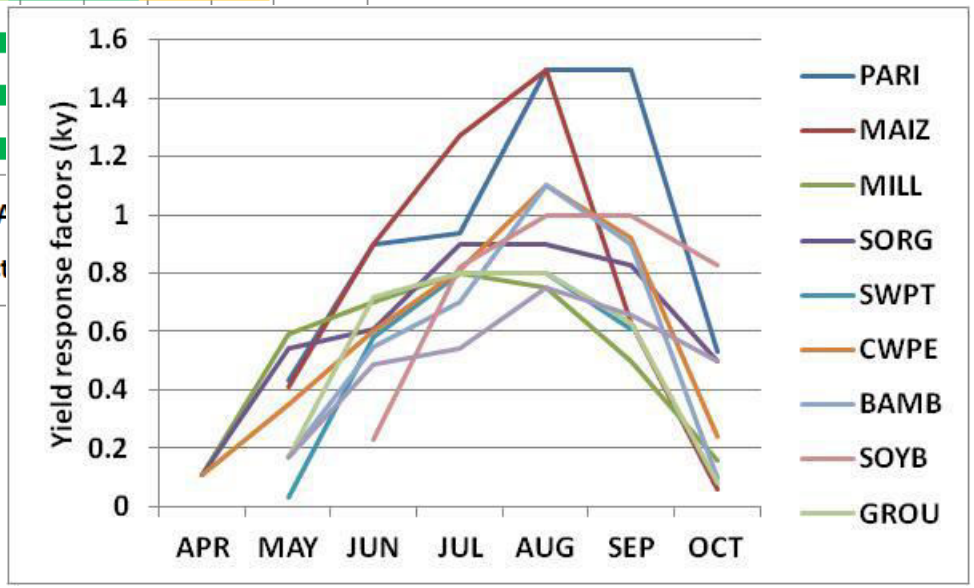
Agronomic data 1

Database

Crop calendars



Yield responses from established crop models



Agronomic data 2

Database

Maximum attainable yields (IFPRI 2009)

Table 4.1 Descriptive statistics of current and maximum potential yields among rainfed cropping systems in the CORAF region

Actual or current yield				Maximum potential yield		
Crop type/item	*N*	Mean	Standard deviation	Mean	Standard deviation	Yield gap (potential/current)
Cereals						
Maize	39	1.24	(0.6)	3.40	(1.1)	2.7
Rice	31	1.49	(0.6)	2.78	(0.6)	1.9
Millet	35	0.72	(0.3)	2.43	(0.8)	3.4
Sorghum	33	0.84	(0.3)	2.75	(0.8)	3.3
Root crops						
Cassava	32	9.15	(5.4)	14.0	(5.4)	1.5
Potatoes	20	6.11	(3.3)	28.4	(10.6)	4.7
Sweetpotatoes	30	8.67	(7.1)	15.3	(10.3)	1.8
Pulses						
Beans	12	0.54	(0.2)	1.14	(0.4)	2.1
Oil crops						
Groundnuts	32	0.83	(0.3)	1.35	(0.6)	1.6
Soybeans	14	0.79	(0.3)	1.50	(0.9)	1.9
High-value crops						
Bananas	23	6.08	(3.0)	27.4	(16.1)	4.5
Cotton lint	19	1.29	(1.3)	3.82	(2.8)	3.0

Source: Authors' calculations using data from Fischer et al. (2001), averaged across the agroecological zones and farming systems among all CORAF countries.

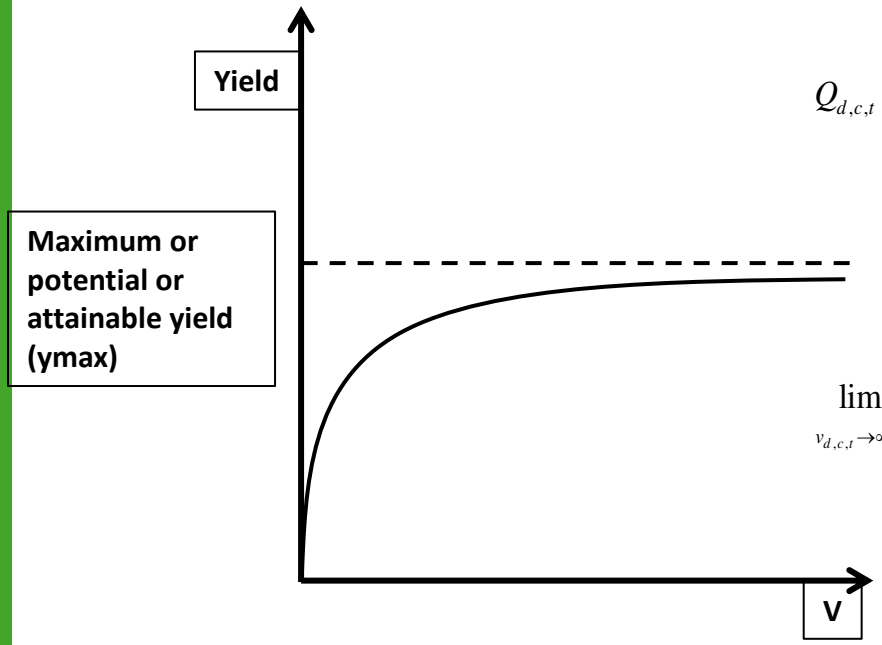
2-Stage model design: Decisions in stage 2 (yield formation)

Methods

- Farmers in district d maximize total revenues **R**, depending on product prices **p**, output quantity **Q**, input prices **q**, variable input quantity **V**, fixed but allocable factor **Z** and its wage **w**
- Decisions are constrained by:
  - Technology: CES production function
  - First period decision: Area planted A is upper bound for area harvested H
  - Minimum consumption requirement B for certain crops (0 if purely marketed)

CES Production/Yield Function

Methods



$$Q_{d,c,t} = \left(\delta^{A}_{d,c,t} A_{d,c,t}^{\frac{\sigma_{d,c}-1}{\sigma_{d,c}}} + \delta^{V}_{d,c,t} V_{d,c,t}^{\frac{\sigma_{d,c}-1}{\sigma_{d,c}}} + \delta^{Z}_{d,c,t} Z_{d,c,t}^{\frac{\sigma_{d,c}-1}{\sigma_{d,c}}} \right)^{\frac{\sigma_{d,c}}{\sigma_{d,c}-1}}$$

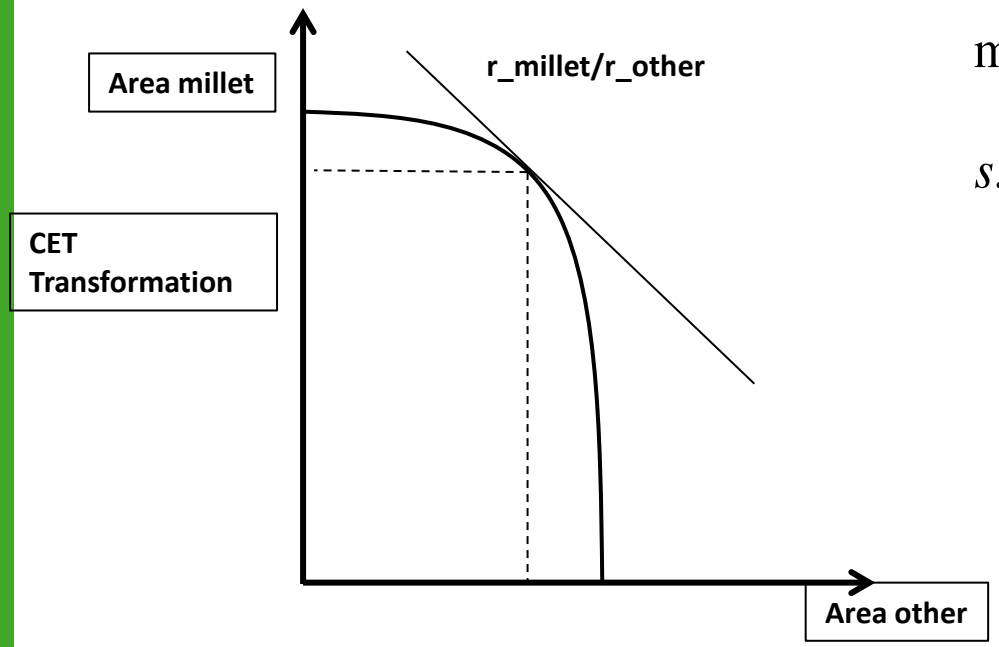
$$= A_{d,c,t} \left(\delta^{A}_{d,c,t} + \delta^{V}_{d,c,t} v_{d,c,t}^{\frac{\sigma_{d,c}-1}{\sigma_{d,c}}} + \delta^{Z}_{d,c,t} z_{d,c,t}^{\frac{\sigma_{d,c}-1}{\sigma_{d,c}}} \right)^{\frac{\sigma_{d,c}}{\sigma_{d,c}-1}} = A_{d,c,t} y_{d,c,t}$$

$$\lim_{v_{d,c,t} \to \infty, z_{d,c,t} \to \infty} y_{d,c,t} = \delta^{A}_{d,c,t}{}^{\frac{\sigma_{d,c}}{\sigma_{d,c}-1}} \equiv y^{att}_{d,c,t}$$

- Yield responses to water and nutrients are very well researched – on field level!
- General observation:
  - Low substitutability of inputs – on field level, could be higher at regional scale
  - Existence of growth plateau empirically supported (Frank et al 1990, Paris 1989, Allen at al 1998 FAO IDP 56)

2-stage model design: Decisions in stage 1 (area allocation)

Methods



$$\max_{A} R^{e} = \sum_{c} r^{e}_{d,c,t} A_{d,c,t} - w_{d,t} \bar{Z}_{d,t}$$

$$s.t.$$

$$\bar{Z}_{d,t} = \left(\sum_{c} \theta_{d,c,t} A_{d,c,t}^{\frac{\tau_d + 1}{\tau_d}} \right)^{\frac{\tau_d}{\tau_d + 1}}$$

- During planting stage, farmers maximize total expected revenues Re per unit of land, depending on wages and available factors (Z, w)
- Decisions are constrained by:
  - Technology: CET transformation function
  - Availability of total fixed but allocable factor Zbar (dominantly labour)

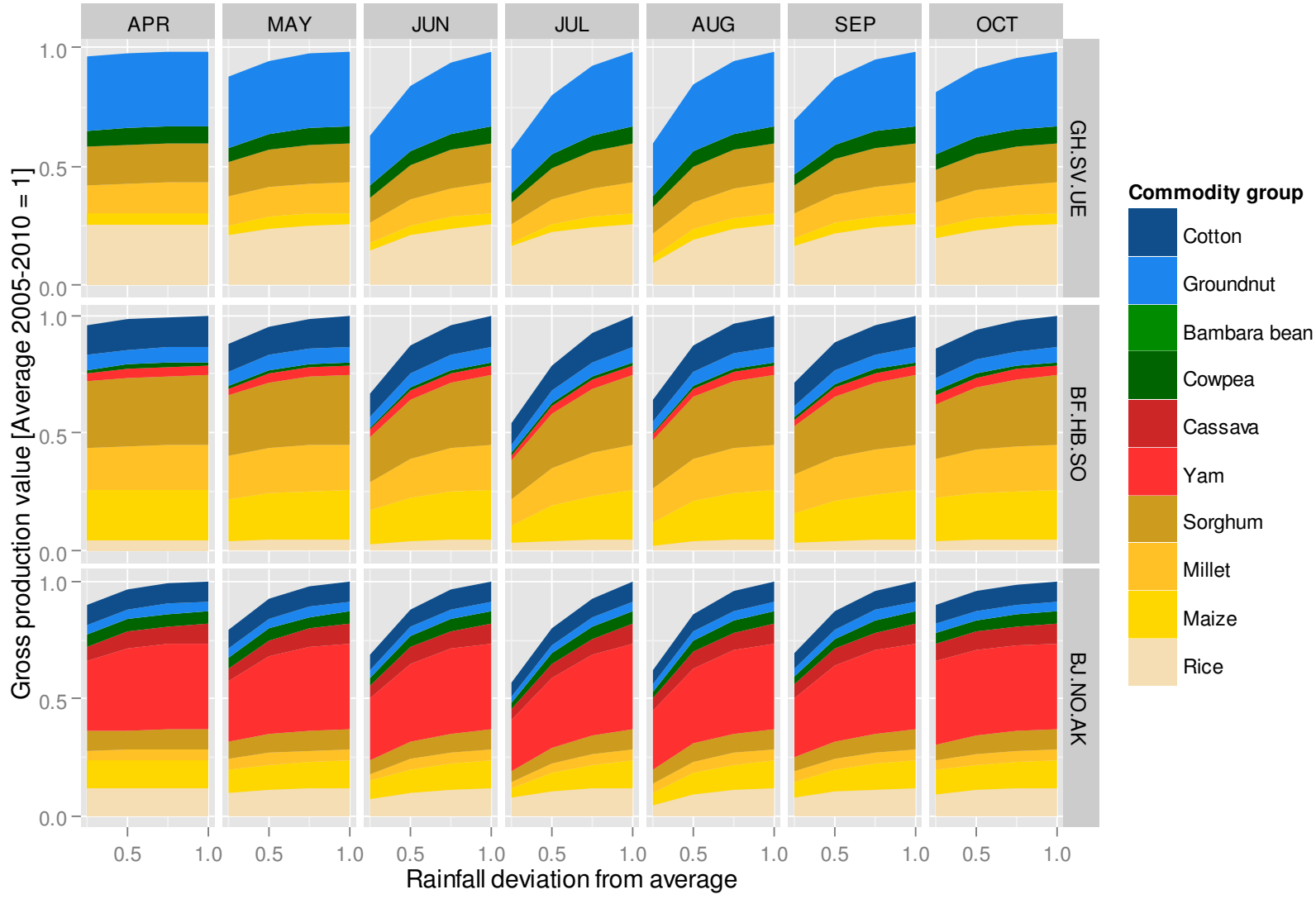
Estimation of „deep parameters“

Methods

- Dependent variables: Yield and Area
- Independent variables:
  - Prices (Output,Input)
  - Population growth
  - Regional fixed effects
  - Monthly rainfall
- Two-stage procedure:
  - OLS on sample data
  - Bayesian estimation based on OLS and agronomic information
- Measurement error for rainfall explicitly modelled:
  - Lower and upper bound from stations/statistics
  - Expected value 0 at arithmetic mean of stations
- Behavioral assumptions:
  - Farmers maximized adaptively expected revenues, considering sustenance needs

Impact of deviations from average rainfall on gross production value (1)

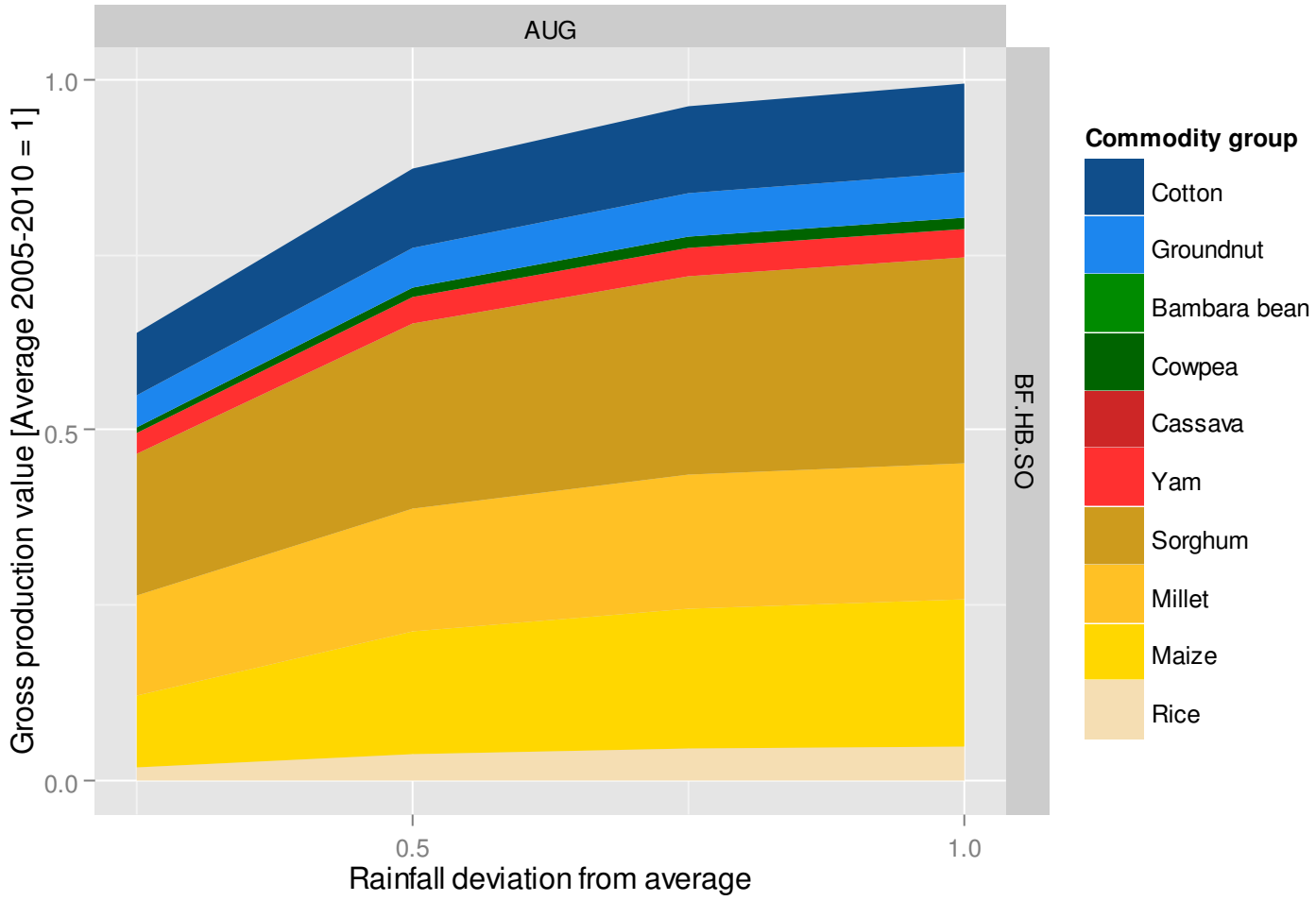
Intermediate results



Impact of deviations from average rainfall on gross production value (2)

Intermediate results

Example: Sud-Ouest, only variation of August rain



Calibration (currently 2005-2009 average)

Methods

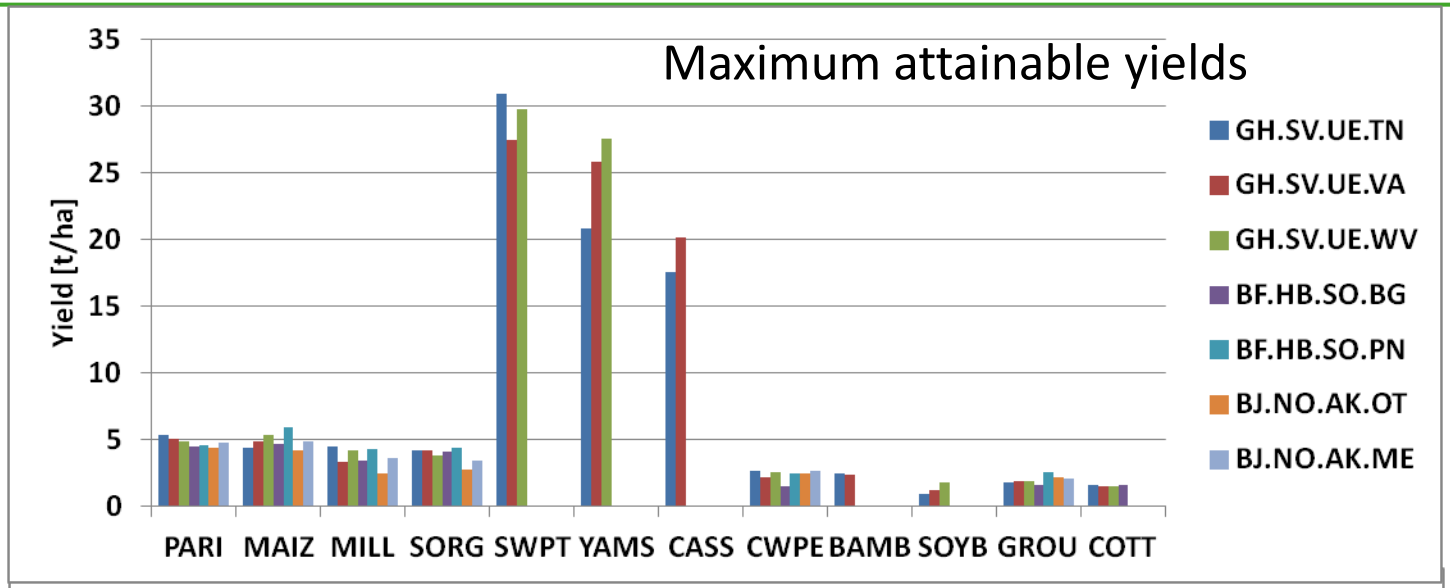
- Based on estimates of elasticities of transformation and substitution ("deep parameters"), it is now possible to calibrate area allocation and yield functions to a baseline
- Historical baseline: Trends for prices, cost, allocated area and yields
- Challenge: Variable input allocation per crop not observed
- Solution:
  - Usage of household survey data on fertilizer allocation and crop budgets (Gleisberg-Gerber 2012, Yilma 2005, Kuhn at al 2011) to derive variable cost shares (**ρ**)
  - Usage of maximum attainable yield data to derive area-cost shares
  - Combination of information by exploiting the identities:

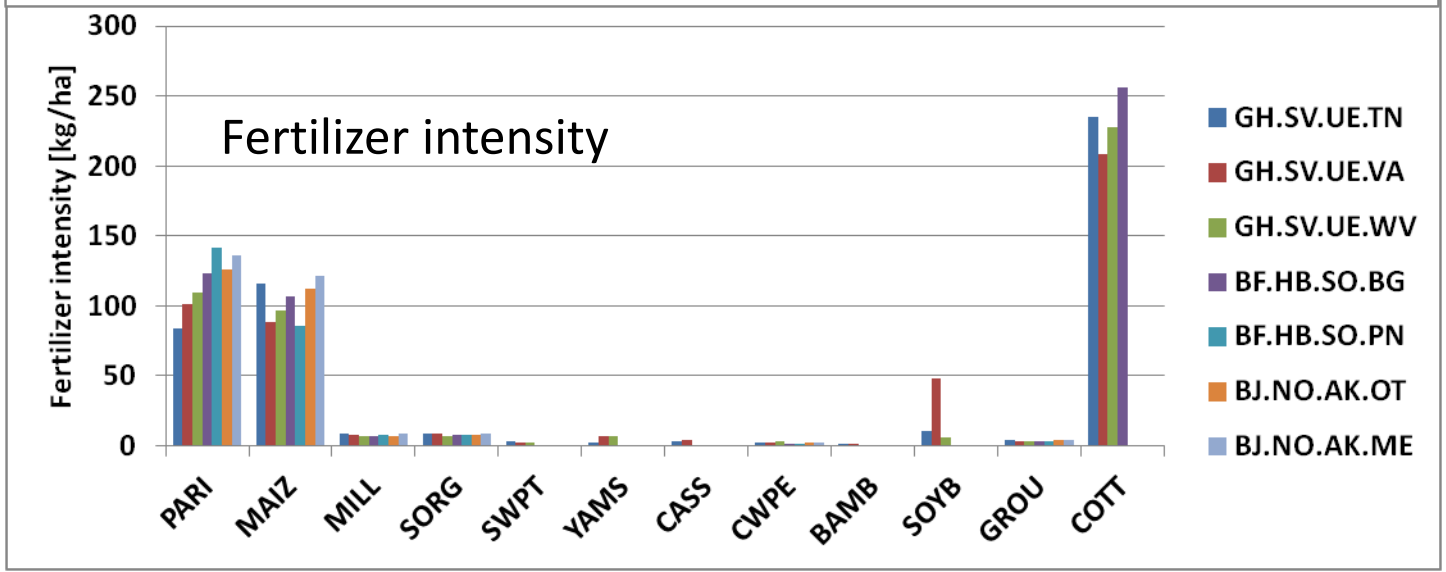
$$\bar{\rho}^{A}_{d,c,t}{}^{\frac{\sigma_{d,c}}{\sigma_{d,c}-1}} \bar{y}_{d,c,t} = \bar{y}^{\max}_{d,c,t}$$

$$\bar{\rho}^{A}_{d,c,t} + \bar{\rho}^{V}_{d,c,t} + \bar{\rho}^{Z}_{d,c,t} = 1$$

Some agric. indicators at calibration point …

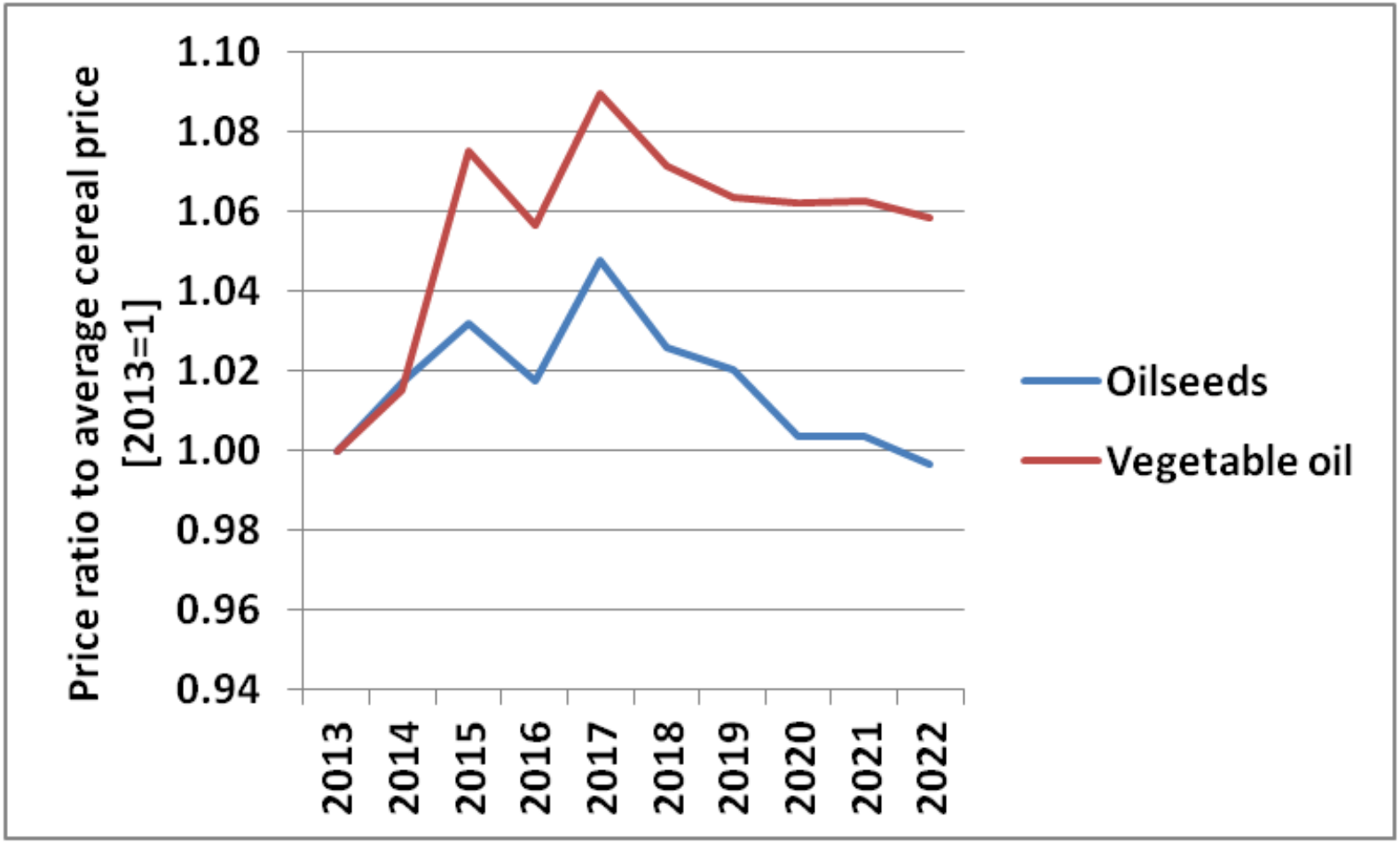
Intermediate results





Projected world market veg. oil and seed prices, relative to cereal prices

Price scenarios

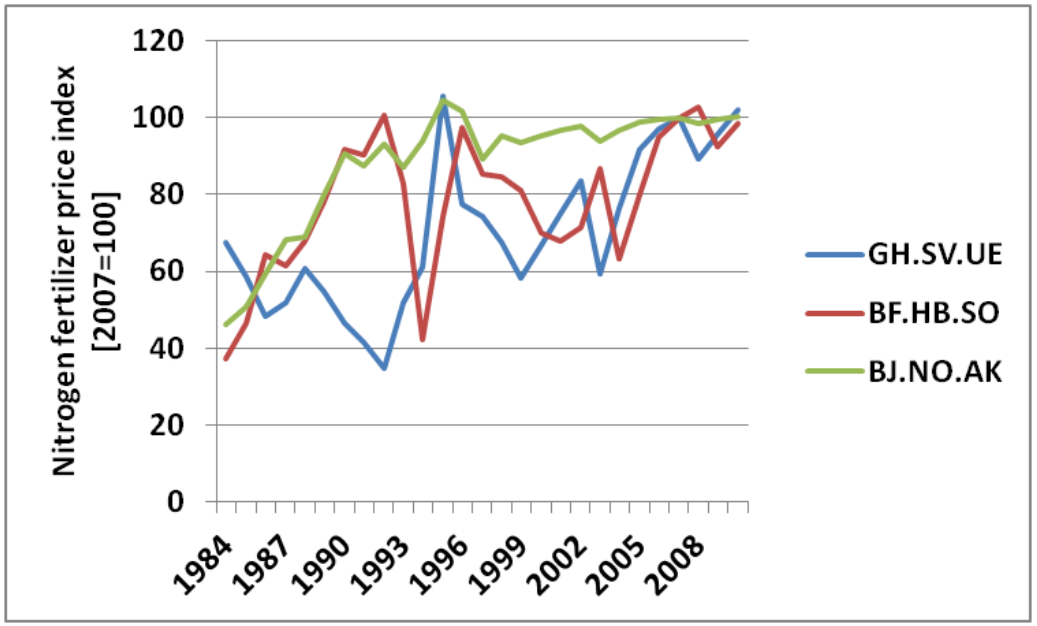


Source: FAO/OECD

Input subsidies

Policy scenarios

- Abolished in late 80s/early 90s in the wake of structural adjustment programs
- Nitrogen fertilizer prices tended to be 40% lower than during late 2000s
- Scenario: IPSB – Decrease input price by 40%



Irrigation

Policy scenarios

- Large-scale irrigation projects ongoing, not necessearily in case study regions.
- Current share of irrigate area <5%, assume double
- Scenario: IRRD – Increase expected yield for rice, maize, and cotton by 10%

Main findings 1: Consumption

Simulation results

- Price increase for veg. oil (by design)
- Increased exports of oilseeds, increased imports of oilseeds
  - Domestic oil processing?
  - On-farm oil-processing? (so far constant share of production)
- Net welfare loss for urban households, impact on rural households generally positive

Main findings 2: Land use

Simulation results

- Conversion of forest/natural vegetation to permanent crops (palm oil):
  - Depends on cost of conversion …
  - If land is fully mobile, 6% price increase for vegetable oil translate only in <1% of increase of palm oil in West African Countries (GH, NG, BJ)
  - Main reason: Annual oil crops dominate
- Conversion of natural vegetation to annual crops (groundnut, soybean, cotton):
  - Until 2020: Dominant driver remains increase of rural population …

Policy scenarios

Outlook

- More recent calibration point?
- Investment in domestic processing?
- Projections to mid-century
  - Infrastructure development and R&D
  - Price scenarios

Focus on innovative policies

Outlook

- **New insurance schemes**
  - **Index insurances**
  - **…**
- **Carbon markets and green economy**
  - **Case studies to establish a clearer picture on service flows from trees and forests**
  - **Evaluate effectiveness of forest conservation instruments such as energy efficient cooking stoves, wood lots, living fences, land tenure reform, etc.**
- **Irrigation**
  - **Shallow wells**
  - **Small dams**
  - **With hydrology team**

Thank you.

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