Analyzing the Long Run Supply and Demand for Land

by
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Motivation

- **Non-CO2 GHG emissions account for 30 % of the greenhouse effect**
- **Agricultural activities generate 58% of non-CO2 emissions (84% of N2O, 47% CH4), while forestry offers considerable scope for carbon sequestration**
- **Projections of changes in land use in the future is key part of any baseline emissions scenario**
- **Building on previous research, this work develops framework for modeling changes in land use in the long run**
- **Approach is very simple compared to most EMF models; *economic behavior in the forefront***

In this presentation

- **Adding dynamics via GTAP-Dyn**
- **Determinants of the LR *demand* for land:**
  - **Overall economic growth and trade balance**
  - **Structure of consumer demand in the long run**
  - **TFP growth in agriculture and forestry**
  - **Timber input-augmenting productivity growth**
  - **Input substitution in response to rel. prices**
- **Determinants of the LR *supply* of land:**
  - **Supply of AEZ land to different activities**
  - **Accessing unmanaged forest land**
- **Long run results: Focus heavily on Asia**

Recursive dynamic extension of the standard GTAP model

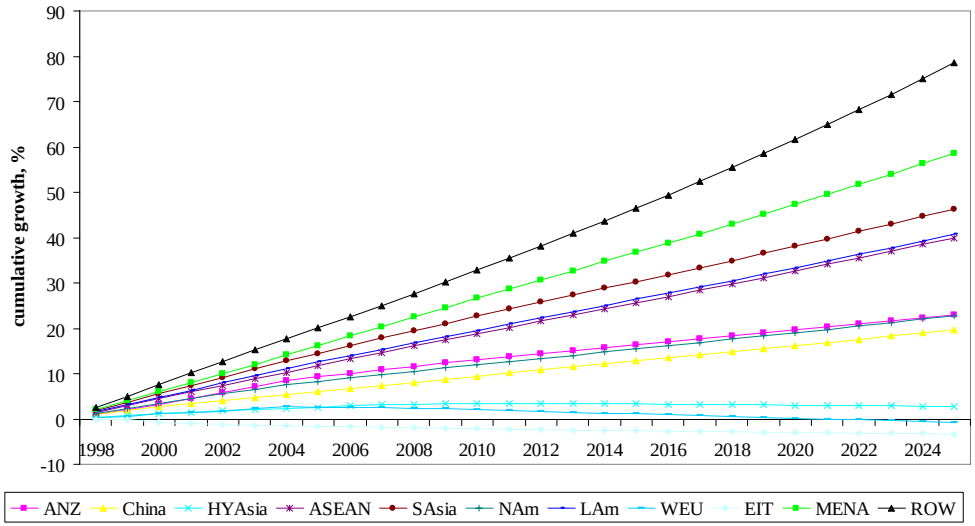
- **History:**
  - **Developed by Ianchovichina and McDougall (2001)**
  - **Recently extended and estimated by Golub (2006)**
- **Special attention to international capital mobility:**
  - **Disequilibrium theory of investment; perfect capital mobility only in the long run**
  - **International capital flows and foreign income pmts are important due to:**
    - **Role in determining balance of trade**
    - **Leakage of emissions due to capital movement**
    - **Impact on national rates of return to capital and land; and hence incentive to "invest" in new land**

Projections: assumptions

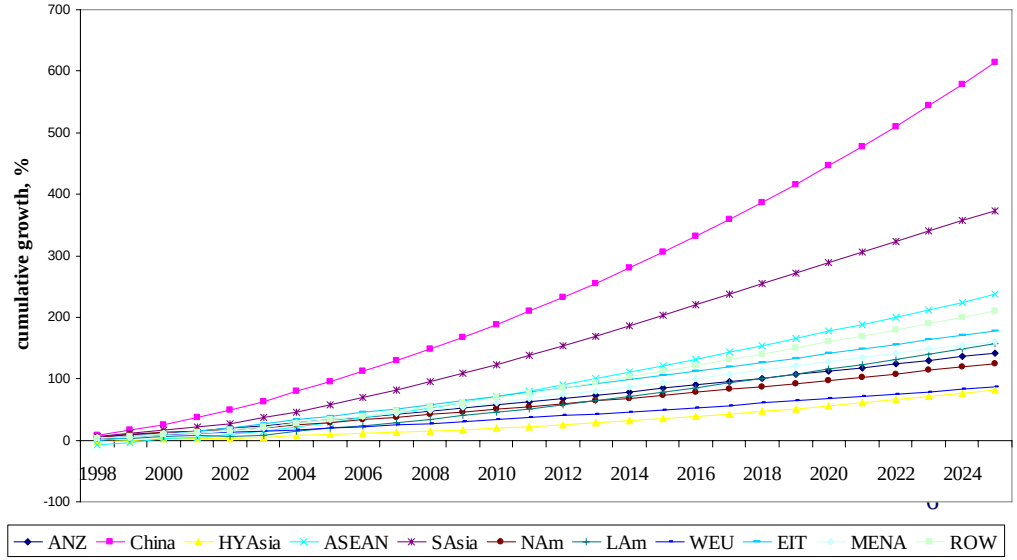
- **Investment and GDP growth endogenously driven by labor, TFP growth**
- **Labor force growth from GTAP baseline (World Bank, Ahuja and Filmer (1995), CPB (1999))**
- **Labor productivity growth in non-land sectors differentiated by sector (Kets and Lejour, 2003); natnl av growth is fastest in China, South Asia, slowest in SSA**
- **Agr TFP growth rates differentiated by ruminants, non-ruminants and crops, forecasts taken from Ludena (2005);**
- **Forestry TFP is weighted av. of other land using sectors; Also introduce lumber augmenting tech. change in forest products using sectors**

Projections: population and GDP

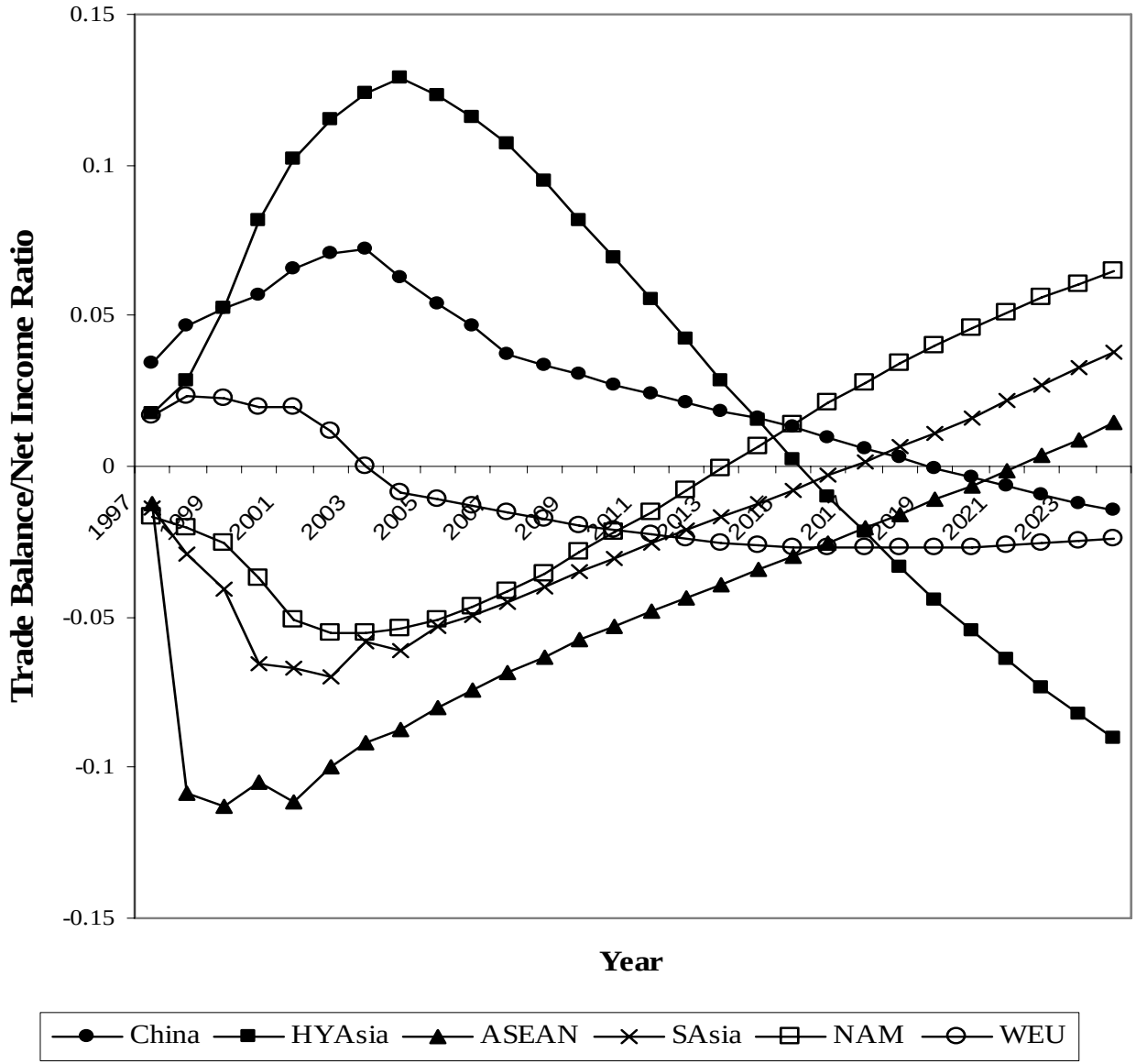
Population growth (Walmsley, 2000)



GDP growth (simulation)



Evolution of the Aggregate Trade Balance: 1997-2025



Trade plays a role in determining the derived demand for land

Cumulative Change in Trade Balance, by Sector: 1997-2025 ($US bill)

Sector	China	HYASIA	NAM	ANZ	WEU
Agr	-310	-65	276	111	-15
PrFood	-162	-145	189	24	-16
Forestry	-15	3	34	15	8
Other	350	-1111	697	-63	-432
Total	-137	-1317	1197	86	-454

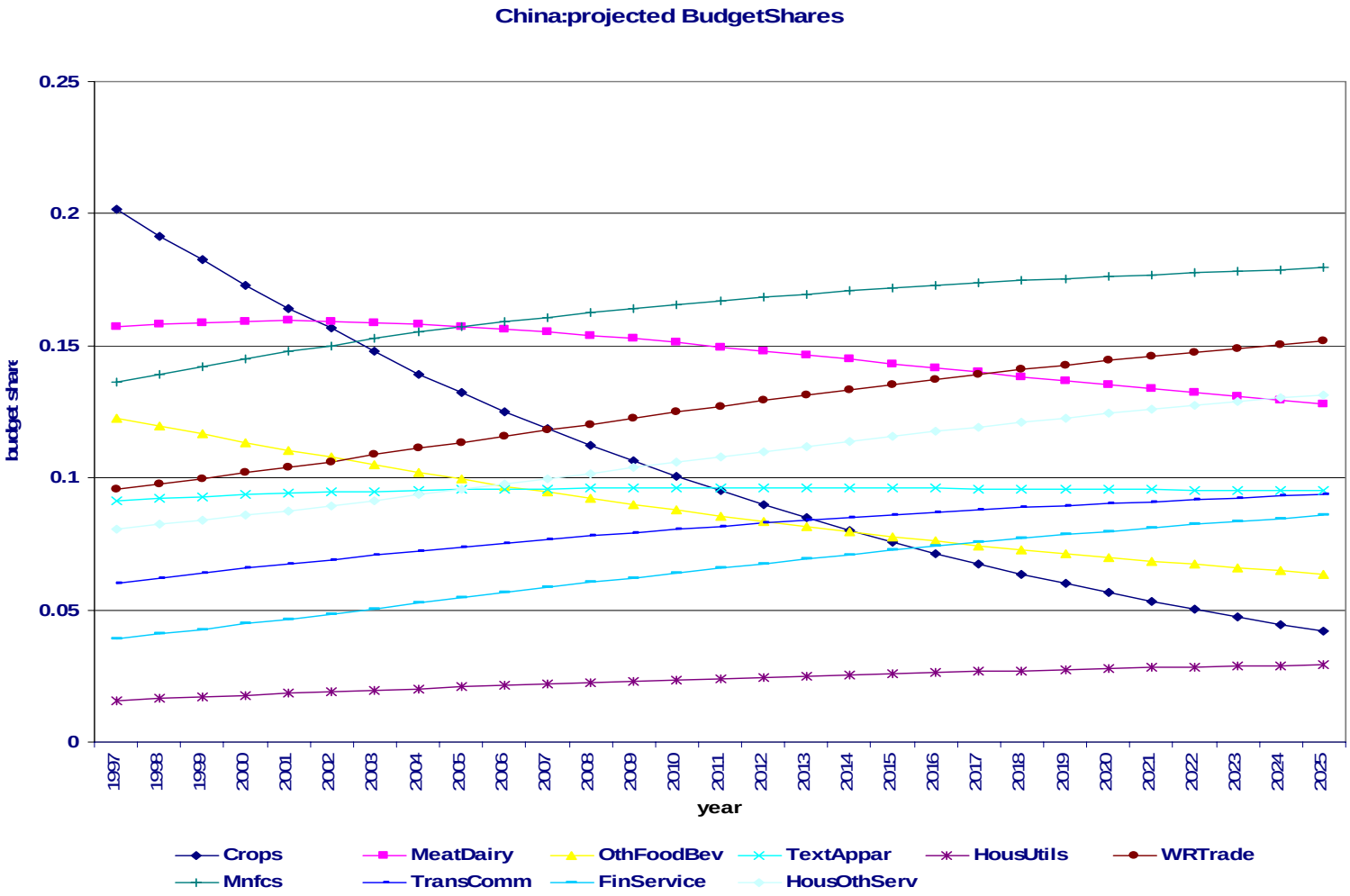
Reduced savings and increased foreign income receipts mean that High income Asia shows deteriorating trade balance

USA and hence NAM mirrors this effect forcing trade surplus to emerge

Translating Economic Growth into Commodity Demand

- **Basic idea: Use observed international variation in consumption patterns to predict the future evolution of demand in the fast-growing lower income countries (e.g., China and India)**
- **Use AIDADS demand system:**
  - **Key properties:**
    - **Globally well-behaved, additive, non-linear in marginal budget shares**
    - **Outperforms other rank 3 demand systems in out-of-sample forecasts**
  - **Estimated using country observations from GTAP data base**
  - **Calibrated to country-specific preferences**
  - **Can also be used to predict differing expenditure patterns across the income spectrum *within countries***

Average Budget Shares for China: 1997-2025



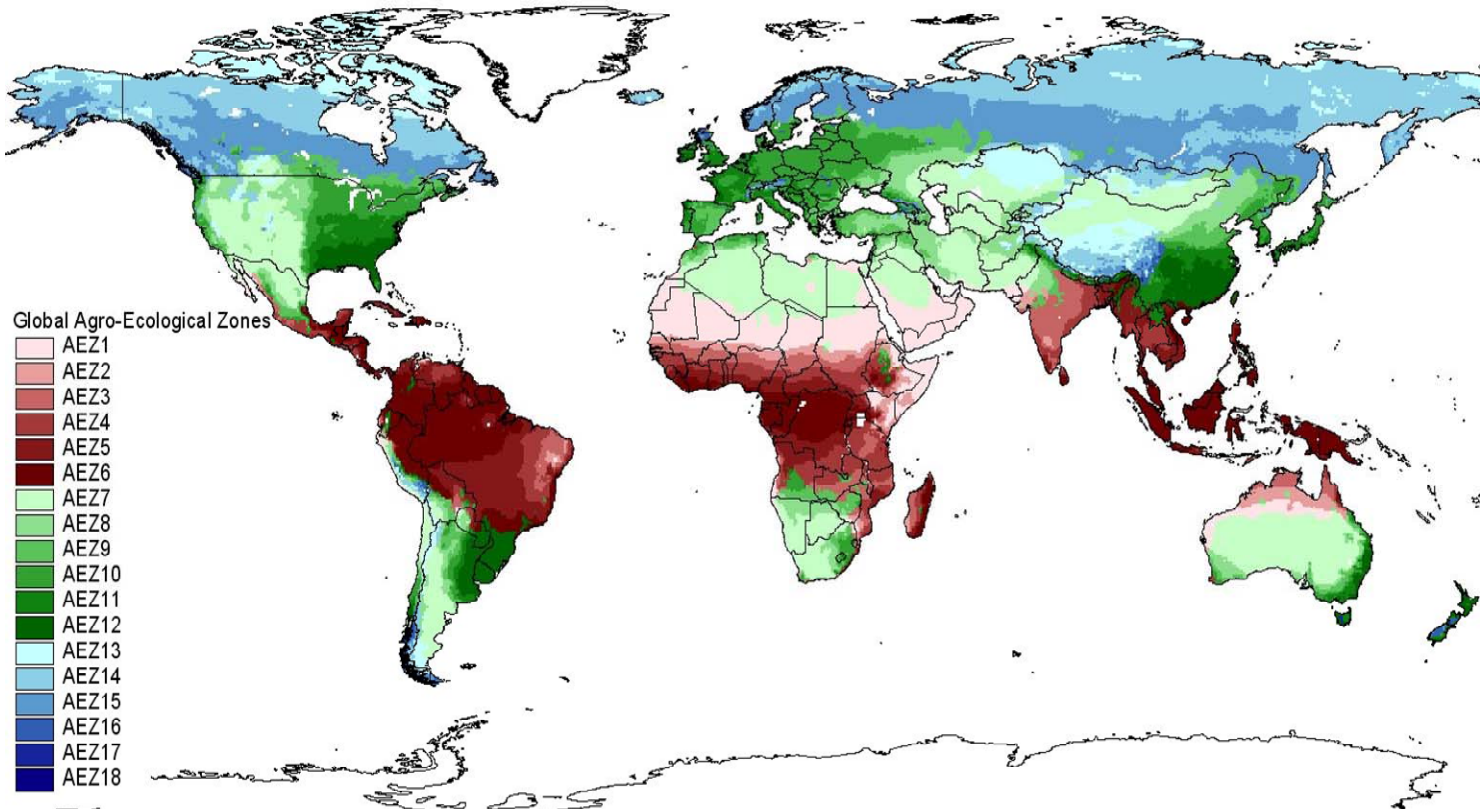
Note: **based on calibrated version of estimated demand system in Reimer and Hertel, *assuming constant prices.***

Supply-side: Where will the increase output come from?

- **S1: Increase in cultivated acreage?**
  - **Competition for global land use from commercial forests, forest conservation, booming bio-fuels**
  - **Water is a limiting factor as well: Agr uses 70% of the fresh water, with rapid urbanization, cities will outbid agriculture**
  - **We incorporate available land through access cost functions**
- **S2: Intensification of production?**
  - **Fertilizer application rates in East Asia have increased tenfold over four decades, now 200 kg/ha**
- **S3: More rapid TFP growth?**
  - **This is key to our projections;**

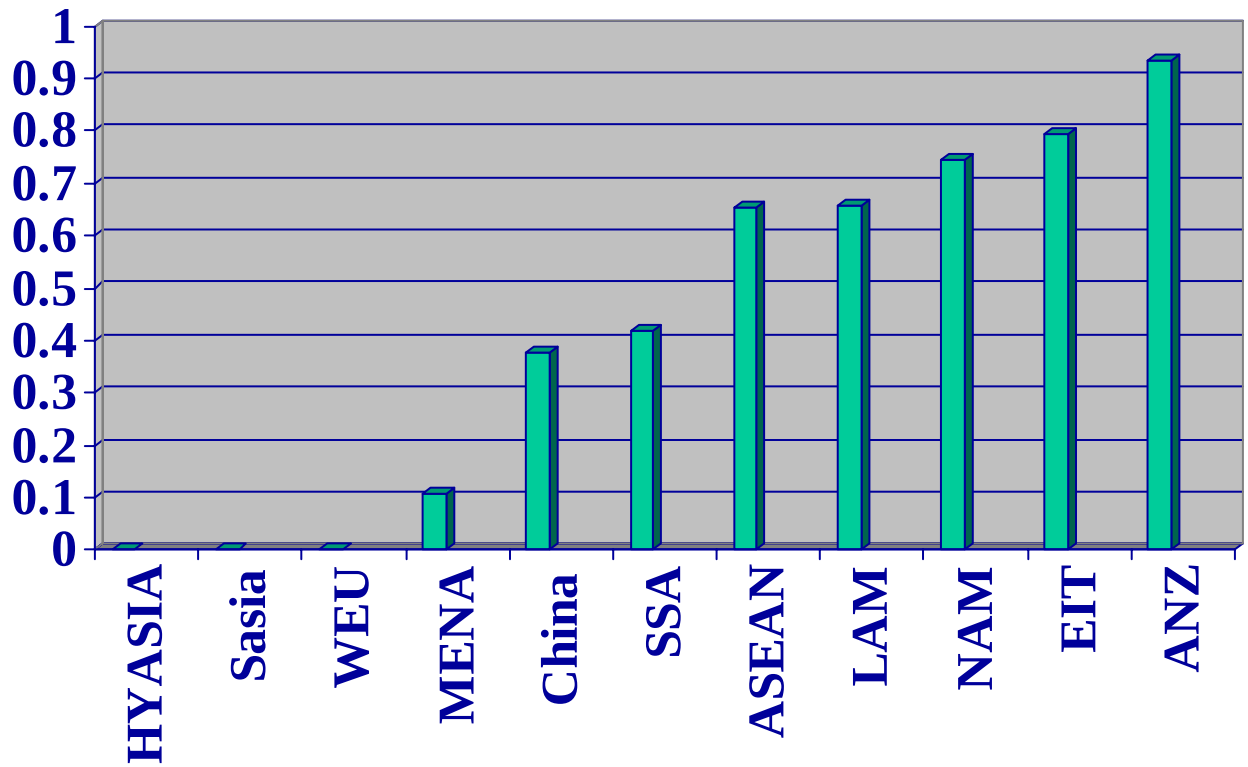
(S1) Land Supply: Availability Restricted by AEZs: but commercial land can be augmented by accessing

Figure 3. Global Distribution of AEZs



S1: The role of unmanaged forest land

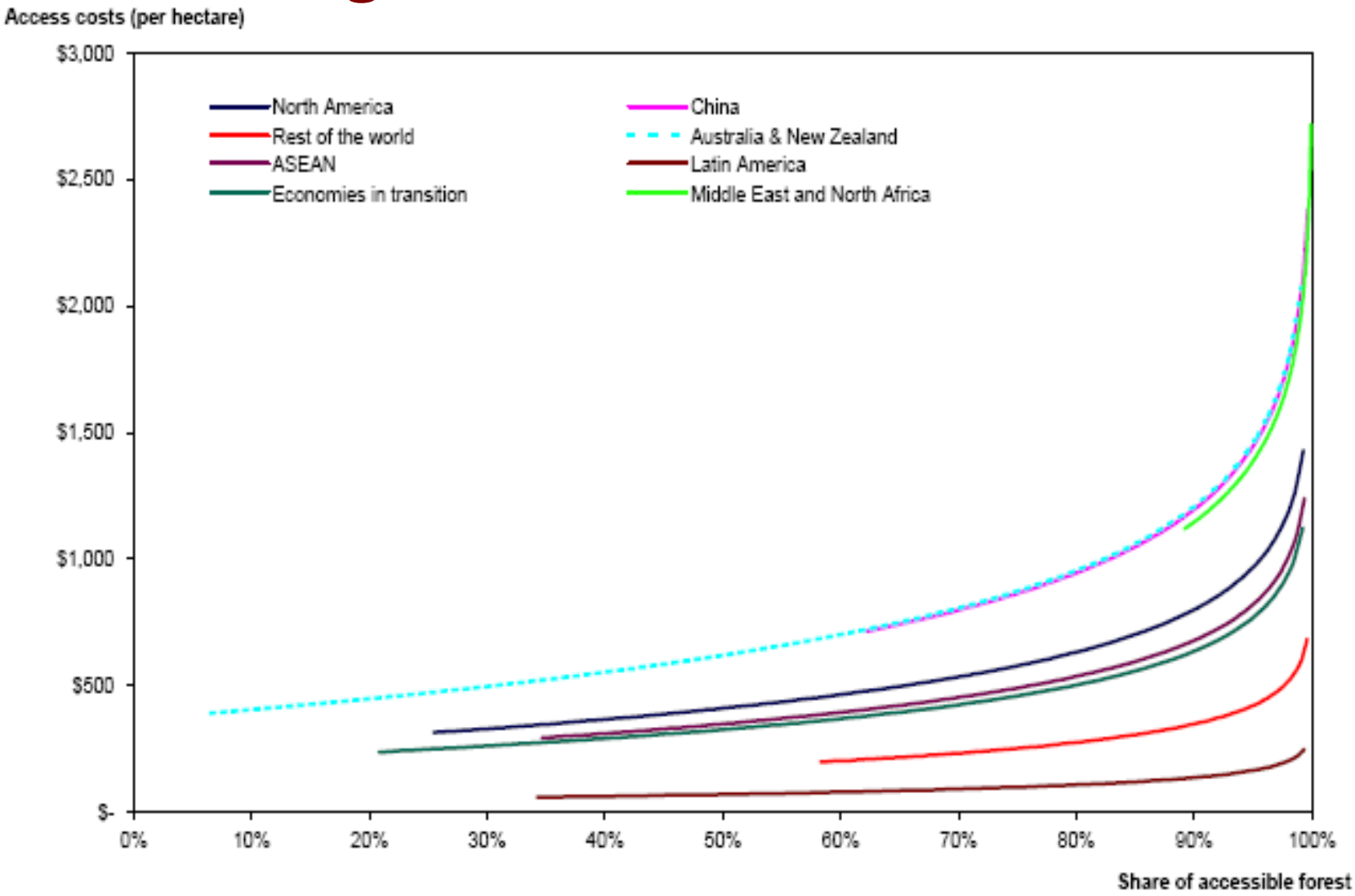
Share of inaccessible land in total forest land endowment



Adding unmanaged land: methodology

- **Converting unmanaged land to land used in production:**
  - **is costly and should consume resources**
  - **is fundamentally an investment decision**
  - **should become more costly as increase access**
  - **equilibrium when the value of land is equal to MC access**
- **In recursively dynamic GTAP-Dyn model, investors value land based on current land rents (assumed to hold into future) and rate of return to capital (Gouel and Hertel, 2006)**
- **Newly accessed land is added to total land in production, proportionally augmenting each AEZ**

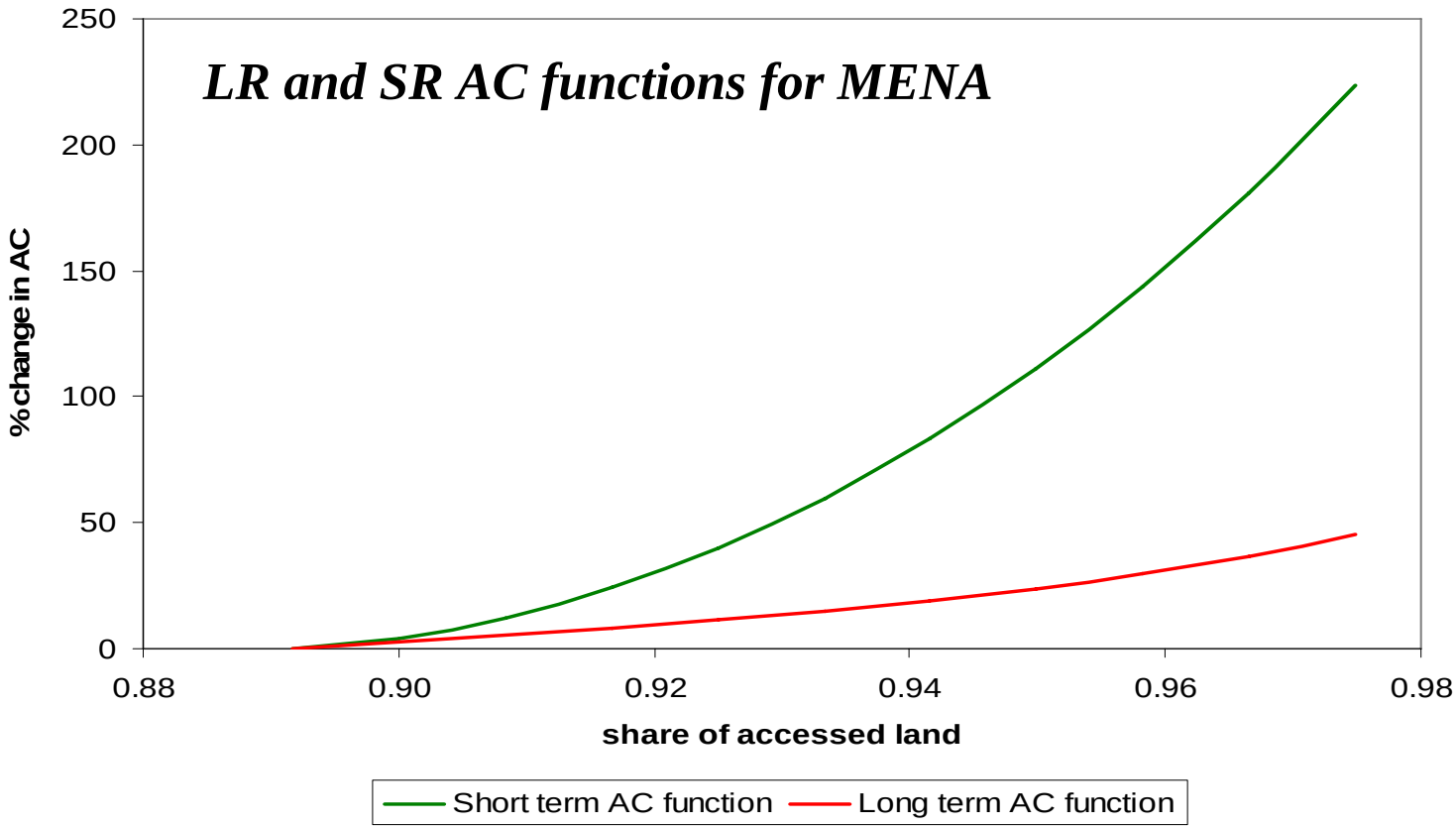
Long Run Access Cost Functions



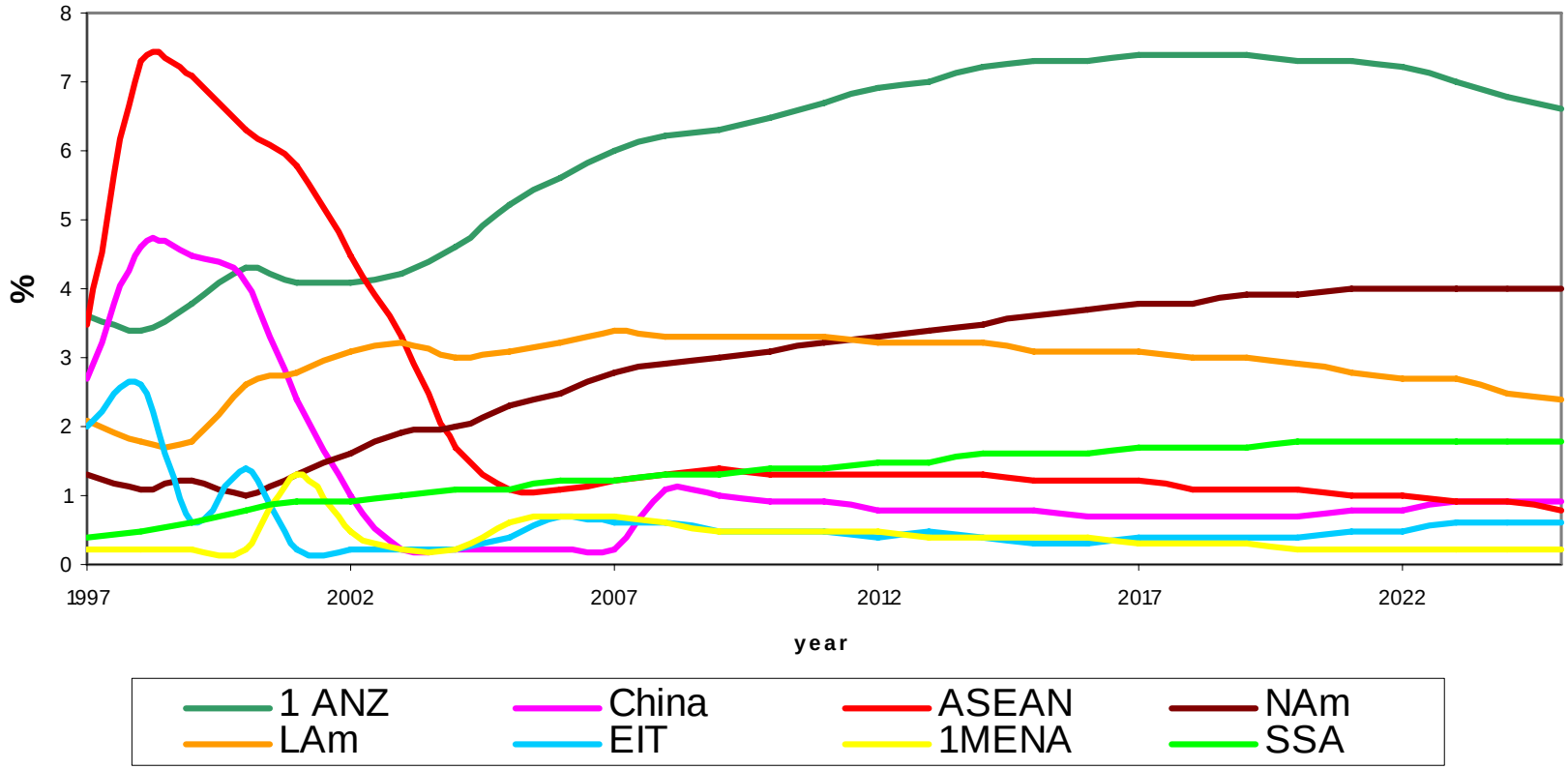
Source: Gouel and Hertel (2006)

Calibration of SR access cost function to rate of deforestation in Global Timber Model (Sohngen)

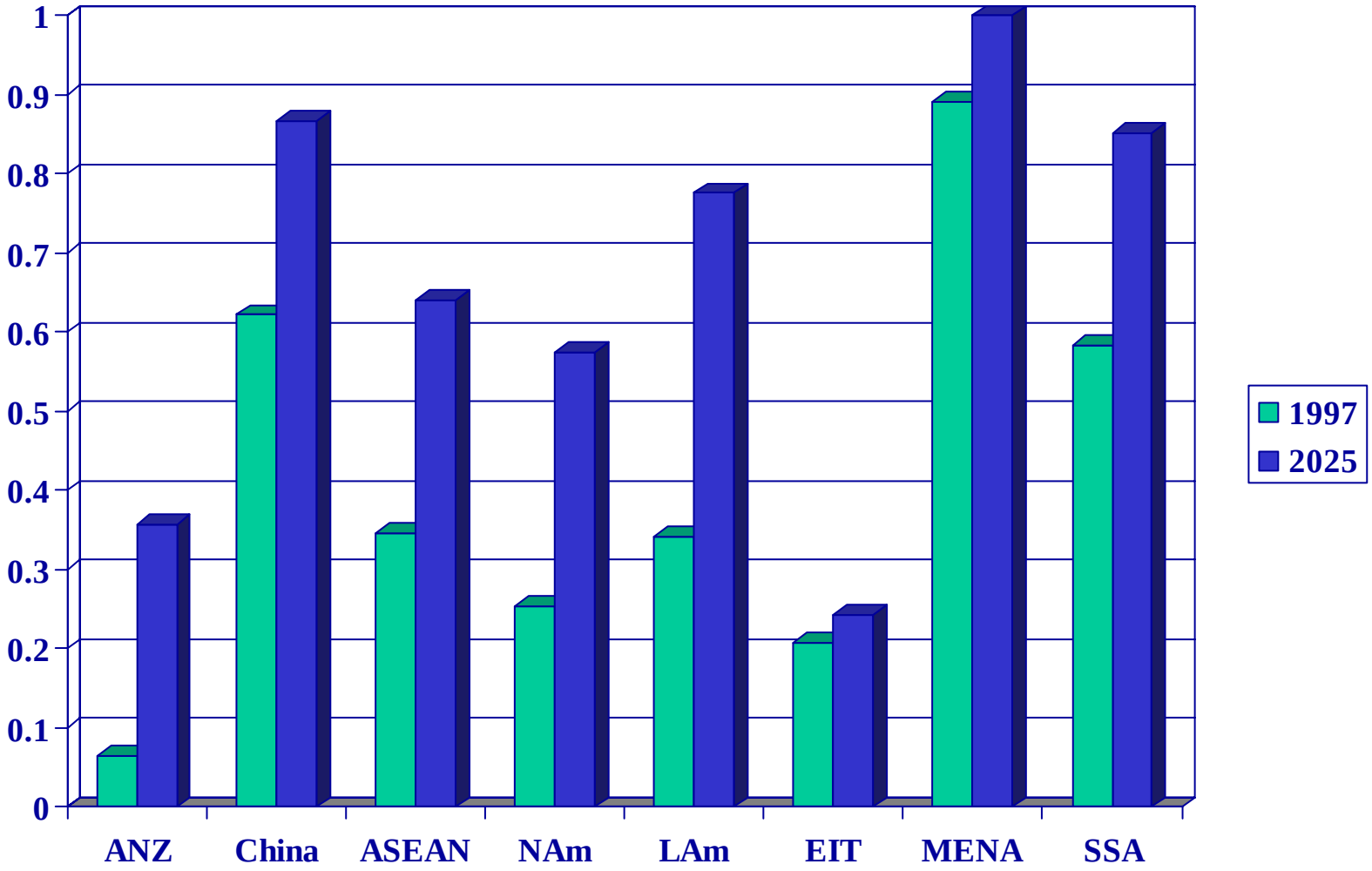
Region	Newly accessed hectares per year as share of	
	inaccessible forests	accessible forests
China	0.043	0.023
NAM	0.004	0.013
MENA	0.018	0.002



Access rate (%), defined as hectares accessed per year divided by total accessed hectares

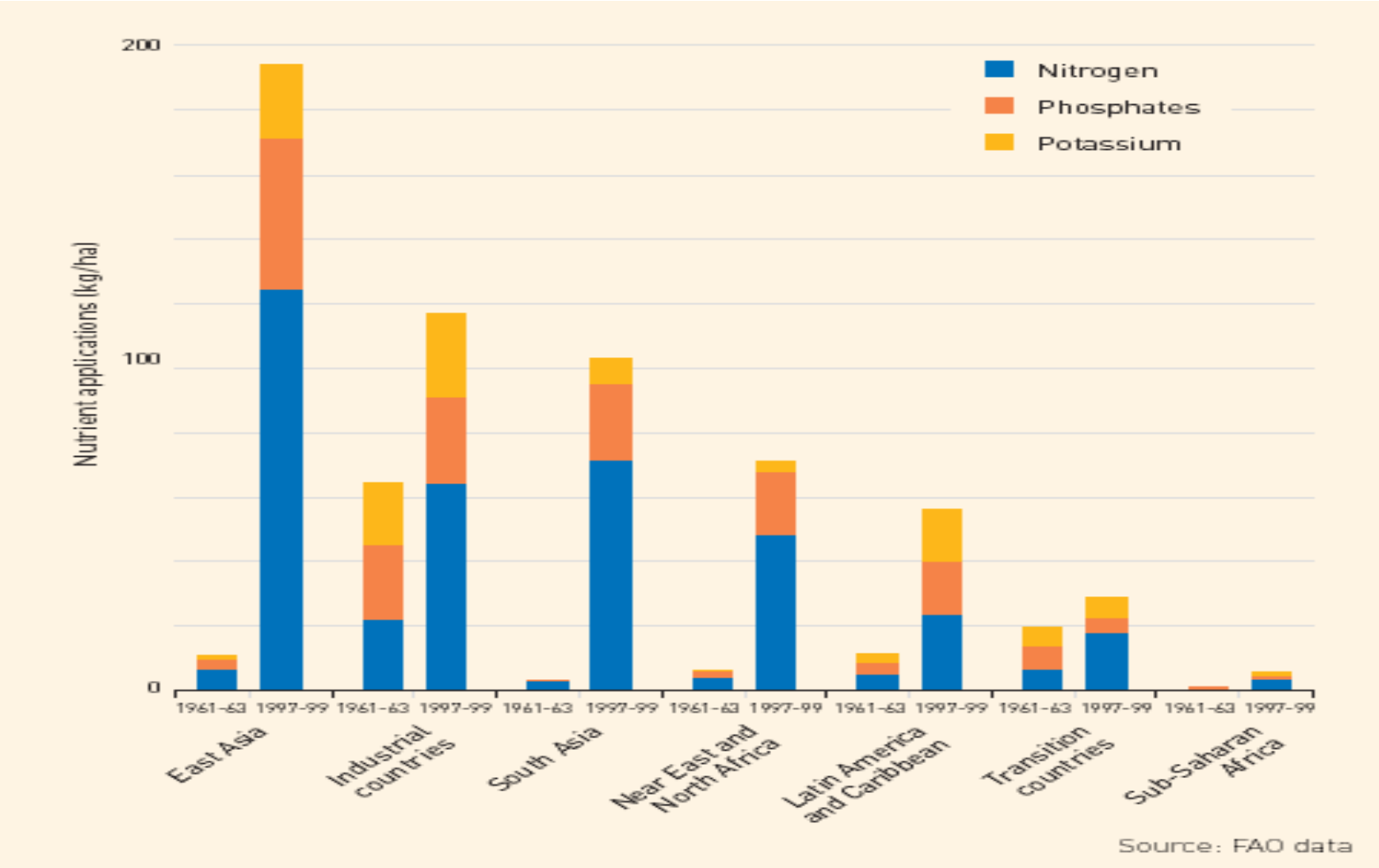


Accessed forestry land as share of total available forestry land



Most significant ha. access in the Americas, followed by SSA; access rate also large in ANZ

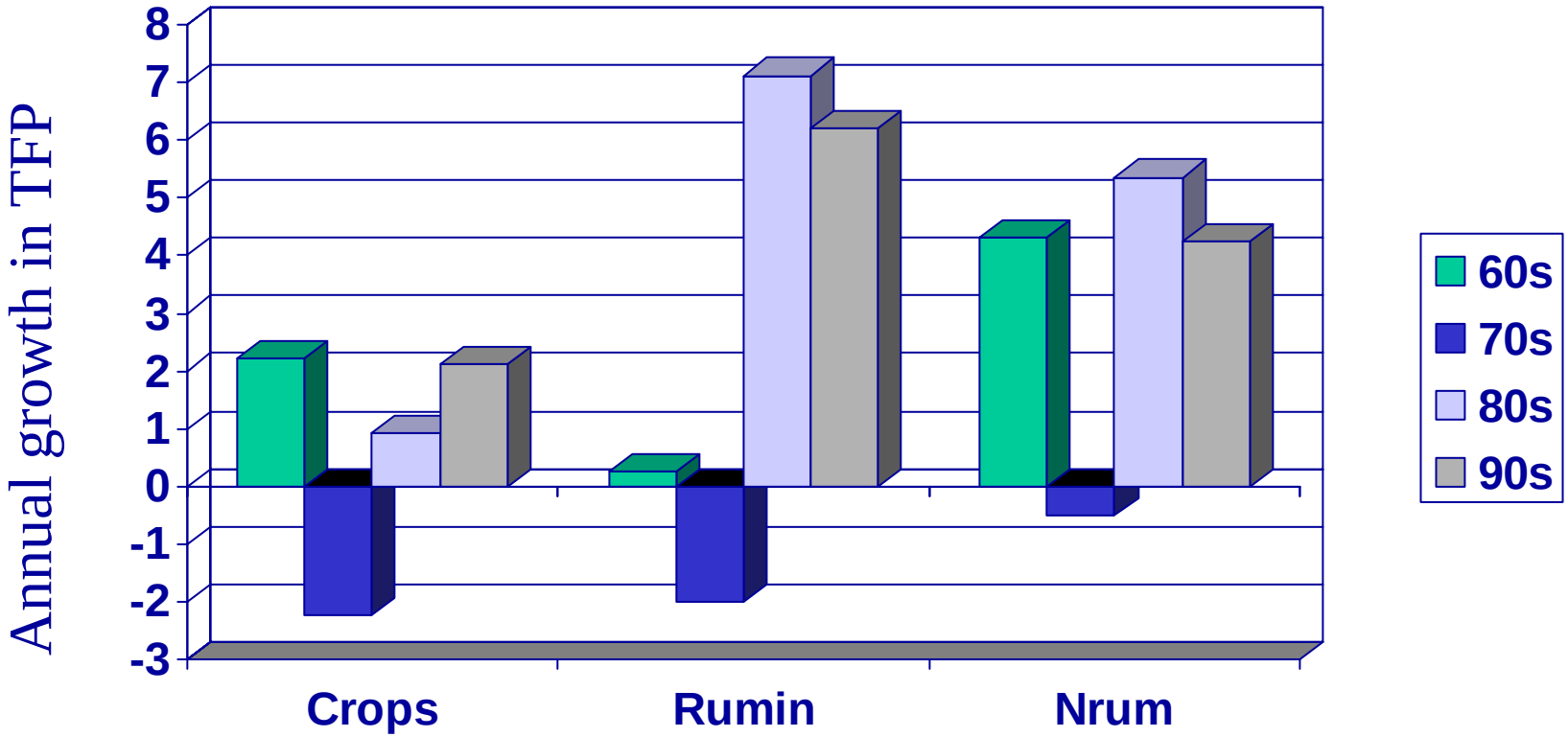
S2: Increased Intensification?
Fertilizer use is already very high in Asia



S3: TFP growth has bridged the gap in the last 20 years, can this continue?

- **Increases in total factor productivity:**
  - **Catching up to the existing frontier: has been important for Asia; bound to slow with time**
  - **Outward movement in the frontier: remarkably steady over the past 40 years**
- **Forecast next 40 years using past 40:**
  - **TFP estimates: FAO data, directional distance fnc.**
  - **Experience in Asia region is quite varied**
  - **Draw on paper by Ludena, et al.**

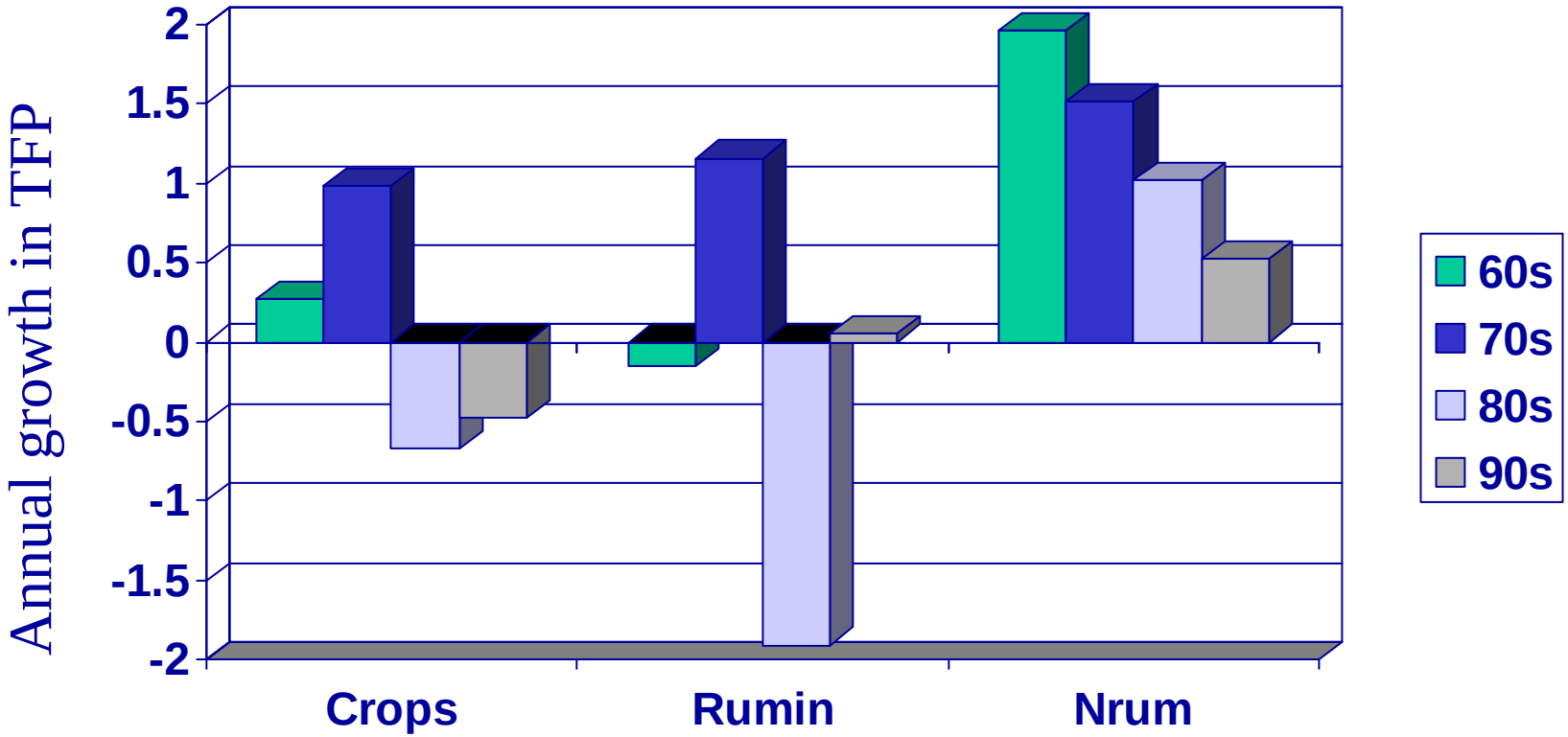
Historical analysis of China's TFP growth: 1961-2000



Impact of rural economic reforms in 80's very evident

Source: Ludena et al., 2006

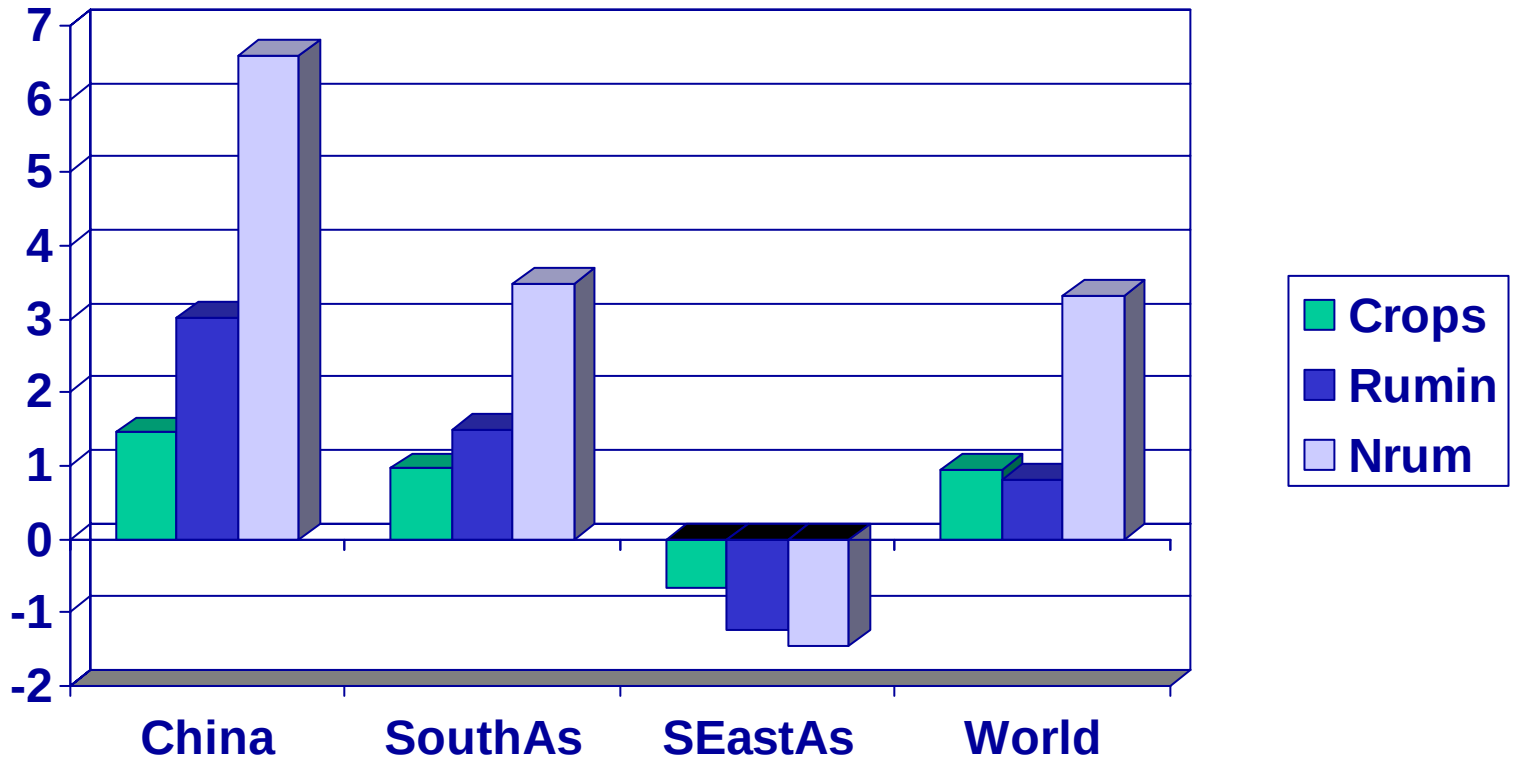
Historical analysis of SE Asia TFP growth: 1961-2000



Crop and Ruminants TFP has stagnated since 1970's

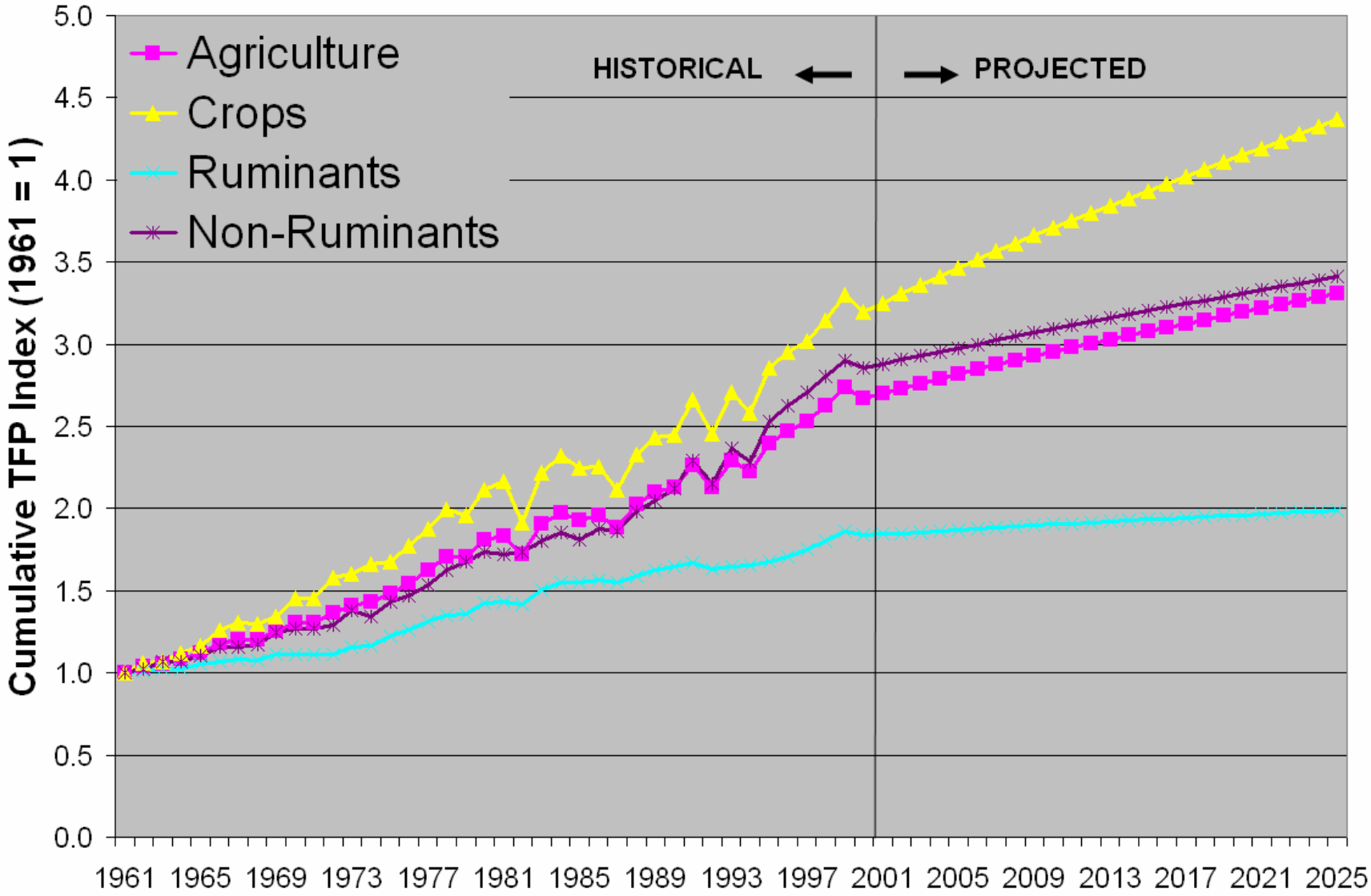
Source: Ludena et al., 2006

Forecast TFP growth in Asia: 2001-2040

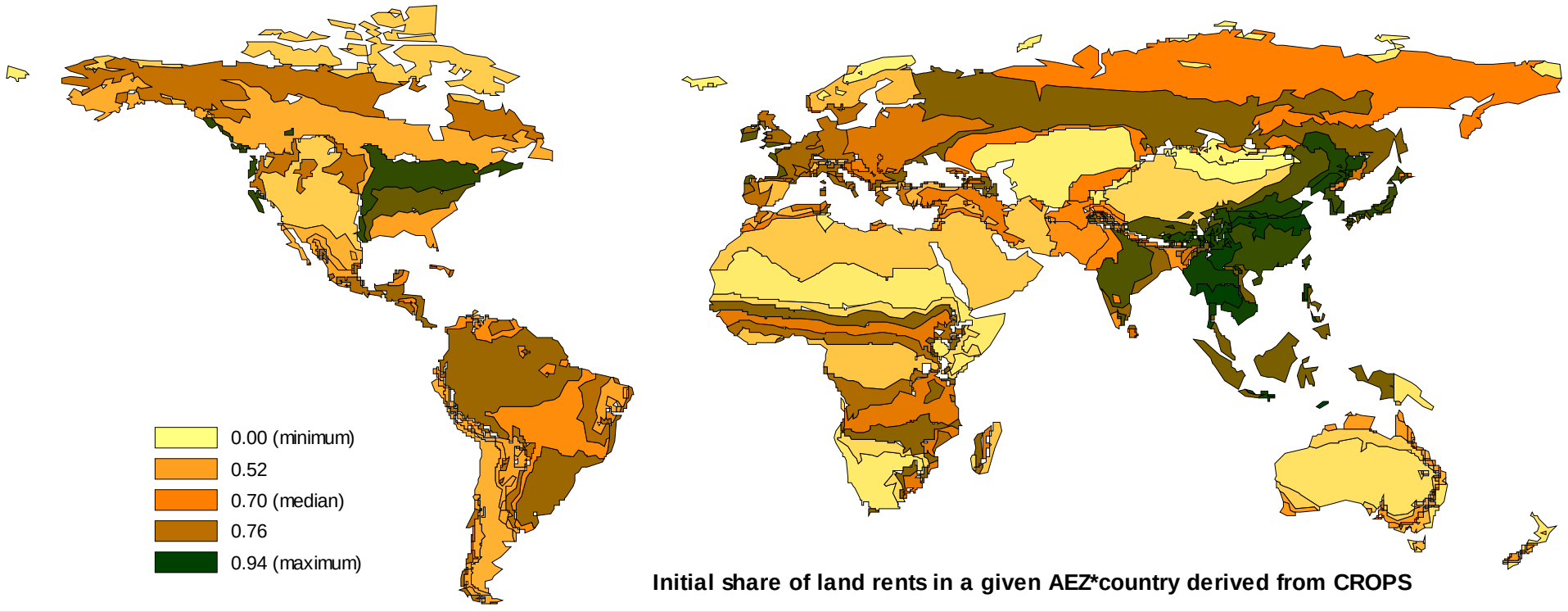


Source: Ludena et al., 2006

In industrialized countries, crop productivity growth is higher



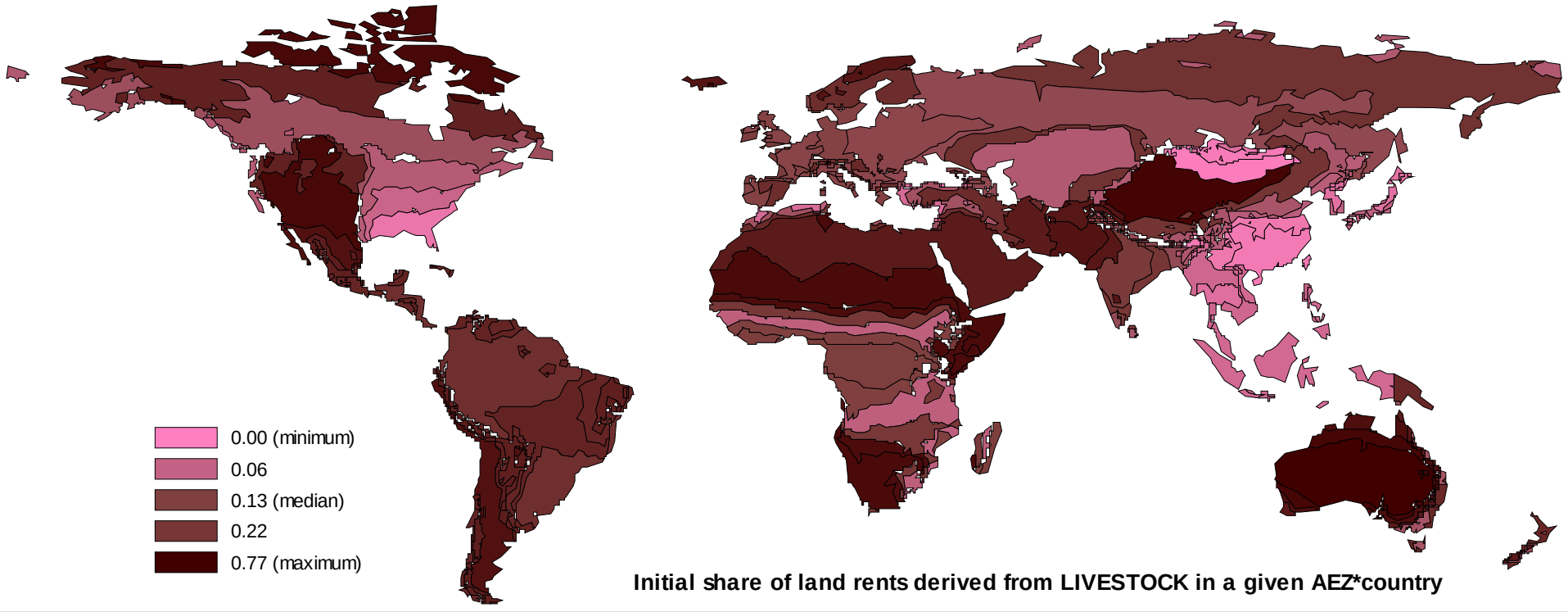
Initial share of land rents derived from crops in a given AEZ*region



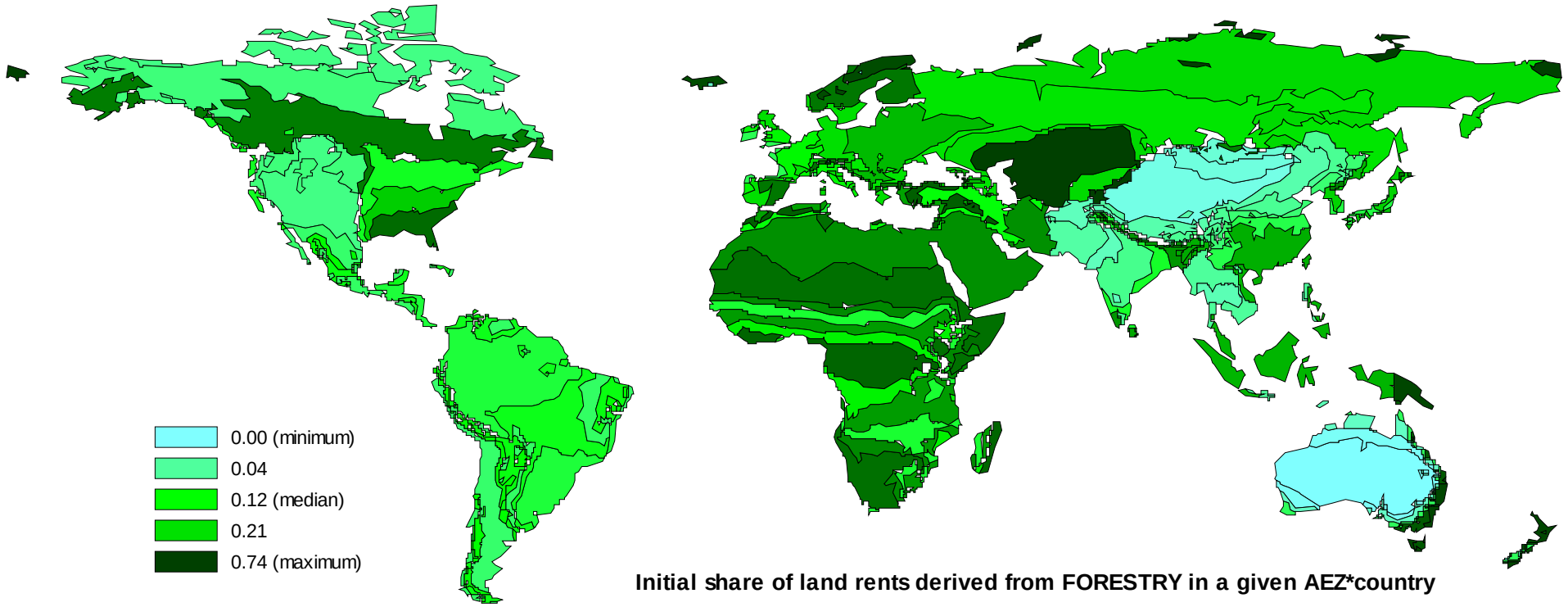
Initial share of land rents in a given AEZ*country derived from CROPS

Note: just 6 AEZs and 11 regions in this aggregation; so resolution is crude

Initial share of land rents derived from livestock in a given AEZ*country



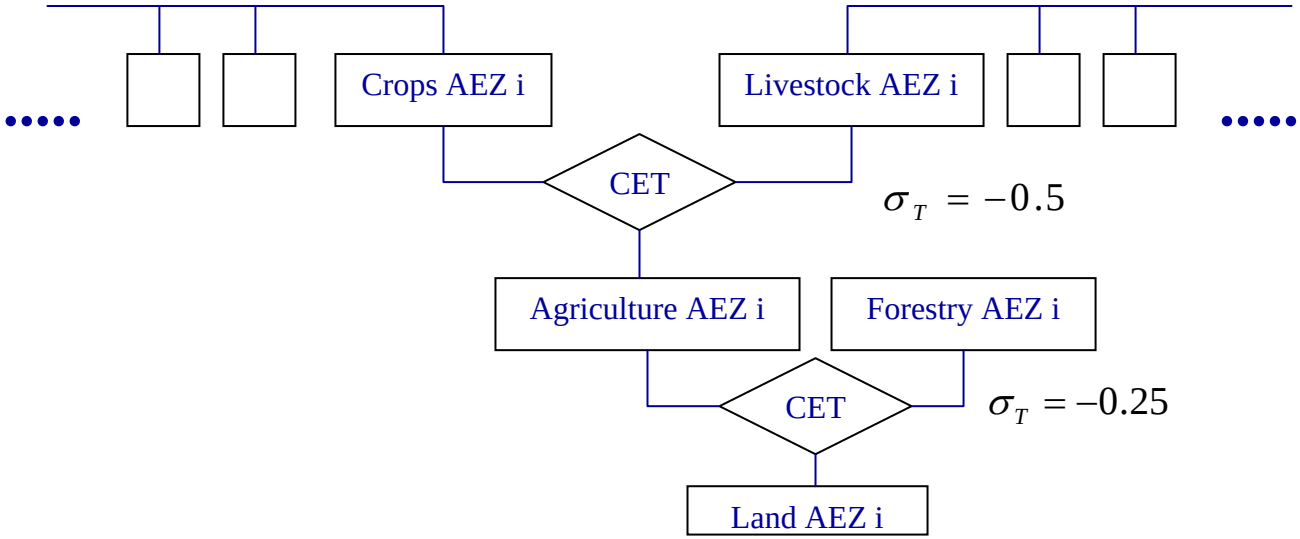
Initial share of land rents derived from forestry in a given AEZ*country



Initial share of land rents derived from FORESTRY in a given AEZ*country

Land Supply: Responsiveness of a given AEZ land to rental rate in alt. activities

- **Aggregate endowment of accessed allocated based on relative rates of return; Initial shares also key**
- **Hierarchy of allocations across sectors:**
  - **Forestry/agr land based on estimates of Sohngen (0.25 elst of transformation)**
  - **Crops/Lstk (0.50)**



We iterate with Global Timber Supply Model to determine forestry price path

- **Given GTAP-Dyn baseline timber consumption path, the Global Timber Model of Sohngen (2006) projects price of forestry sector output**
- **In GTAP-Dyn, we target this global price by endogenizing global forestry input-augmenting technical change in forestry processing:**
  - **Unobserved, but evidence is that this is very important**
  - **In US, much of additional demand has been satisfied with little increase in timber harvest**
- **Plays a key role in determining the long run demand for forest land, and hence land rents**

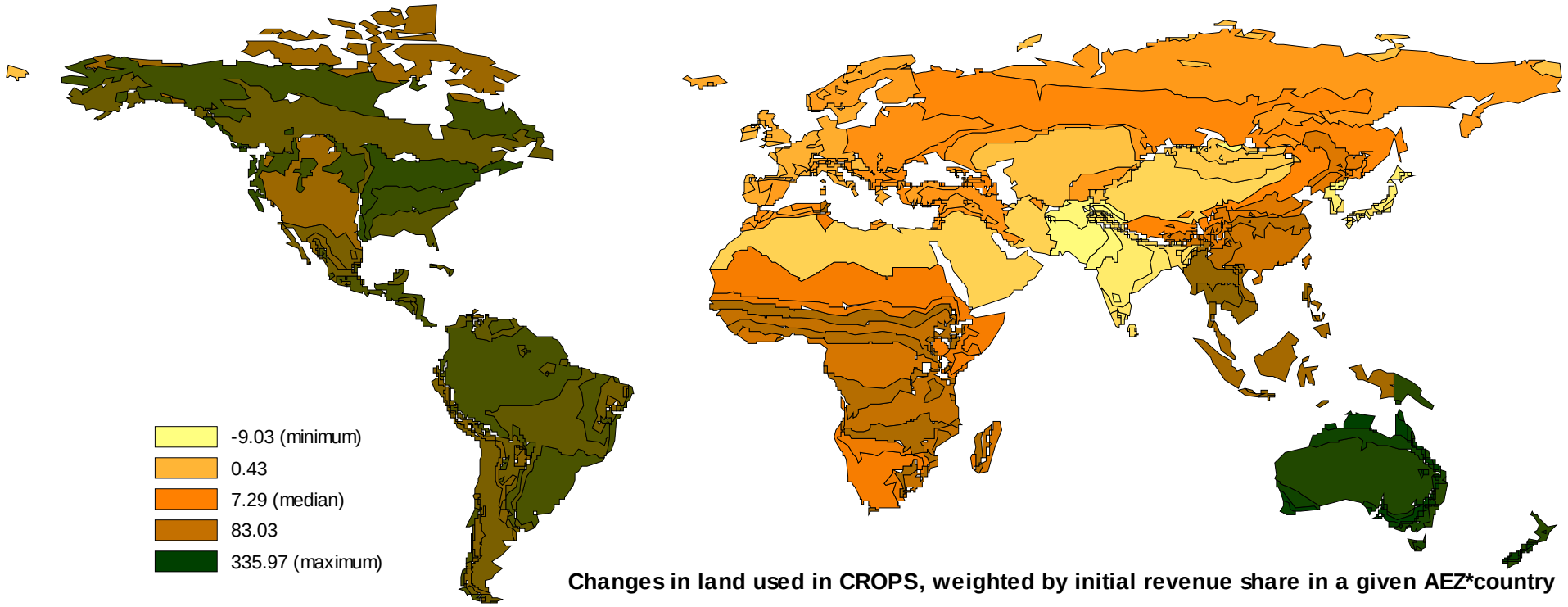
Forestry and all land rents projections under different assumptions about productivity in forestry processing sector and access

Diff = tech chng **Diff = access**

Region	Growth rate 1997-2025, %	*No tech. change, no access*	*Tech. change, no access*	*With tech. change and access*		
NAM	cumulative	4002	162	34		
	annual average	14.18	3.5			
ASEAN	cumulative	2675	219	72		
	annual average	12.60	4			
HYAsia	cumulative	1827	95	5	No chng built-up	
	annual average	11	2.4			
China	cumulative	6705	427	262		
	annual average	16	6			
South Asia	cumulative	3922	1264	973		
	annual average	14	9.8			

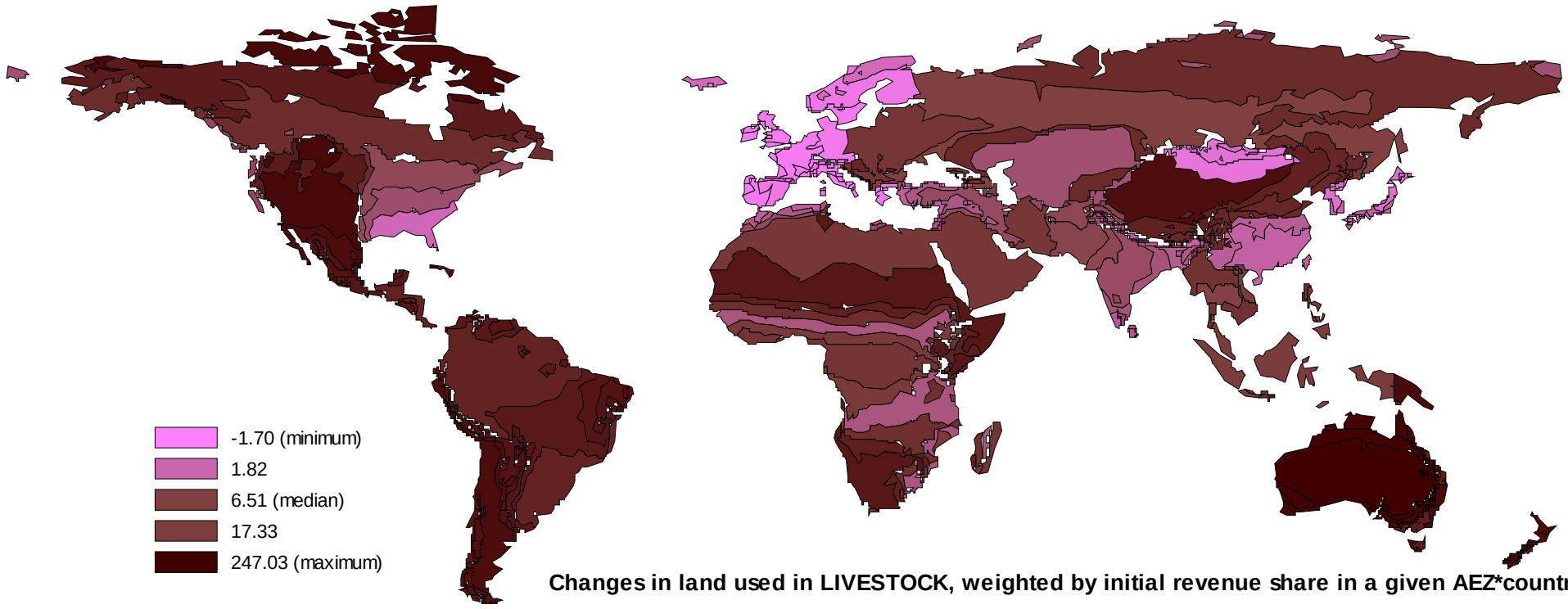
Red = forest land rents growing faster than av land rents

Changes in land used in crops, revenue-share-weighted %

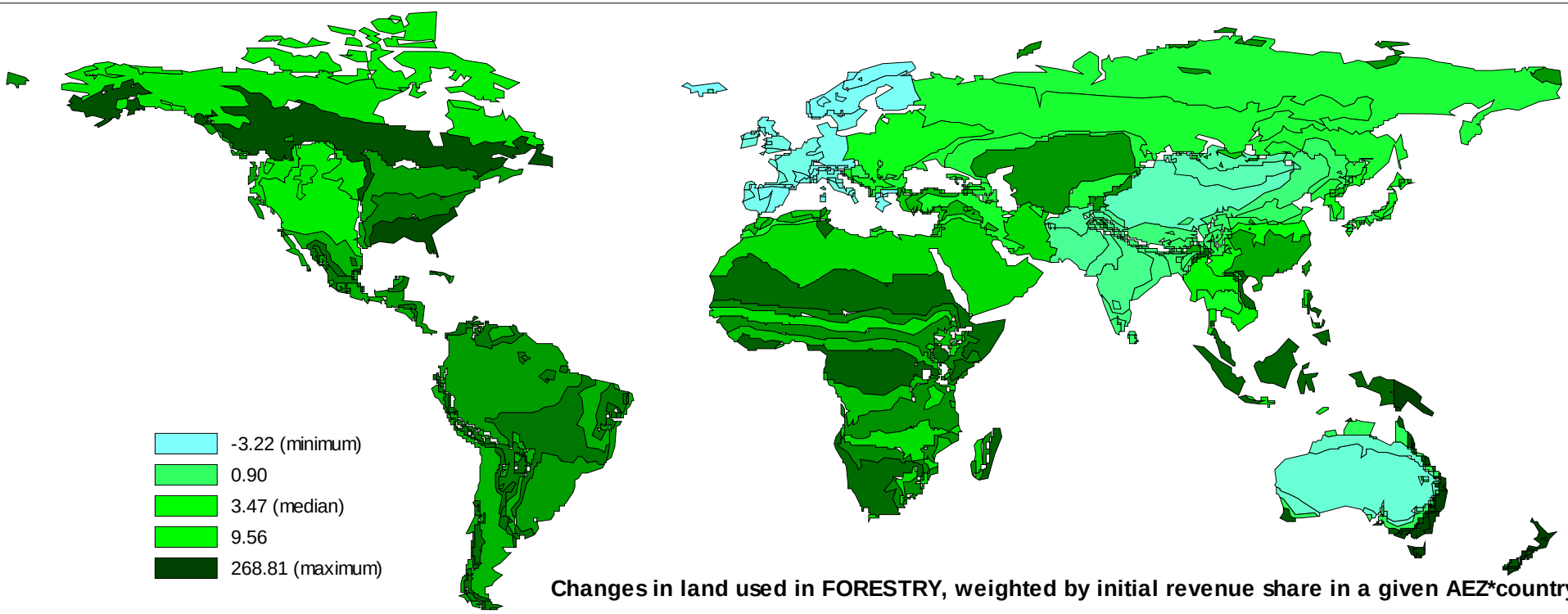


Changes in land used in CROPS, weighted by initial revenue share in a given AEZ*country

Changes in land used in livestock, revenue-share-weighted %



Changes in land used in forestry, revenue-share-weighted %



Conclusion

- **The goal of this work is to provide insights into the fundamental determinants of the LR demand and supply of land in order to improve on baseline projections of land use and hence emissions**
- **Critical factors include:**
  - **Disaggregation of land use by AEZ**
  - **Specification of consumer demand**
  - **Technological change**
  - **Cost of accessing new land**
- **Next steps:**
  - **Add demand for built-up land (critical in HYAsia)**
  - **Historical validation**
  - **Merge with emissions model (see next presentation)**