



International Institute for  
Applied Systems Analysis  
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science for global insight

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# Improving representation of socioeconomic heterogeneity in integrated assessment models

## An illustration with GLOBIOM

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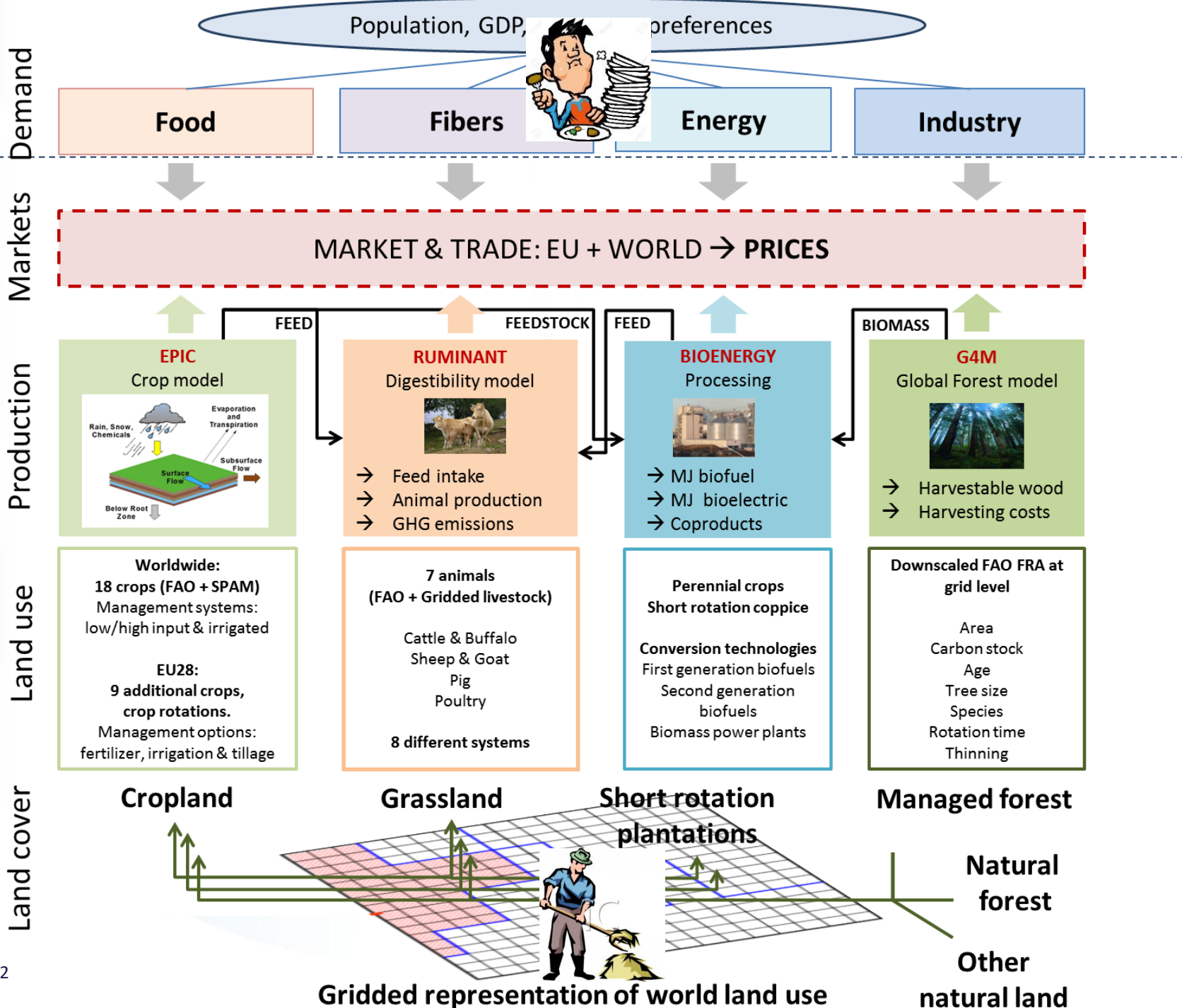
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Narasimha Rao, Samir KC, Kieswetter G., Michael  
Obersteiner...



IIASA, International Institute for Applied Systems Analysis



# Socioeconomic heterogeneity matters for global change analysis

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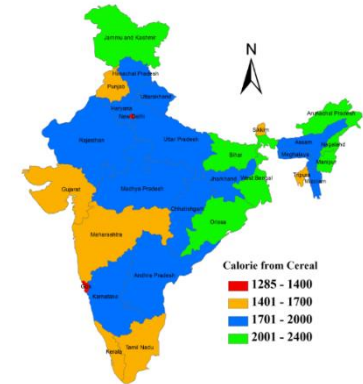
- ▶ Different vulnerabilities  
⇒ different impacts of global changes and related policies on well-being
- ▶ Different preferences / consumption patterns  
⇒ different impacts on the environment



# Two examples of integration of socioeconomic heterogeneity in GLOBIOM

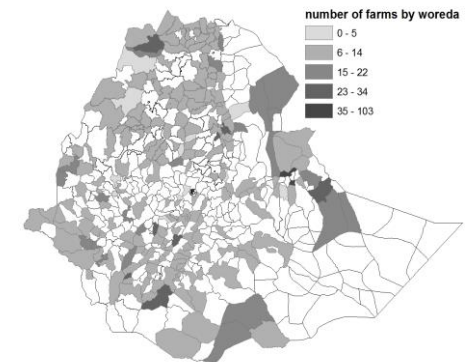
- ▶ Demand side: application to India

- ▶ Work from IIASA cross-cut project



- ▶ Supply side: application to Ethiopia

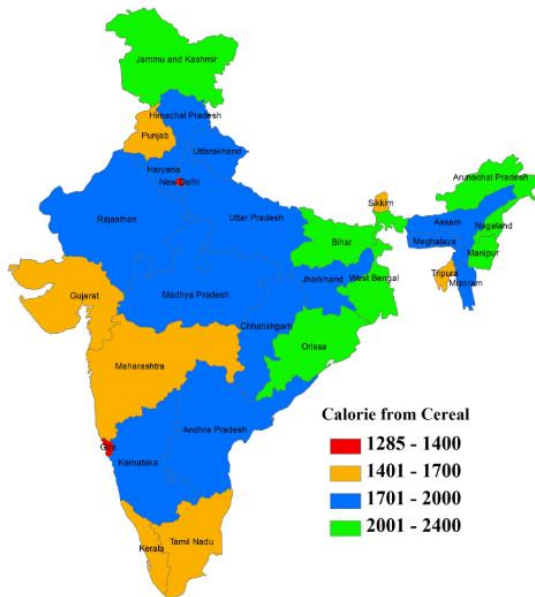
- ▶ Boere E., Mosnier A., et al.



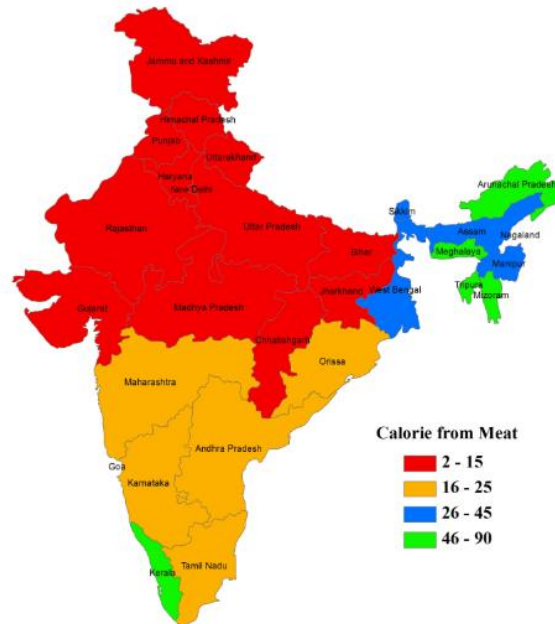
# Application to food demand in India

- ▶ India 2015 = 1.31 billion consumers (18% of global population)
- ▶ Dietary patterns vary per region, socioeconomic and cultural group...

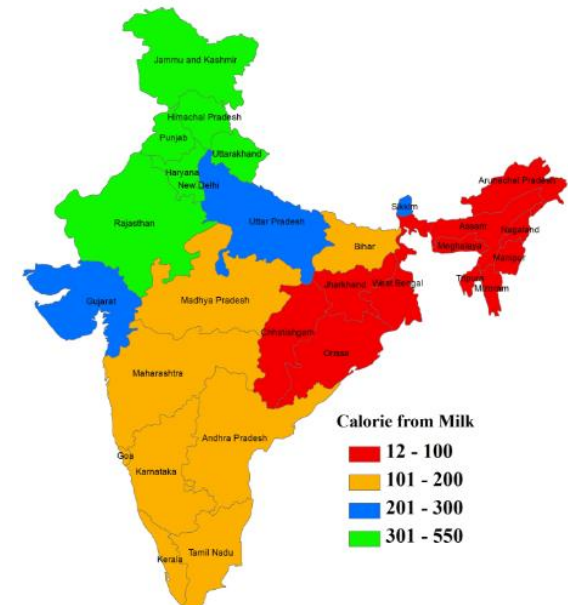
### Cereals



### Meat



### Milk

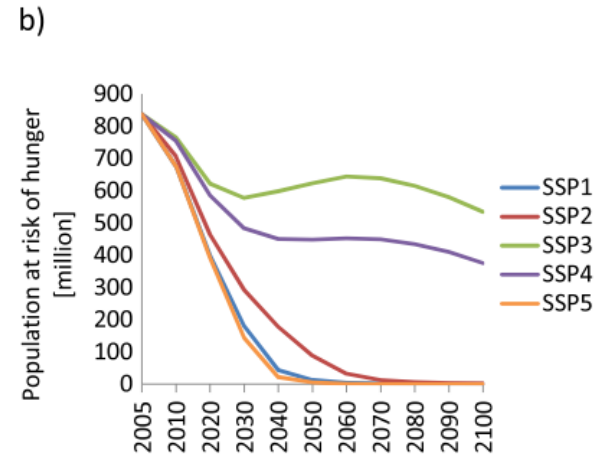
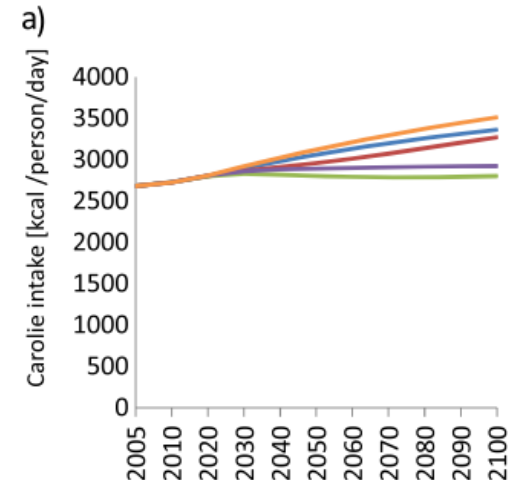
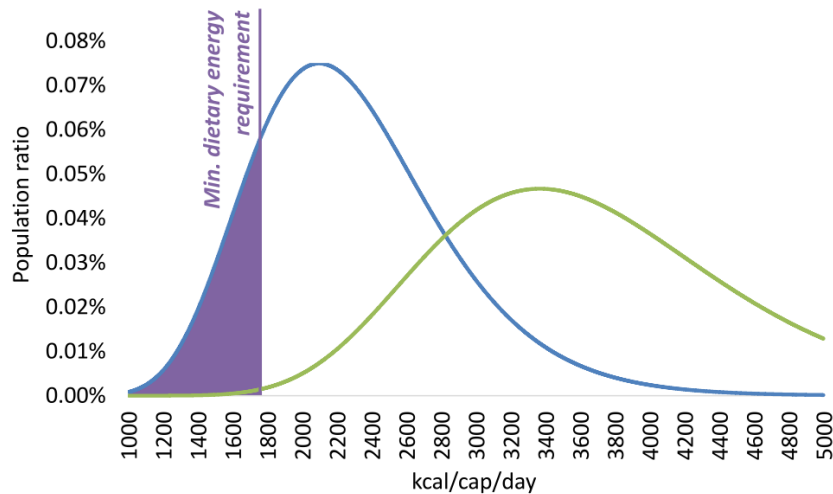


Source: Borkotoki et al., in prep.



# Socioeconomic heterogeneity and food demand

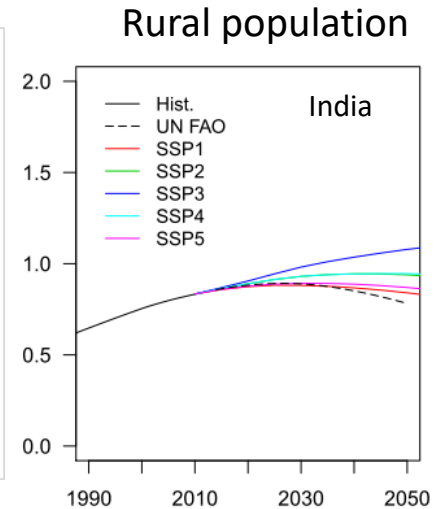
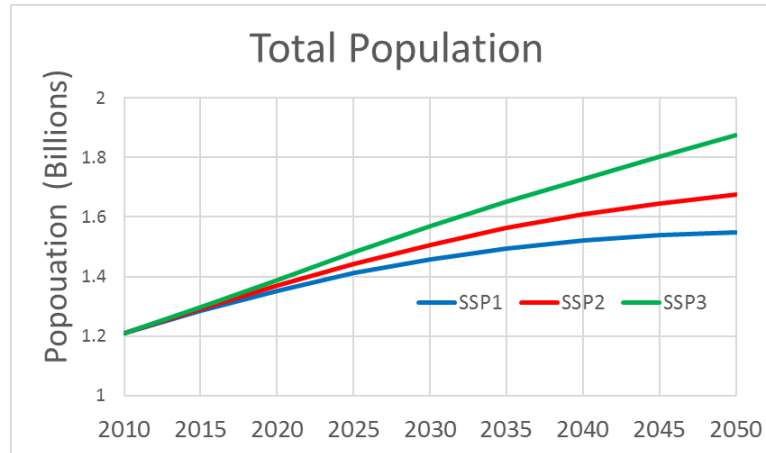
- ▶ Current progress to take account of food distribution heterogeneity
  - ▶ FAO approach fo food distribution
    - ▶ Adapted to IAMs by Tomoko Hasegawa (NIES)



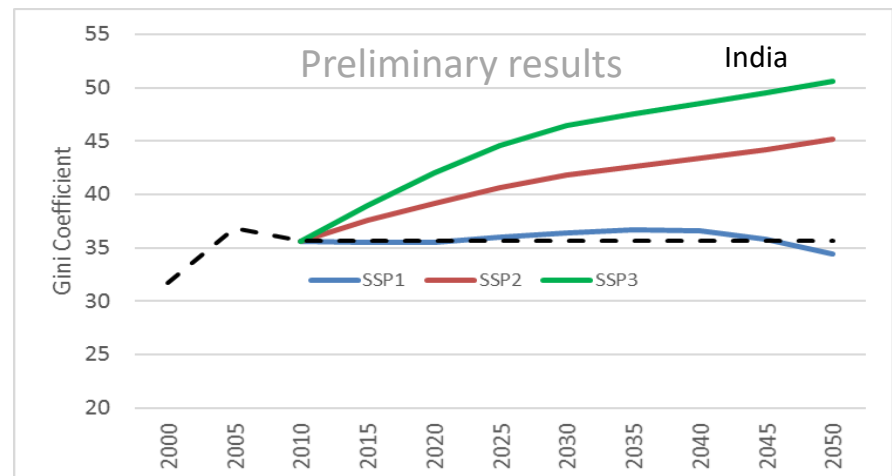
Source: Hasegawa et al., ERL, 2015

# Expanding SSP set of drivers

- ▶ Population
- ▶ GDP per capita
- ▶ Education
- ▶ Age
- ▶ Sex
- ▶ Urbanisation



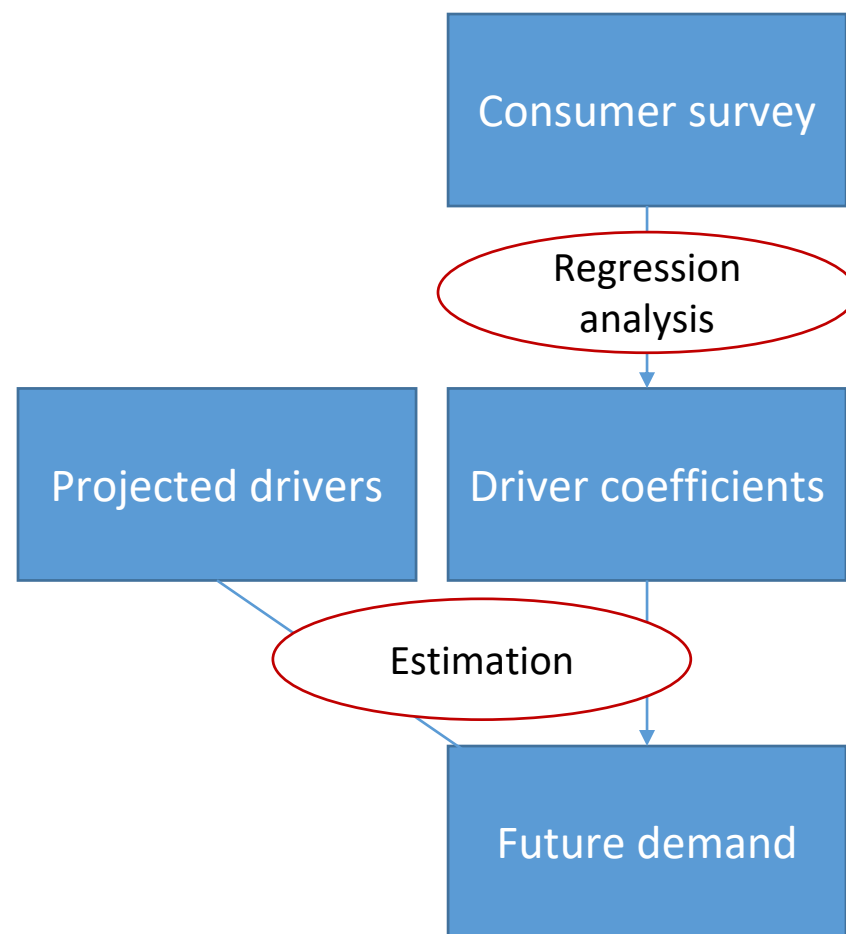
- ▶ Inequality (Gini)
  - ▶ Rao et al., 2016
  - ▶ Drivers: TFP, education, trade openness...



Source: Rao et al., in review.

# Analyzing and projecting India diets with SEH

- ▶ Historical analysis using Consumer Expenditure Surveys on 1993-2012
- ▶ SEH drivers:
  - ▶ Income
  - ▶ Education
  - ▶ State location
  - ▶ Place of residence (urban rural)
  - ▶ Religion
  - ▶ Labor occupation (agri/non agri)
- ▶ 11 food groups
- ▶ Two-stage regression (probit + linear regression) to assess:
  - ▶ Whether consumers purchase or not a food product
  - ▶ If they purchase a food product, what quantity?

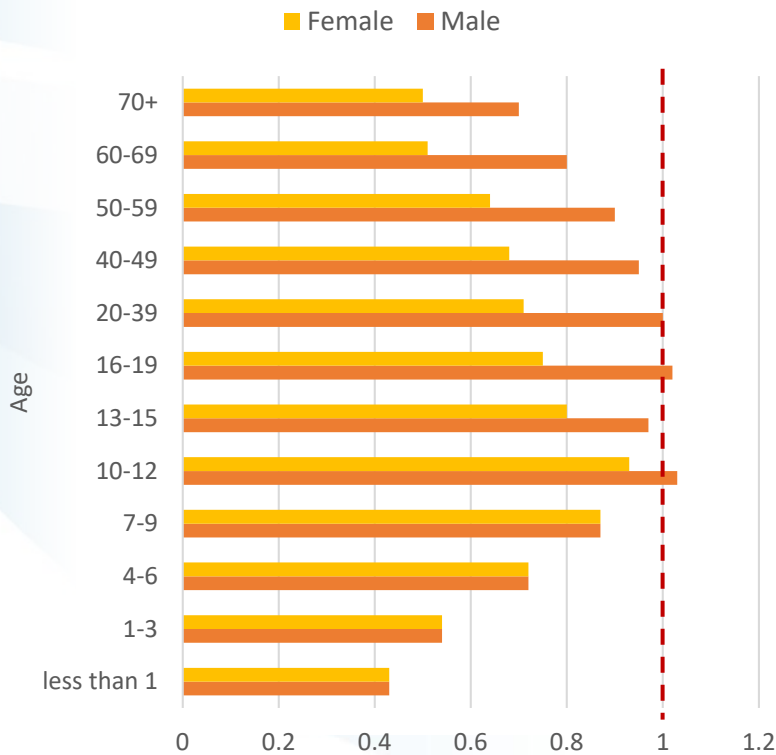




# Importance of age and gender

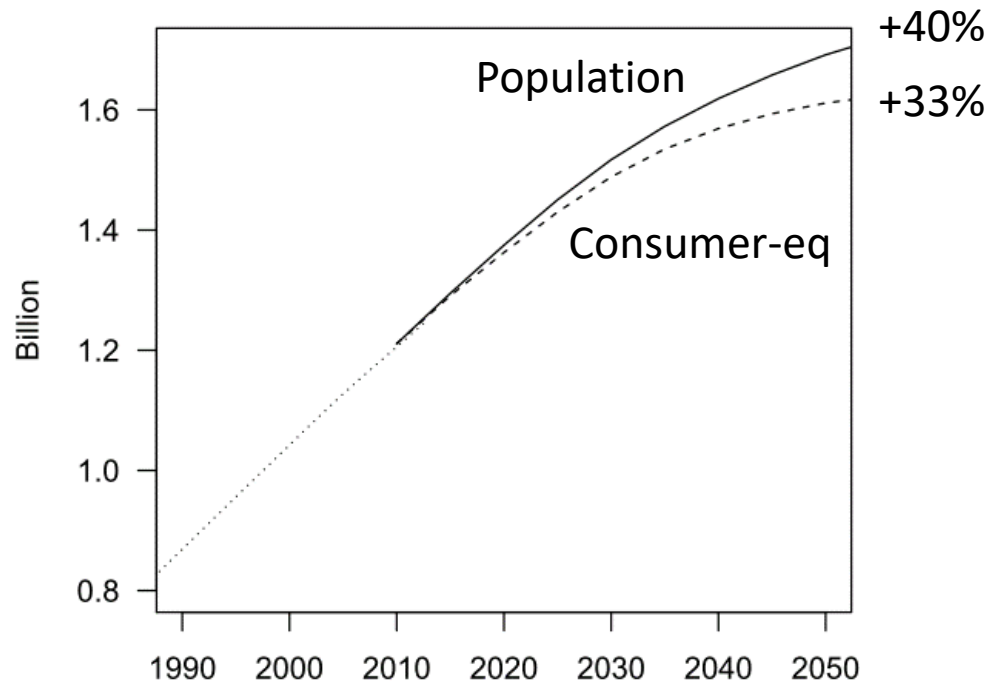
- ▶ Projecting food demand requires taking into account heterogeneity in food requirements depending on age and gender

## Physiological food requirements



Adult male  
20-39 years old

## Consumer-eq vs population growth



Source: Borkotoki et al., in prep.

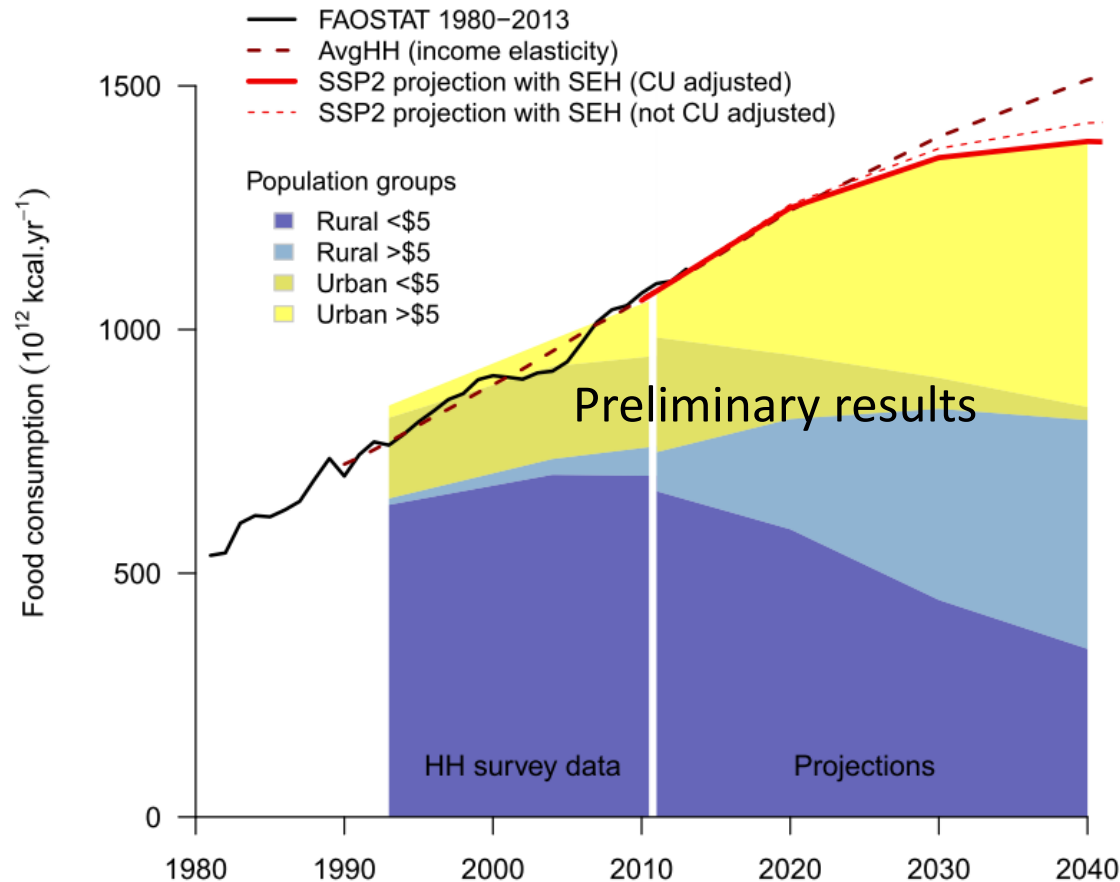
# Determinant per product

+++ : >50%, ++: 10% to 50%, +: 1% to 10%  
 ~: -1 to 1%, -: -10 to 1%, --: -50% to -10%, ---: < -50%

	cereal	pulses	milk	sugar	oil	egg	meat	veg	fruit	misc	proc
<b>Intercept</b>	1864	83	425	187	148	11	14	78	31	59	17
<b>Time (10 years)</b>	~	~	-	-	+	~	-	-	-	--	-
<b>Residence</b>											
<b>Rural(Ref)</b>											
<b>Urban</b>	--	-	--	--	+	-	-	-	--	--	++
<b>Education of HH Head</b>											
<b>No education</b>	++	+	--	-	-	-	++	~	--	---	-
<b>Incomplete primary</b>	+	.	--	.	~	+	+	+	-	++	+
<b>Complete primary</b>	+	.	--	~	-	-	+	~	-	--	+
<b>Completed lower secondary</b>	+	.	-	+	.	-	+	.	-	--	.
<b>Complete upper secondary(Ref)</b>											
<b>Post-secondary</b>	-	-	+	-	-	+	-	-	+	++	+
<b>Expenditure Group</b>											
<b>&lt;750</b>	--	---	---	---	---	--	---	---	---	--	---
<b>750-1000</b>	--	--	---	--	--	--	--	--	---	--	---
<b>1000-1250</b>	-	--	--	--	--	--	--	--	--	-	--
<b>1250-1500(Ref)</b>											
<b>1500-2000</b>	+	++	++	++	++	++	++	++	++	+	++
<b>2000-2500</b>	+	++	++	++	++	++	++	++	++	++	+++
<b>2500-5000</b>	+	++	+++	++	++	+++	+++	++	+++	++	+++
<b>5000-7500</b>	++	+++	+++	+++	+++	+++	+++	+++	+++	++	+++
<b>7500-10000</b>	++	+++	+++	+++	+++	+++	+++	+++	+++	++	+++

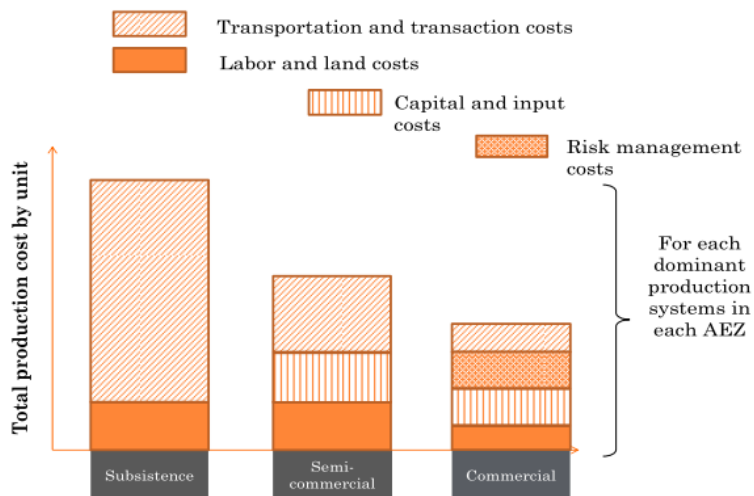
# Main Results : Inclusion of SEH Matters

- ▶ Extent of food demand overestimated without considering heterogeneity

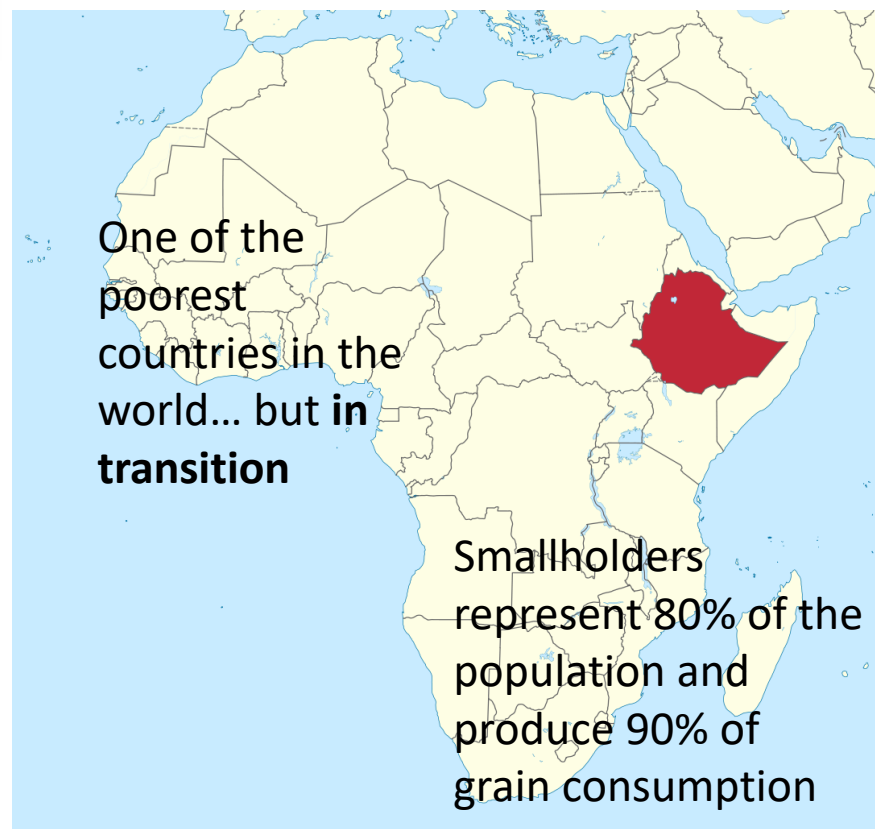


# Supply side

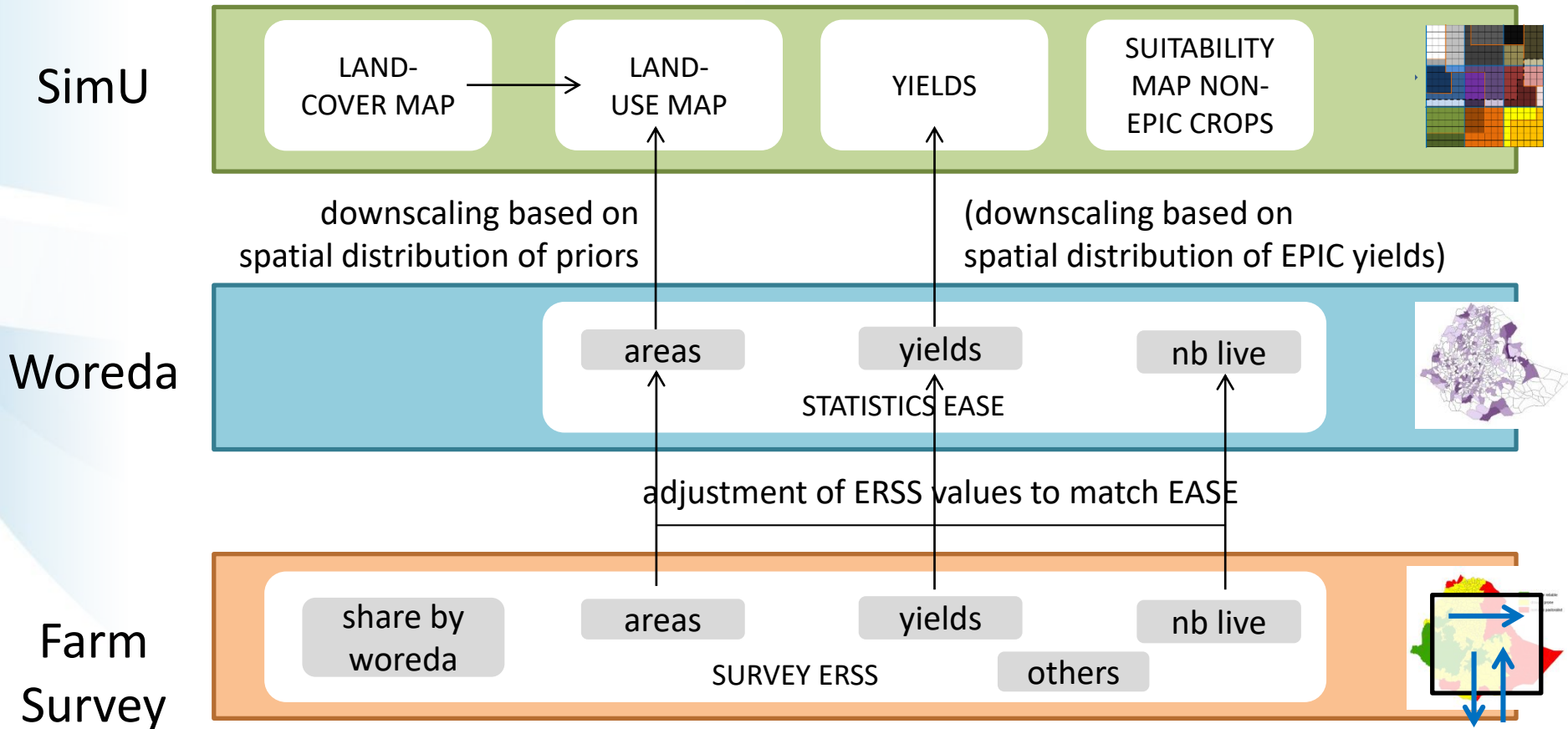
- ▶ What are the main characteristics of farmers behind production features?
- ▶ What are the impacts on various policies on transition pathways?



- ▶ Selected country: Ethiopia

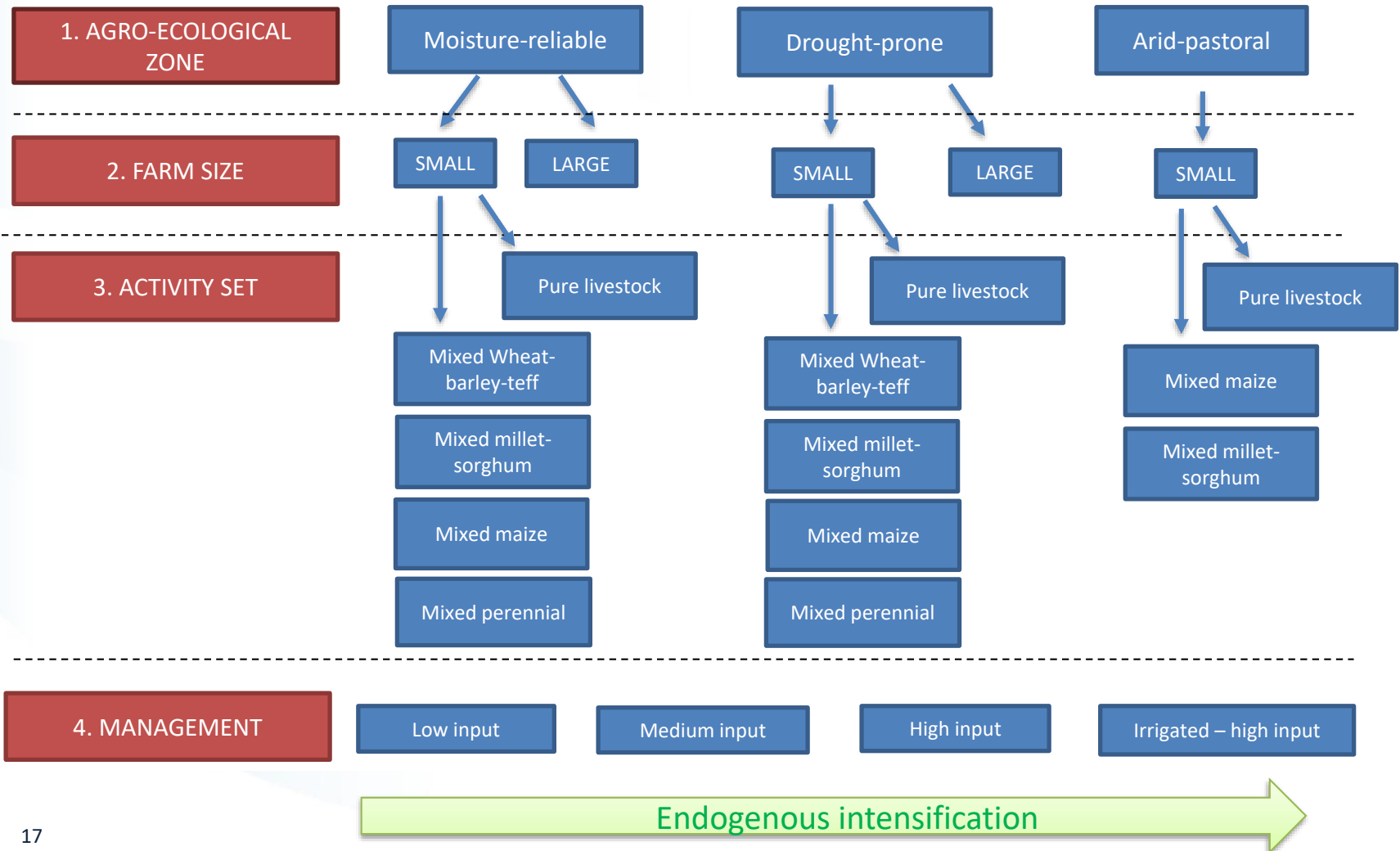


# 1. Dataset construction



# New typology to represent farming systems in Ethiopia

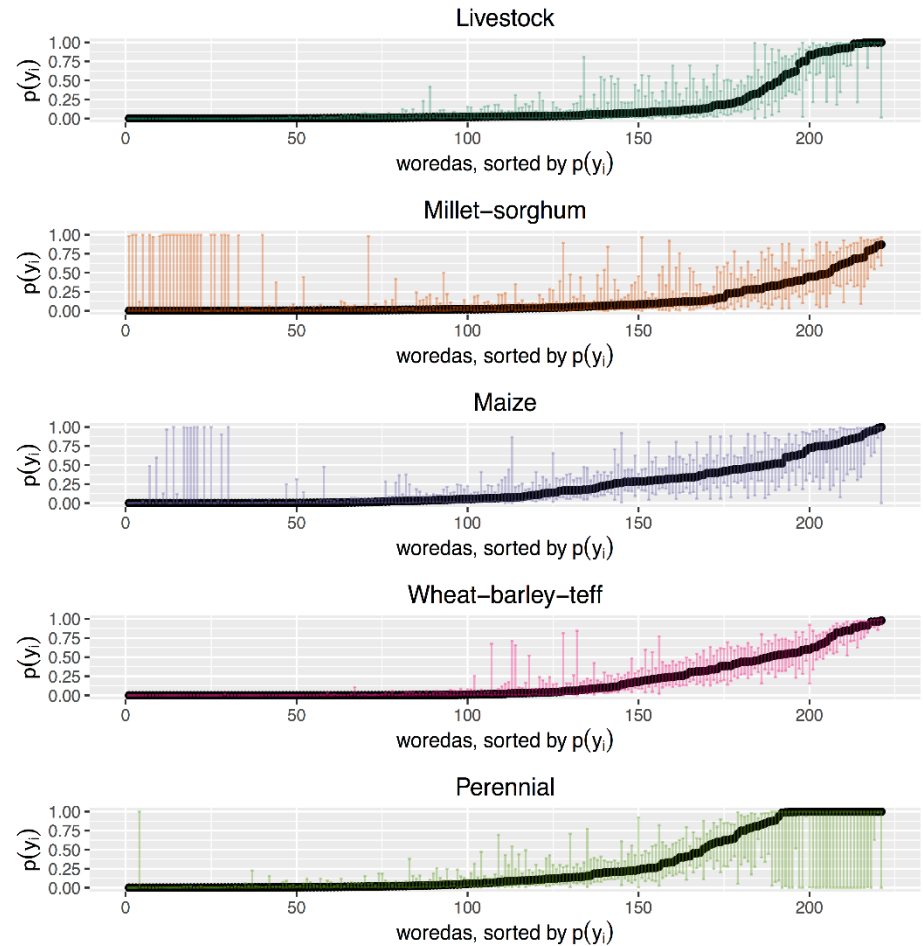
► New typology of farming systems built on 4 criteria:





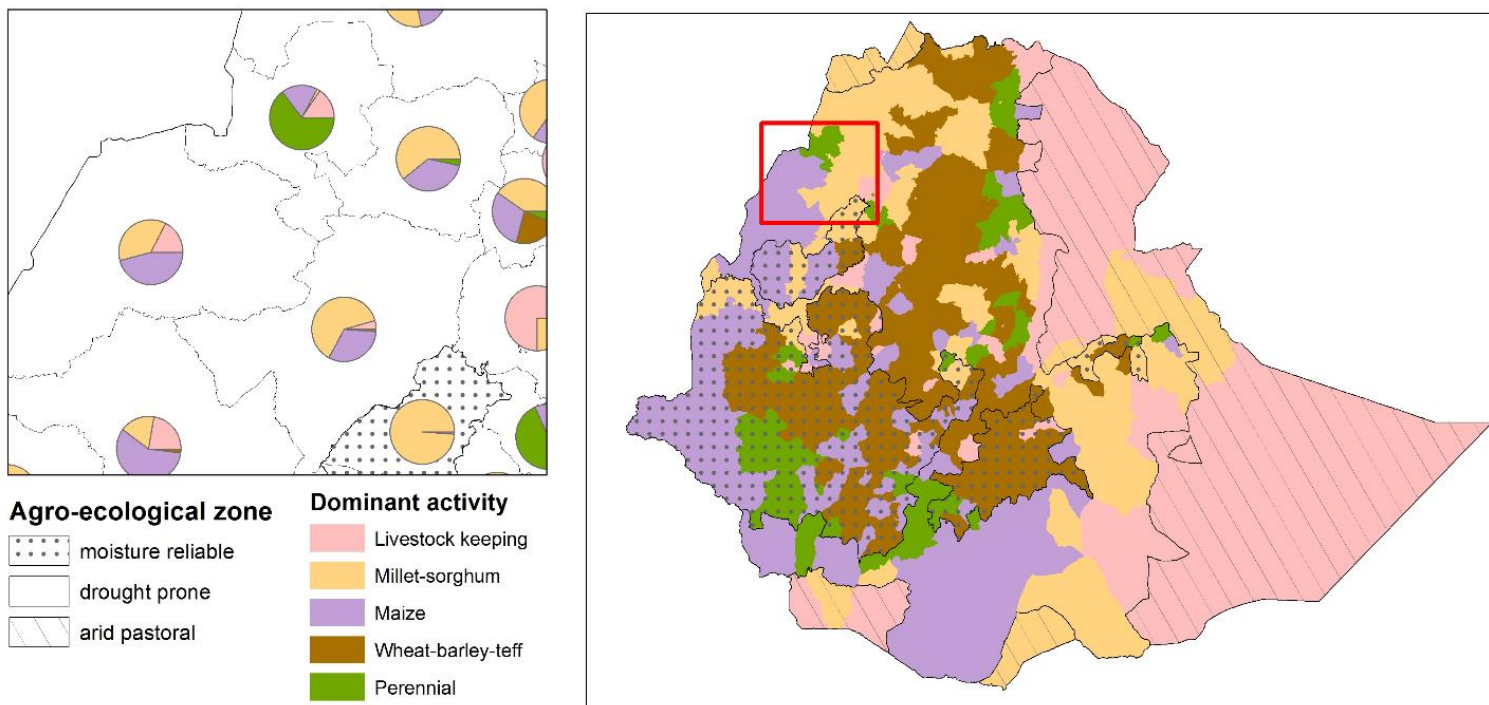
# Activity set

- ▶ LSMS-ISA/ERSS data is not representative at the woreda level, nor does it cover whole country.
- ▶ Use a multinomial logit estimation to extrapolate the share of farms in each activity set per woreda



*Extrapolated smallholder's activity per woreda. Points represent posterior median, error bars denote the lower 5<sup>th</sup> and the upper 95<sup>th</sup> quantile*

# Spatial distribution of AEZ and activity-set

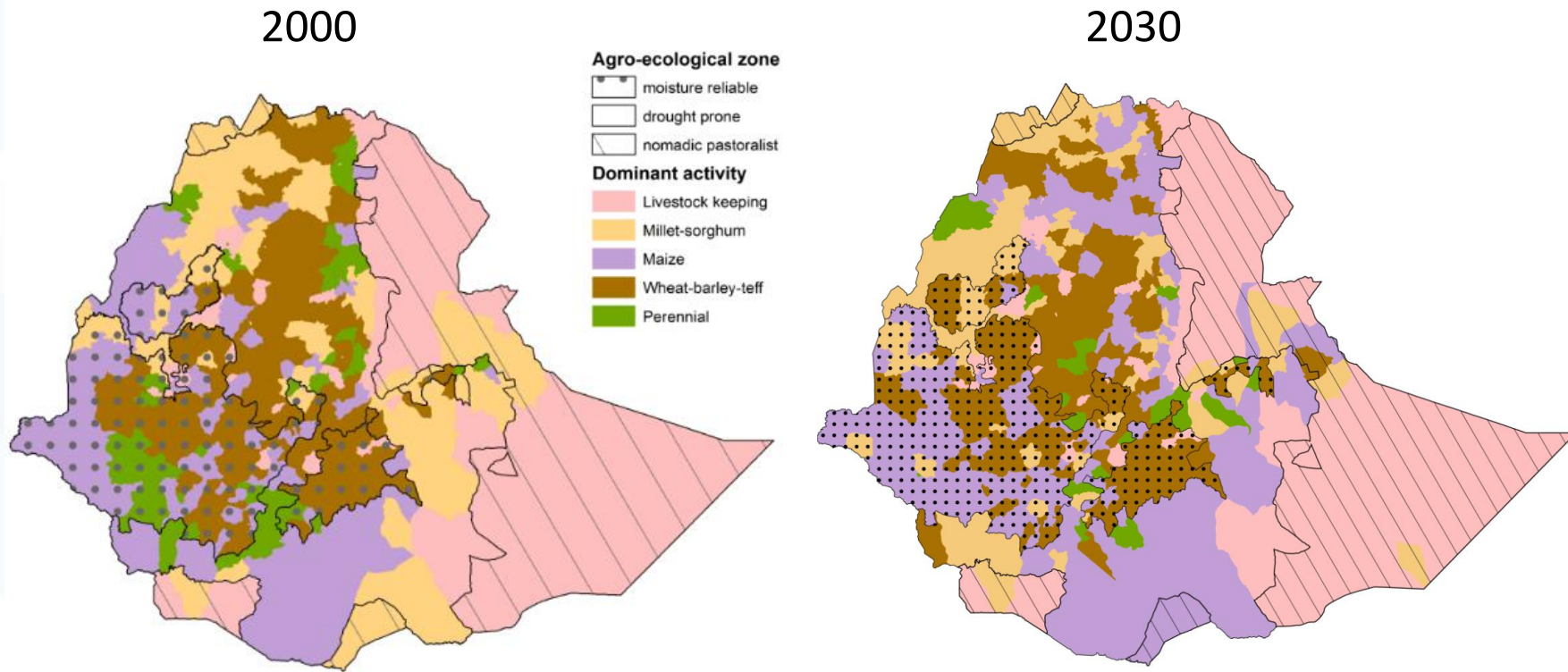


*Dominant activity set for all woredas in Ethiopia and distribution of activity sets by woreda for a selected number of woredas*

- ▶ *Pure livestock and millet-sorghum activity-sets dominate in arid-pastoral zone, maize in South-West, wheat-barley-teff in highlands in centre, perennials very concentrated*

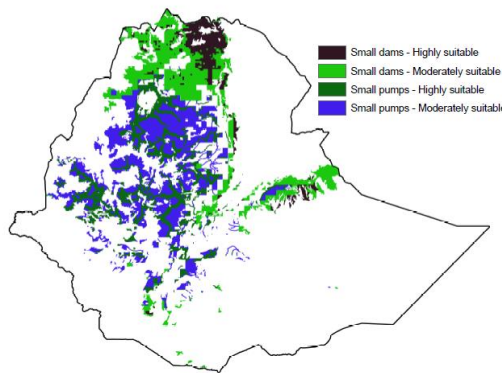
# Evolution of farming systems: 2000-2030

*Dominant activity-set by woreda*

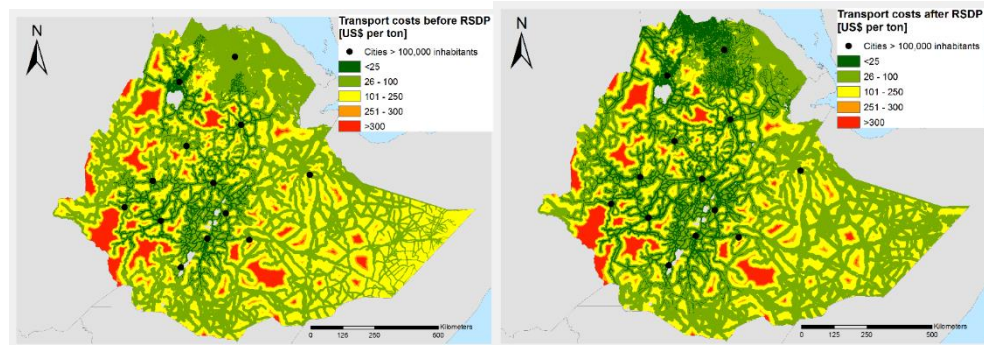


# Scenarios

Scenario	Explanation
Base	No policy scenario
Infrastructure	The development of infrastructure network to improve access to markets
Irrigation	The development of irrigation infrastructures to increase production
Fertilizer subsidy	Fertilizer subsidies to increase production
Combined	A combination of infrastructure, irrigation and fertilizer subsidy policies



Potential irrigated area from FAO (2016).



Transportation costs before and after road development

# Scenario-specific results

- ▶ Scenarios show different results in terms of farm management, natural resources and food security.

	Infrastructure	Irrigation	Fertilizer subsidy	Combined
Farm management	Largest share for medium and high input use	Most intensification: Mostly towards irrigated land	Largest share for medium and high input use	Most intensification: Towards high input and irrigated land
Natural resources		Smallest uptake of cropland	Largest uptake in cropland: at the cost of forest land	Largest uptake in cropland: at the cost of forest land
Food security	Smallest increase in kcal produced and consumed			Largest increase in kcal consumed and produced
Macro-economic	Smaller decrease in prices	Smaller decrease in prices	Decrease in prices	Largest decrease in prices

- ▶ A combined scenario is most beneficial in terms of food security, the irrigation scenario might be more beneficial in terms of income and natural resource protection.

# What's next?

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- ▶ Heterogeneity matters, especially for impact literature using SSPs
- ▶ Both case studies: climate change impact and adaptation analysis...
  - ▶ Consumer impact
  - ▶ Farm system transformations
- ▶ Demand side and supply side presented separately
  - ▶ Closing the loop
- ▶ Extension:
  - ▶ Some more case studies: Zambia, cities?
  - ▶ Challenge of upscaling
  - ▶ Data issue... Availability, access...
  - ▶ Admin resolution, dataset harmonisation
- ▶ Global scale: reduced form models taking into account more comprehensive set of drivers



# Thank you !

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## References

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