FROM GLOBAL TO LOCAL: MODELING LOW EMISSIONS DEVELOPMENT STRATEGIES

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The Challenge

Climate Change forces us to change the planning time horizon:

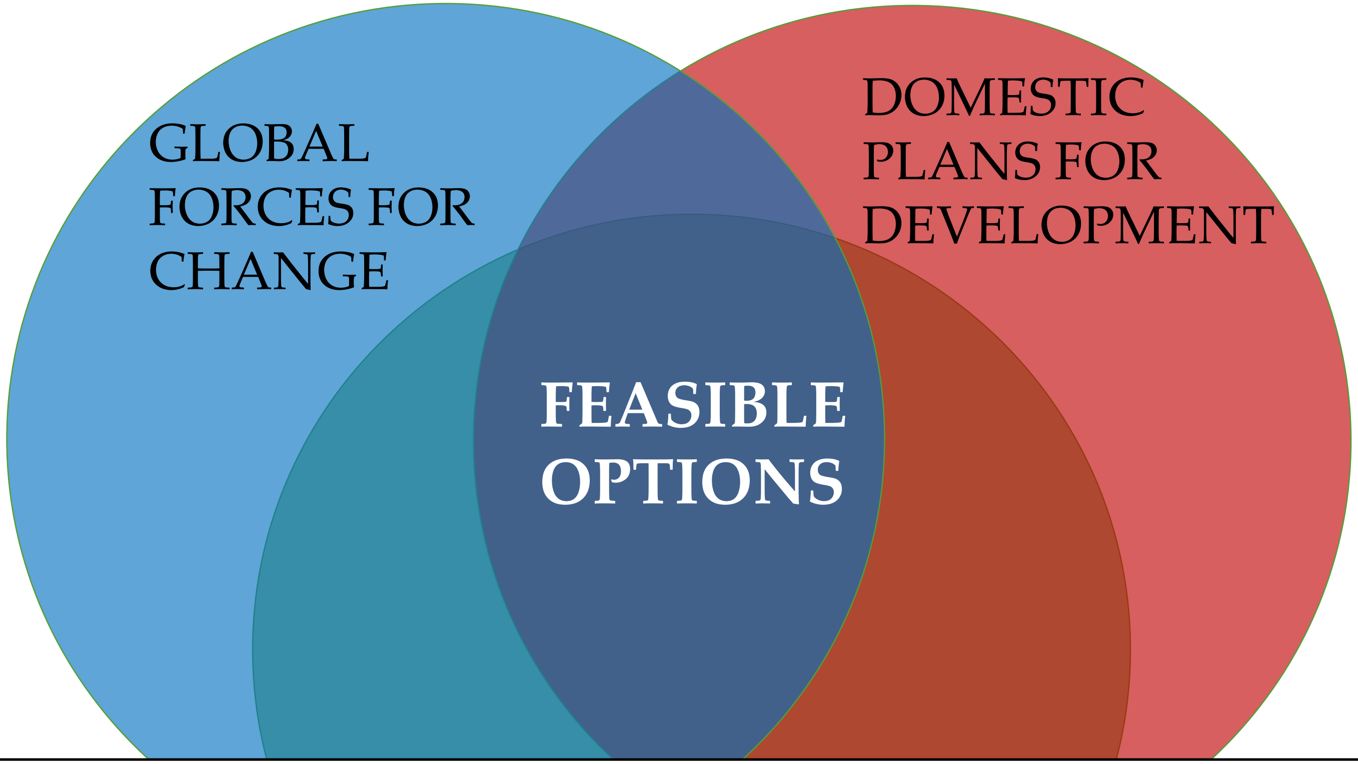
policies and analyses necessarily span
long time periods of 20-30 years.

The Challenge

- Policies need to be economically and politically sustainable.
- Policies need to take into account the worldwide economic landscape and the pressures deriving from world markets.

The risk of having policies that crumble under budgetary pressures of unfavorable market forces or dissolve due to the erosion of political consensus is high.

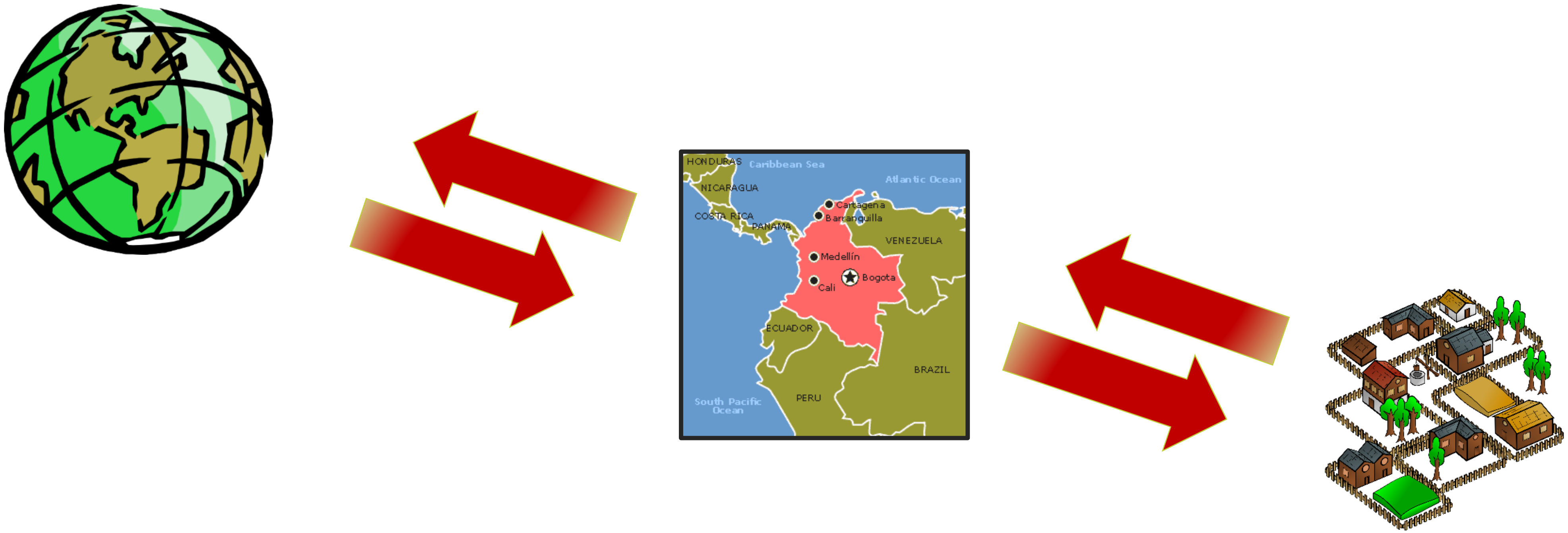
Searching for feasible options



Need to have plausible representations of the future

The importance of multiple scales

- Feasibility vis a vis global and exogenous forces
- Feasibility vis a vis local realities



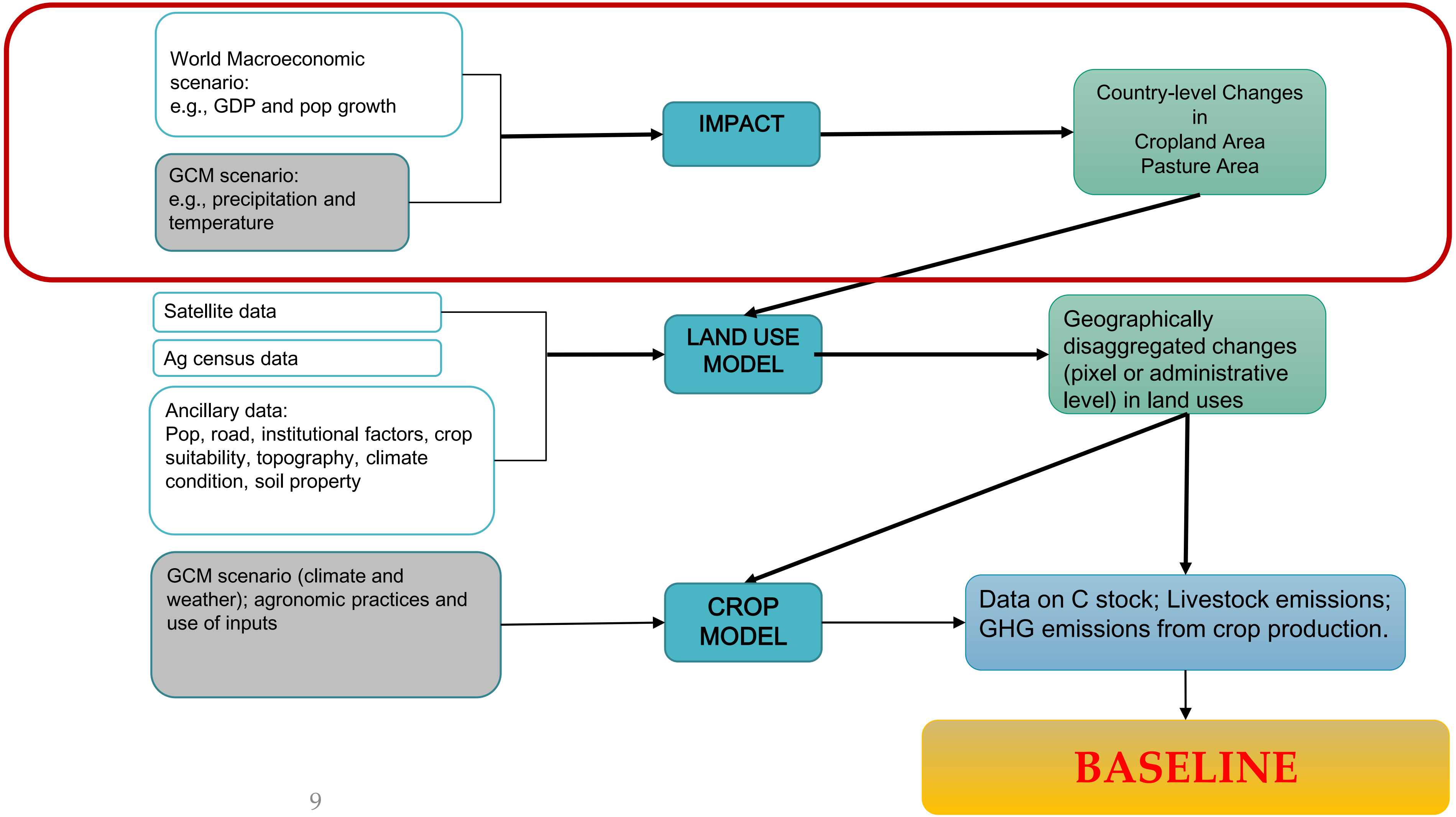
IFPRI's Conceptual Approach

- Need to combine and reconcile
  - Limited spatial resolution of macro-level economic models that operate through equilibrium-driven relationships at a subnational or national level with
  - Detailed models of biophysical processes at high spatial resolution.

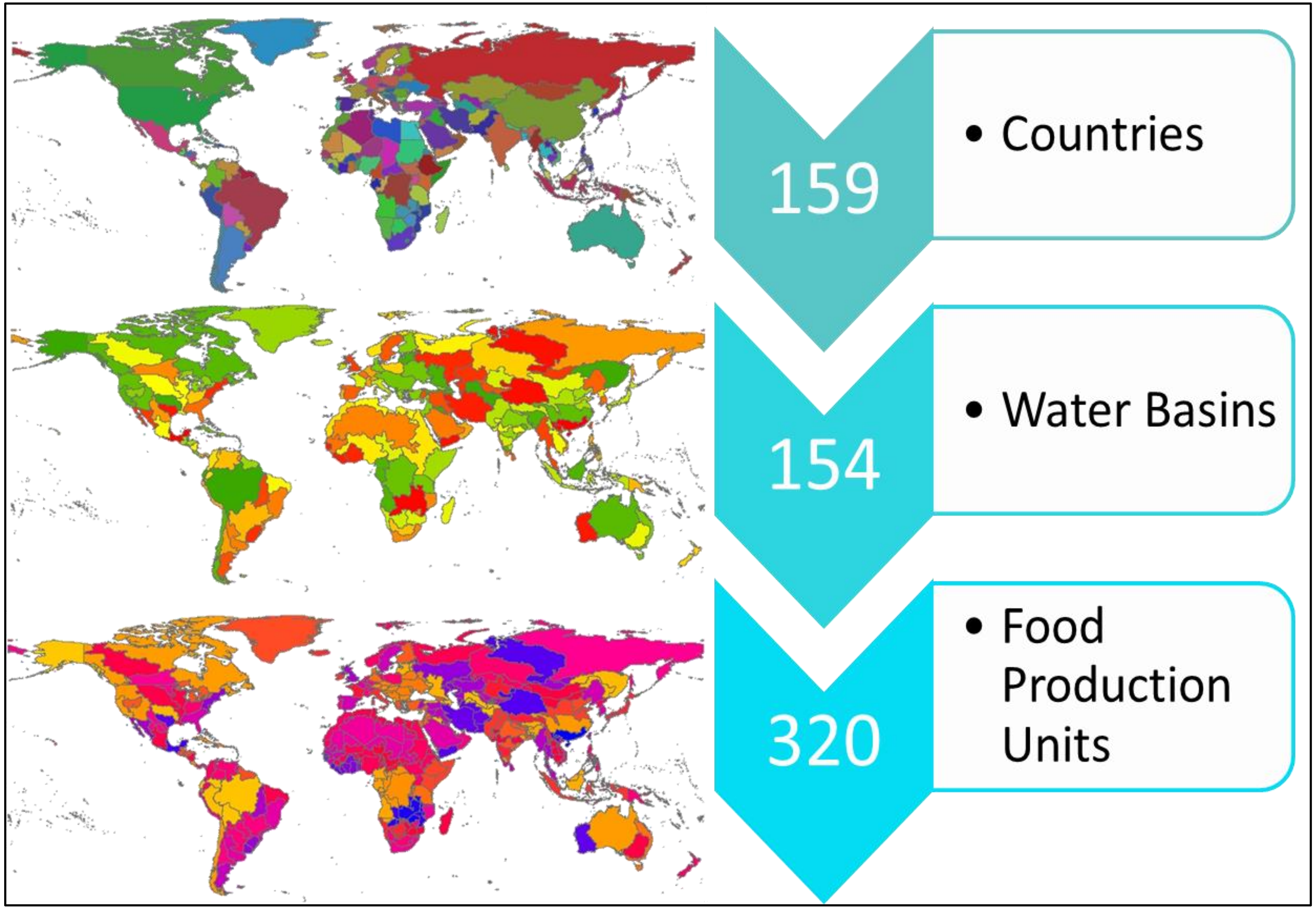
Output: <u>spatially explicit country-level results that are embedded in a framework that enforces consistency with global outcomes.</u>

MODELING APPROACH

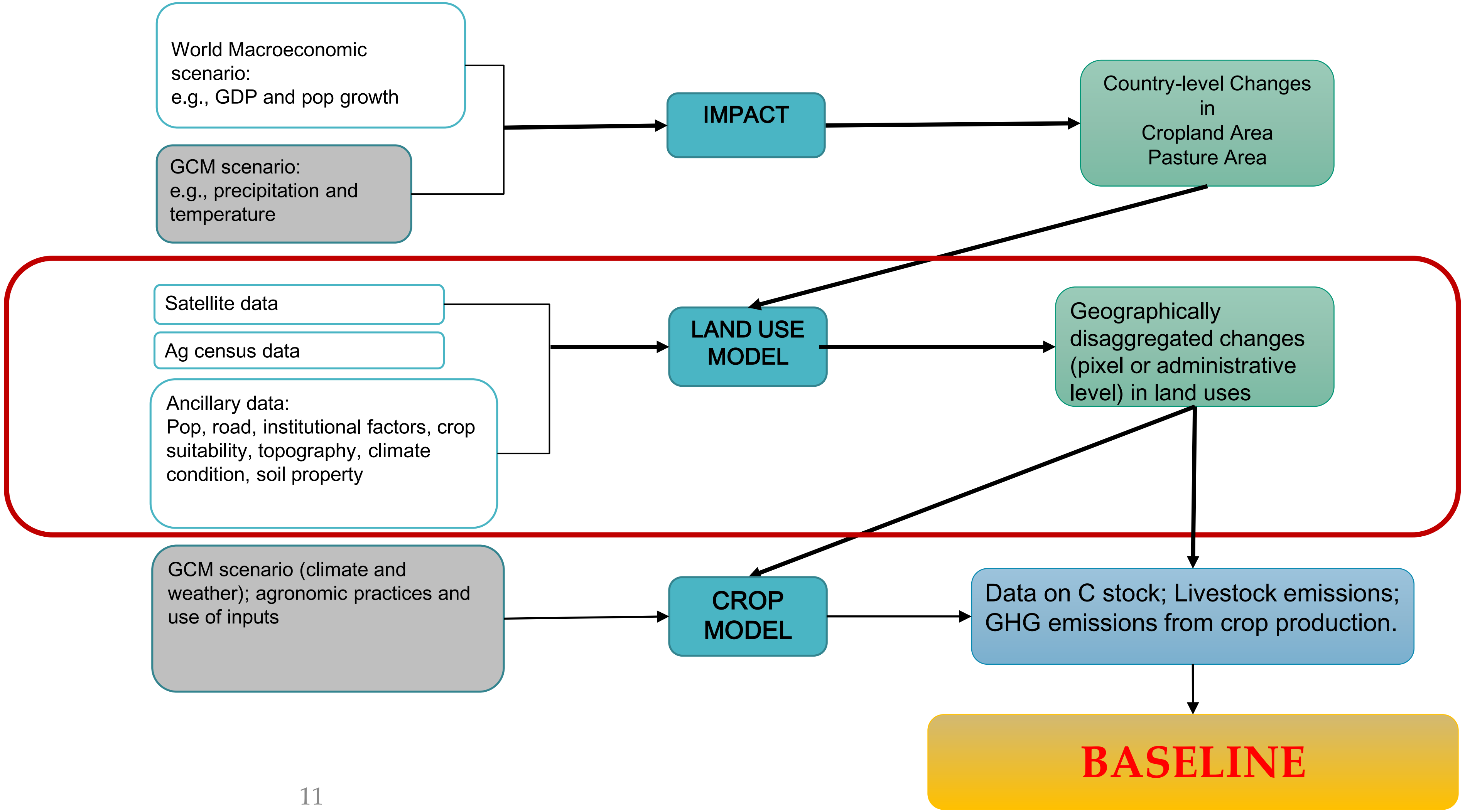
Modeling Framework



IMPACT: Global Food Production Units (320 FPUs), 64 agricultural commodities



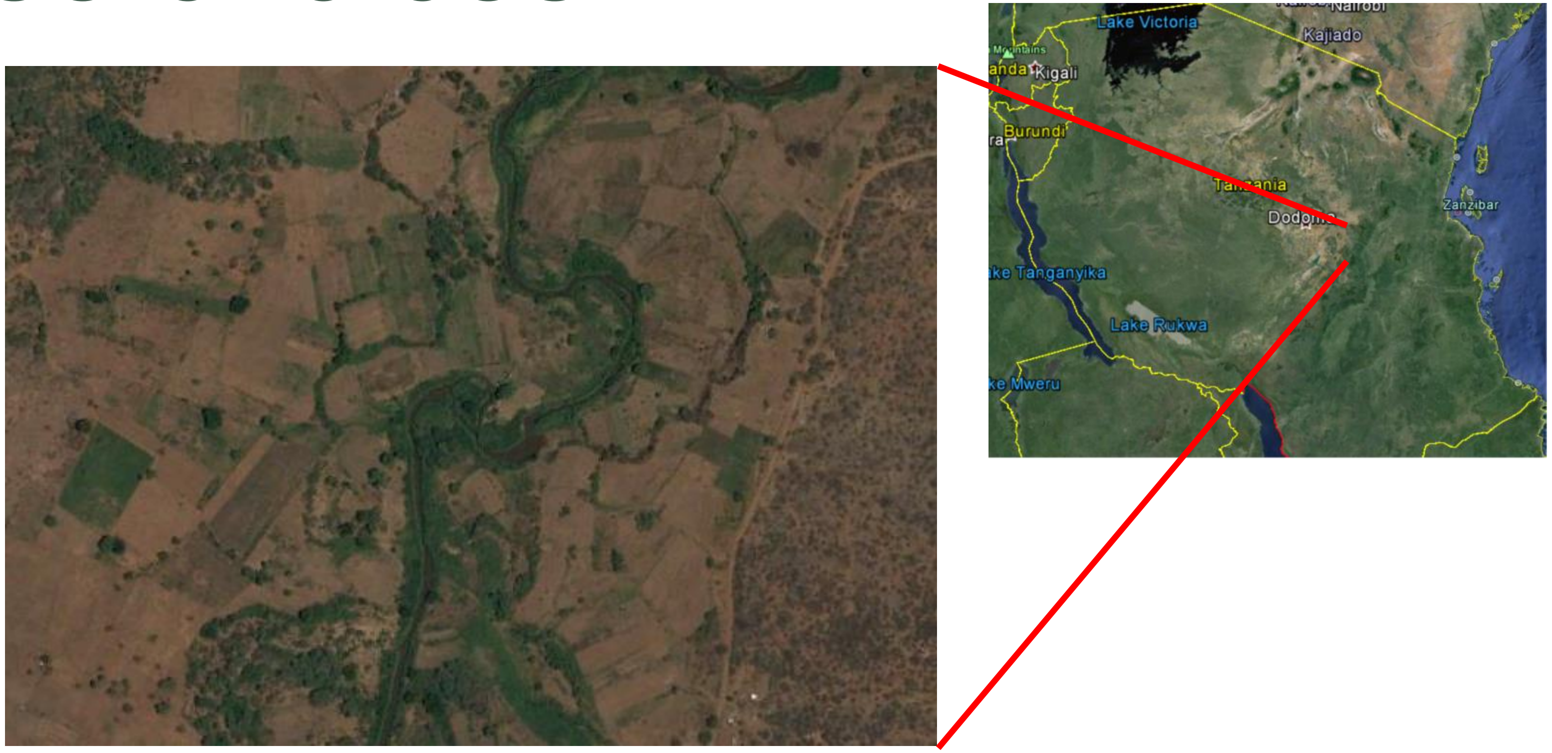
Modeling Framework



Why do we use an econometric model?

- We do not to use historical data to predict future land uses:
  - Past not always a good predictor for the future (e.g. Colombia and DRC).
  - We treat the past as another determinant of land use choices rather than the only one.
- We try to connect to and be consistent with economic theory.
- Ideally, we would want to model land use change =>panel data (rarely available),
- Commonly we model land use choices or land allocations for which we use cross-section data and exploit spatial variability in place of temporal variability.

An incredible wealth of data on land use choices



These are choices that optimize some decision process. It is up to the modeler to represent the decision process correctly.

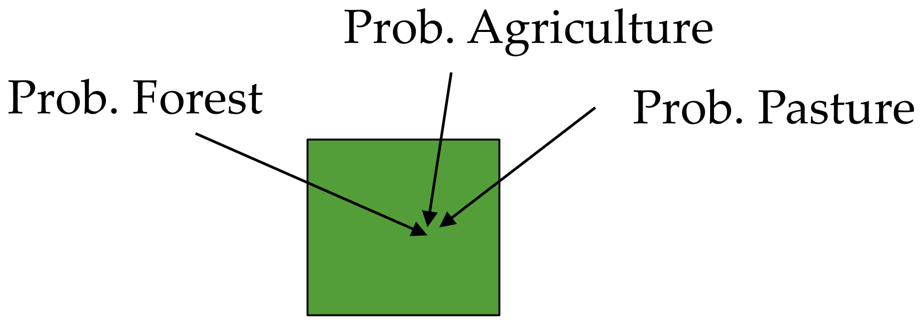
We statistically evaluate the effect of each explanatory variable

- Method of estimation: discrete choice models, e.g. multinomial logit, nested logit, etc.

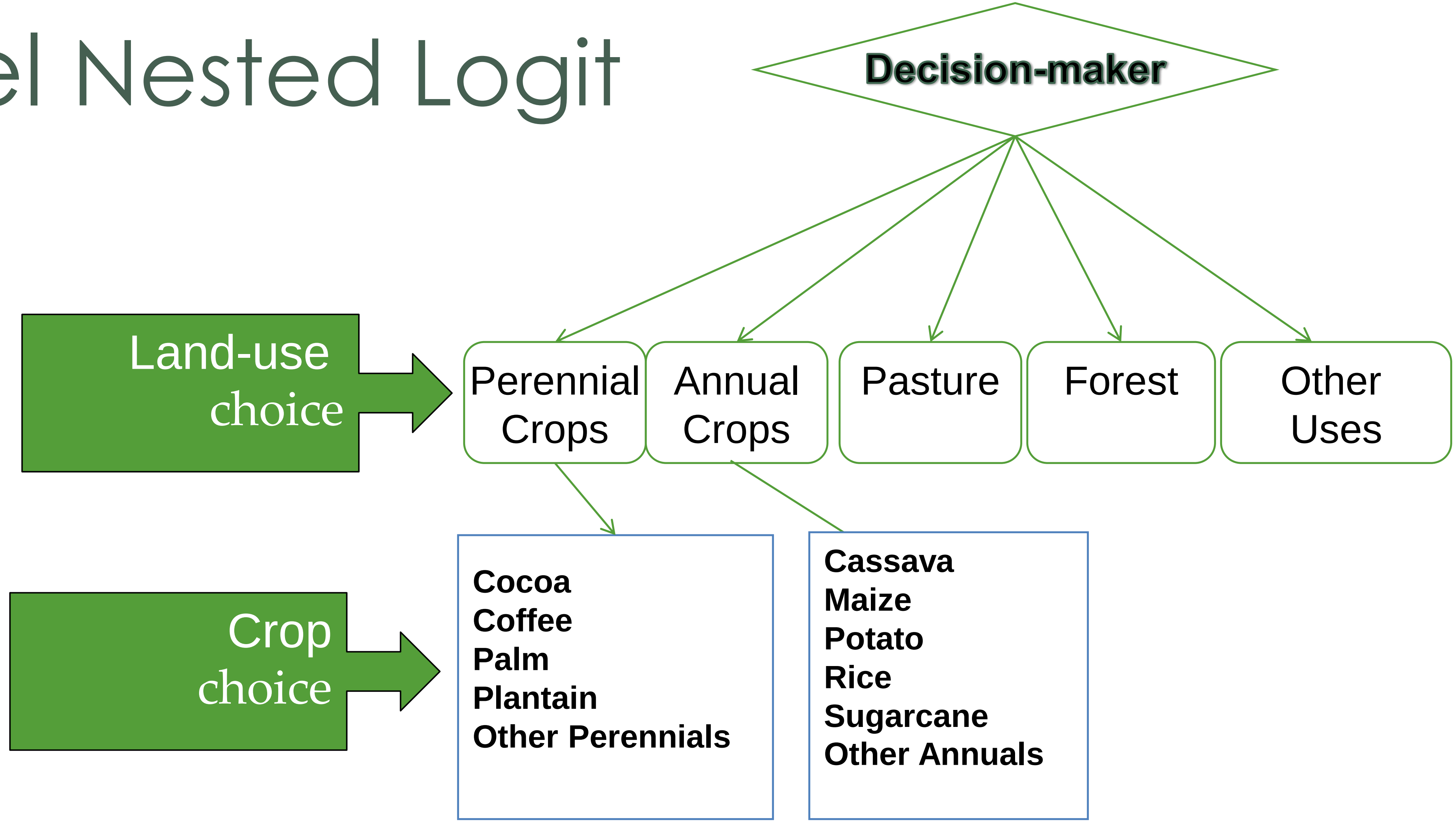
$$B_{lmaize} = \eta_{0j} + \eta_{1maize} slope_{lmaize} + \eta_{2maize} soil_{lmaize}$$

$$+ \eta_{3lmaize} price_{lmaize} + \eta_{4lmaize} production\ costs_{lmaize} \ldots\ldots$$

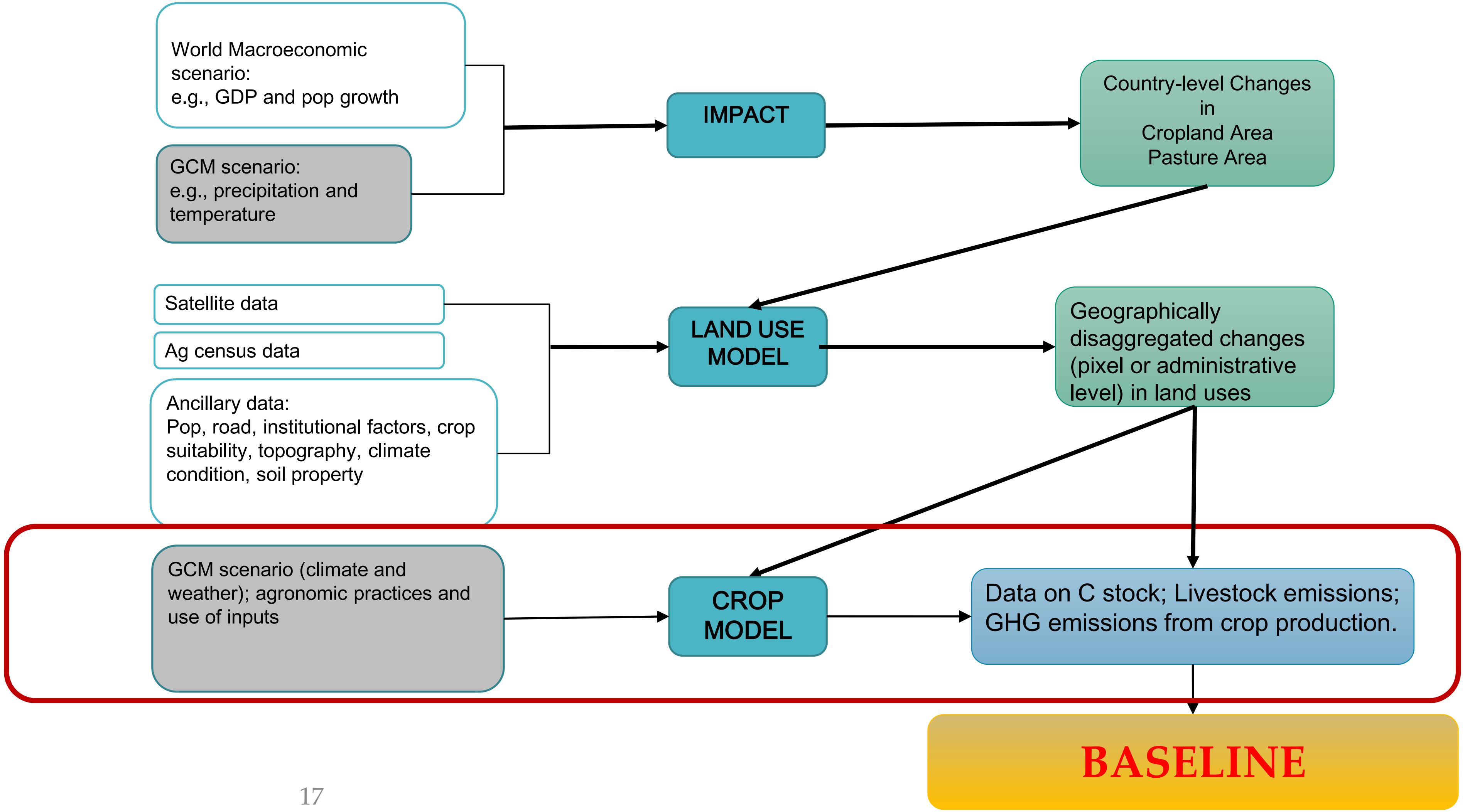
- For each land use we estimate the probability for that use to be chosen



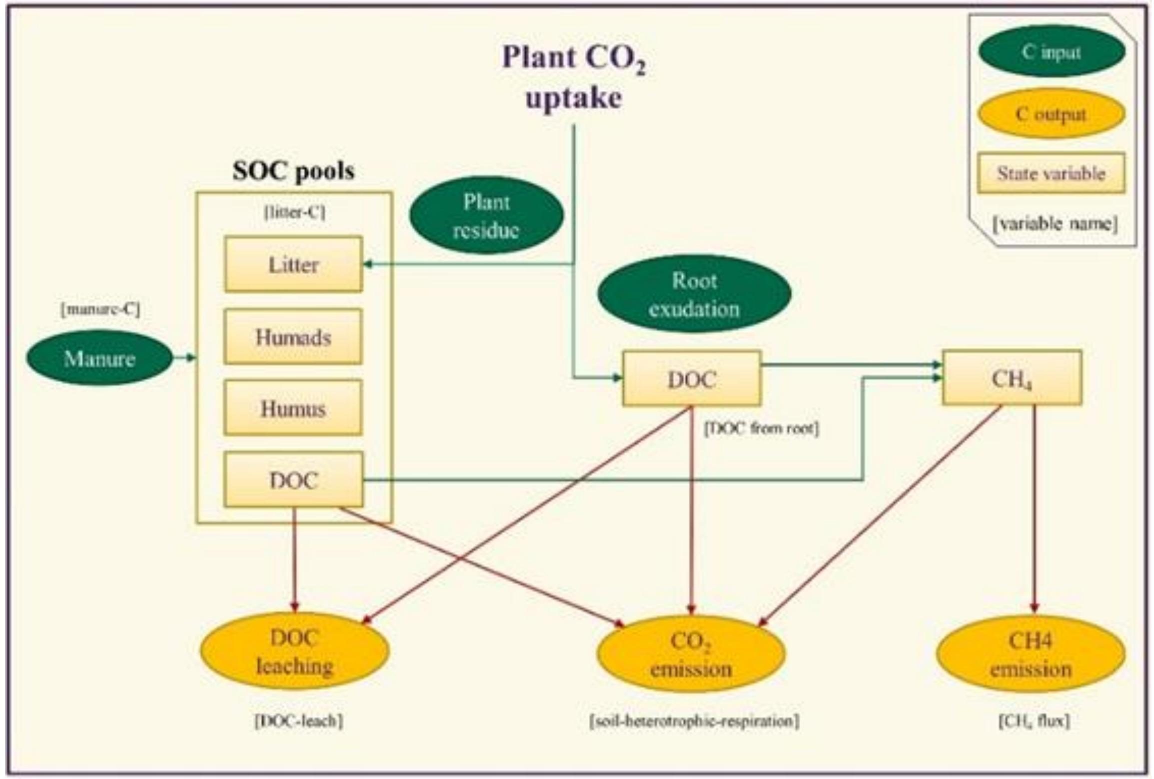
Model Specification: Two-level Nested Logit

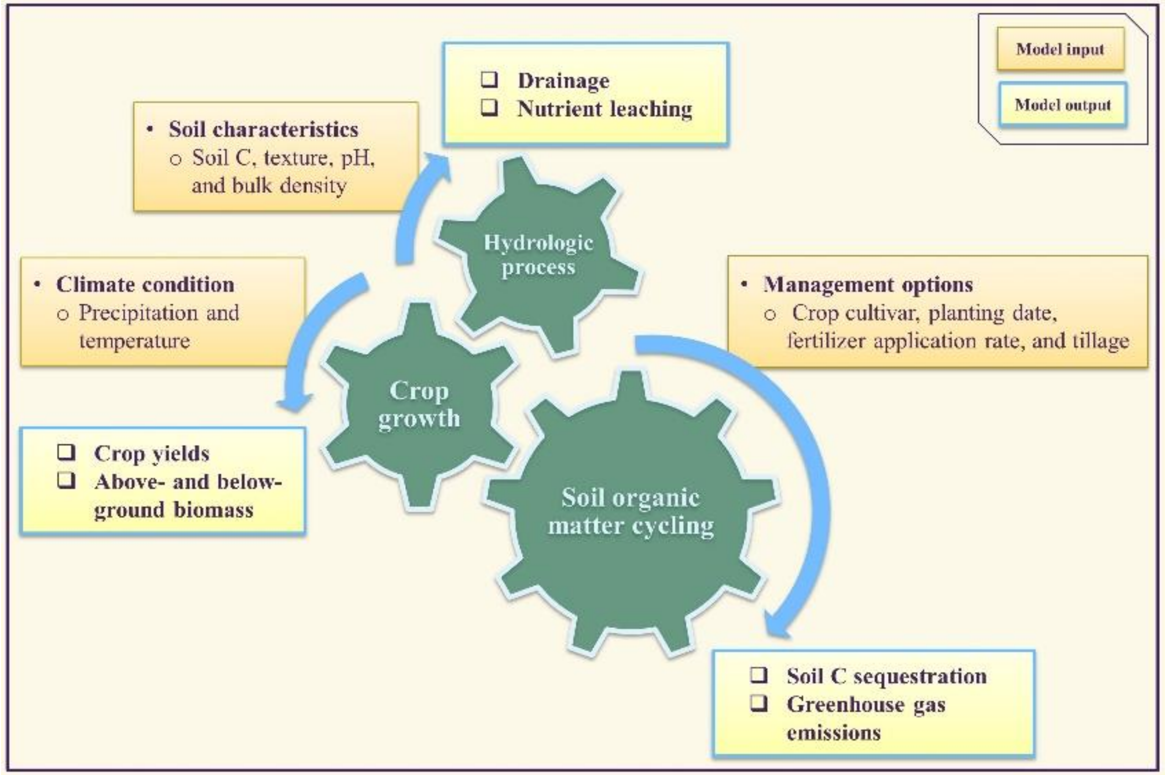


Modeling Framework

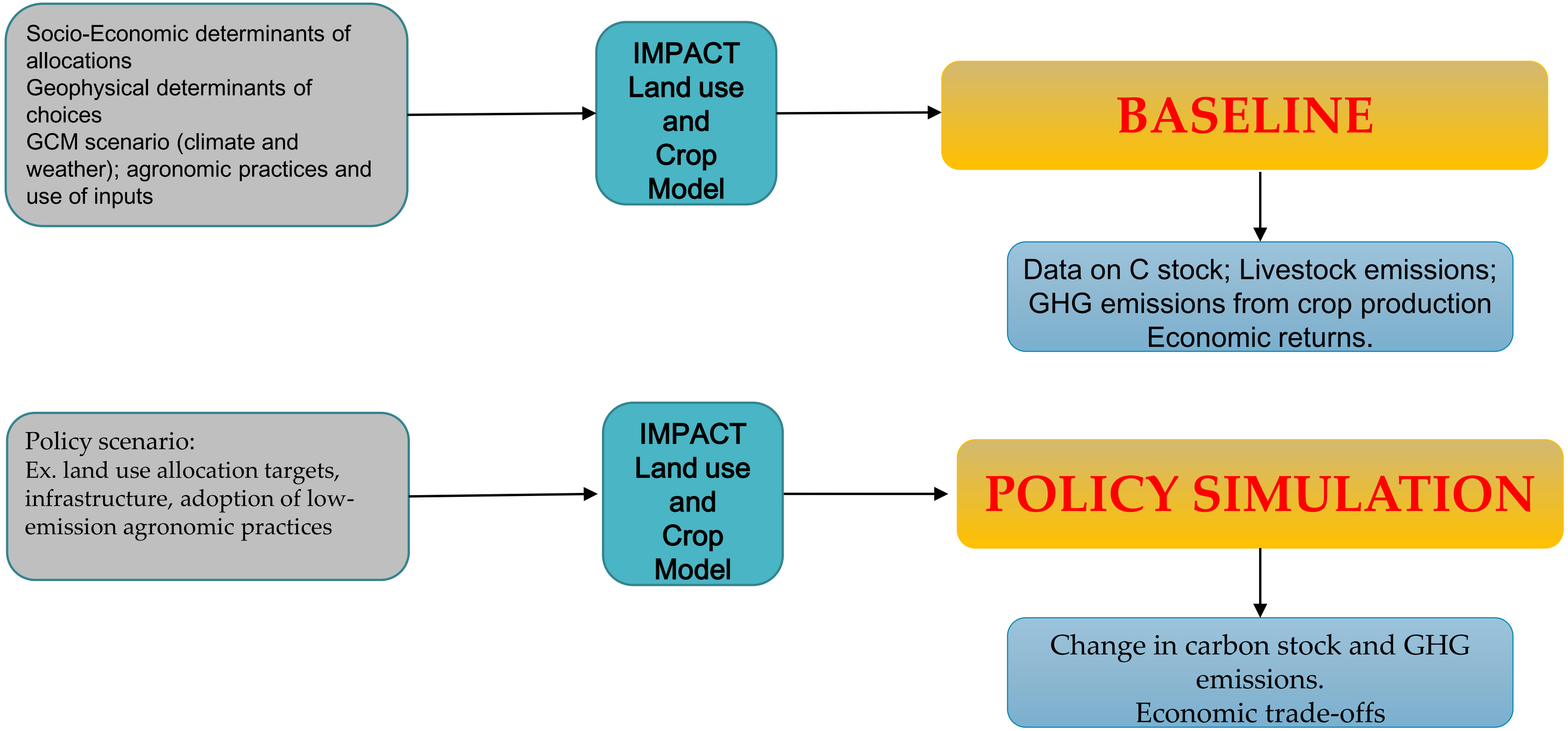


Crop Model – DeNitrification and DeComposition (DNDC)





Modeling Framework

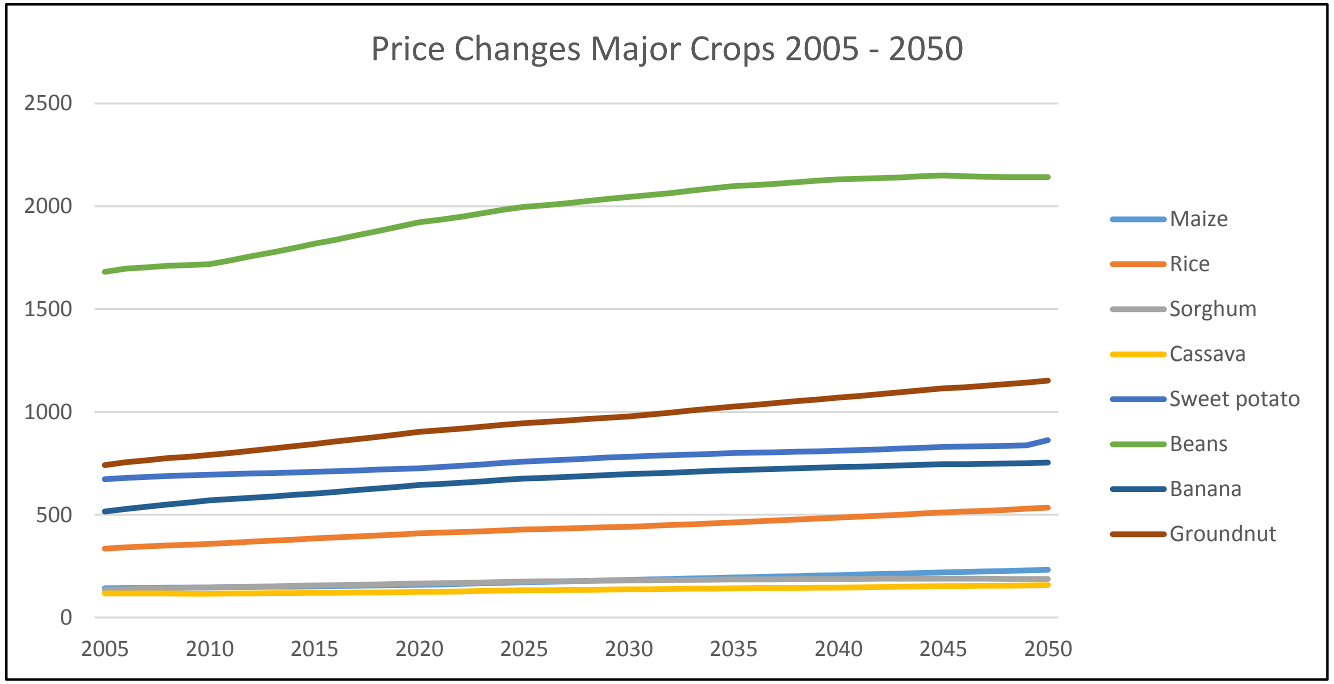


DATA NEEDS

Data Set for Land Use Model

- Data used
  - Observed land use choices, generally satellite or census data,
  - Explanatory variables: all the things we believe contribute to land use allocation decisions

Changes in Crop Prices: IMPACT Scenarios



Crops	Price 2005 ($UD/Ton)	Price 2050 ($UD/Ton)		% price change between 2005 and 2050
Maize	142	232		63%
Rice	335	534		59%
Sorghum	134	187		40%
Cassava	116	157		35%

Changes in Crop Prices and Areas: IMPACT Scenarios (Colombia)

Crop	Price 2010 (USD/ton)	Price 2050 (USD/ton)	Projected change in price (%)	Area 2010 (1,000 ha)	Area 2050 (1,000 ha)	Projected change in area (%)
Cacao	1,990	3,052	53%	180	192	7%
Coffee	1,723	2,524	46%	800	825	3%
Palm	24	49	107%	389	449	16%
Plantain	616	771	25%	467	533	14%
Other perennial	1,064	1,349	27%	180	324	80%
Cassava	121	228	89%	180	192	11%
Maize	119	238	100%	800	825	6%
Potato	267	354	33%	389	449	11%
Rice	649	1,049	62%	467	533	10%
Sugarcane	5	14	186%	180	324	57%
Other annual	940	1,115	19%	157	160	2%
Cow meat	4,449	4,999	12%	-	-	-
Cow milk	287	328	14%	-	-	-

Other Land Use model data needs

Variables	Year	Resolution	Source
Annual and perennial crop area	2008	Municipality	Ministerio de Agricultura y Desarrollo Rural
Price for crop and meat	2008	National	FAO
Timber price	2008-2010	Regional	Macia, 2014
Crop and cattle production cost		Regional	SIGOT
Crop suitability	2009	10 km resolution	Global Agro-ecological Zones (v1.0) Assessment by IIASA/FAO
Pasture area, forest area	2007	100m resolution	Leyenda Nacional de Coberturas de la Tierra (IDEAM, 2010b)
Elevation	2012	1 km resolution	Harmonized World Soil Database Version 1.2 (HWSD)
Terrain slope	2012	1 km resolution	HWSD V1.2
Soil PH	2012	10 km resolution	ISRIC-WISE
Annual precipitation	1980-2010	1 km resolution	Metrological data of Colombia
Mean annual temperature	1980-2010	1 km resolution	Metrological data of Colombia
Population density	2000	1 km resolution	Global Rural-Urban Mapping project by CIESIN/Columbia University/IFPRI, The World Bank, CIAT
Travel time to cities of 50,000 or more people	~ 2000	1 km resolution	JRC-IES-LRM
Inclusive values for cropland, forest and pasture			Derived from the estimation of the lower-level model
National parks	2012	250m	RUNAP / SINAP
Afrodescendent area (Tierras de comunidades negras)		250m	IDEAM

Data for crop model DNDC

Data	Source	Spatial resolution
Soil texture, soil C, pH, soil bulk density	FAO/IIASA/ISRIC/ISS-CAS/JRC (2012)	30 arc sec grid
Crop calendar	Sacks et al. (2010)	5 arc min grid
Inorganic N rate	FAO Fertistat (http://www.fao.org/ag/agp/fertistat/index_en.htm)	Country level
Tillage rate, residue incorporation rate, irrigation rate, rotation, potential yield (for sugarcane, cassava, potato, palm)	Agronet.gov.co, fedepapa.co, other local institutions	1-2 representative production areas for each crop
Precipitation and temperature	Marksim weather generator (www.ccafs-climate.org/pattern_scaling)	5 arc min grid

Country-specific Analyses

Examples from two countries that appear to be presently on two very different trajectories:

Colombia: Strong pressure for continued deforestation

Vietnam: Little, if any, pressure for deforestation

Country-specific Analyses

***"Broad"* targets:**

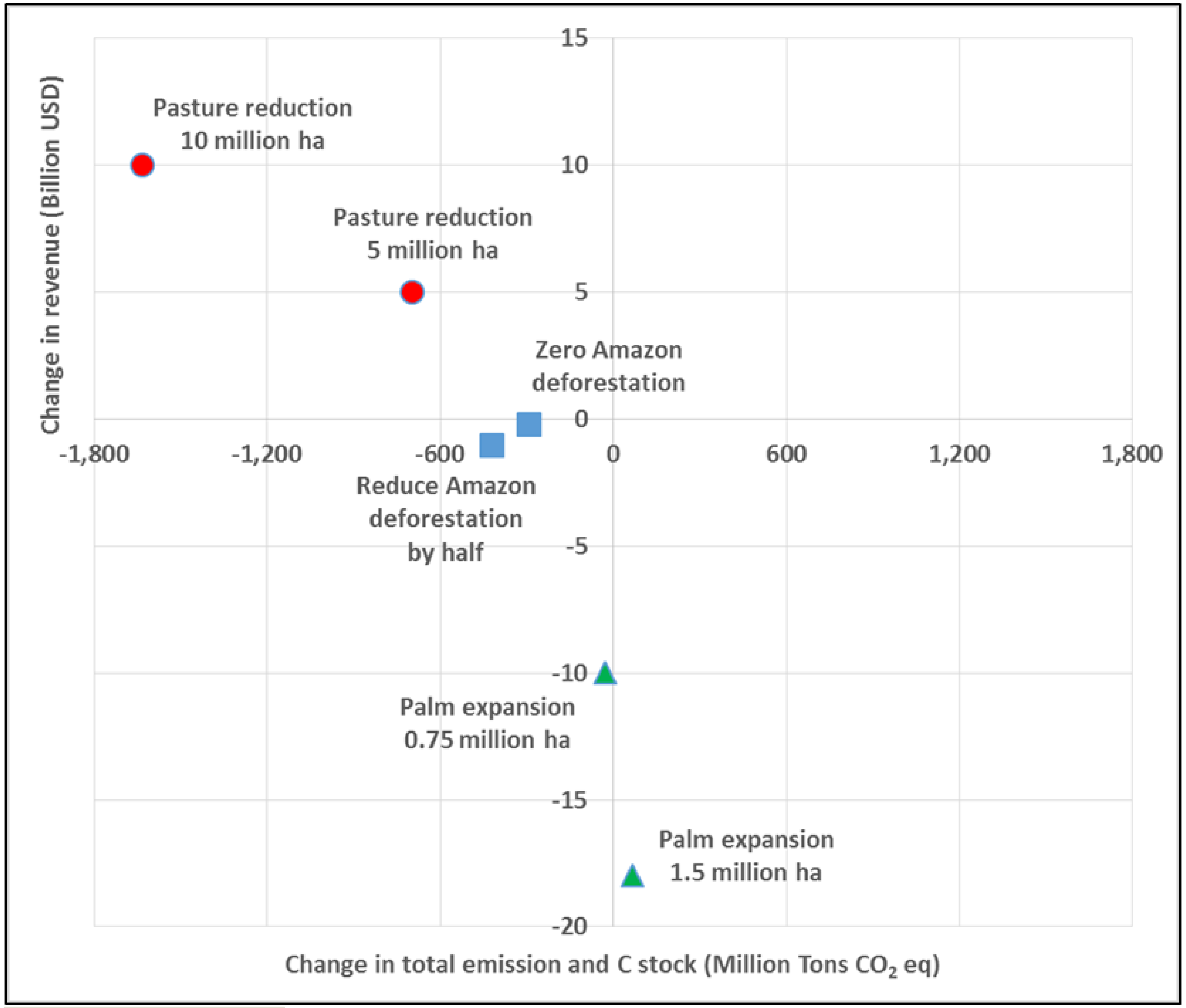
- Total forest cover increased to 45% of land area by 2030 – Vietnam
- Cropland allocated to rice cultivation kept constant at 3.8 million hectares - Vietnam
- Halt or reduce deforestation (50%) in the Amazon - Colombia
- Reduction of pastureland by 10 million hectares – Colombia
- Total land allocated to oil-palm production reaches a total of 1.3 million hectares – Colombia

***"Narrow"* targets:**

- Adoption of Alternate Wet and Dry (AWD) in rice paddy - Vietnam
- Replace conventional fertilizer in rice paddy with ammonium sulfate – Vietnam
- Introduce manure compost in rice paddy in place of farmyard manure - Vietnam

Policy Outcome Comparison - Colombia

Additional investigation is necessary but, results unmistakably indicate the centrality of the livestock sector in emission reduction policies.



Source: Authors

Policy Outcome Comparison - Vietnam

	Change C Stock ($Tg\ CO_2$ eq)	Change in GHG Emissions (Tg CO2 eq)	Change in Total Revenue (Billion USD)
Total forest cover increased to 45% of land area by 2030	513.8	-114.4	-6.6
Cropland allocated to Rice cultivation kept constant at 3.8 million hectares.	69.73	-68	-1.8
Adoption of Alternate Wet and Dry (AWD) in rice paddy:	0	-1550	-2.7
Introduce manure compost in rice paddy.	0	-260	-5.3
Replace conventional fertilizer in rice paddy with ammonium sulfate.	0	-102	1.2

Source: Authors

Downscaled Results

Three new directions

Vietnam, Zambia, Colombia

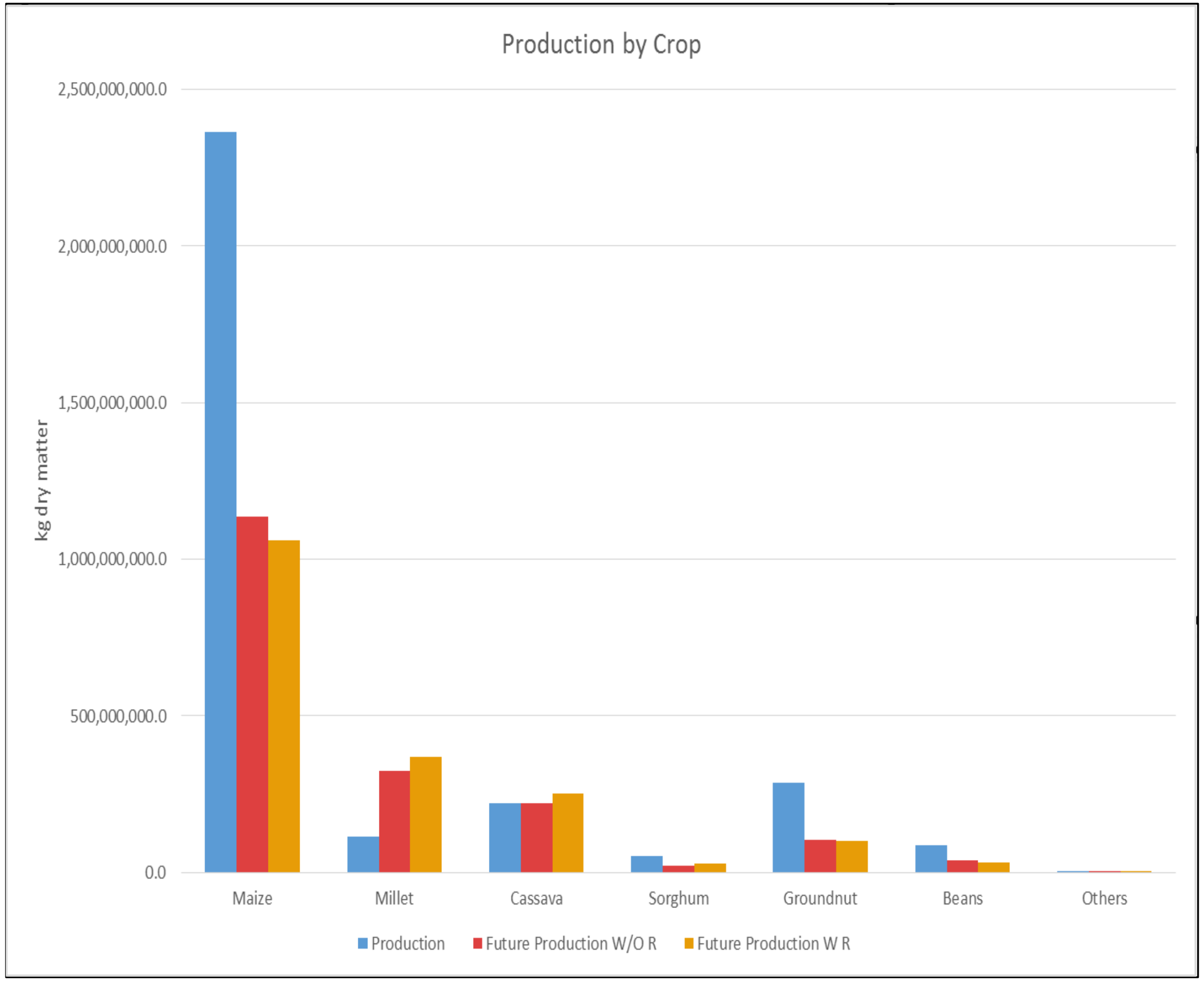
Optimal Climate-smart trajectories:

Pressure for land use change Ha Tinh and Yen Bai provinces

	Ha Tinh Province				Yen Bai Province			
Land use	Area 2009 (1,000 ha)	Area 2050 (1,000 ha)	Net change (1,000 ha)	Percent change	Area 2009 (1,000 ha)	Area 2050 (1,000 ha)	Net change (1,000 ha)	Percent change
Cropland	86.9	79.3	-7.6	**-9%**	48	62	15	**31%**
Mosaic cropland	134.1	119.6	-14.4	**-11%**	167	197	30	**178%**
Woody savannas	75.3	29.9	-45.4	-60%	246	94	-152	-62%
Forest	236.6	259.3	22.8	10%	378	464	86	23%
Shrub/grassland	11.9	18.5	6.5	55%	9	17	8	94%

Upscaling analysis from household level data

Simulating the aggregate effects of crop choices by individual risk-averse farmers due to climate change.



Colombia

- Household-level analysis of land use choices in post-conflict areas
- De-funded (CCAFS): LEDS across scales

Thank you

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