Methodological Tools to Address Mitigation Issues

Presented by:

Alex de Pinto, IFPRI

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Alex De Pinto

IFPRI

Dakar

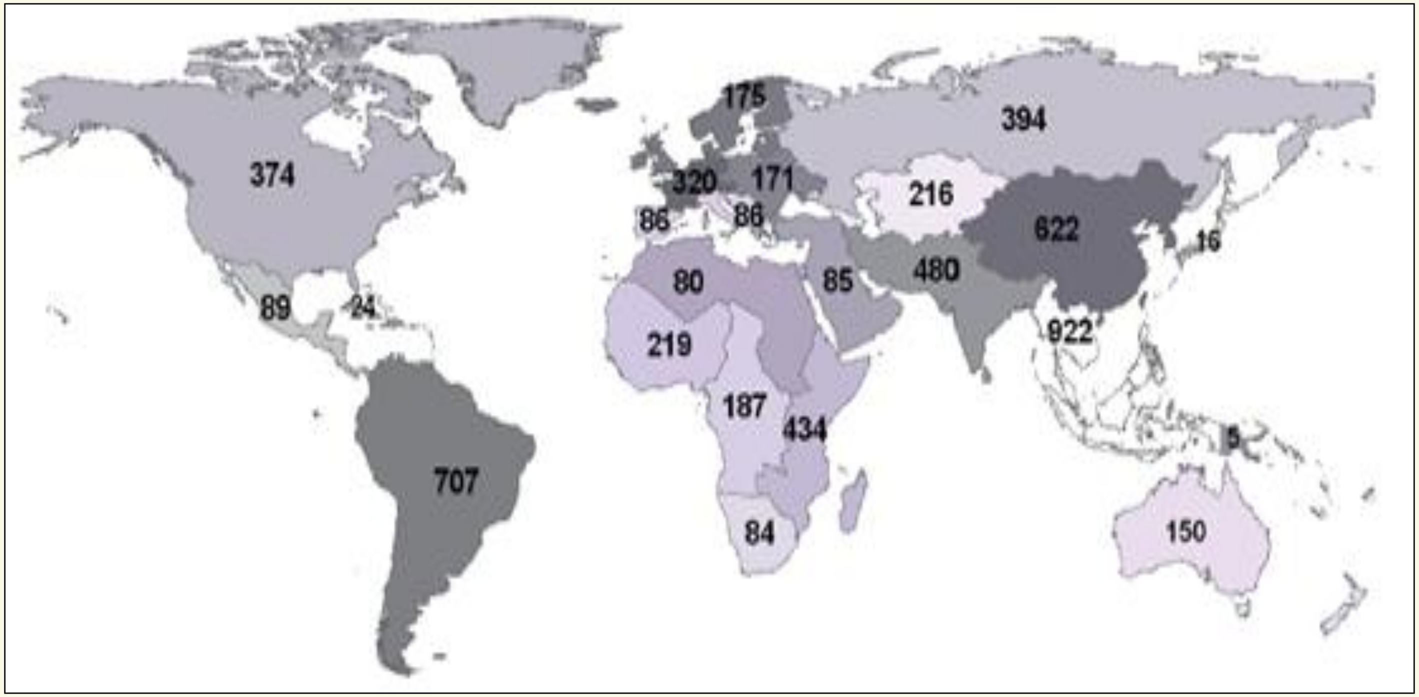
June, 2011

Agriculture is net emitter of GHG

- Agriculture emits an estimated 14% of total GHG emission

  - Fertilizers and soils (nitrous oxide or N2O)
  - Livestock (methane/CH4)
  - Rice production (methane/CH4)
  - Soil ‘mining’ (depleting soil C)/Land degradation
  - Drying of peat and wetlands for agriculture

Global mitigation potential in agriculture



Total technical mitigation potentials (all practices, all GHGs: MtCO2-eq/yr) for each region by 2030.
Note: based on the B2 scenario though the pattern is similar for all SRES scenarios.
Source: Smith et al. (2007a).)

Agriculture's GHG emissions are large, but shares differ by region

Region	Total GHG emissions (Mt CO_2e)	Share from agriculture	Share from land-use change and forestry
Europe	7,600	9.1	0.4
North America	7,208	7.1	-4.7
South America	3,979	23.6	51.6
Sub-Saharan Africa	543	12.7	60.4
Asia	14,754	14.4	26.8
Developing countries*	22,186	15.7	35.6
World	40,809	14	18.7

Source: WRI CAIT, 2009

* - Non Annex 1 countries

Agriculture can play a role in mitigating climate change

- Modifying and introducing agricultural practices so that:
  - Sequester CO_2 from atmosphere and store it soils
  - Reduce GHG emissions
- CO_2 sequestration, and in part methane emission reduction, is generally considered more viable than N_2O reductions

Challenges and Opportunities

- Opportunities
  - Help small poor farmers dealing with the effects of climate change
  - Provide farmers with an additional source of income
  - Food security and resilience
- Challenges
  - Uncertainty

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Co-benefits of mitigation

- Positive correlation between soil C and crop yield. Some agricultural practices improve soil fertility and induce C sequestration
- More efficient water use (reduces CO_2 from fuel/electricity) and methane from rice paddy
- Agricultural R&D, advisory services, and information systems

Constraints to climate change mitigation using agriculture

- Growing literature on the barriers to access carbon markets:
  - Defining the baseline
  - Evidence of additionality
  - Cost-effectiveness
  - High transaction costs
  - Property rights
  - Leakage
  - Permanence

Biophysical (Defining the baseline; Evidence of additionality)

Socioeconomics (Cost-effectiveness; High transaction costs; Property rights)

Modeling Tools (Leakage; Permanence)

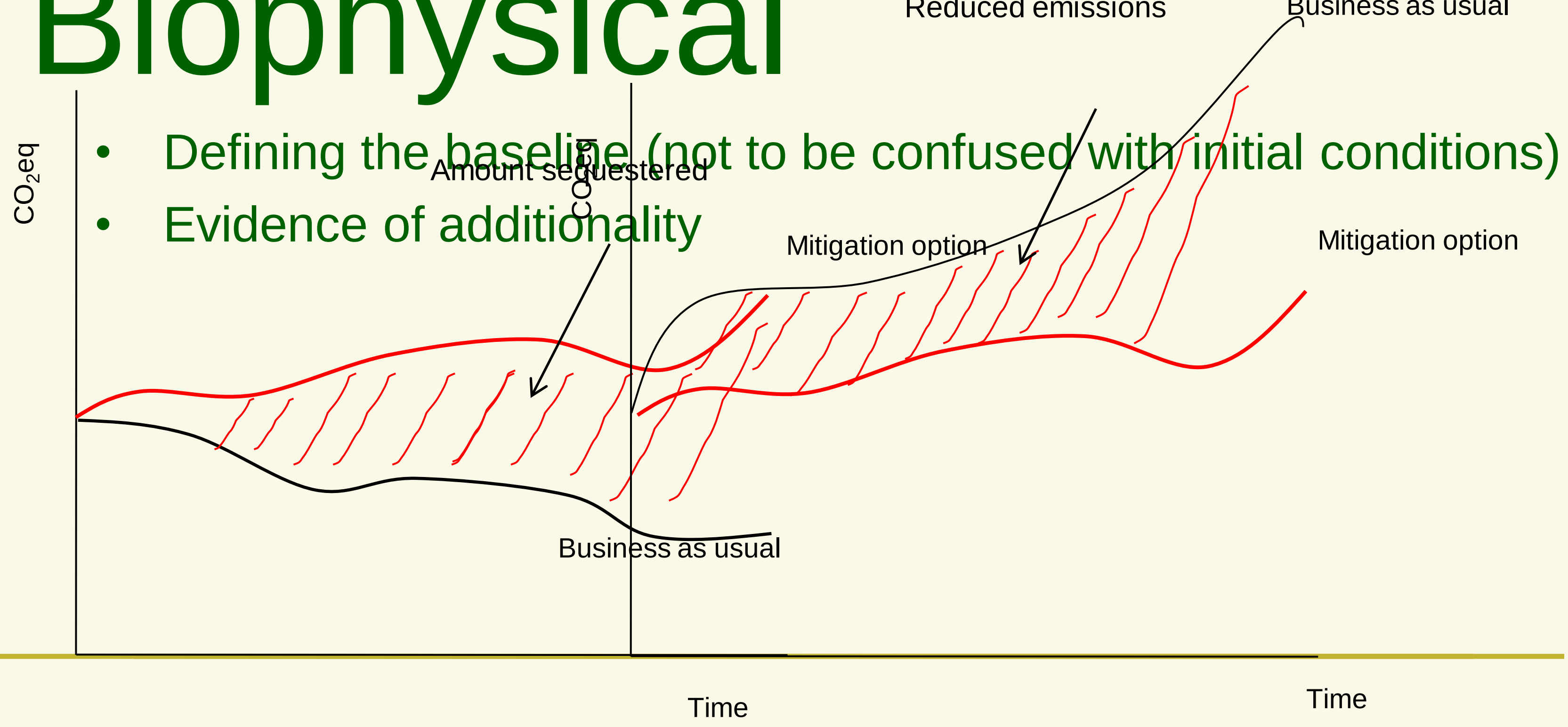
Defining the Baseline and Evidence of Additionality

- Requirements:
  - Knowledge / quantification of how different agronomic practices and different crops affect GHG emissions (DSSAT/Century, CropSys, EPIC)
  - Capability of "reasonably" predict future land-use choices, crop choices, agronomic practices (surveys, models of land-use change)

Constraints to climate change mitigation using agriculture

Biophysical

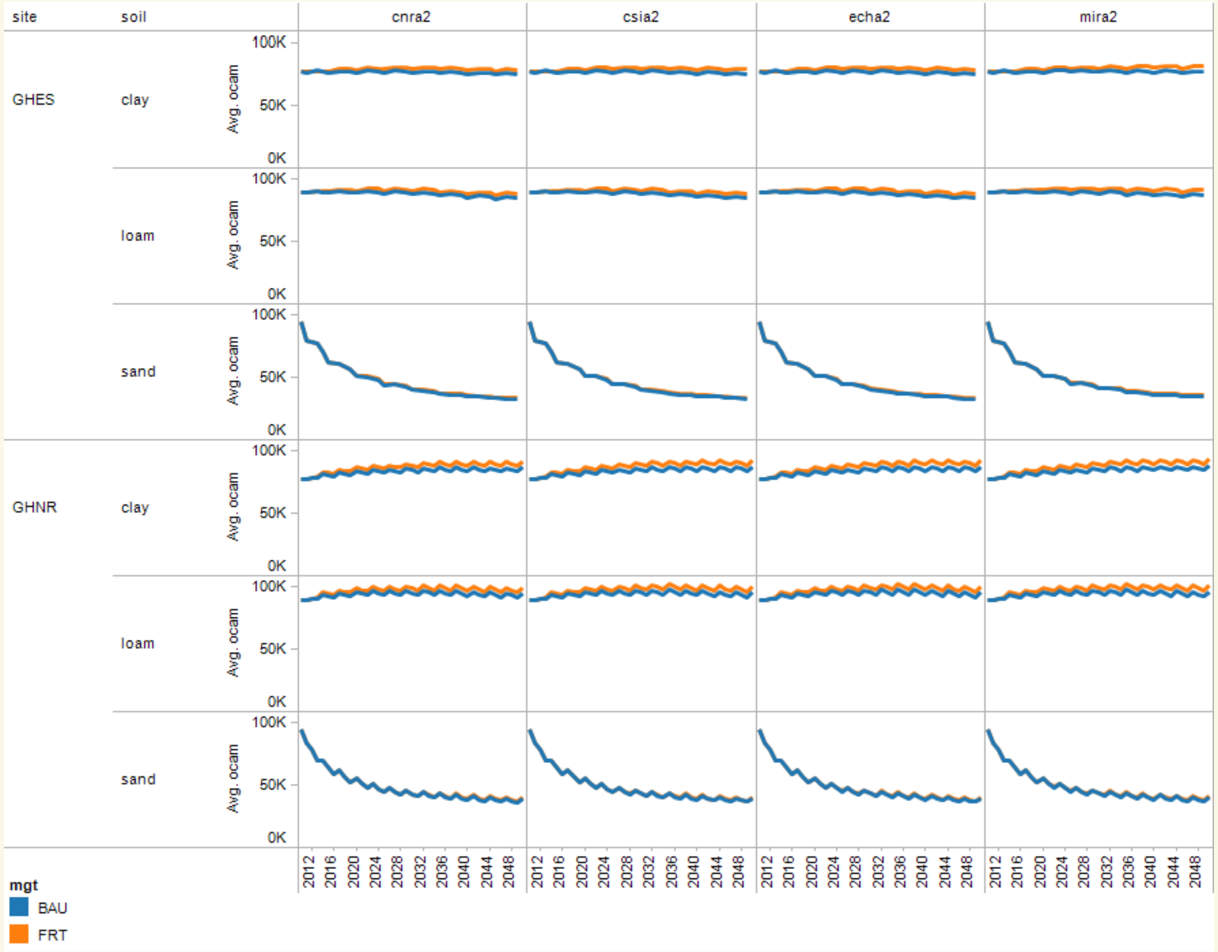
- Defining the baseline (not to be confused with initial conditions)
- Evidence of additionality



The Case of Ghana

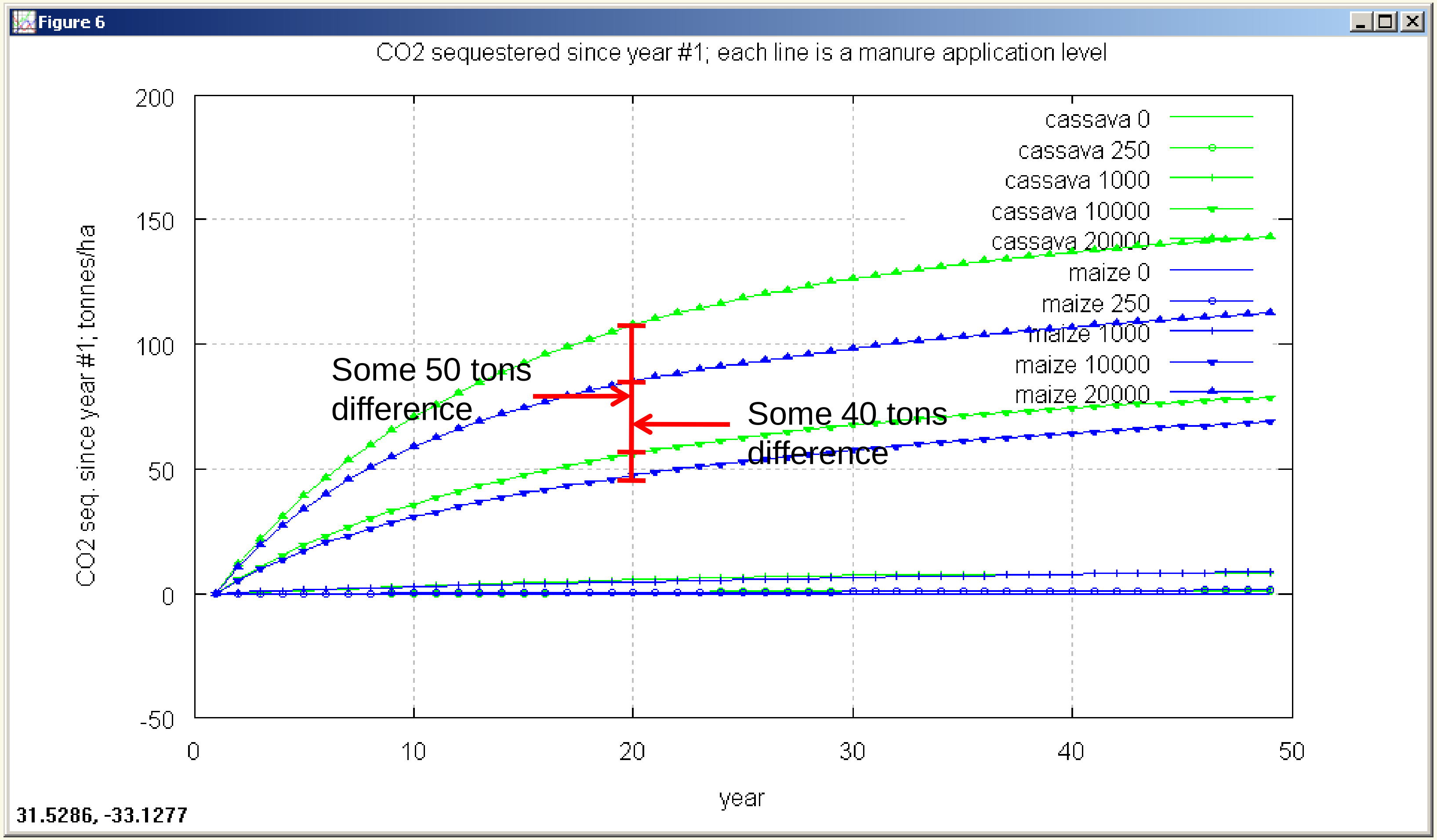
Province	Most Common Cropping system/rotation	Most Common Cropping system/rotation	Mitigation Options
Ashanti	Maize, cassava, 2 years fallow		No- burning/Manure/recommended amount of fertilizer
Brong Ahafo	Maize, cassava, 2 years fallow	Yam, 2 years fallow	No- burning/Manure/recommended amount of fertilizer
Central	Maize, cassava, 2 years fallow		No- burning/Manure/recommended amount of fertilizer
Eastern	Maize, cassava, 2 years fallow Evolving into oil palm		No- burning/Manure/recommended amount of fertilizer
Greater Accra	Tomato, watermelon, maize	Tomato, watermelon, maize	Manure/recommended amount of fertilizer/no-till
Northern	Yam, maize, groundnuts, 1 year fallow		Manure/recommended amount of fertilizer
Upper East	Sorghum, groundnuts, maize, fallow	Millet, groundnuts, sorghum, fallow	Manure/recommended amount of fertilizer
Upper West	Sorghum, groundnuts, maize, fallow	Maize, groundnuts, sorghum, fallow	Manure/recommended amount of fertilizer
Volta	Maize, cassava, 2 years fallow	Yam, 2 years fallow, maize, cassava, 2 year fallow	No- burning/Manure/recommended amount of fertilizer
Western	Maize, cassava, Evolving into cocoa		

The Case of Ghana



Source: own simulations with DSSAT

The Case of Ghana



Source: own simulations with DSSAT

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Defining the Baseline and Evidence of Additionality

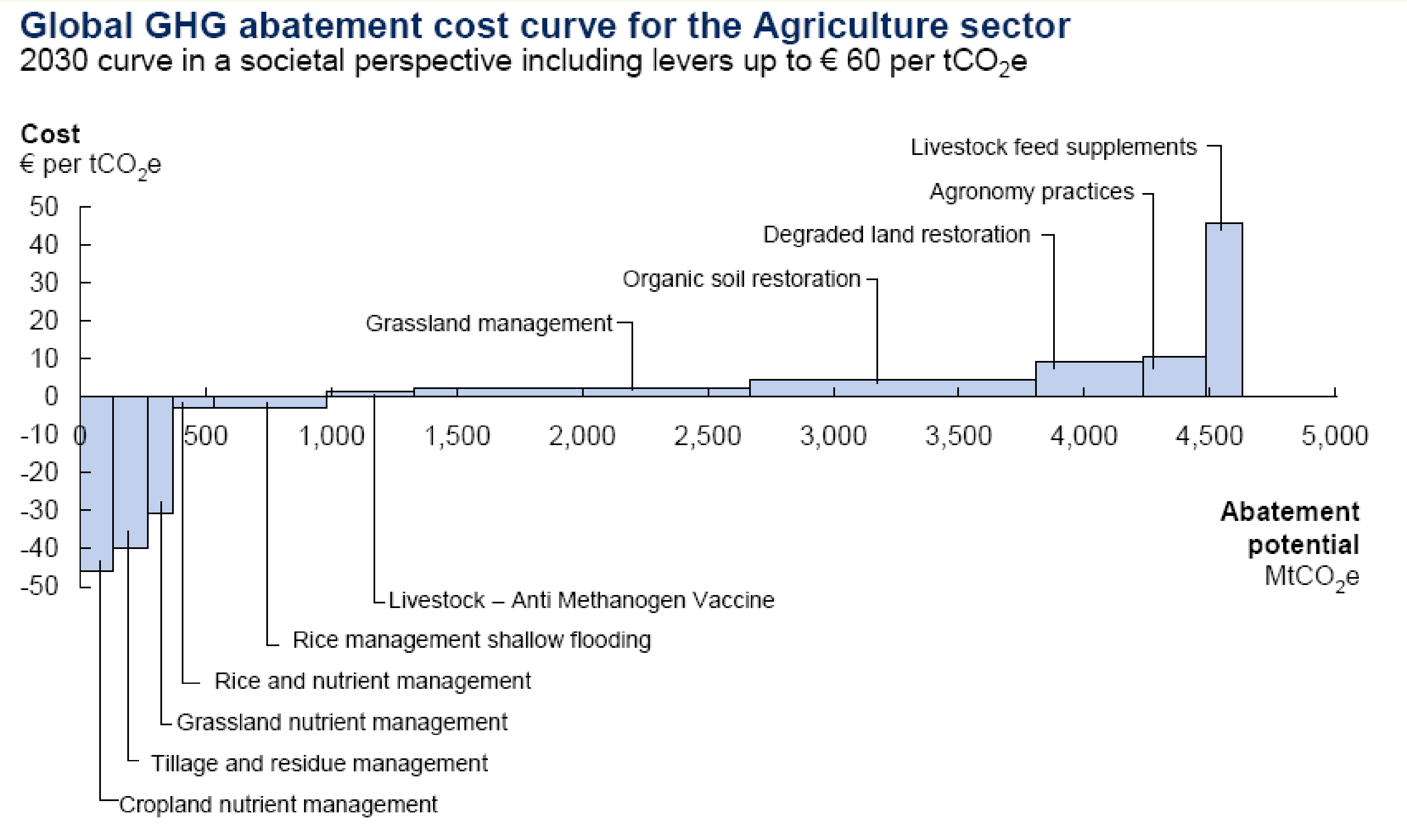
- Certain practice/crops “deliver” in terms of mitigation, but
- Tremendous level of uncertainty
- Can we reduce it?
- What is the level of certainty necessary for the private sector?
- What is the level of certainty necessary for the public sector/intl. organizations?
- Predictability IS A MUST

Constraints to climate change mitigation using agriculture

Socioeconomics

- Cost-effectiveness
- High transaction costs
- Property rights

Cost-effectiveness and Adoption of Mitigating Measures



Source: McKinsey (2009) - Pathways to a low-carbon economy *Version 2 of the Global Greenhouse Gas Abatement Cost Curve*

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Cost-effectiveness and Adoption of Mitigating Measures

- Effectiveness depends on the goal
- If goal is reduction of *X* tons of CO^2eq: one set of choices
- If goal is to make agriculture carbon neutral: a different set of choices

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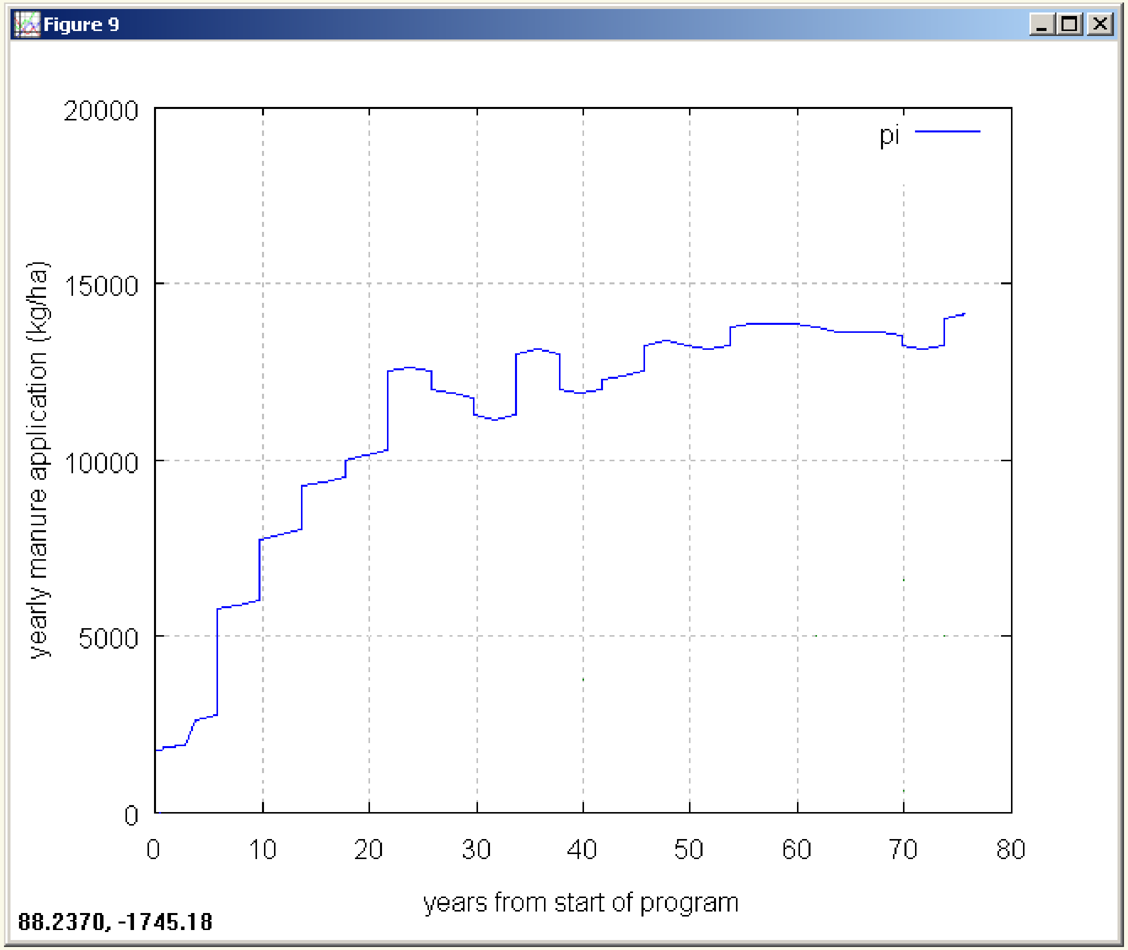
Cost-effectiveness and Adoption of Mitigating Measures

Transition to profitability
in time.
Cassava, min. tillage,
Chicken manure applications



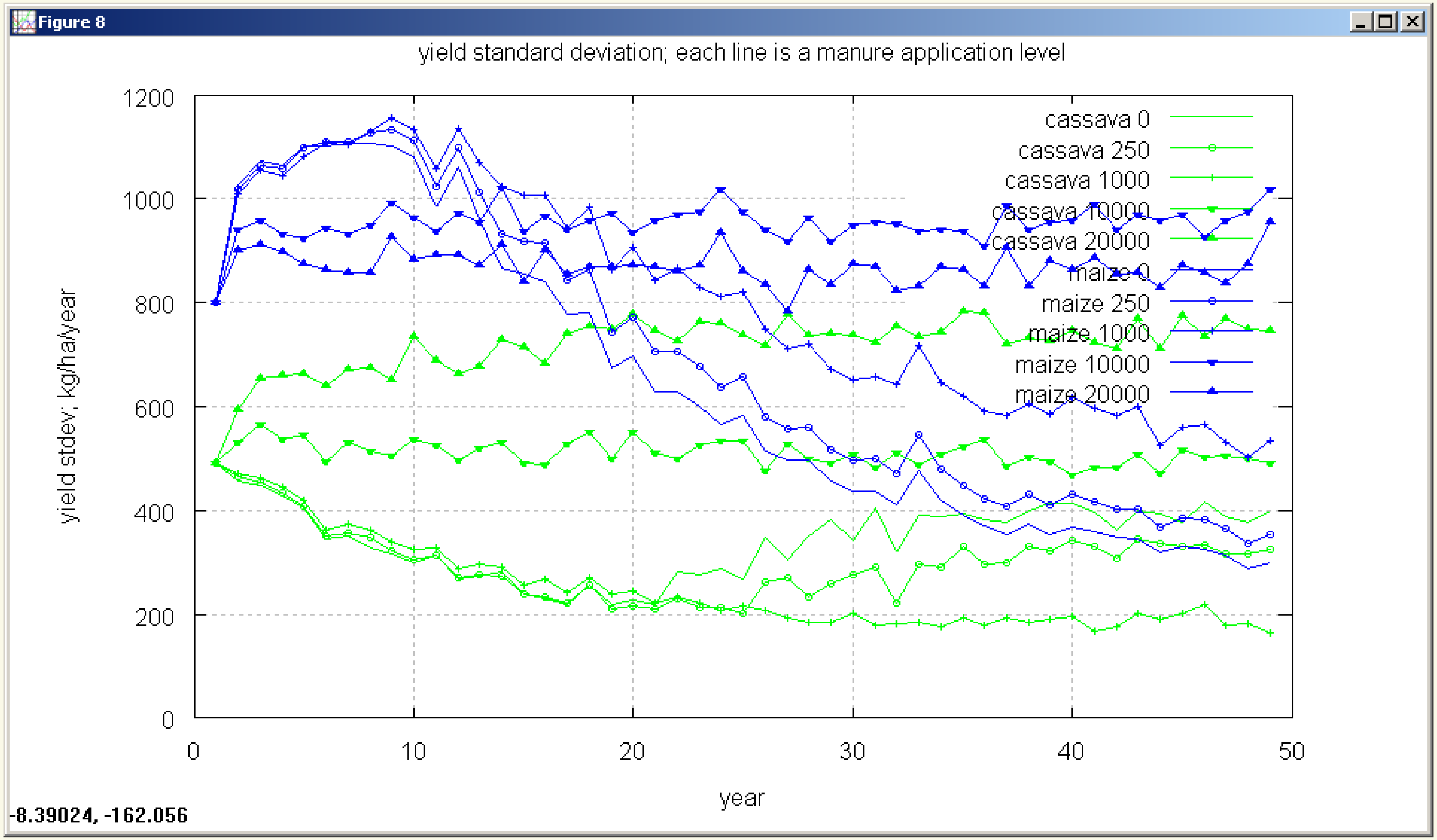


Figure 8
yield standard deviation; each line is a manure application level
yield stdev; kg/ha/year
year
cassava 0
cassava 250
cassava 1000
cassava 10000
cassava 20000
maize 0
maize 250
maize 1000
maize 10000
maize 20000
1200
1000
800
600
400
200
0
0
10
20
30
40
50
-8.39024, -162.056

Role of Uncertainty and Risk

- There is plenty of evidence that farmers are not likely to be neutral to risk and actually tend to be risk averse (Antle 1987; Chavas and Holt 1990; Bar-Shira, Just, and Zilberman 1997; Hennessy 1998; Just and Pope 2002; Serra et al. 2006; Yesuf and Bluffstone 2007)
- and that risk considerations affect input usage and technology adoption (Just and Zilberman 1983; Feder, Just, and Zilberman 1985; Kebede 1992).
- Risk considerations should not be ignored in the analysis of adoption of carbon sequestration practices.

Mean-Standard Deviation Utility Function

- We follow Saha (1997) and we assume that farmers' preferences can be represented by a mean-SD utility function $V(\mu,\sigma) = \mu^{\theta} - \sigma^{\gamma}$
- Changing γ change risk attitude
- Under the assumption of risk aversion, decreasing (constant) [increasing] absolute risk aversion preferences require $\theta > (=)[<]1$
- Decreasing (constant) [increasing] relative risk aversion is denoted by $\theta > (=)[<]\gamma$

The simulation settings

- We used the DSSAT crop modeling system to simulate maize yields and soil carbon content.
- Cropping system maize and with fallow ground for twenty years.
- Daily weather data simulated using DSSAT's
- Record the yield and soil carbon content repeated 100 times using a different random seed each time: obtain an estimate of yield variability
- Through this series of simulations we obtain yields, yield-variability, as well as the soil carbon content at the end of the 20 year period.

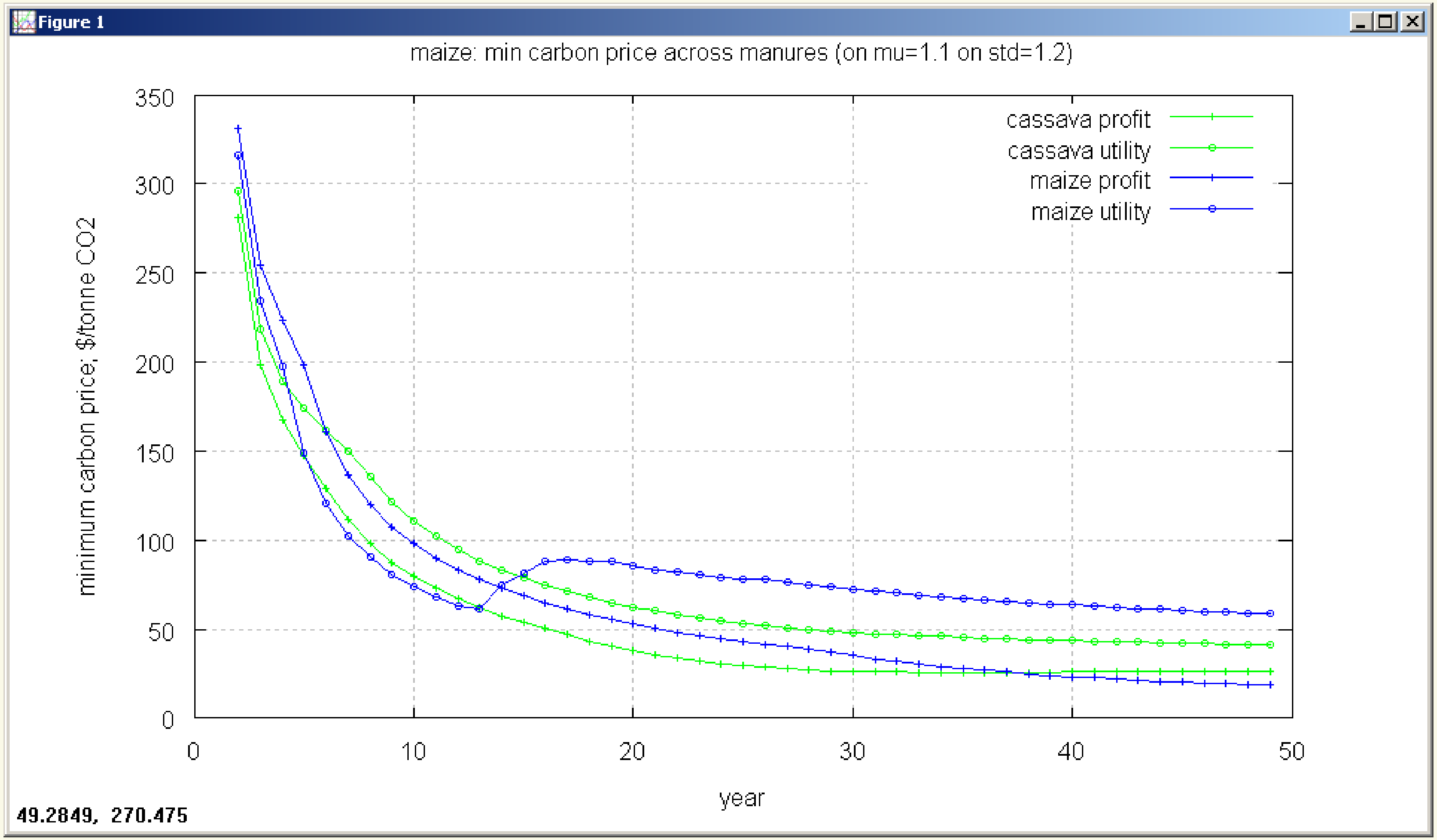


Figure 1
maize: min carbon price across manures (on mu=1.1 on std=1.2)
minimum carbon price; $/tonne CO2
350
300
250
200
150
100
50
0
0
10
20
30
40
50
year
cassava profit
cassava utility
maize profit
maize utility
49.2849, 270.475

Considerations

- Risk-neutrality hides some of the complexities of implementing payment for environmental service schemes
- Per-hectare payment schemes can be very inefficient: Antle et al. (2003).
- Could save money proposing the “right practices” to the “right” farmers

Challenges

- Implementation challenges
  - costs involved in organizing farmers (aggregation process)
  - costs of empowering farmers with the necessary knowledge
  - costs of Monitoring, Reporting and Verification (MRV)
- ***Review and analysis of institutional structures***
  Assess current policies and institutions affecting access of the rural poor to carbon markets. Institutions will include the potential of various supply chains, producers of high value export crops, non-governmental organizations (NGOs), and farmer organizations as aggregators and disseminators of management system changes and measurement technologies

Constraints to climate change mitigation using agriculture

Modeling Tools

- Leakage
- Permanence

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- REDD: the use of forested land is intimately connected to other land uses.
- Historical data are not sufficient to predict the future (the case of the forest in the Congo basin), simple extrapolation from historical deforestation trends may underestimate future deforestation rates.
- Countries are part of a global economic system, where prices that farmers face reflect developments that range from changes in national investment policies and global trade flows. Mitigation policies are to be devised based both on national characteristics and needs, and with a recognition of the role of the international economic environment.

- GTAP, DREAM, IMPACT
- REDD, and mitigation efforts require a higher level of spatial disaggregation that these models currently offer

IFPRI Approach

- Combines and reconciles
  - 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.
- Essential components are:
  - a spatially-explicit model of land use which captures the main drivers of land use change
  - the core IMPACT model, a global partial equilibrium agriculture model that allows policy and agricultural productivity investment simulations;
  - the SPAM spatially-explicit data set of agricultural area and production by various management systems, and
- For a more accurate representation of the effects of climate change we might also have to use:
  - a hydrology model at high spatial resolution;
  - a water model that incorporates supply and demand drivers of water use;
  - the DSSAT crop model suite that estimates yields with varying crop genetic productivity shifters, management systems and climate change scenarios.

The use of this modeling environment provides detailed country-level results that are embedded in a framework that enforces consistency with global outcomes.

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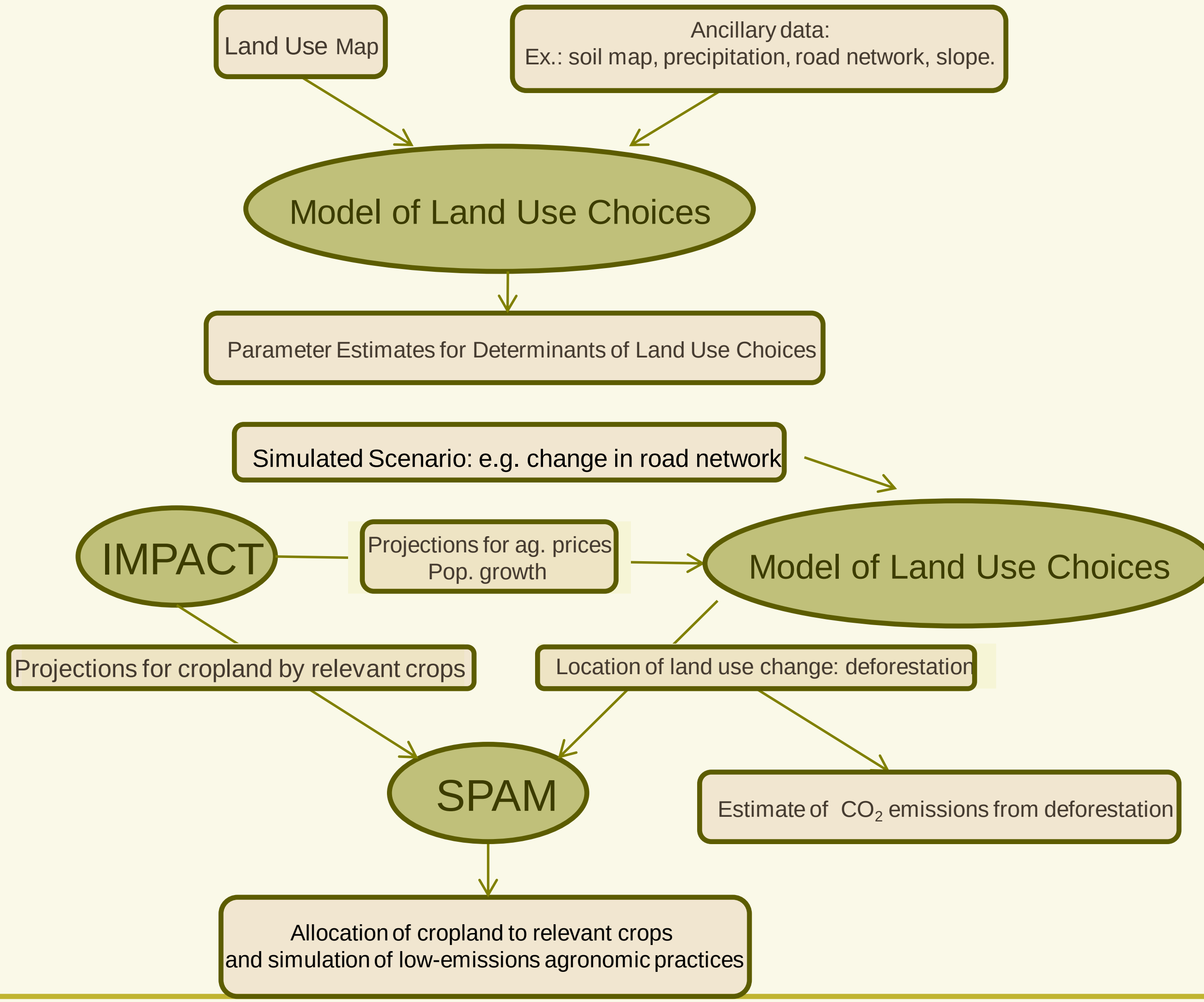
Models Currently Working as Separate Entities Can Work Together



Conclusions