Role of agricultural research in mitigation of climate change in LAC region

By

CIAT and its partners

Workshop

Climate change and mitigation in agriculture
in Latin America and the Caribbean: Investments and actions
Rome, 19-20 April, 2010

Outline

- Agriculture in LAC
- Agriculture and mitigation of climate change
- Role of research in improving eco-efficiency of agriculture
- Three major agroecosystems of LAC
- Best bet eco-efficient agricultural options
- Need for future investments for agricultural mitigation of climate change

Importance of LAC

- Latin America and the Caribbean - LAC - conformed by more than 30 countries and with a population close to 600 million people (less than 10% of the world population) has 23% of the world's arable lands, 31% of its water resources, 23% of its forests and 46% of its tropical forests.
- LAC is an actor of increasing importance in the global food supply.
- LAC has an enormous potential to contribute to its own and global food security and sustainable and equitable development, and that the agricultural research for development - ARD - is essential to achieve it.

Agriculture in LAC

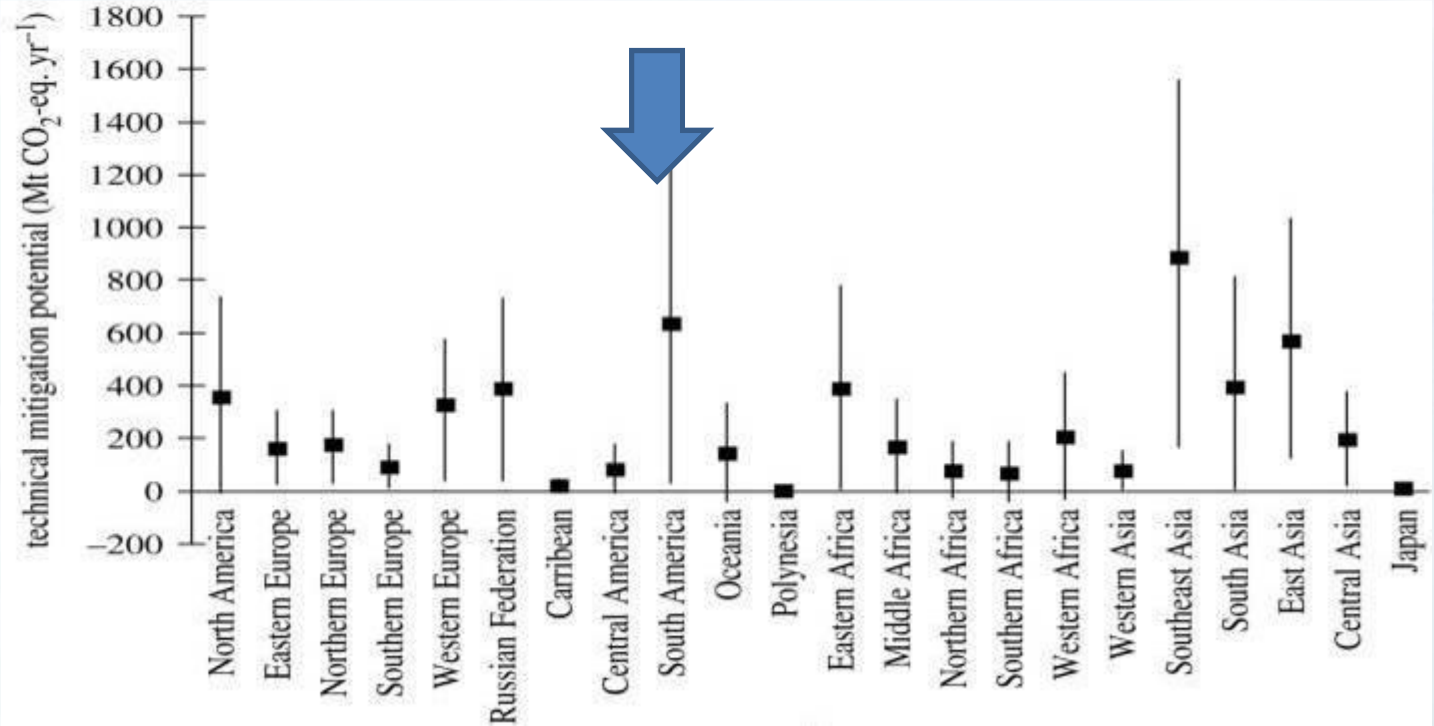
- The agricultural environments of Latin America and the Caribbean (LAC) are highly diverse in their resource endowments, production systems, and market orientation.
- Within LAC, there has been complete evolution from agriculture-based through transforming to urbanized economies.
- Research for development efforts made in LAC for generating global public goods are not only highly relevant to its own agricultural development but also are likely to be useful in many parts of Africa and Asia.

Agriculture and mitigation of climate change

- Agriculture is the human enterprise that is most vulnerable to climate change.
- Tropical subsistence agriculture is particularly vulnerable, as smallholder farmers do not have adequate resources to adapt to climate change.
- Agroforestry systems and crop-livestock systems may play a significant role in:
  - Reducing emissions and mitigating the atmospheric accumulation of greenhouse gases (GHG).
  - Help smallholder farmers adapt to climate change.

Total biophysical mitigation potentials (all practices) for each region by 2030:

best estimate using the mean per-area mitigation potential (square)
range of estimates derived using the low- and high-per-area mitigation potentials (line)



B1 scenario shown though the pattern is similar for all SRES scenarios

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Smith P et al. Phil. Trans. R. Soc. B 2008;363:789-813

Components of eco-efficient agriculture

- Eco-efficient agricultural production uses resources more efficiently to produce more food, enables family farms to be more competitive, and delivers sustainable increases in productivity, while avoiding natural resource degradation and negative externalities.

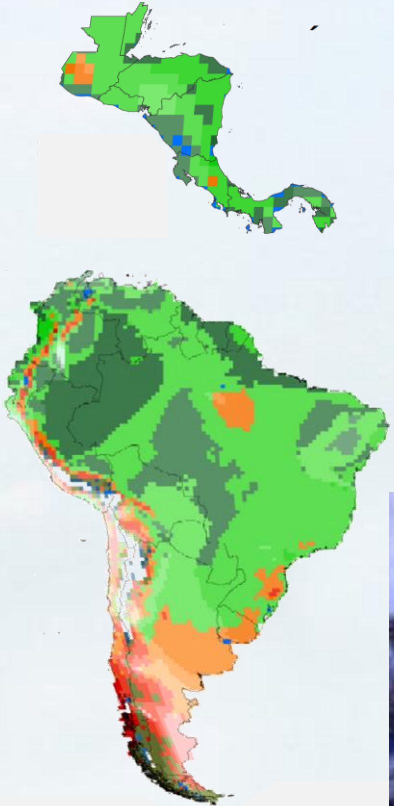
Environmental

Social

Economic

Three major tropical agroecosystems in LAC

Hillsides (96 Mha)



Savannas (250 Mha)

Forest margins (44 Mha)

Agroecosystems in LAC

- Tropical hillsides and lowlands are the most important agroecosystems of LAC. They sustain a large rural population.
- Hillsides cover three quarters of all land in southern Mexico, Central America and parts of the Caribbean region.
- Andean hillsides cover 96 million ha (Mha) in Peru, Ecuador, Colombia and Venezuela. They constitute the main source of water, forest and biodiversity for lowlands and are the main resource for domestic food supply of maize, beans, potatoes and cassava.
- With over 250 Mha, savannas represent one of the last frontiers in the world for agricultural expansion of integrated crop-livestock systems.
- Of the 300 Mha of the Amazon basin, 44 Mha cover the forest margins agroecosystem with livestock production as a major land use.

Best bet eco-efficient agricultural systems in LAC

Agroecosystem

- Hillsides: Quesungual agroforestry system
- Savannas: Agropastoral systems with minimum till
- Forest margins: Systems to recuperate degraded pastures

Hillsides:
Quesungual Slash and Mulch Agroforestry System (QSMAS)

Is a smallholder production system with a group of technologies for the sustainable management of vegetation, soil and water resources in drought-prone areas of hillside agroecosystems of the sub-humid tropics.

QSMAS integrates local and technical knowledge and provides resource-poor farmers an alternative to replace the non-sustainable, environmentally unfriendly slash and burn (SB) traditional production system..

Quesungual Slash and Mulch Agroforestry System

- Evaluated in collaboration with MIS consortium of Central America with funds of the CPWF of CGIAR
- Practiced in Honduras by over 6,000 farmers in around 7,000 ha, as an alternative to the slash and burn system
- Agricultural and environmental benefits:
  - ✓ Food security: increased resilience, productivity, sustainability and profitability
  - ✓ Water: improved availability and quality for human consumption, agriculture and energy
  - ✓ Biodiversity: maintenance and recovery of local species in around 60,000 ha
  - ✓ Environmental quality: elimination of burning; mitigation of deforestation, land degradation and GHG emissions; increasing C sequestration
- Needs to be evaluated in other suitable tropical areas for improving livelihoods and protecting the environment in the face of climate change

Four basic principles of QSMAS

1. **No slash & burn**
   Management (partial, selective, and progressive slash-and-prune) of natural vegetation

2. **Permanent soil cover**
   Continual deposition of biomass from trees, shrubs and weeds, and through crop residues

3. **Minimal disturbance of soil**
   No tillage, direct seedling, and reduced soil disturbance during agronomic practices

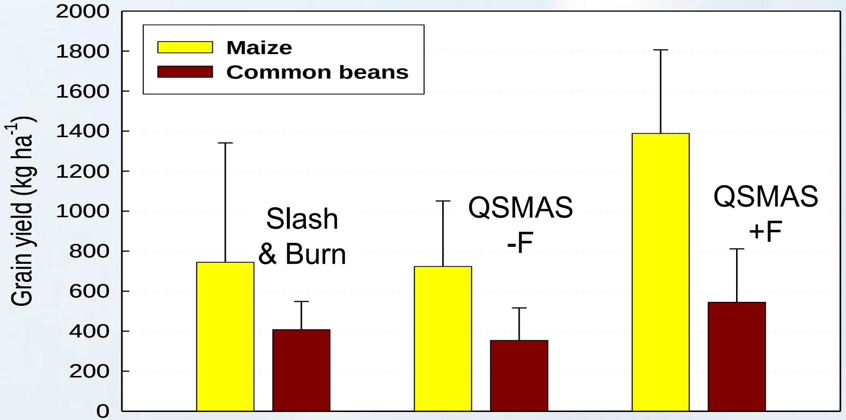
4. **Efficient use of fertilizer**
   Appropriate application (timing, type, amount, location) of fertilizers

QSMAS implies:

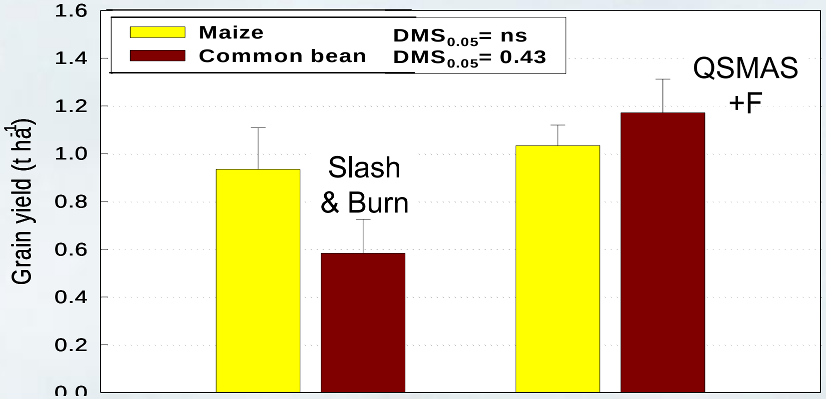
- **Secondary forest:** 7-10 years of natural regeneration of native vegetation
- **Productive plot (10-12 years):**
  - Selective, partial and progressive slash and prune of trees and shrubs
  - Firewood extraction and biomass dispersion
  - Direct seeding of maize, sorghum and/or common bean
  - Fertilization
  - Weeding
  - Harvest leaving crop residues

Productivity & profitability (2005-2006)

- **Honduras:**
  - Crop productivity: maize ⇧42%, common bean ⇧38%

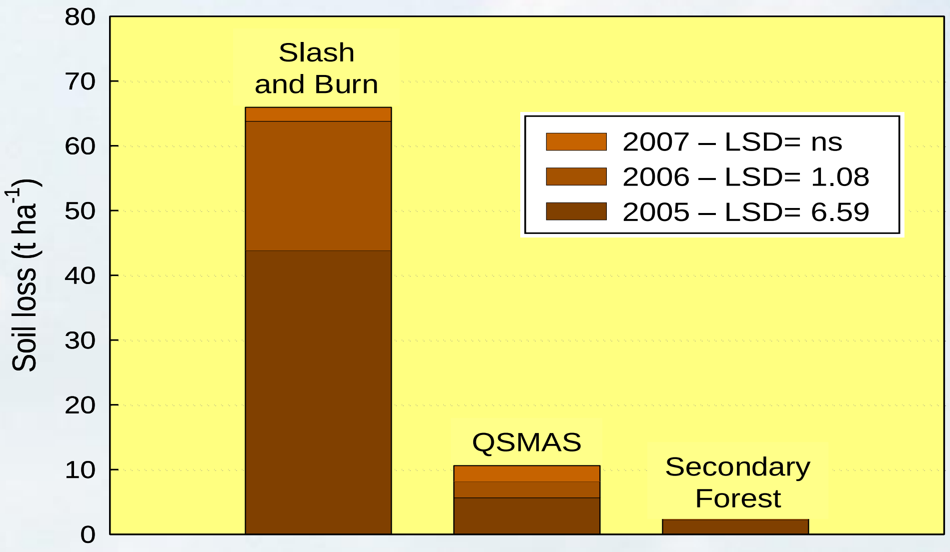


- **Nicaragua:**
  - Net income maize + common bean = ⇧83% (vs. SB)



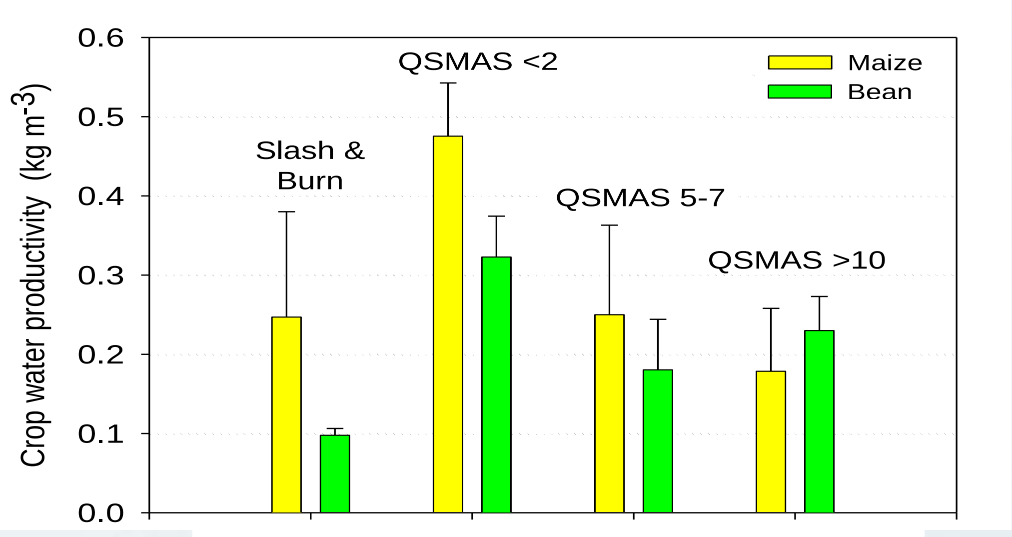
Soil losses (2005-2007)

- **QSMAS (average of fertilized plots):**
  - ✓ 2005-2006: 7.5 times lower than SB
  - ✓ Loss of N, P, K are around 10 times higher in SB system



Crop Water Productivity

- **Honduras (2007):**
  QSMAS improves crop water productivity compared to SB



- **Crop yield and soil water data obtained in 2007**
- **ET estimated according to the method of Penman and Monteith (FAO, 1998).**

Greenhouse gas (GHG) fluxes

- **QSMAS farms:**
  - Relatively low emission of nitrous oxide (N_2O)
  - Sink for methane (CH_4)
  - C sequestration (SOC)

- **Global Warming Potential (GWP) where QSMAS is practiced:**
  - 12 municipalities, 67,000 inhabitants
  - 1143 km^2

Payment for Environmental Services

Provisioning services:	Food security through improved: • Crop water productivity and yields at lower costs • Water cycling (increased infiltration, soil water storage capacity and use of green water; reduced runoff, erosion, water turbidity and surface evaporation)
Regulating services:	• Reduced global warming potential through lower methane emission and improved C accumulation
Supporting services:	• Mitigation of soil degradation through improved structure, biological activity, organic matter, nutrient cycling and fertilizer use efficiency • Restoration and conservation of biodiversity
Cultural services:	• Improved quality of life through the regeneration of the landscape

Payment for Environmental Services

Water and Soil
(runoff, infiltration, water holding capacity, and soil losses)

+

C sequestration
(C in soil organic matter)

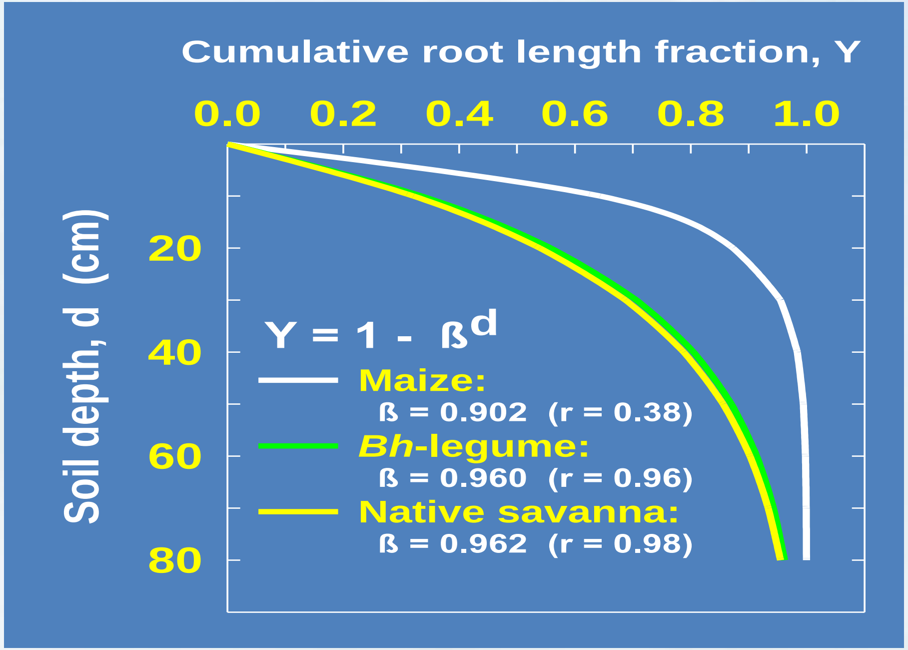
=

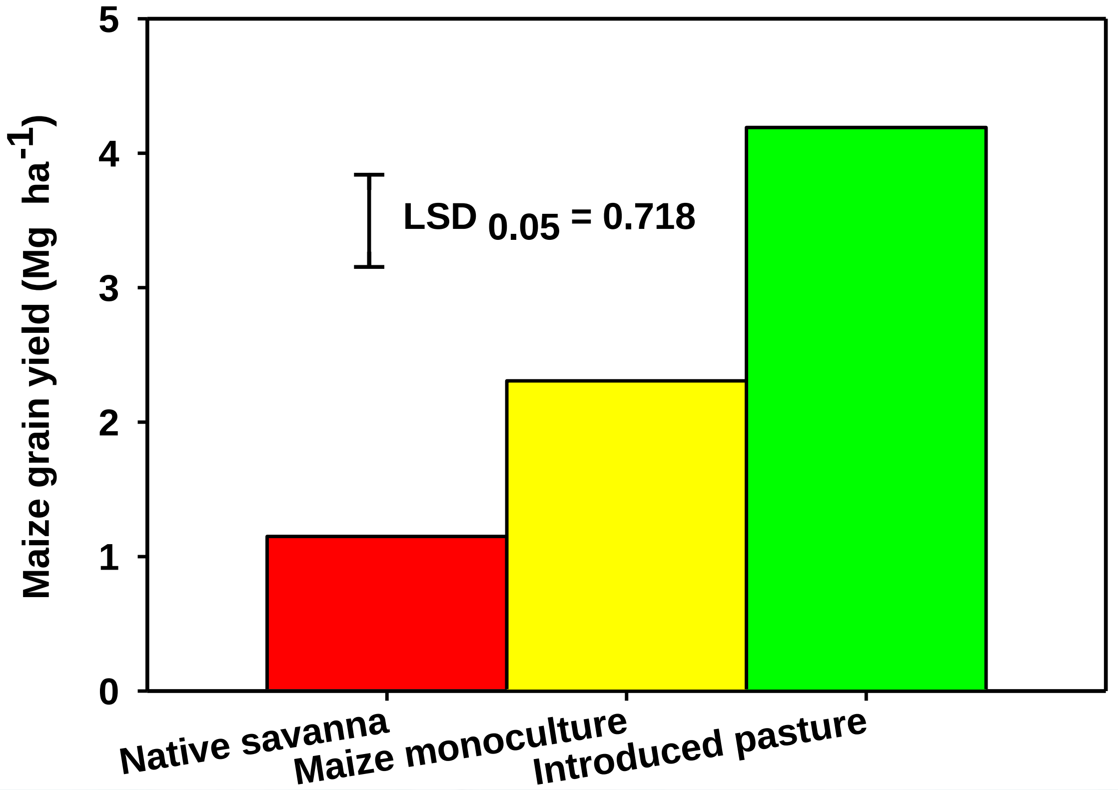
Value of environmental services:
US$ 2,240 per hectare

Savannas: Crop-livestock systems

Root distribution differences among three systems

Fisher et al (1993) Nature
Friesen et al. (1997) Plant and Soil



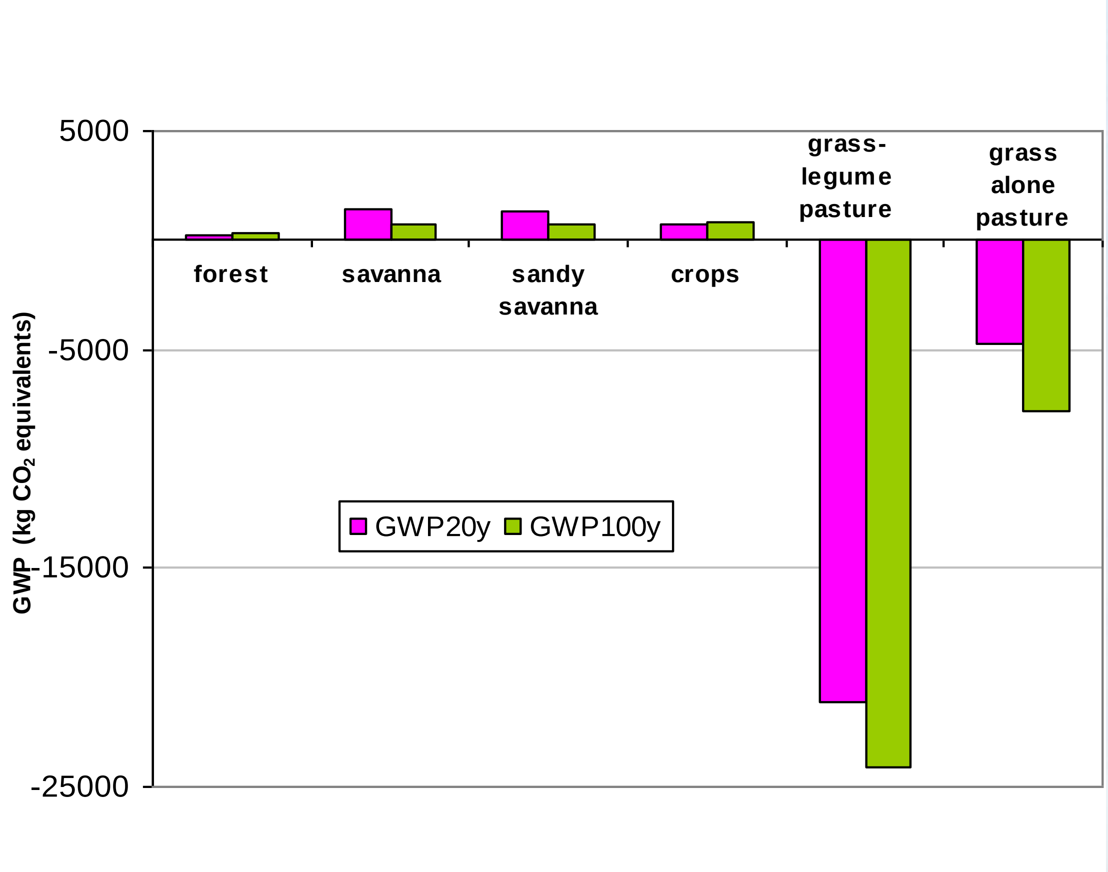


Impact of building up of an arable layer on maize grain yields

Amézquita et al., 2007

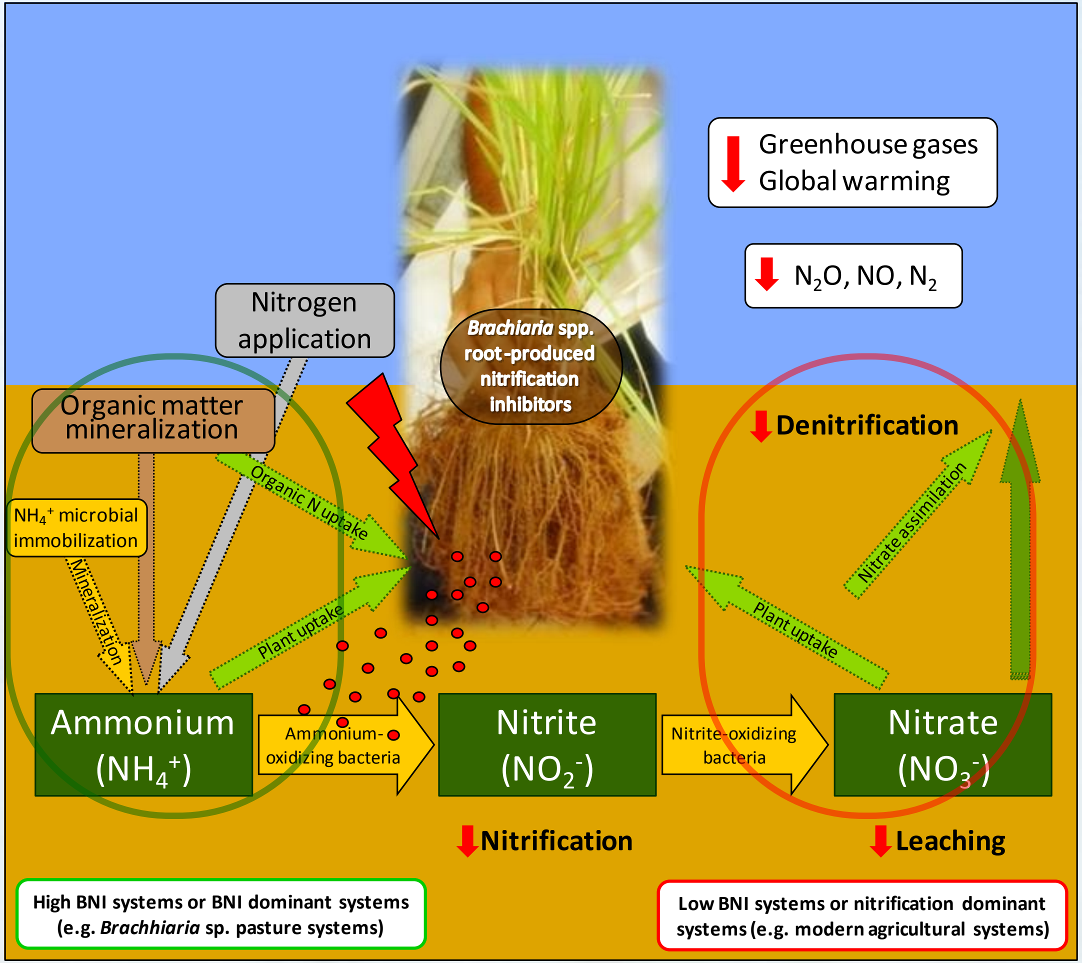
Integrated Global Warming Potential (GWP) of different land uses in the savannas of Colombia

(Rondon et al., 2006)



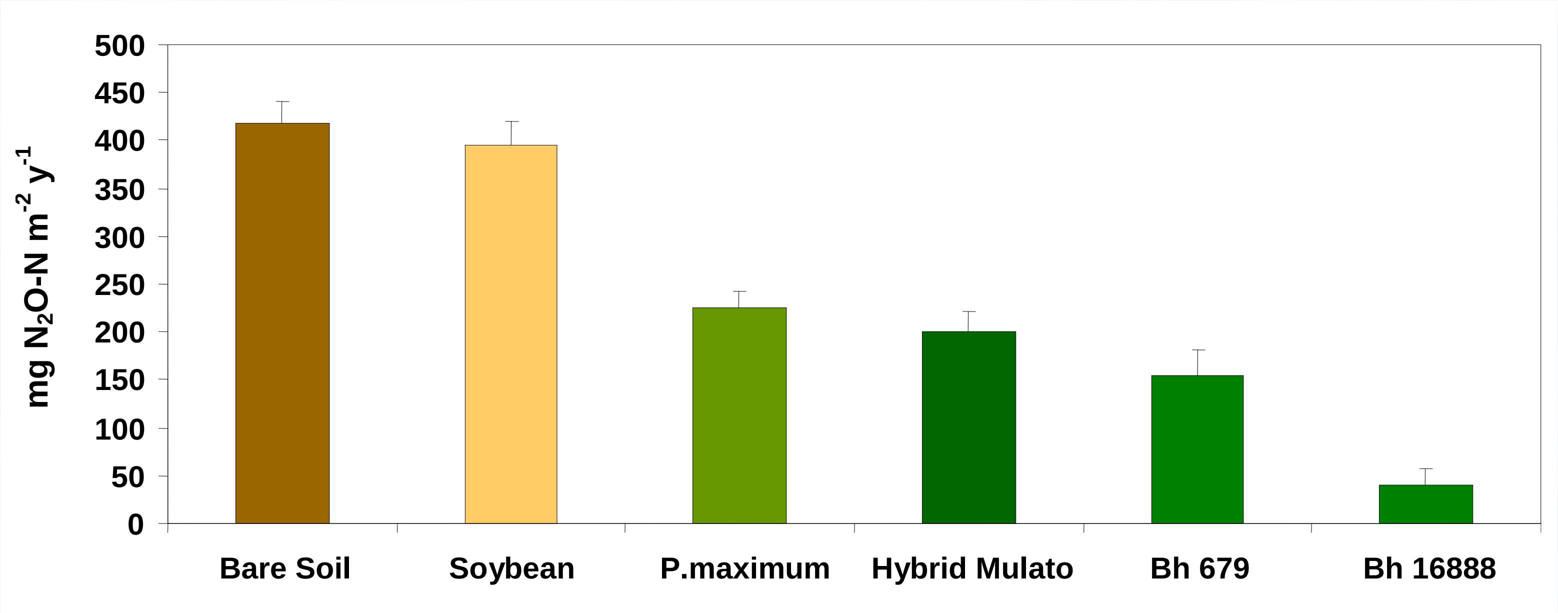
Biological Nitrification Inhibition (BNI)

Modified from Breeding Sci. 59: 529-545 (2009)



Cumulative nitrous oxide emissions from field plots of tropical pasture grasses

(monitored monthly from 2005-2008)



PNAS 106: 17302-17307 (2009)

Forest Margins: Amazon Initiative-Ecoregional Program (AI-ERP)

- Amazon basin is the world's largest tropical ecosystem and gene bank
- Deforestation and natural resource degradation - vulnerable rural communities are being threatened
- Emission of GHG due to pasture degradation and slash and burn agriculture
- AI-ERP created in 2006 and initiated activities in 2008
- **Focus:** mitigation and adaptation to climate change, sustainable production in deforested and degraded lands, maintenance of forest ecosystem services, and development of market-value chains for Amazonian products

Forest Margins:
Amazon Initiative-Ecoregional Program (AI-ERP)

The aim of AI-ERP:

- Provide guidelines for policies
- Develop technological and institutional innovations to help maintain environmental services
- Improve living conditions in the Amazon Basin
- Encourage sustainable land use

Forest Margins:
Carbon sequestration project
(Dutch Govt.2001-2006)

Conclusions:

- Improved grass-legume pastures and silvopastoral systems are sustainable if well managed and could store significant amounts of carbon in soil
- Developing mosaic land uses of these systems will contribute to diversity and complexity of landscapes while improving productivity of farms and C sequestration
- Establishment of legume-based pastures, silvopastoral systems and forage banks requires investments beyond the capacity of farmers, making necessary to use incentives to promote their introduction

Contribution of land uses to C stock and sequestration, income, rural employment and food security

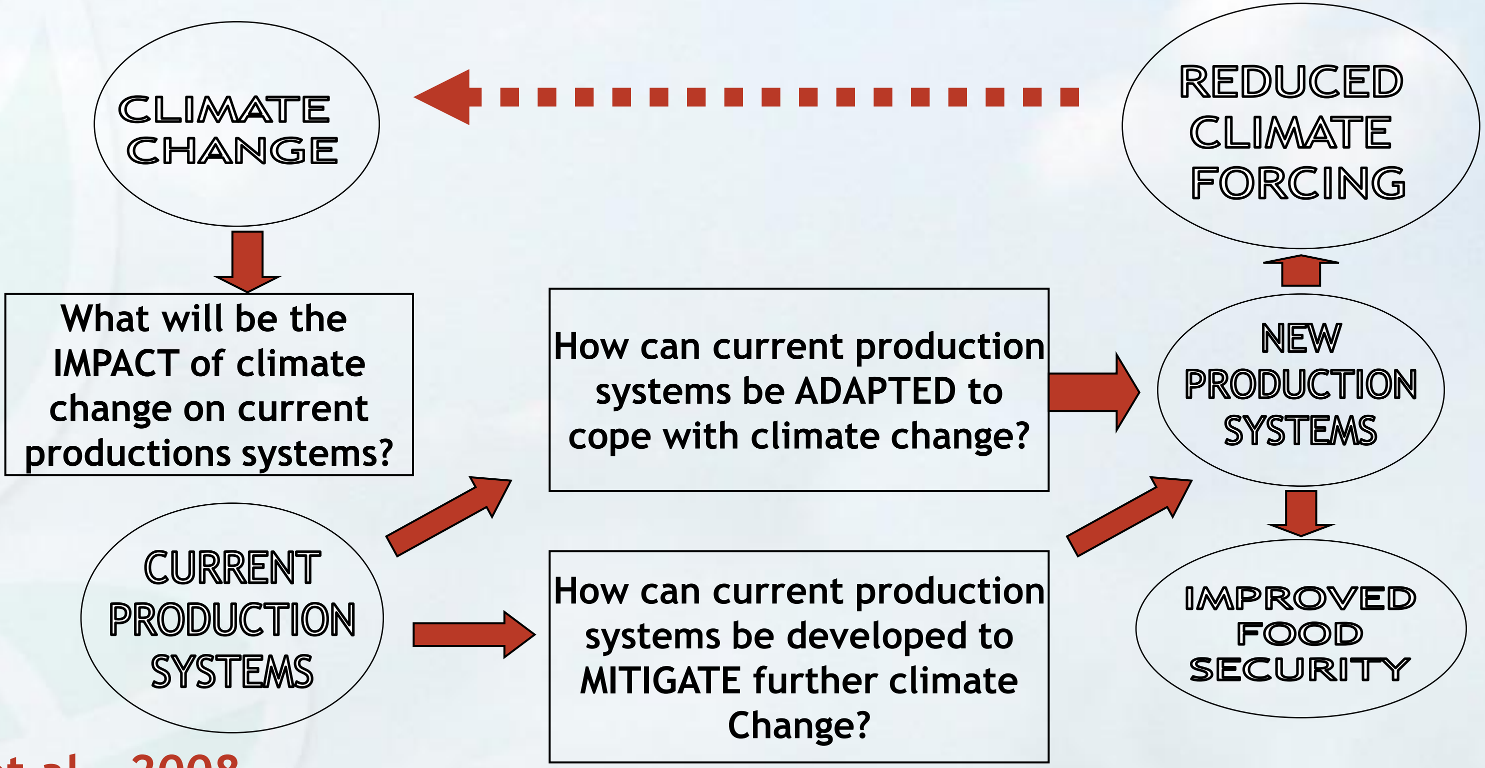
Land use	C stock and sequestration	Economic benefits	Rural employment	Food Security	Environmental Services
Native Forest	Greater	No significant	No significant	No significant	Greater
Degraded pasture and soil	No significant	No significant	No significant	No significant	No significant
Forage banks	No significant	Greater	Greater	Greater	Intermediate
Improved pasture	Greater	Intermediate	Intermediate	No significant	Intermediate
Silvopastoral systems	Greater	Greater	Intermediate	No significant	Intermediate

Contribution: Greater | Intermediate | No significant

Lessons learned

- Opportunities for agricultural mitigation of climate change exist in all three major agroecosystems of LAC
- Integrated crop-livestock systems with improved eco-efficiency are the best bet technological options
- Improved C sequestration in soil, reduced methane emissions from animals and reduced nitrification in soil are possible solutions to agricultural mitigation in LAC
- Smallholder farmers need to be linked to markets and PES schemes need to be developed for sharing multiple benefits from eco-efficient agricultural landscapes

Overarching research questions



Ingram et al., 2008

Research needs for mitigation

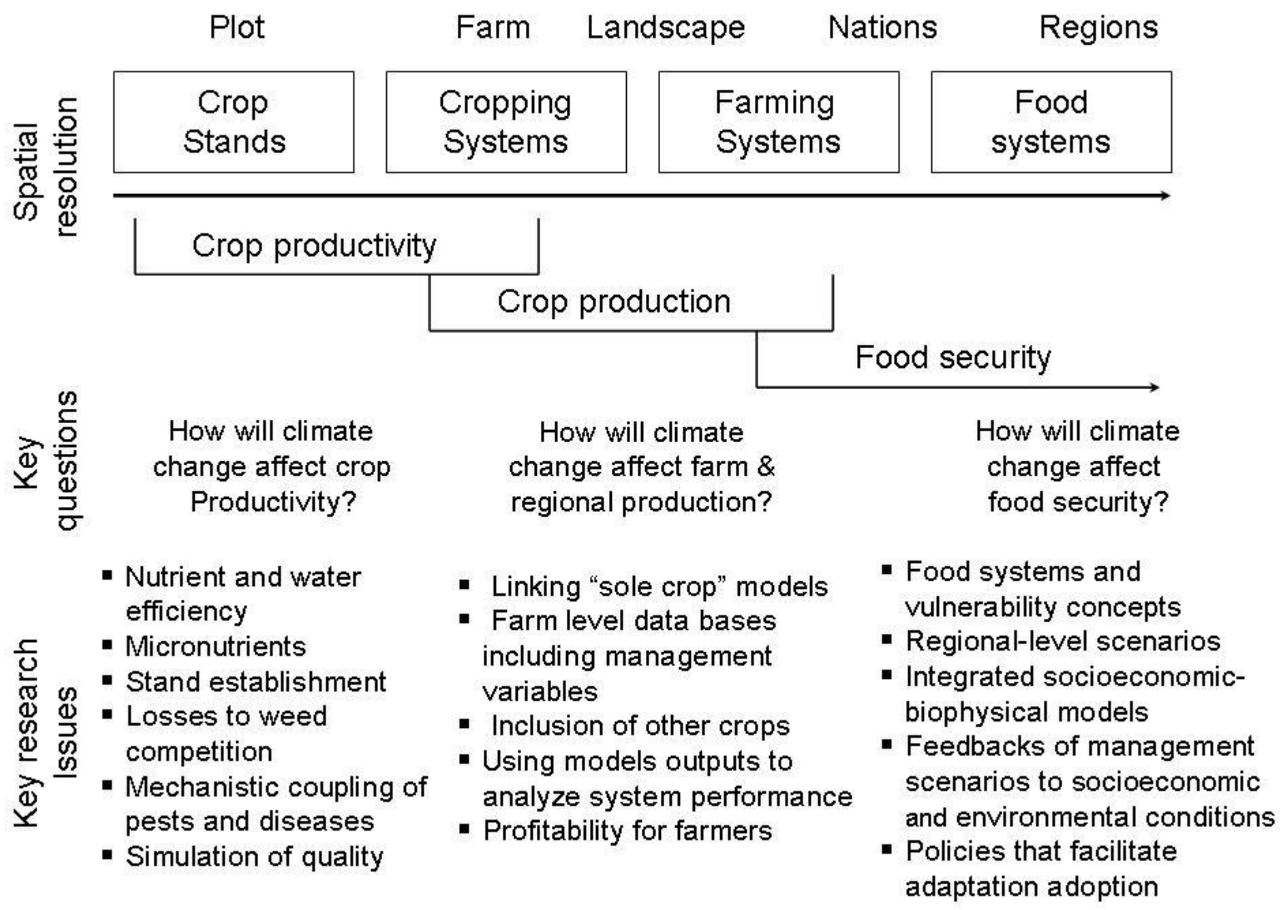
- Agronomic and environmental research to evaluate and document the reductions in GHG emissions from newer crop-livestock technologies and eco-efficient agricultural practices
- Standardized, widely accepted, credible and scientifically sound methodologies to measure and monitor reduced GHG emissions at system and landscape level
- Decision support tools for eco-efficient agriculture should be developed that take GHG impacts specifically into account
- Strategies and tools to design PES at farm level
- Design and implementation of REDD+ schemes at national level (institutions, land ownership and access rights, equity and benefit sharing, rights of local communities)

Need for future investments in LAC

- Capacity building in NARS in eco-efficient agriculture and agricultural mitigation of CC
- Incentives for farmers to recuperate degraded lands
- Policies and mechanisms that benefit smallholder farmers through PES and/or REDD+ schemes
- **Funding needs:** Initial funding of US$10-20 million per year over 5 years (improved germplasm-40%; eco-efficient landscapes-30%; institutional innovations-30%)

Thanks!

Relationship between spatial resolution, key research questions and issues



Ingram et al., 2008

AMAZ project
Socio Economic determinants of Biodiversity and Ecosystem Services in Amazonian landscapes

In 54 farms representative of 6 landscapes in Amazonian arc of deforestation :

- Socioeconomic, landscape, biodiversity parameters, production of commodities and ecosystem services significantly covaried;
- A given socioeconomic group creates a specific landscapes that has specific production and environment performances
- An Eco efficiency index is proposed to compare farms:

$$E_f = P_e * S_q * B_d$$

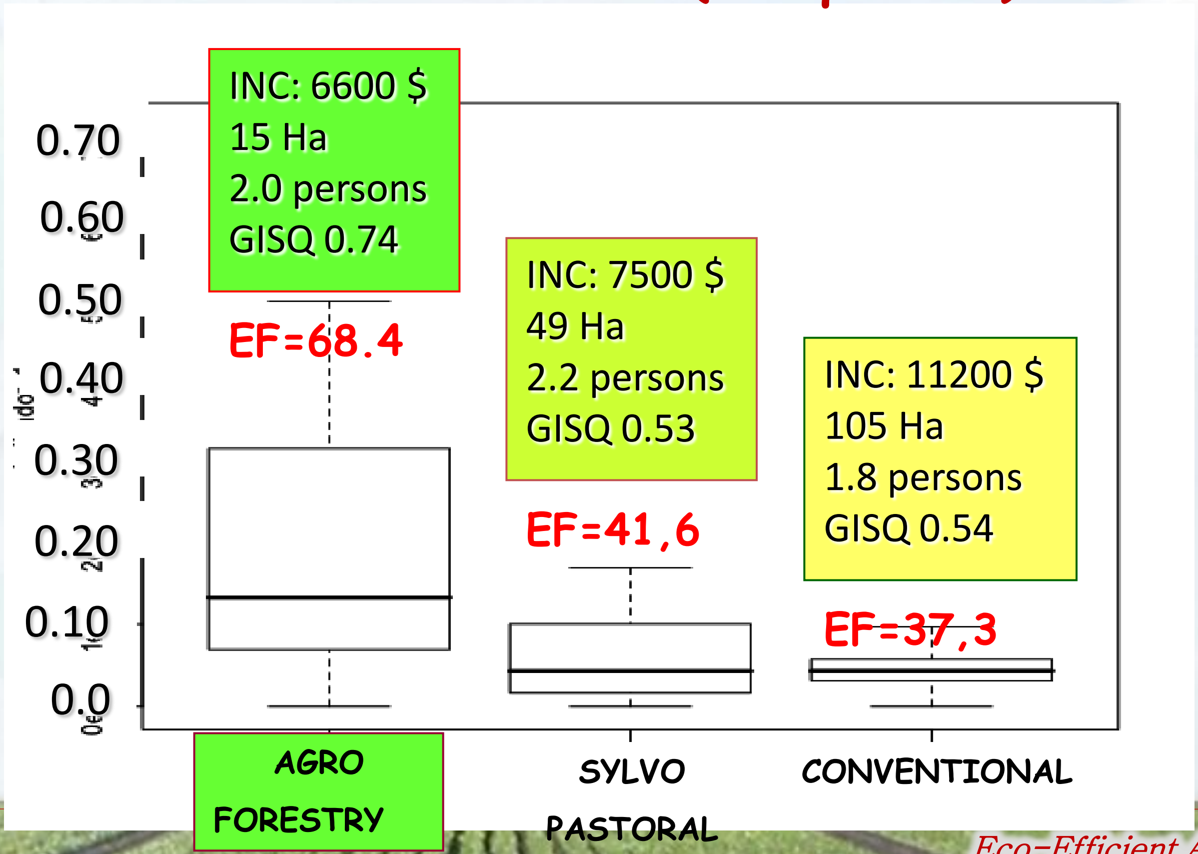
With

E_f = income $ /ha used/labour UTE unit

S_q : soil quality (GISQ index; Velasquez et al., 2007) 0.1 to 1.0

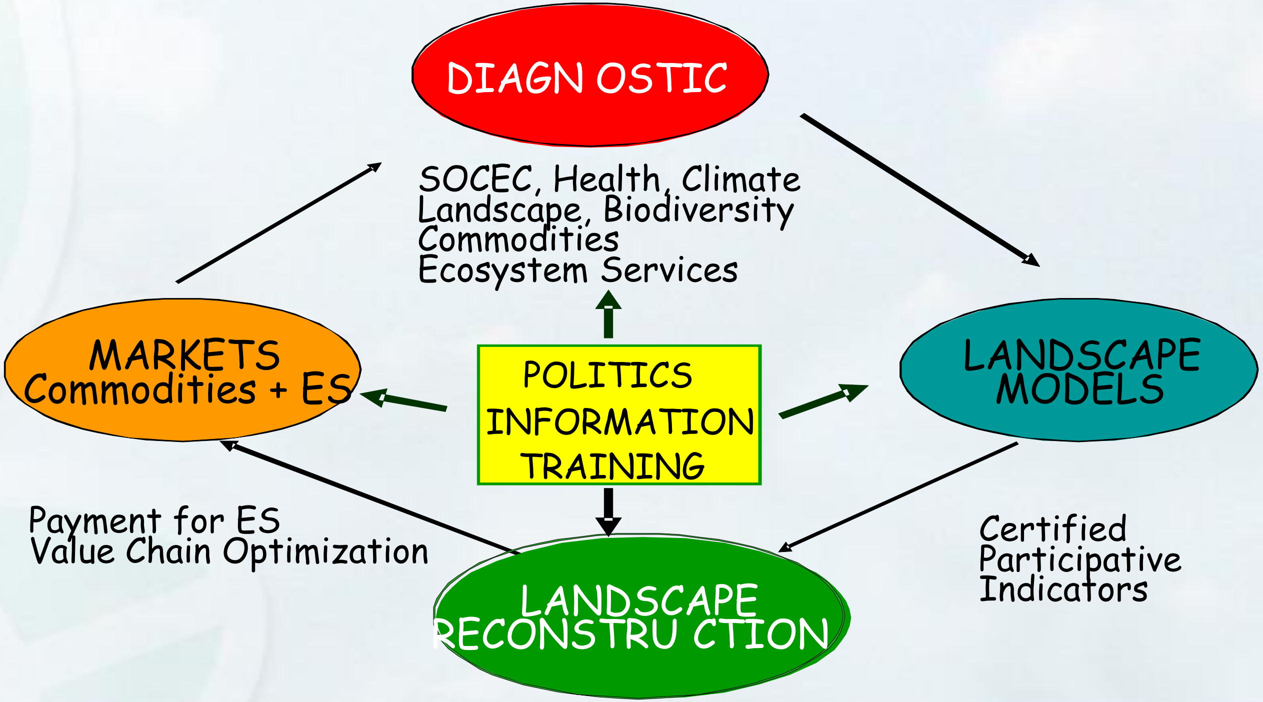
B_d : Biodiversity index (0.1 to 1.0)

Eco efficiency in different landuse systemss in Colombia (Caqueta)

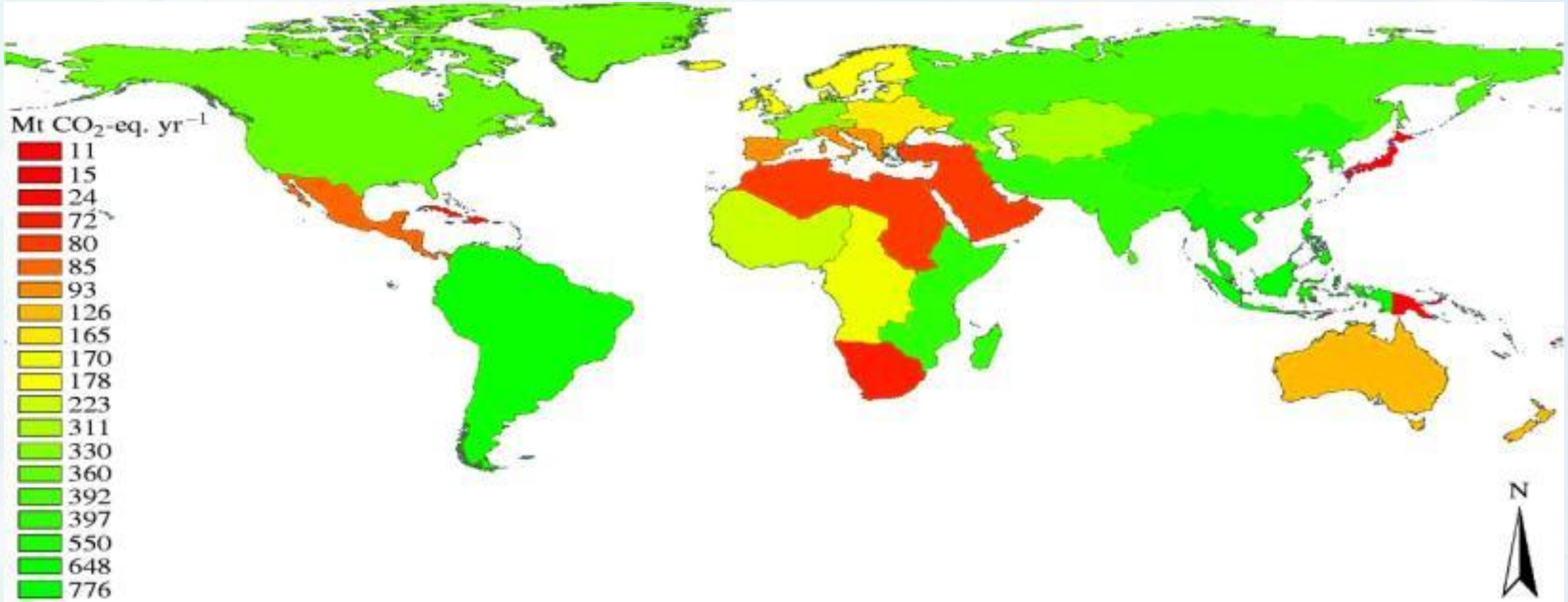


Source P. Lavelle and the AMAZ team, unpub.

Rebuilding eco efficient landscapes for 2030
The Amazonia 2030 project



Mean estimates of total biophysical mitigation potentials for each region by 2030 (all practices, all GHGs)



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