Conservation Agriculture as a Potential Pathway to Better Resource Management, Higher Productivity, and Improved Socio-Economic Conditions in the Andean Region

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- Instituto Nacional de Investigaciones Agropecuarias (INIAP), lead partner
- International Plant Nutrition Institute (IPNI)
- Secretaría Nacional de Ciencia y Tecnología (SENACYT)
- Universidad Estatal de Bolívar (UEB)
- Escuela Superior Politécnica del Chimborazo (ESPOCH)
- Secretaría Nacional del Agua (SENAGUA)
- Gobierno de la Provincia de Bolívar (GPB); Alcaldía de Guaranda y Chillanes
- Sistema de Información Geográfica Agropecuaria (SIGAGRO-MAG)

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Host-Country Partners: Bolivia

- Foundation for the Promotion and Research of Andean Products (PROINPA), lead partner
- Universidad Mayor de San Simon
- Centro Regional Avaroa
- Sindicato Agraria Tiraque, Alcaldía de Tiraque
- USAID Food Security Program, Fundacion Valles

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- Jorge A. Delgado**,** Soil Plant Nutrient Research Unit, USDA/ARS, Fort Collins, CO

Other Partner

- CIAT, Cali Colombia

Project Objectives

- Identify and evaluate production practices and farming components that can be assembled into CA production systems for Bolivar, Ecuador and Tiraque, Bolivia;
- Validate candidate CAPS in terms of impacts on: soil health, soil retention and carbon and other nutrient balances; sustained productivity; profitability; risk bearing; the environment; compatibility with household livelihood strategies; and social conditions including gender considerations;
- Promote adoption of the most appropriate CAPS by identifying mechanisms to increase their profitability;

Project Objectives

- Design and evaluate mechanisms for disseminating results to similar areas;
- Evaluate overall impacts of the research along several dimensions including soil health, productivity, economic, social and environmental; and
- Strengthen the capacity of government and non-government institutions to develop and disseminate CAPS in the Andean regions of target countries

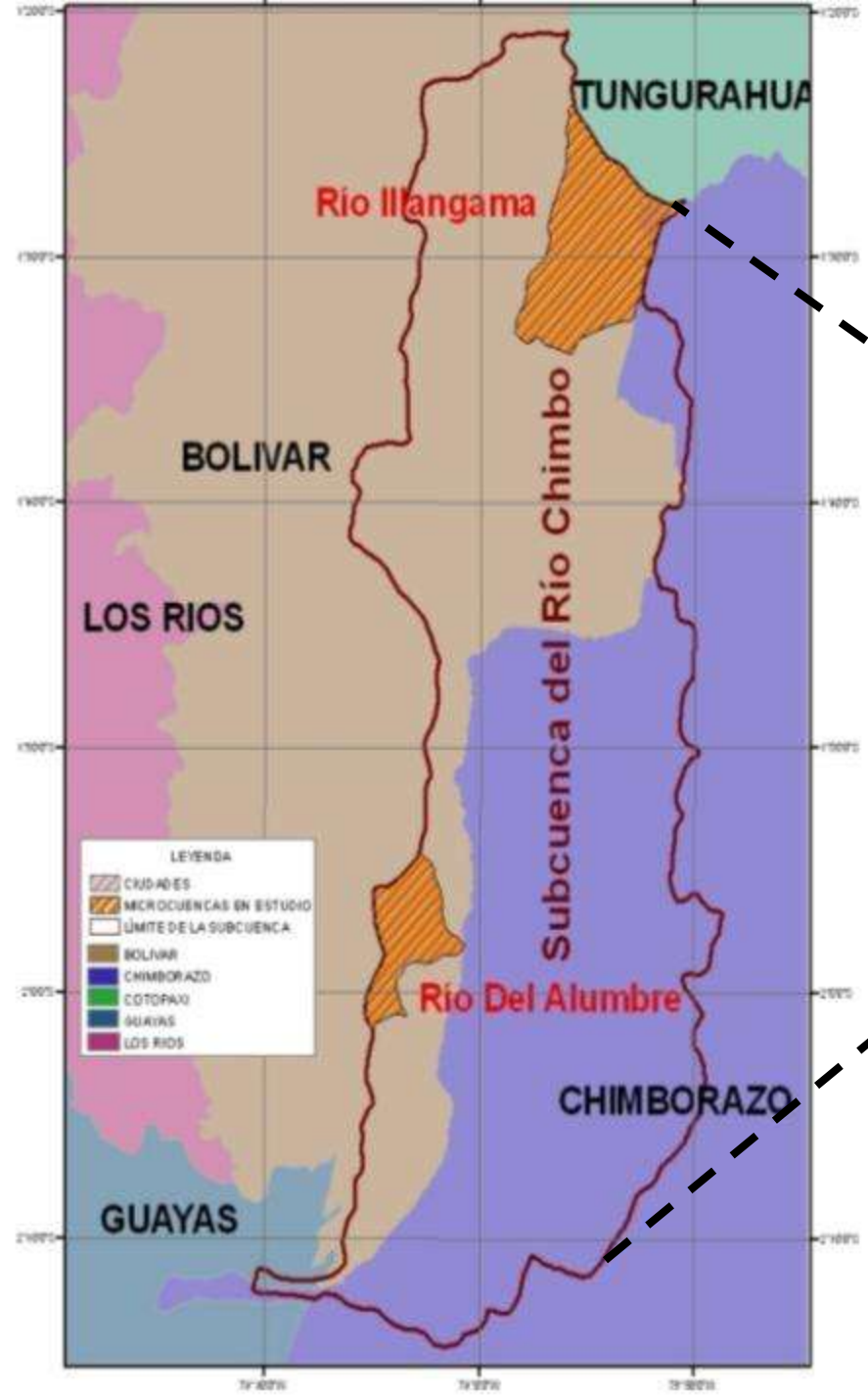
Conservation Agriculture

- In its purest form, CA is based on three principles: (i) minimum or no mechanical soil disturbance; (ii) permanent organic soil cover; and (iii) diversified crop rotations
- We view CA as a continuum running from a single or small number of practices to a full-blown CAPS
- **Our proposal**: investigate alternatives to increase agricultural productivity in a sustainable fashion through improvements in soil health, better rotations, cost-effective and sustainable pest and nutrient management, and improved water management. Off-farm innovations can also raise incomes and reduce the stress on the natural resource base
- **Key point:** we are working beyond the trinity of the pure form of CA

"Other" CA Components: Our Project

- Bio-inputs to increase soil productivity
- Pest control methods to increase profitability
- Agro-forestry: control erosion, manage water, income diversification and biological diversity
- Economic considerations:
  - Costs and profitability of CA: beyond the production system
  - External costs and benefits: mechanisms to capture these

Sites: Chimbo, Ecuador & Tiraque, Bolivia


TUNGURAHUA
Río Illangama
BOLIVAR
LOS RIOS
Subcuenca del Río Chimbo
Río Del Alumbre
CHIMBORAZO
GUAYAS
LEYENDA
CIUDADES
MICROCUENCAS EN ESTUDIO
LÍMITE DE LA SUBCUENCA
BOLIVAR
CHIMBORAZO
COTOPAXI
GUAYAS
LOS RIOS

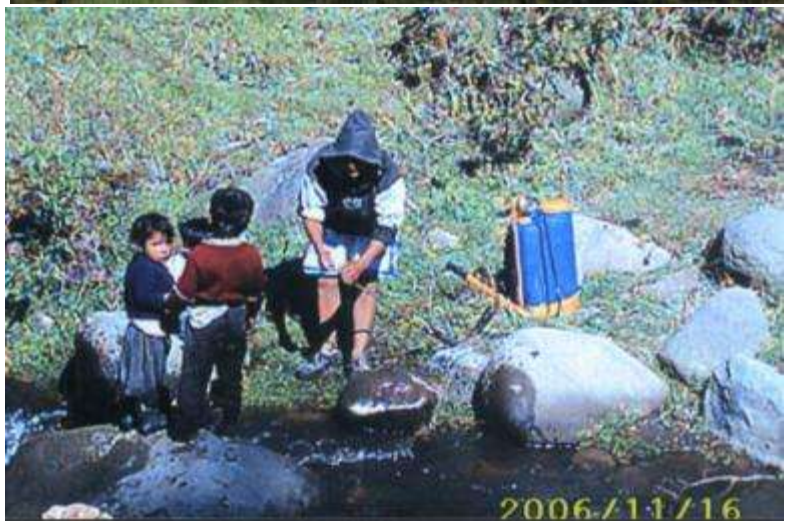

COLOMBIA
QUITO
ECUADOR
Guayaquil
PERU
Legend:
Principal Cities
INAMHI Meteorological Stations
INIAP Agricultural Experiment Stations
Rivers
Province Boundaries
0
65
130
260
Kilometers

General Conditions in the Chimbo Sub-watershed

- Provide between 30 and 40% of the total water into the Guayas River.
- Three distinct ecological regions (paramo, high plain and subtropical).
- Range from 300 to 4500 meters in elevation and receive between 500 and 4000 millimeters of annual rainfall.

Environmental Conditions in Sub-watersheds

- High rates of erosion contribute to sedimentation and turbidity in surface water
- Reduction in water levels and flows caused by deforestation and expansion of the agricultural frontier
- Less water available and more variability in rainfall in recent years

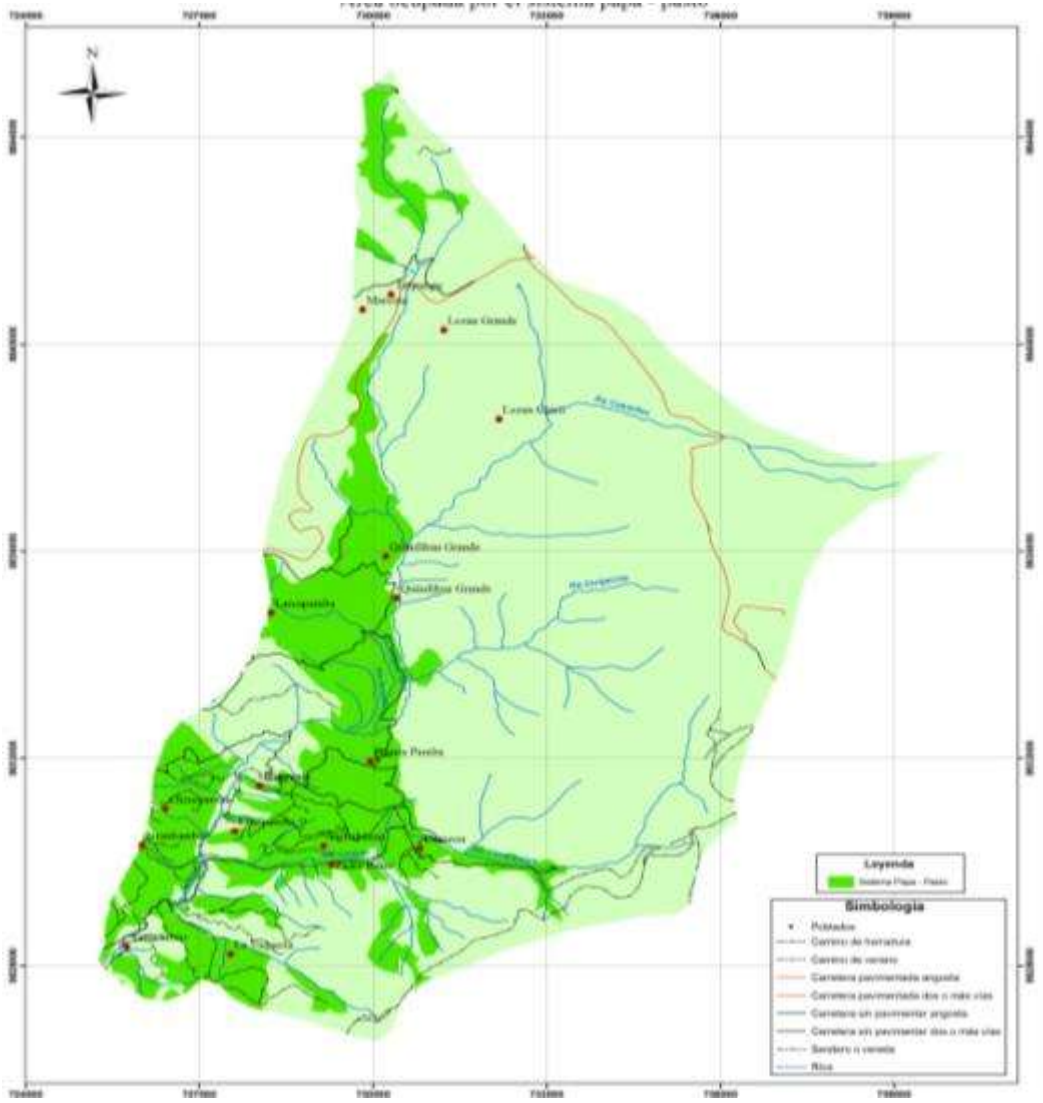


Two Micro-watersheds

- Illangama:
  - High elevation, more rainfall, cold and frost
  - Predominantly indigenous
- Alumbre:
  - Lower elevation, semi-tropical
  - Mestizo families

Potato-Dairy System

Illangama Microwatershed



Additional Information--Illangama

- High organic content of soil (14% on average)
- Phosphorus is limiting factor
- Needs:
  - Means of intensifying the pasture component of the potato-pasture rotation to get more out of potato;
  - Means of intensifying the annual crop rotations which include quinoa, faba and oats in rotation with potato and pasture;
  - Means of increasing available phosphorus to improve potato yields; and
  - Appropriate perennial strips to improve soil retention.

Maize-Bean System
Alumbre Microwatershed

Management Alternatives: Prior SANREM Phase

Improved pastures with deviation ditches

Management of improved pastures

Potato cultivation in contours

Reduced-tillage maize

Soil Management Alternatives

Strip cultivation

Deviation ditches

Native plants as live barriers

Contour planting

Preliminary Research Activities

- Evaluation of:
  - Cultivation systems and ground cover, tillage options and rotations in potato
  - Tillage options in faba beans
  - Cultivation systems and ground cover, tillage options and rotations in hard maize
  - Varieties and tillage practices in soft maize
- Development of a suitable silvopastoral system using native species of trees and bushes: Yagual (*Polylepis racemosa*), Quishuar blanco *(Buddleja incana*) y Lupina *(Buddleja coriacea*).

Example: Potato Experiments

- **Factors being considered:**

  Erosion control: S0 = with deviation ditches
  S1 = without

  Tillage: L1 = conventional
  L2 = reduced

  Rotations: R1 = oats-vicia and forage mix
  R2 = forage mix

- **Number of treatments:** 8
- **Number of repetitions:** 3
- **Experimental design:** Partial divided

Example: Preliminary Experiments Hard Maize

- **Factors being considered:**

  Erosion control: S0 = with deviation ditches
  S1 = without

  Tillage practices: L1 = conventional
  L2 = seeding with sticks

  Rotations: R1 = with peas
  R2 = with bush beans

- **Number of treatments:** 8
- **Number of repetitions:** 3
- **Experimental design:** Partially divided

Variables and Indicators

Variables	Indicators
Erosion reduction	Depth of eroded soil Total weight of eroded soil Apparent density Soil moisture content Compaction
Effects on nutrient dynamics	Nutitional content (macro and micro) Nutrient uptake by plant and crop Number of plants harvested Dry yield Fertilizer efficiency Biomass production and total C and N content Available phosphorus
Economic factors	Costs by cost component Production and productivity Values of production Values of nutrients and C

Additional Experiments

- Identification of suitable perennial hedgerows appropriate for maize/beans-based rotations;
- Annual crop systems that are less reliant on purchased inputs;
- Improved cover-crop management regimes;
- Introduction of additional perennial crops such as avocadoes, citrus, guava and higher-valued woody tree species

Field Trials in Alumbre Ecuador: Tillage and Deviation Ditches

Bolivia

Departament of Cochabamba

Conditions in Tiraque, Bolivia

- Research site located in southern Tiraque Province, 70 Km from Cochabamba
- Between 3000 and 4200 masl, with slopes between 10 and 25% in areas under cultivation and between 20 and 40% in pastured areas.
- Comprised of 14 communities, with a population of approximately 3,000
- The area is semi humid, with approximately 550 mm of annual rainfall, and cold climate

Characteristics Bolivia: 3 Zones

Lower zone	Middle zone	Higher zone
3000 - 3200 (masl)	3000 - 3200 (masl)	3800 - 4300 (masl)
Characteristics: 2 communities Intensive agriculture in rain season and under irrigation	Characteristics: 10 communities Agriculture in rain season and under irrigation	Characteristics: 2 communities Agriculture only in rain season. Low temperatures
Main crops		
Potato, faba bean, pea, maize, wheat, barley, oat, quinoa grain & vegetables	Potato, faba bean, barley, oat, pea, oca tuber & some vegetables	Potato, faba bean and potato seed in higher places.


SANREM CRSP
Delimintación de la
Sub-cuenca Jatun Mayu
Tiraque
Kewiña Khocha
Lushkha Khocha
Koarl Khocha
Sank'ayani Alto
ZONA ALTA
Laguna Jatora Khocha
Payqo Mayu
Ucuchi Cancha
Waylla Pujru
Waca Wasi
Toralapa Baja
ZONA BAJA
Ch'aki Khocha
Boquerón Alto
E.E. Toralapa
Toralapa Alta
Caña Cota
Cebada Jich'ana
ZONA MEDIA
Dany Rancho
Boquerón Grande
Suraj Mayu
Cháupi Rancho

Conditions in Bolivia

- Major problems facing producers in area:
  - Low soil fertility caused by low soil organic matter, pathogen buildup, and long-term soil loss
  - Soil loss is a growing problem caused by inappropriate production technologies, removal of soil cover during dry season, and erratic rainfall
  - Water availability and changing rainfall present problems to producers
  - Our assessment is that current cropping systems will not be sustainable and, in the long run, the productivity will be lowered if these problems are not addressed.
  - The project has prioritized investigations into cover crops to protect soil loss, manage soil humidity and develop soil health over time
  - These cover crops and rotations need to fit into the predominant potato systems

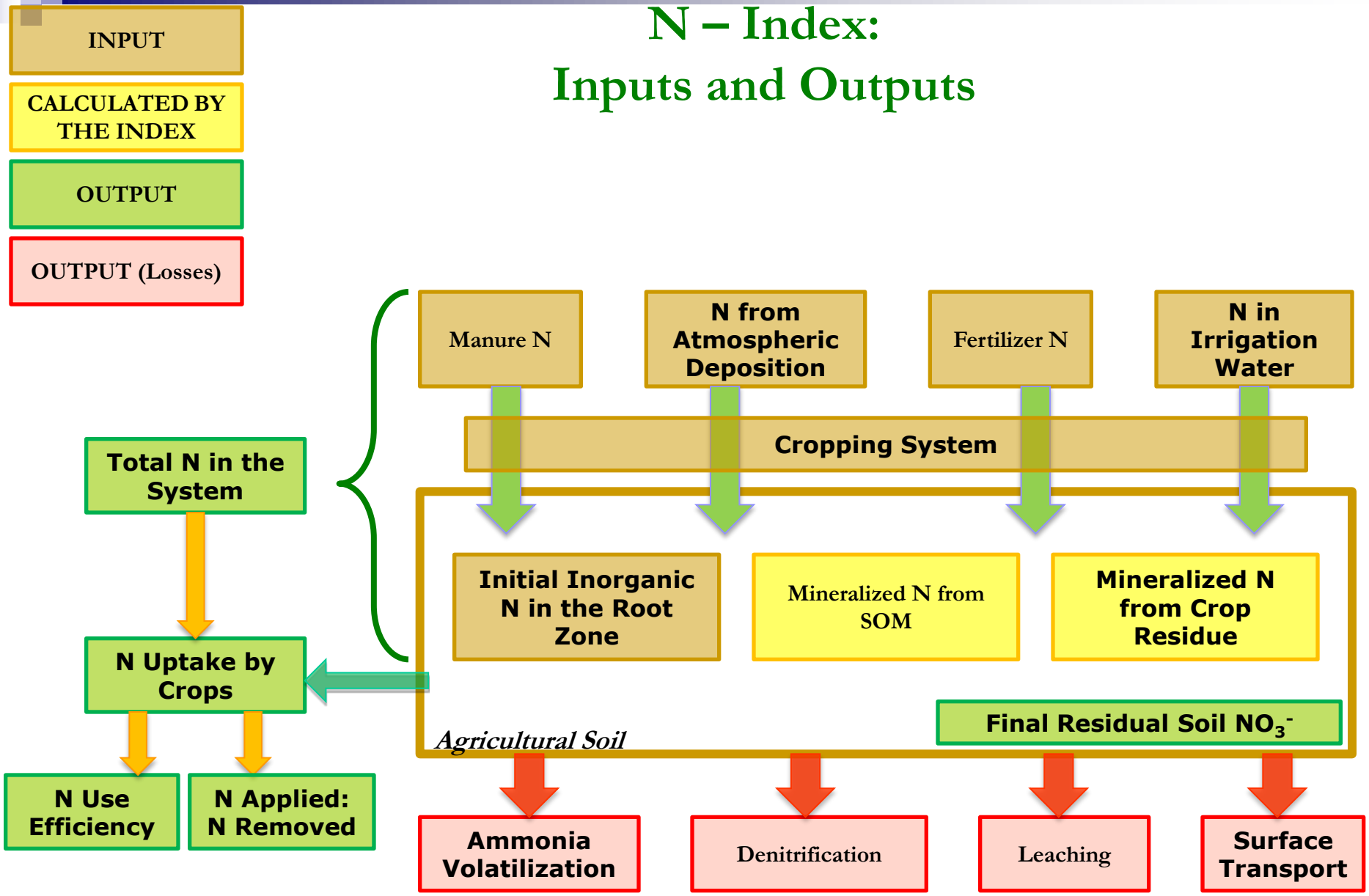
Lower and medium watershed – design 1

Treatment	1	2		3	4
1	fallow/pasture	Potatoes Conventional tillage Manure-based fertility	fallow	Quinua Reduced tillage	Fava Reduced Tillage
2	oats – residue harvested		sudan grass harvested		
3	oats – residue retained		sudan grass retained		
4	oat/Vetch – residue harvested		sudan grass/legume harvested		
5	oat/vetch – residue retained		sudan grass/legume retained		

Other Research Components

- Development of a nitrogen index tool to facilitate farm planning
- SANREM Internship Program (research opportunities for UG students)
- Tradeoffs analysis: on/off-farm, productivity-environment
- Tool to identify adoption propensities

N – Index:
Inputs and Outputs



Algorithms used by the N-Index are published in:
Delgado et al., 2008. Ecol. Eng. 32:108-120

Monitoring & Impacts

- Soil health:
  - Minimum data set: ME recommendations
  - Timing of changes—when do we expect to observe differences?
- Productivity and profitability:
  - Costs of production for each practice/each experimental treatment
  - Timing and duration of measurement
  - Profitability
    - Increase local demands
    - Reduced input costs
    - Producer organizations and market access

Off-farm Impacts

- Water quality and run-off
- Payments for environmental services
  - Water quality, reduced sedimentation
  - Carbon sequestration
  - Potential value capture for adopters—institutional barriers to this capture
- Adding up—aggregation
  - End of project—adoption and spread

Ecuador: Major Floods in Low-lying Areas 2009

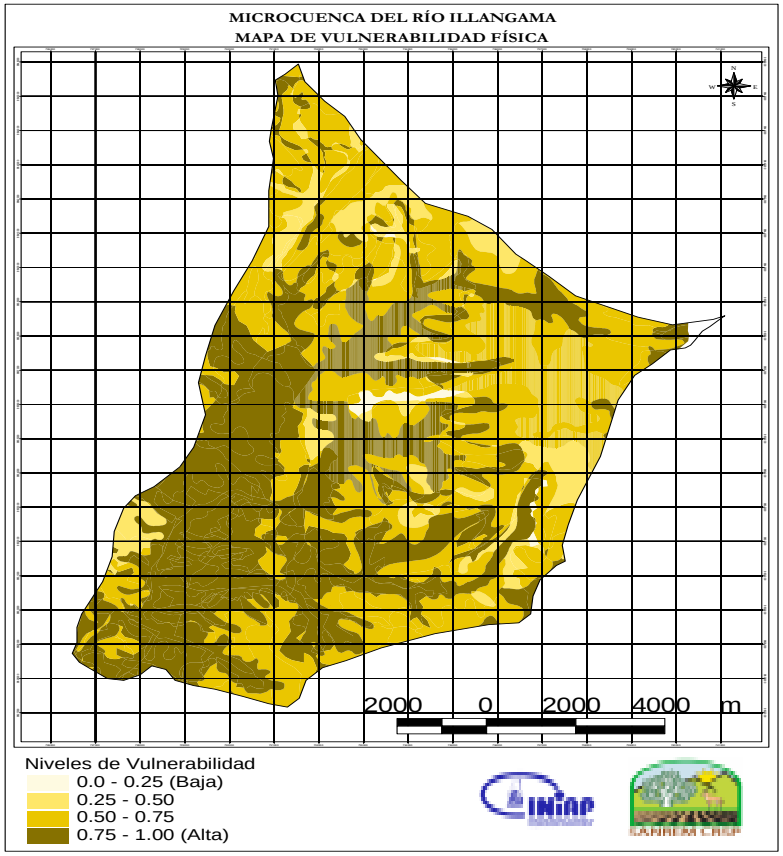
Photos from "El Comercio", January, February, March, 2009

- Agricultural losses due to floods exceeded $160 M (MAGAP, 23 February 2009).
- More than $ 1 B needed for rehabilitation of damaged infrastructure and other costs in the flooded regions (MICSIE, 5 March 2009).

Monitoring physical processes

- Seven meteorological stations installed in Ecuador sub watershed
- Seven water flow measurement sites
- Training project personnel and local stakeholders

Vulnerability mapping



- Based on GIS overlays of variables including: slope and erosivity, current land uses, soil cover, population pressures, others
- More than 3664 ha in Illangama and 2259 ha in Alumbre are "highly vulnerable"
- Local governments have begun process of reforestation in vulnerable areas and water-sensitive areas.

Thank you!

Chimborazo Volcano, Ecuador