Watershed-based Natural Resource Management in Small-scale Agriculture: Sloped Areas of the Andean Region

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SANREM CRSP

Objectives of Presentation

- Present an overview of our SANREM research project, including objectives, methods, and relationships among research activities
- Present major findings
- Discuss implications
- Potential Directions for SANREM IV

Host-Country Partners

- **Ecuador:** INIAP—Victor Barrera, Elena Cruz, Franklin Valverde; ECOCIENCIA—Adriana Cardenas, Juan Calles; SIGAGRO-MAG—Carlos Montufar; ECOPAR—Kelvin Cuevas
- **Bolivia:** PROINPA—Ruben Botello, Ilich Figueroa, Nadezda Amaya, Norka Ojeda, Giovanna Plata, Javier Franco, Gladys Main; PROMIC—Omar Vargas, Ana Karina Saavedra; UMSS --Susana Arrazola ; CERES—Jean-Paul Benavides, Harry Soria Galvarro
- **CIP:** Javier Osorio

US Partners

- Jeffrey Alwang Ag. and Applied Economics, Virginia Tech
- Darrell Bosch, Ag. and Applied Economics, Virginia Tech
- George W. Norton Ag. and Applied Economics, Virginia Tech
- Sarah Hamilton, International Development, Univ. of Denver
- Mary Leigh Wolfe, Bio. Systems Engineering, Virginia Tech.
- Brian Benham, Center for TMDL and Watershed Studies, Bio. Systems Engineering, Virginia Tech
- Conrad Heatwole, Bio. Systems Engineering, Virginia Tech
- Paul Backman, Plant Pathology and Biocontrol, Penn State
- Jonathan Lynch, Plant Nutrition, Penn State University
- Wills Flowers, Entomology and Biological Control, Florida A&M

Project Objectives

Overall goal: Enable and support local capacity to plan policies and interventions to raise incomes, improve social conditions and protect and improve the environment in Guaranda, Ecuador and Tiraque, Bolivia.

- Identify economic, social, political and environmental conditions in the watersheds and understand the determinants of these conditions.
- Generate and validate environmentally sustainable alternatives to improve production systems and enhance income generation.
- Create a means of evaluating the impacts of alternative actions, policies and interventions on income generation, and social and environmental conditions
- Build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital

Organizing Concept

- The main organizing instrument of the project is an adaptive watershed management approach whereby local actors are brought together to examine how human activities within the watershed contribute to environmental degradation, and how management alternatives will affect this degradation

Research Activities

- Bio-physical research activities to identify potential solutions to constraints faced by watershed farmers, including plant diseases, variety selection and testing, feasibility of alternative varieties, soil erosion and means of mitigation
- Social science-based research on the determinants of household livelihood strategies, the profitability of livelihood alternatives, costs and benefits of enhanced natural resource management, and institutional considerations affecting governance

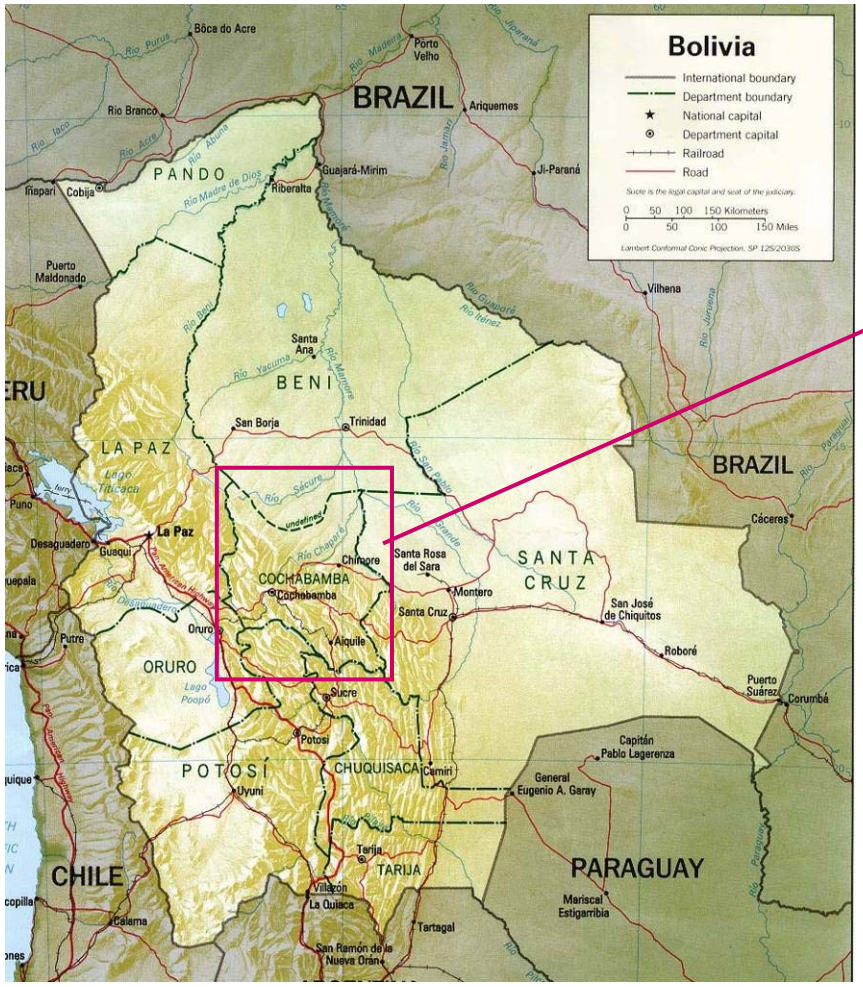
Research Activities

- Tied together through comprehensive physical and social models of the watershed
- Model results are being used in a participatory watershed planning process to inform local decisionmakers about the impacts and consequences of alternative land use plans
- Project is engaged in an ongoing dialogue and participation in different components by local stakeholders to build ownership of the research outputs

Sites: Chimbo, Ecuador & Tiraque, Bolivia

- Ecuador:
  - Western Andean watersheds include the Guaranda, Chimbo, San Miguel and Chillanes cantons and provide between 30 and 40% of the total water into the Guayas River
  - Two distinct ecological regions (high plain and subtropical), and four distinct Holdridge zones (subtropical humid forest, low temperate mountain, temperate mountain and boreal)
  - Range from 300 to 4500 meters in elevation and receive between 500 and 4000 millimeters of annual rainfall

Bolivia: Sub-watershed location



Departament of Cochabamba

Sub-watershed "Jatun Mayu" river

Bolivia 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


SANREM CRSP
Delimintación de la
Sub-cuenca Jatun Mayu
Tiraque
Kewiña Khocha
Lushkha Khocha
Koari Khocha
Sank'ayani Alto
ZONA ALTA
Laguna Totora Khocha
Sind. Villa Flores
Payqo Mayu
Uchuchi 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
1ro. de Marzo
Damy Rancho
Boquerón Grande
Suraj Mayu
Chaupi Rancho

Research Highlights: Bio-physical research

- Biodiversity assessment and adjustments to methodology (community-based biodiversity assessment)
- Identification of alternative crop varieties, fertilization recommendations and pest management
- Generation and diffusion of soil conservation practices (Ecuador)

Biodiversity assessment in Bolivia





Evaluation of rotational crops and varieties

- Years 1 & 2: fertilizer recommendations and new alternatives
- Rotations: pasture-potato-barley-haba, quinoa, legume-pasture interactions, alternatives for maize-bean and maiz-haba associations
- Improved pasture
- All evaluations are participatory and include training

Agronomic Research in Bolivia

Maca root

Possibility for production of kañawa grain in the middle zone supports food security (high nutritional value)

Farmers from the upper zone empowered in the production of a new and profitable crop.

Kañawa grain

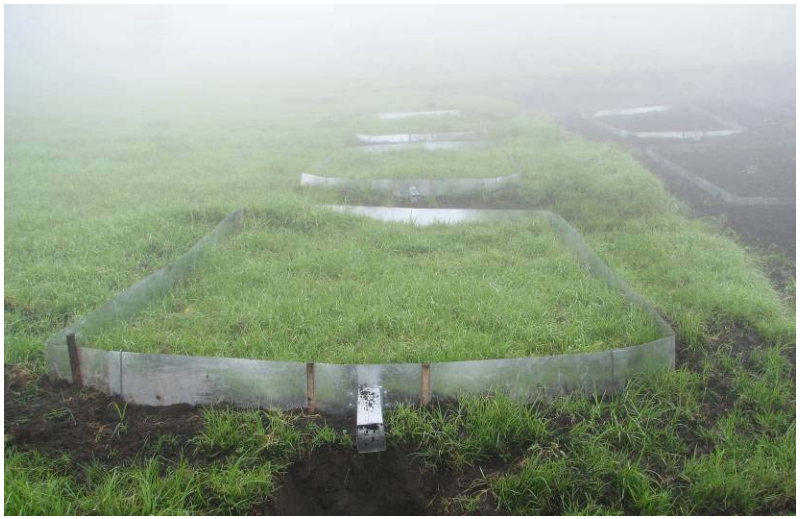
Agricultural Alternatives: Bolivia.
Alleviate pest constraints to annual crops

Study of isolation of endophyte bacteria in faba beans, quinoa and potato in process

Plant pathogenic nematodes controlled through "bio-fumigation using mustard and arugala"

Techniques to reduce soil erosion Bolivia & Ecuador

- Determine quantities of soil lost due to runoff under different management practices
- Quantify nutrient losses due to soil erosion (nutrient balances)
- Study effects of soil and nutrient loss on biomass productivity
- Results—technologies for reduced erosion and better nutrient management



Soil conservation in Ecuador

- Techniques: contour planting, deviation ditches, belt/strip cultivation, live barriers with native species and cash perennials, reduced tillage in beans and peas, terracing and horticultural production

Contour cultivation and ground-cover, Alumbre

Cultivation in belts

Institutional strengthening

- Bolivia—PROINPA
  - Molecular Biology Labs built
  - USAID economic development grant built bioproducts production capability
- Ecuador—INIAP
  - More than $300,000 in local counterpart funding SENACYT to support SANREM activities
  - Additional support: construction of new bio-technology, molecular biology, soils, and plant sanitation laboratories

Research Highlights

1. Study of determinants of livelihood strategies and impacts on household well-being completed in Ecuador
2. Assessment of risk and its impact on farmer decisions in Ecuador and on potato variety choice in Bolivia
3. Biodiversity assessment methodology validated; community biodiversity monitoring ongoing
4. Soil conservation techniques evaluated in Ecuador: assessment of adoption recently completed (undergraduate interns)
5. Identification of two high-potential crop alternatives for Bolivian highland
6. Use of A-bomb radionucleides to monitor soil loss over 50 years in Ecuador
7. Collection of nutrient solubilizing, nutrient fixing, and host defense induction orgs estsblished at PROINPA and INIAP

Research Highlights: Social science

- Livelihood clusters defined; models of determinants of livelihood choice have been estimated
  - Policy can influence spatial distribution of livelihood strategies (education, access to land, access to markets, access to irrigation)
- Uptake of soil conservation has been studied
- Risk responses:
  - Potato diversity in Bolivia a function mainly of access to markets (and not natural and pest risks)
  - Production efficiency in Bolivia: spatial clustering of "inefficient" plots associated with household risk exposure

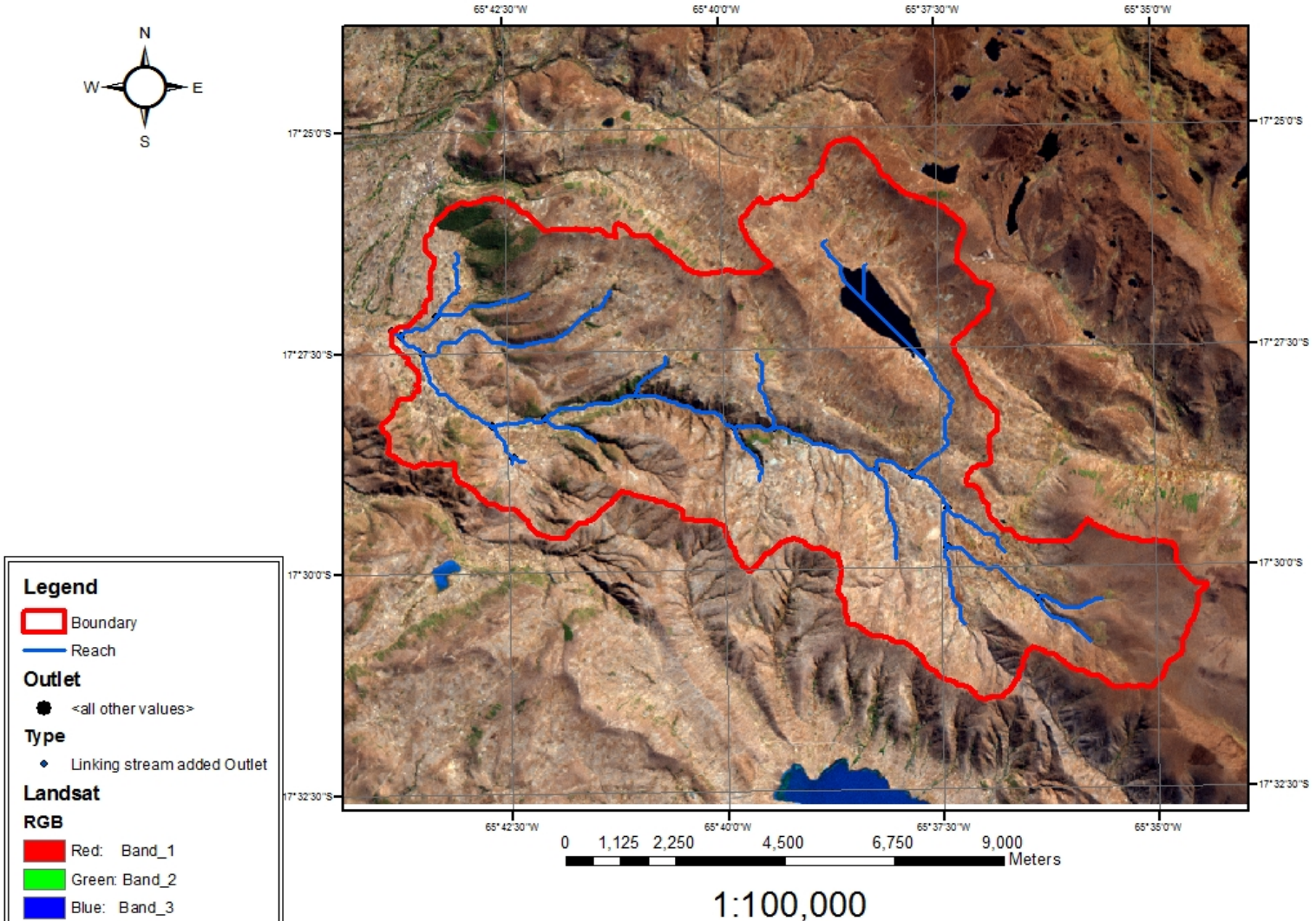
Research Highlights: Watershed modeling

- GIS established in both sites:
  - Information used in socioeconomic studies
  - Maps of vulnerability created
- Watershed models under construction/being used in both sites

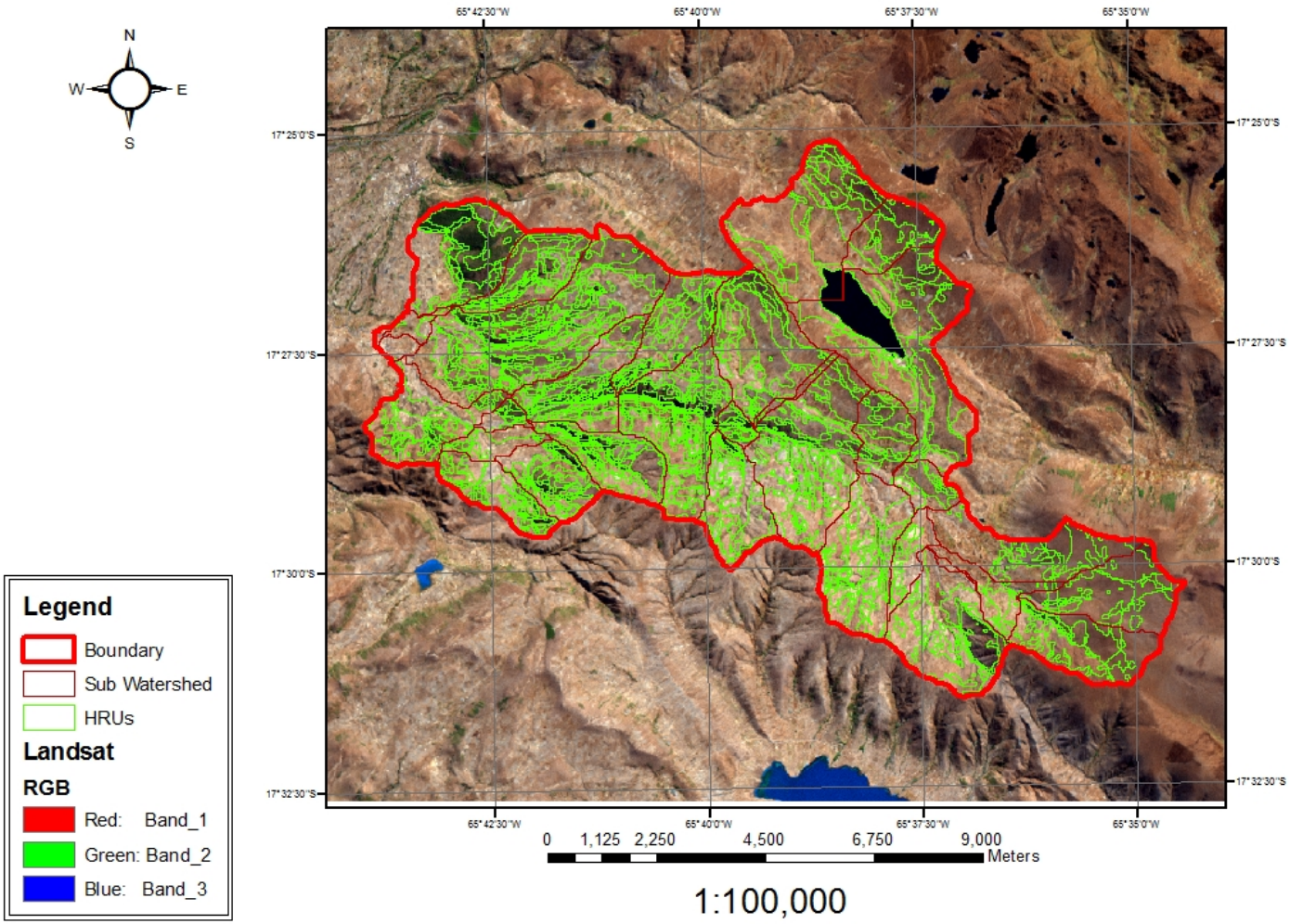
Modeling Activities

- Assembled GIS data layers for watersheds in Ecuador and Bolivia
  - Digital elevation models (DEMs) obtained and additional analysis done
  - Soils – current data in place; in both watersheds additional soils mapping and descriptions are being developed by in-country partners
  - Landuse – satellite images obtained and classified; additional work being done to refine classifications
  - Weather data – have 14 years of daily data from Bolivian watershed; available for purchase for Ecuador
- Applied SWAT model to Bolivian watershed

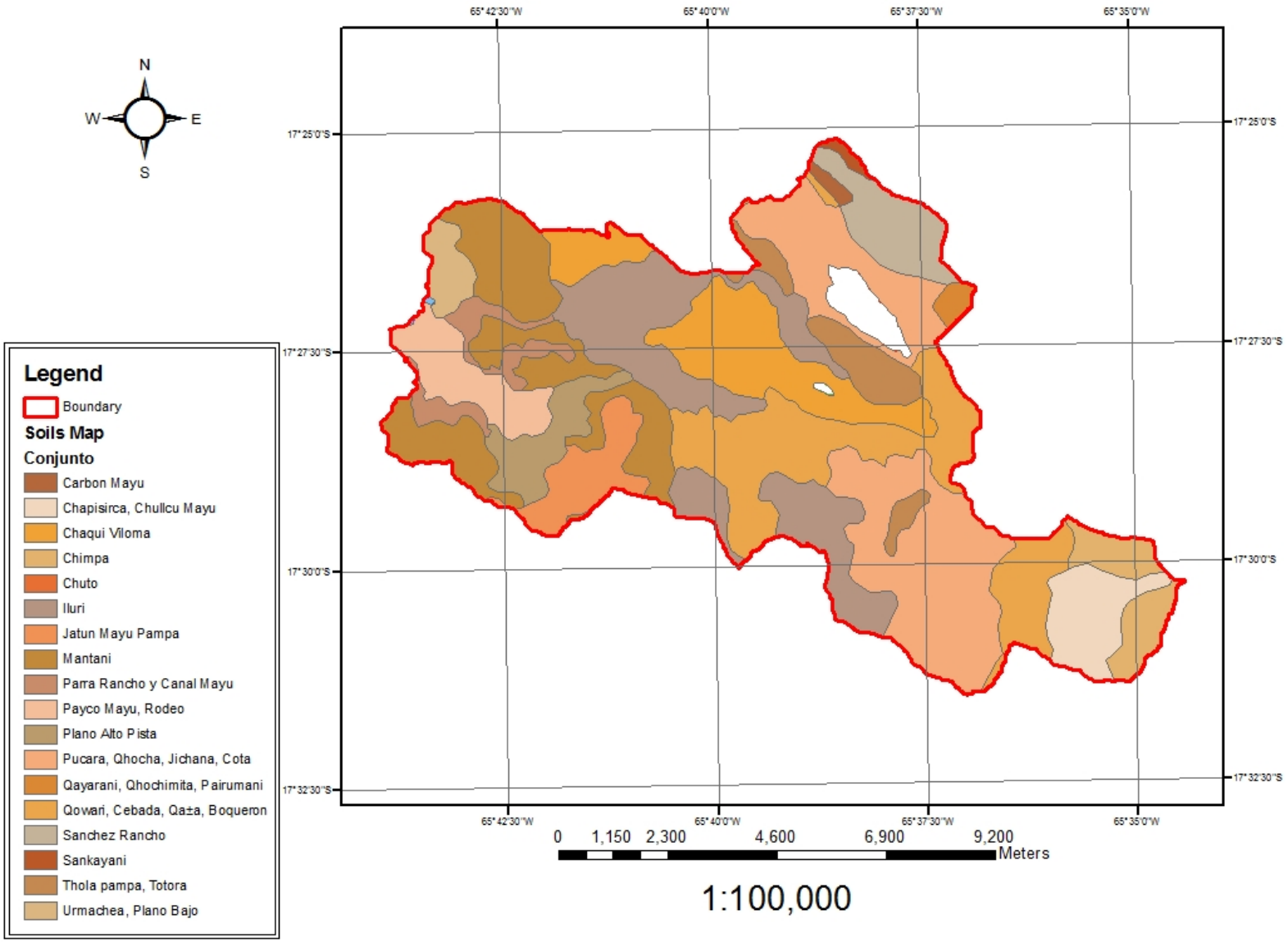
Stream network over a LANDSAT image of the Jatun Mayu River Watershed



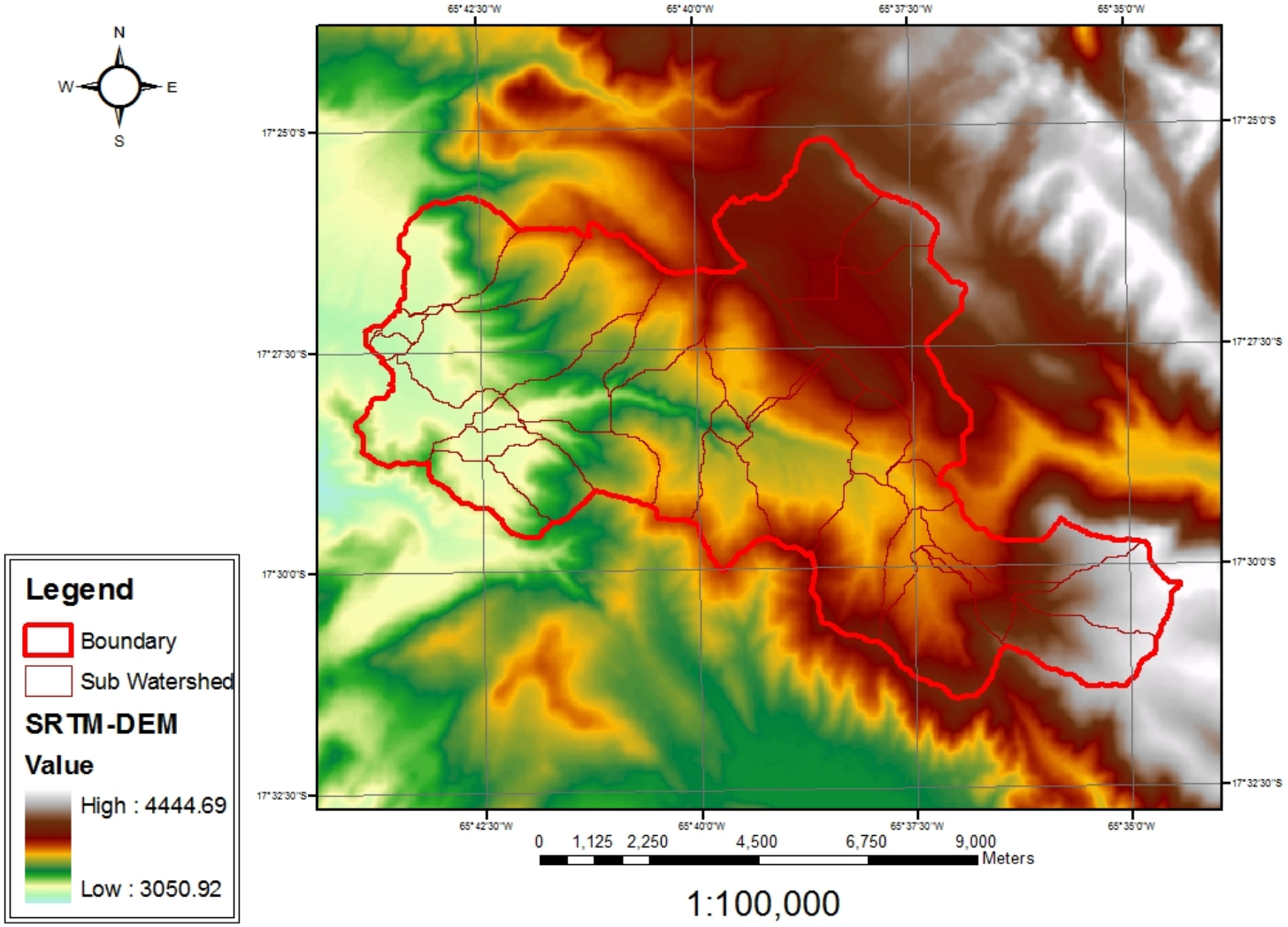
Subwatersheds and HRUs over a LANDSAT image of the Jatun Mayu River Watershed



Soils map for the Jatun Mayu River Watershed



SRTM - 30 m resolution Digital Elevation Model



Modeling Activities 2008-09

- Simulate changes in management and landuse based on livelihood study results
- Apply a field-scale model (GLEAMS) to selected individual management systems to provide more detailed input to SWAT
- Evaluate water quantity and quality impacts of different livelihood scenarios

ONE SPECIFIC STUDY

- Accelerated soil erosion is an increasing global problem that threatens sustainable agricultural production. Therefore, analyzing soil erosion risks is an important task, especially in vulnerable areas.

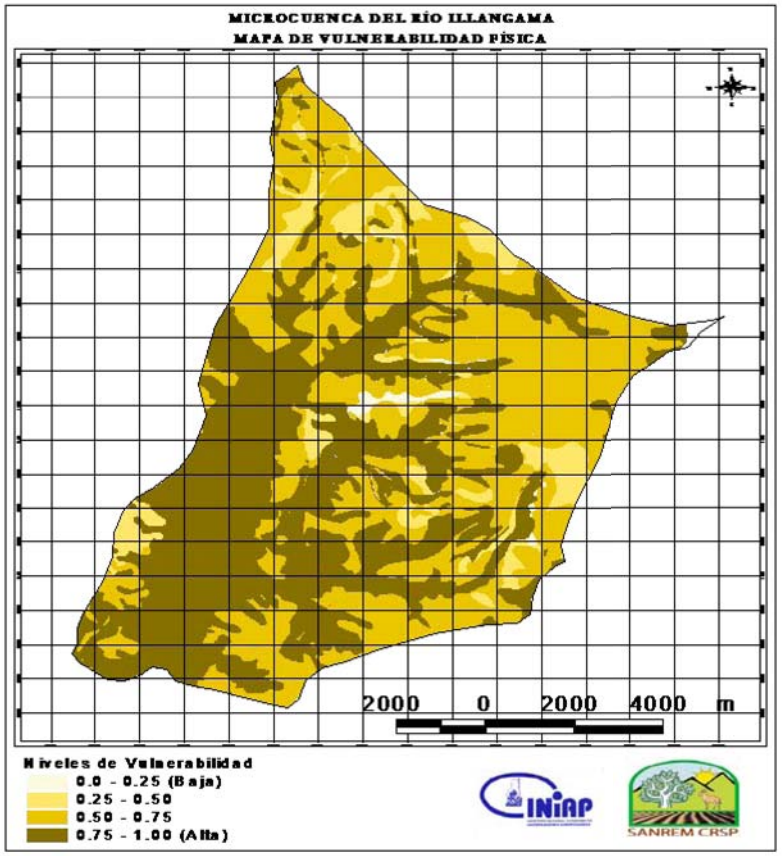
Objective

- To compare a qualitative erosion risk assessment approach (PROMIC) to a quantitative approach (SWAT) for the Jatun Mayu River Watershed.

Ongoing Modeling Activities

- Simulate changes in management and landuse based on livelihood study results
- Apply a field-scale model (GLEAMS) to selected individual management systems to provide more detailed input to SWAT
- Evaluate water quantity and quality impacts of different livelihood scenarios

Vulnerability mapping



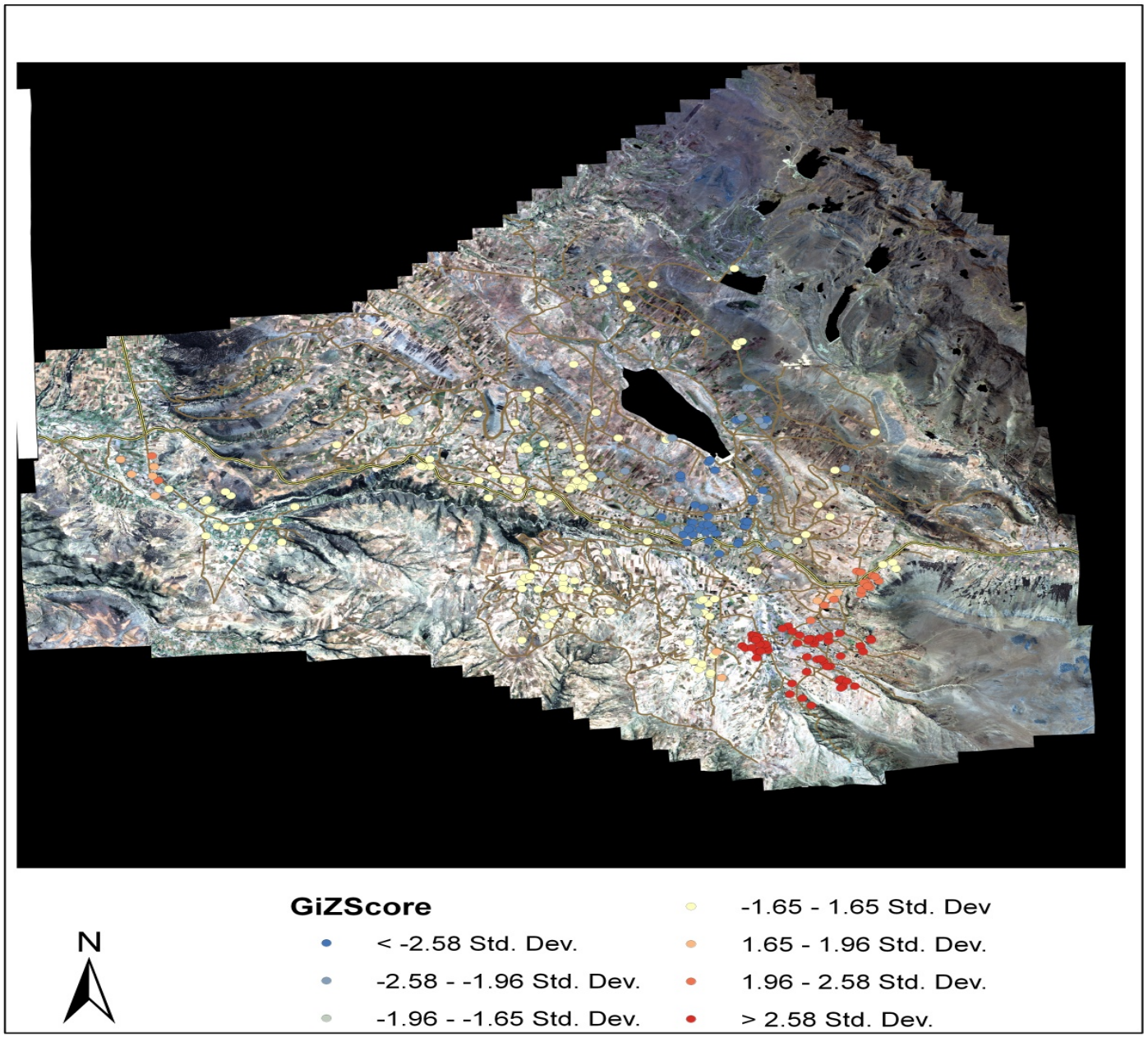
- Based on GIS overlays of variables including: slope and erosivity, current land uses, soil cover, population pressures, others
- More than 3600 ha in Illangama and 2200 ha in Alumbre are “highly vulnerable”
- Local governments have begun process of reforestation in vulnerable areas and water-sensitive areas.

Variables in the inefficiency model

Variables	Effect on inefficiency	Mean
Farm size (ha)	Unknown	2.0726
Ratio of adults to family size	Decrease	0.6005
Ratio of nonfarm income	Increase	0.2937
Household head age	Unknown	45.3415
Household head literacy	Decrease	0.8455
Household head gender (1 = Female)	Unknown	0.1545
Agricultural Decision-Maker: Male	Unknown	0.4553
Agricultural Decision-Maker: Both	Unknown	0.3577
Percent of adults with secondary educ.	Decrease	0.1364
Nb observations	123	

Variables	Effect on inefficiency	Mean
Field Area (Ha)	Increase	0.3174
Distance from field to paved road (m)	Increase	2428.699
Distance from field to dirt road (m)	Increase	98.2829
Nb observations	287	

Hot Spot Analysis for technical efficiency scores based on field locations



Main findings

- Important clusters of low and high technical efficiency scores are found when the analysis is performed at the field-level.
- These clusters are practically inexistent when the analysis is performed based on the household locations.

Conclusion

- Variability in efficiency seems to be explained more heavily by the environmental factors than by the family characteristics
- Efficiency would be greater if households were analyzed as an unit
  - Having fields in different locations that are managed differently in term of inputs used according to the potential or real environmental shocks can be seen as a diversification strategy by the household to mitigate risk.

Cross-cutting activities: Water quality monitoring

- Extensive collaboration with Conrad Heatwole's initiative: monitoring stations established, local communities engaged, data being collected
- Water quality testing:
  - Laboratory samples in Ecuador indicate high quantities of fecal and other coliforms at monitoring sites; differences by site and over time
- Community engagement: macro-invertebrates as indicators of water quality. An outcome of biodiversity assessment in Ecuador: school children and teachers are regularly examining water for macro-invertebrates as indicators of water quality

Water monitoring in Bolivia

- Six flow monitoring stations to determine hydrologic balances
- Six weather monitoring stations established

Participatory Activities

- Participation of farmers in field-level research
- Identification of water management goals
- Regular interactions with local decision makers

Cross-cutting Activities: Gender

- Study of access to information and gendered potato markets in Bolivia. Major findings: (i) women are main participants in markets in Bolivia (historical and cultural reasons); (ii) access to information (cell-phone technologies) has large impact on market choice; (iii) access to information does not affect gender relations in market
- Study of gendered dairy markets in Ecuador. Main findings: (i) marked differentiation in gender roles in production (women are responsible for livestock and cheese production) and marketing (men conduct most of the marketing negotiations with dairy market intermediaries); (ii) in households with smaller-scale production, women process artisanal cheese and market it themselves; (iii) implication for promotion of commercial dairy production is that women might lose access to the market