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Modelling the Adaptation Strategies of Farmers of the Andes Against Climate Change and the Related Development of Land Use / Land Cover

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Problem Statement: There is a strong demand from policy makers for predictions about the impacts of climate change and the effect of potential adaptation strategies of farmers on the local scale. This can be a difficult task, especially when dealing with highly complex socio-ecological systems.

Objective: To assess the development of farming systems under potential climate change scenarios in agricultural systems of the Andes of Peru.

Methodology: The research uses mathematical programming-based multi-agent systems (MP-MAS), an ABM software application for simulating land use change in agriculture and forestry. MP-MAS couples a cellular automaton representing a physical landscape with an agent-based model representing land-use decision making.

A model prototype was implemented and parameterized with the data available from the INCA project of the Achamayo watershed located in Junín, Peru. It considers a single agent with averaged resources and constraints (e.g. household members, land availability).

MODEL PURPOSE

To understand how households allocate their assets to different agricultural land uses, when facing a diversity of agricultural options and set of constraints.

SOFTWARE

The model was generated using the XSingleAgent.xls of MP-MAS, which uses linear programming for testing different sets of constraints and finding the optimal solution to linear problems.

AGENT

- A farm household

AGENT CHARACTERISTICS

- Four Household members (2 working adults in average age of 50 years and 2 children)
- Only adults supply labor

INITIAL CONDITIONS

Cash available: 1400 nuevos soles
Land available: 1,6 has.
Labor available: 389 day labor

ACTIVITIES

The household (agent) can choose from 5 different types of crops to grow:

- **potato1** (yungay variety - *Solanum tuberosum*),
- **potato2** (canchan variety - *Solanum tuberosum*),
- **olluco** (*Ullucus tuberosus*),
- **barley** (*Hordeum vulgare*) and
- **haba bean** (*Vicia faba*)

CONSTRAINTS

- The crop rotation period is considered to be 8 years
- Potato varieties can only be planted once every 8 years
- Olluco can only be planted once every 8 years
- Cebada and habas can be planted any time except during fallow

RESULTS AND DISCUSSION

Figure 1. Agricultural Land Use

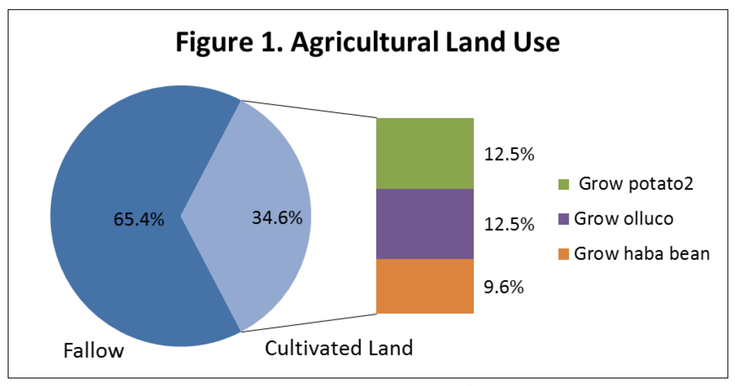
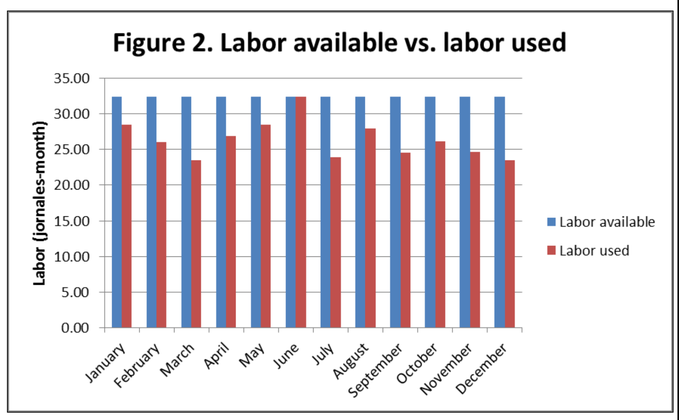


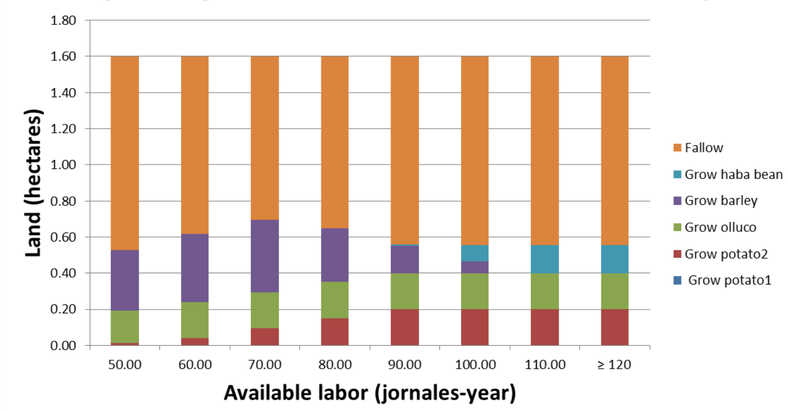
Figure 2. Labor available vs. labor used



Base line with average household data (Figures 1 & 2):

- **Crop mix**: in order to maximize its expected total gross margin, the household chooses a combination of 3 crops (see figure 1.). The selection is nevertheless **price sensitive**. A small increase in the selling price of potato1 (+0,33%) leads to start producing potato1 instead of potato2. In real life, this is reflected by the fact that small farmers usually grow both varieties simultaneously, **minimizing risks** of loss due to fluctuation in market prices.
- At the present time, **labor** is a main constraint when analyzed on a **monthly basis** (Figure 2). This counts particularly for harvesting season in June. Harvesting is generally done using labor-intensive techniques.

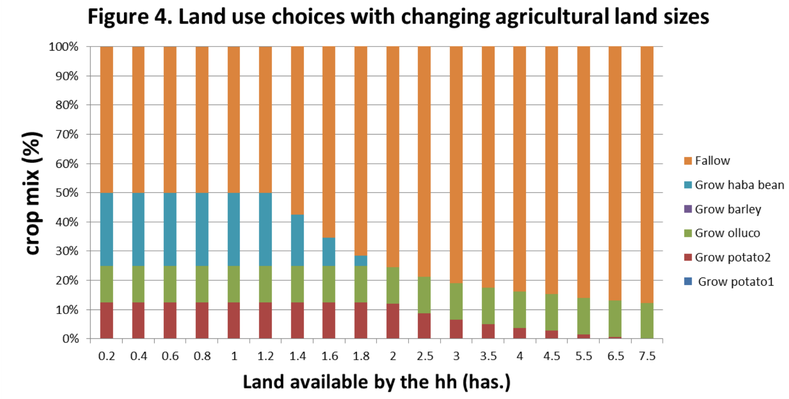
Figure 3. Agricultural Mix with Different Labor Availability



Scenarios (Figures 3 & 4):

- With an increase in labor availability (Figure 3), the household would shift its production to a more labor demanding (but also more profitable) crop mix.
- With increasing land availability, labor and cash become constraints. A specialization of the household, producing only the most profitable crop (Olluco) would be the optimal strategy for maximizing profit (Figure 4).

Figure 4. Land use choices with changing agricultural land sizes



Conclusions:

- Cash is a main determinant in the decision on crop mix. Therefore, low cash input at the beginning of an agricultural season, which is common for small scale farmers, would lead to a less profitable crop mix.
- Labor is also an important constraint when analyzed in a monthly basis. Hiring labor and reciprocity are some of the commonly used strategies to solve the seasonal requirement of labor.
- Further productive activities and constraints need to be taken into account in order to better approach the decision making at household level for the study area.

Further Steps:

Further model development will broaden the scope from a single household to the community level. Other land use types will be included such as agriculture, grasslands, forest plantations and urban areas. Water availability as abiotic driver of land use change, market forces, as well as potential policy interventions (e.g. credit, subsidies) for local livelihood improvement will be considered. Based on this, the relative impact of the main drivers behind systems dynamics will be addressed.