Multi-criteria evaluation of cropping systems: multi attributes hierarchies and linear programming methods

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A need for multi-criteria evaluation methods

- How sustainable is a certain cropping system?
  - social
  - economic
  - environmental

- several point of views among stakeholders (farmers, development workers, researchers, policy makers...)
Main features of two major approaches

- Optimization Under Multiple Constraints (OUMC), or “linear programming”
- Multi Attributes Hierarchy (MAH)
Study in family agriculture of central Brazil using OUMC and MAH

- DMC systems (DMCr, DMCb, DMCb) ex-ante evaluated as environmentally sound alternatives to Conventional Systems (CS)
- Subsistence farms in transition toward dairy production with increasing needs for maize and fodder, cattle herd rapidly evolving
Optimization Under Multiple Constraints (OUMC) approach

1. Structure of the farm model

**Activities**
- Cropping Systems x Environment
  - list of CS (including list of expected products per time period)
  - list of Env. Units
  - list of possible combinations (CS x EU)
- Livestock Systems x Env
  - ..... 

**Prices**
- costs of inputs, labour, products (per period)
  - Off farm activities

**Farm resources**
- land (per EU, Land Value Units)
- labor force (time period)
- initial cash and stocks (products, animals,....)

**Decision model**
- goal(s) (e.g., max farm income)
- constraints (e.g., food and other consumption needs)
- risk aversion / perception

**Model outputs**
- set of production activities (area in CS x EU....)
- Income
- Env externalities
  - ..... 

**« Technical coefficients »**
- (per activity x time period)
  - yields (per P)
  - inputs
  - labour force
  - env externalities (e.g., N lixiviated)

**Solver**

**Prices**
- of inputs, labour, products (per period)

**Scenarios of change**

**Farm resources**
- land (per EU, Land Value Units)
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Optimization Under Multiple Constraints (OUMC) approach. 2. Modelling procedure

• data acquisition (“technical coefficients”): survey + agronomic trials (+literature, expert knowledge)
• validation with baseline scenario (innovative CS not present in the list of possible activities) on 6 farms representing 3 farm types: simulated matching actual farm plan (= set of activities with their level: ha, number of animals, labour force sold/purchased, etc...)
• Introduction of innovative CS in the list of activities: do they appear in simulated farm plans and to what extent?
Examples of outputs from OUMC

1/2

Simulated increase in farm income permitted by the introduction of DMC in the list of possible activities
Examples of outputs from OUMC

2/2
Multi Attributes Hierarchy

- Participatory (farmers, development agents and researchers) definition of:
  - list of criteria covering the three dimensions of sustainability.
  - note (scale 1 to 5) given for each CS to each criterion
  - weights attributed to each criterion for criteria aggregation.
Comparative scoring for conventional (blue line) versus DMC system (red line) for each criteria in the bottom-up participative methodology. (Total Scoring DMC 85 and Conventional 65)
Results

• Same ranking of CS with the two methods: DMCr > DMCc = DMCb > Conventional systems when economic and social criteria predominate over environmental criteria

• Differing from “objective” environmentally based hierarchy (or the point of view of agronomists): DMCc > DMCb > DMCr > Conv Syst. on environmental criteria (erosion, nutrient leaching, herbicides use)

• Similar uncertainties in the two methods:
  – nutritional values of the cover crop as fodder for the dairy cows
  – labor requirements of DMC

• Same main research question generated by MAH and OUMC: need for more accurate data on agronomic performance (including quality as fodder) of the cover crops in DMC systems.
Tentative list of comparative advantages of the two methods

**OUMC approach**
- validation against actual farms
- “embedded” sensitivity analysis
- huge worldwide community of users sharing experience in forums + papers, manuals...
- screening windows of options,
- testing scenarios of change in the economic environment
- farm level assessment plus assessment of land and labour productivity of activities
- fully practicable ex-ante (when no farmer has experience or knowledge about the studied CS)

**MAH**
- point of view of farmers is explicit
- favours dialogue between farmers and scientists (and/or other stakeholders) and consensus building
- easy to describe / understand / learn
Tentative list of comparative drawbacks

- **OUMC**
  - apparent objectivity masking role of scientist’s point of view
  - difficult to describe / understand / learn

- **MAH**
  - apparent participatory approach masking role of scientist’s point of view
  - sensitivity analysis difficult due to thresholds, categorical data
  - cannot determine whether land or labour productivity is the most relevant criterion for economic evaluation of a given CS in a given farm
Conclusion

• MAH = useful discussion tool between stakeholders.
• OUMC = more objective, virtual test bench (what if...)
• None is free from subjectivity: prescriptive use should be avoided