Multi-Objective Decision Making Tool for Agriculture

Effective and Consistent Decision-Making

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What crops should I plant next year, why, where, and what is the risk? What kind of yields can I expect if I do... what will this mean to my bottom line:

**Crop Planning:**
- Provide an annual crop production plan that determines the area to be used for different crops while fulfilling the demand, land, capital and region limitations.
  - Objectives to consider:
    - Maximize income/revenue
    - Minimize revenue fluctuations (risk)
    - Minimize Working Capital deficit
    - Maximize employment (agriculture is seasonal)
    - Minimize fertilizer usage
    - Minimize water usage (irrigation, ground water)
  - In nation wide planning problems additional environmental objectives are considered such as land sustainability.

**Sugarcane Cropping & Logistics in light of Supply Chain Management**
- Provide a plan for the sequence of lots (fields) to crop.
  - Objectives to consider:
    - Minimize the number of operating days
    - Minimize total traveling distance of trucks
    - Minimize deterioration time of harvested sugarcane
    - Maximize Income
      - Maximize PCC and Fiber
    - Under constraints such as:
      - Desired constant Tonnage (the minimum to guarantee constant supply to the mill)
A typical fruit grower targets multiple objectives, likely conflicting:

- maximize fruit yield
- minimize overall risk (climatic risk, root disease, etc.)
- minimize overall cost (irrigation, labor, etc.)
- maximize storage quality
- maximize taste ranking
- maximize sustainability of soil (e.g., as a function of fertilization)

Environmental regulations may be formulated as constraints:

- Total Nitrogen and total Phosphorus (irrigation and fertilizer management)

Product constraints:

- Toxicity (e.g., leaf toxicity as LCI measure)

The solution: an Optimization & Decision Making Framework to obtain the best fruit growing strategy per the farmer’s preferences and existing field.
Multi-Objective Decision Making

The Challenge
- A need to balance multiple (often conflicting) factors
- A very large number of alternatives
- What are the optimal alternatives? What are the preferred ones?

The Benefit
This tool assists decision-makers:
- Provides insights into the nature of the conflict and the available tradeoffs:
  - What factors are conflicting?
  - What are the tradeoffs? Are there good compromises?
- Increases the transparency of the selection process
  - What do we gain or lose by selecting a specific strategy?

The decision-maker can clearly justify the selection of a certain strategy
IBM Multi-Objective Decision Making Tool

- Upgrade existing manual or otherwise sporadic “what-if-scenario” approaches to attain the Pareto Optimal solutions of the multiobjective problem.
- Employ novel Visual Analytics tools for the exploration process
- Boost decision-making by utilization of novel algorithms (learning, tradeoff analysis, interaction)

**Multiobjective Optimization**
- ILOG-based Solvers, or Evolutionary Algorithms

**Visual Analytics**
- Parallel Coordinates
- SOMMOS [IP]

**Insight**
- Tradeoff Highlighter [IP]
- Analytical Selection [IP]
- Interactive Decision [IP]
Our Tool’s UI: Visualizing the Pareto Frontier

Trade Off Analysis

- What is the nature of the conflict?
- Can we identify solutions in which a marginal loss in one of the objectives will bring a large gain in the others?

* All values were normalized.
Summary

- We suggest to take agronomists work to the next level – employ simulation-based optimization based upon Agronomic modeling.
- Upgrade the existing sporadic “what-if-scenario” approach to attain the Pareto Optimal solutions to the multiobjective problem.
- Employ novel Visual Analytics for the Decision Making process [partially shown here; IP].

A 5 min demo of the tool: 