RESEARCH PROGRAM ON Dryland Systems

CGIAR

Food security and better livelihoods for rural dryland communities

Methodological options for modelling agent's decision-making in MAS

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Why is human decision-making a matter?

- Human-induced changes in ecosystems and environment is the subject of management
- Any kinds of those changes is directly caused by concrete actors (human agents)
- Actor's decision-making about resource uses is a integral process that combines social, political, economic and ecological information flows, thus play as core engines for human-environmental dynamics

Alternative methods to model agent‘s behavior

- Heuristic approach
  - Simple reflex decision-making (IF-THEN)
  - Heuristic rule-based process (Decision Tree)

- Rational approach
  - Goal-driven process (e.g. optimization)

- Bounded rational approach

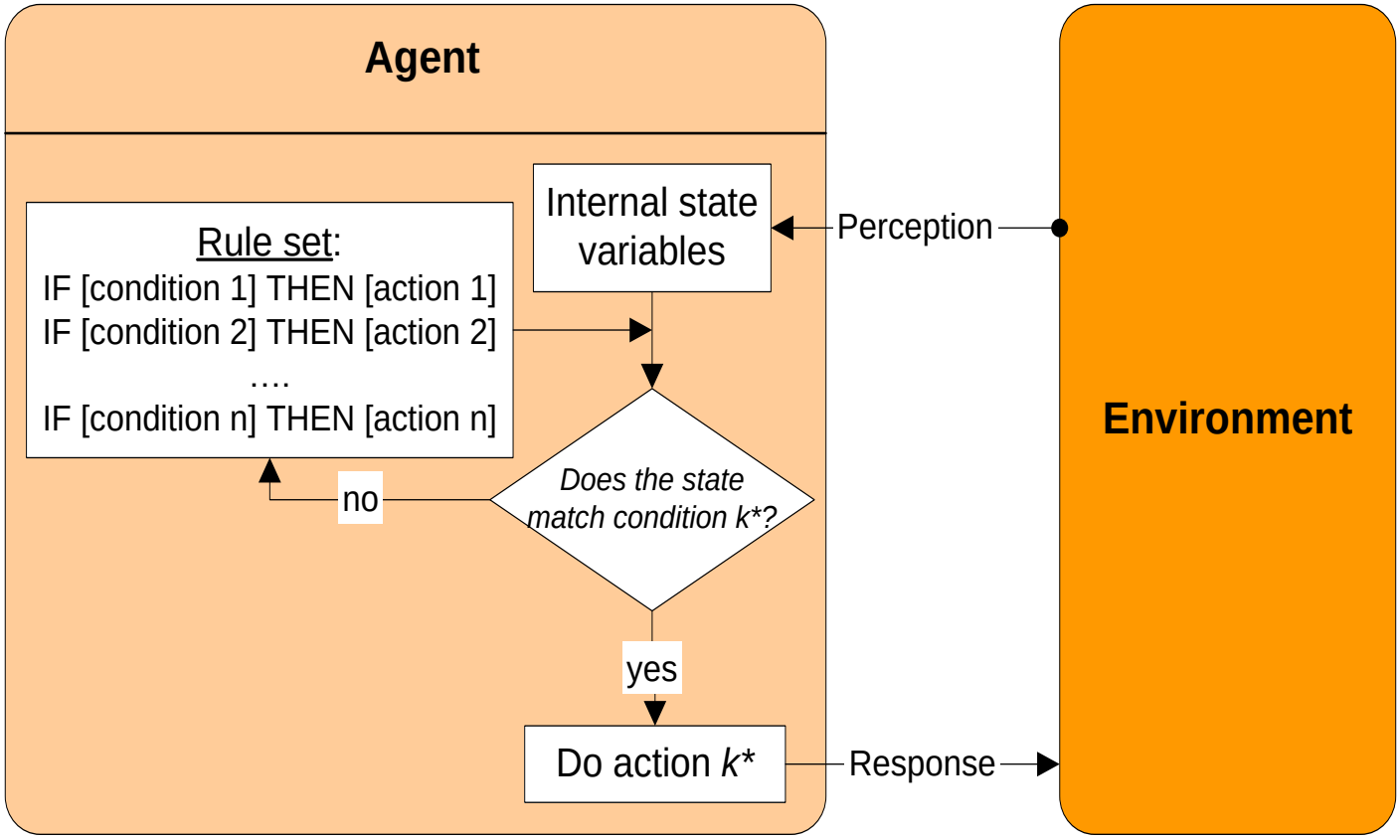
- Hybrid approach

Reflex decision-making: assumption

- **Assumption**: people do not (or cannot) calculate any anticipated values of alternatives, but rather react in a timely fashion according to their daily routines to select directly options based on current conditions.

- Based on a set of IF-THEN rules:
  IF [*condition X*] THEN [*action Y*]

Reflex decision-making



Source: Le (2005)

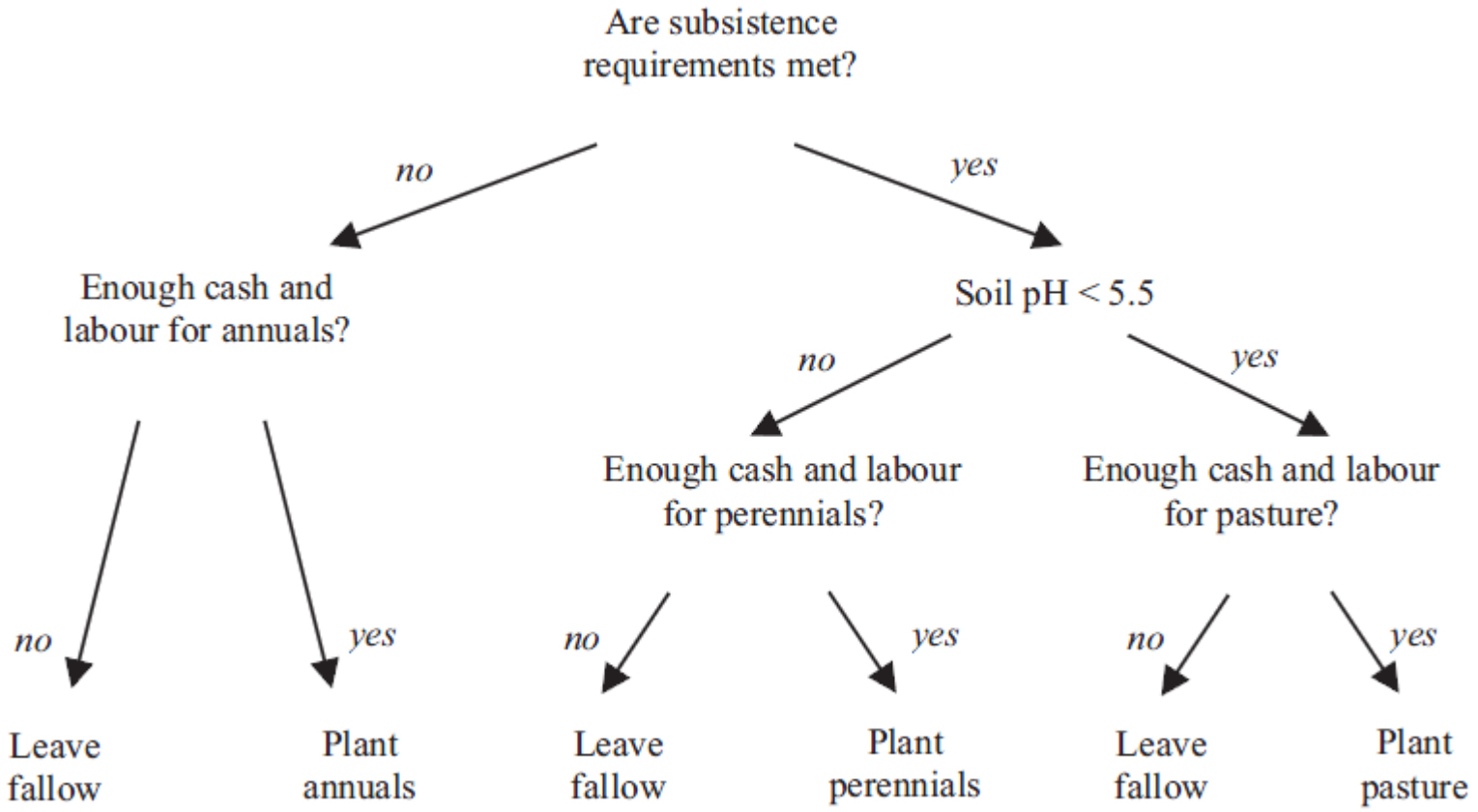
Heuristic rule-based process

- A decision tree (set of nested reflex rules) is defined for selecting options based on current conditions

- No goal is assumed, and no anticipated value of options is calculated.

- Structure of rule set:
  - Rules sense the states of the agent itself and the environment (incl. policies)
  - Rules control other rules
  - Rules direct agent's action

Heuristic rule-based process: example



Land-use decision tree by small holders in an region in Amazon

(Source: Deadman et al., 2004)

Heuristic rule-based process: How to discover and parameterize?

- Social research method (e.g. Huigen 2004)
- Data-mining techniques applied to survey data (e.g. Ekasingh et al. 2005)
- Participatory role-playing games (e.g. Castella et al. 2005)
- Laboratory experiments (e.g. Deadman, 1999)
- Expert opinions

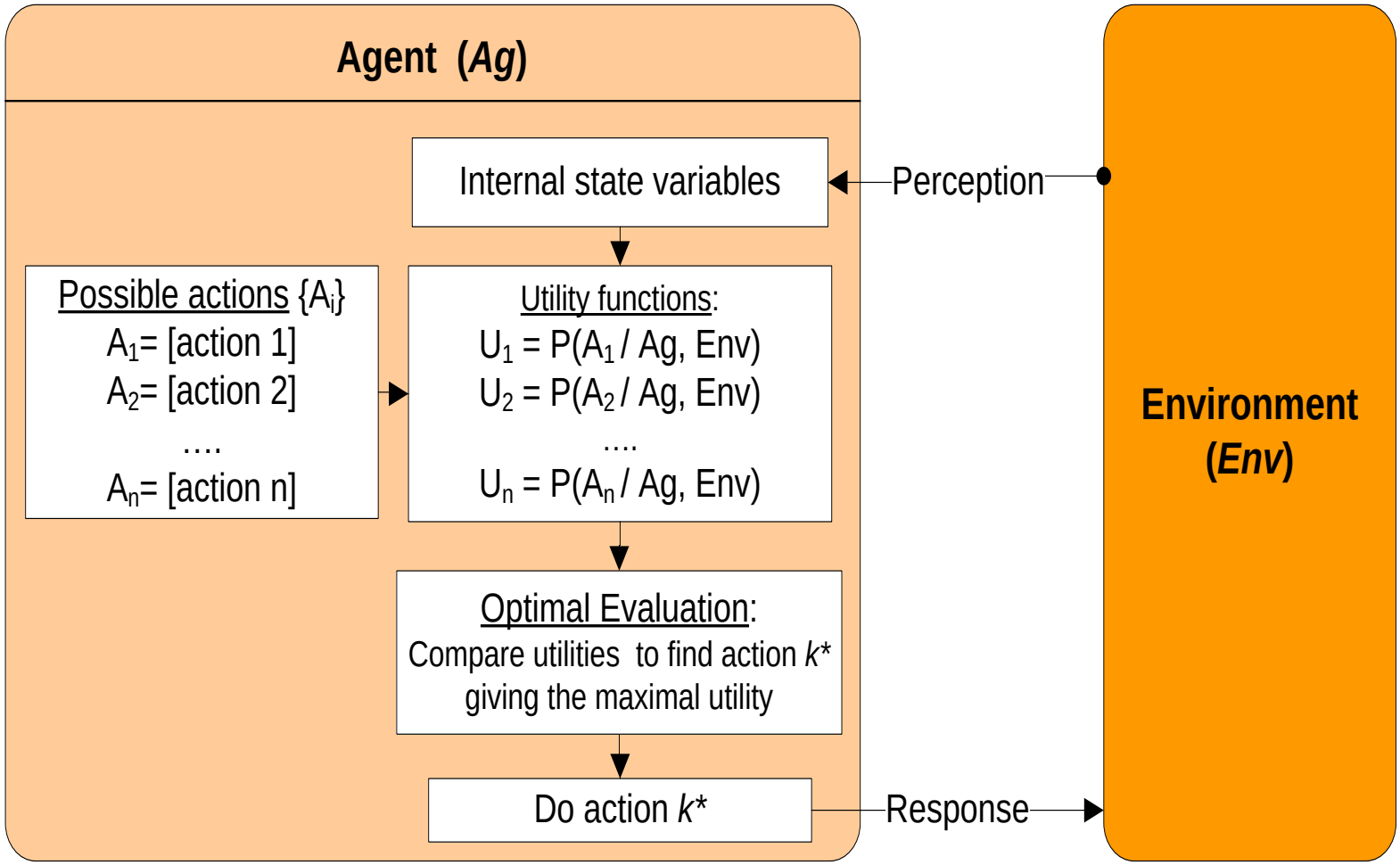
Goal-driven process

- **Assumptions**:
  - **Clear, persistent goals**
  - People have a **perfect knowledge to recognize** and select the best option from a range of feasible alternatives with respect to their goal.
  - Decision/alternative "space" = range of feasible alternatives known and fixed

- **Objective function**: numerical value of an alternative with respect to goal's achievement , which provides an evaluation basis for making decisions about actions.
  - Profit (to be maximized)
  - Risk (to be minimized)
  - Utility ("happiness", possibly a combination between profit and risk)

- **Constraints** shaping agents' evaluation of alternatives (e.g. limited resources)

Utility-maximizing decision



Source: Le (2005)

Bounded-rational decision-making

- Low uncertainty + high aspiration (low satisfaction) support more rational behavior

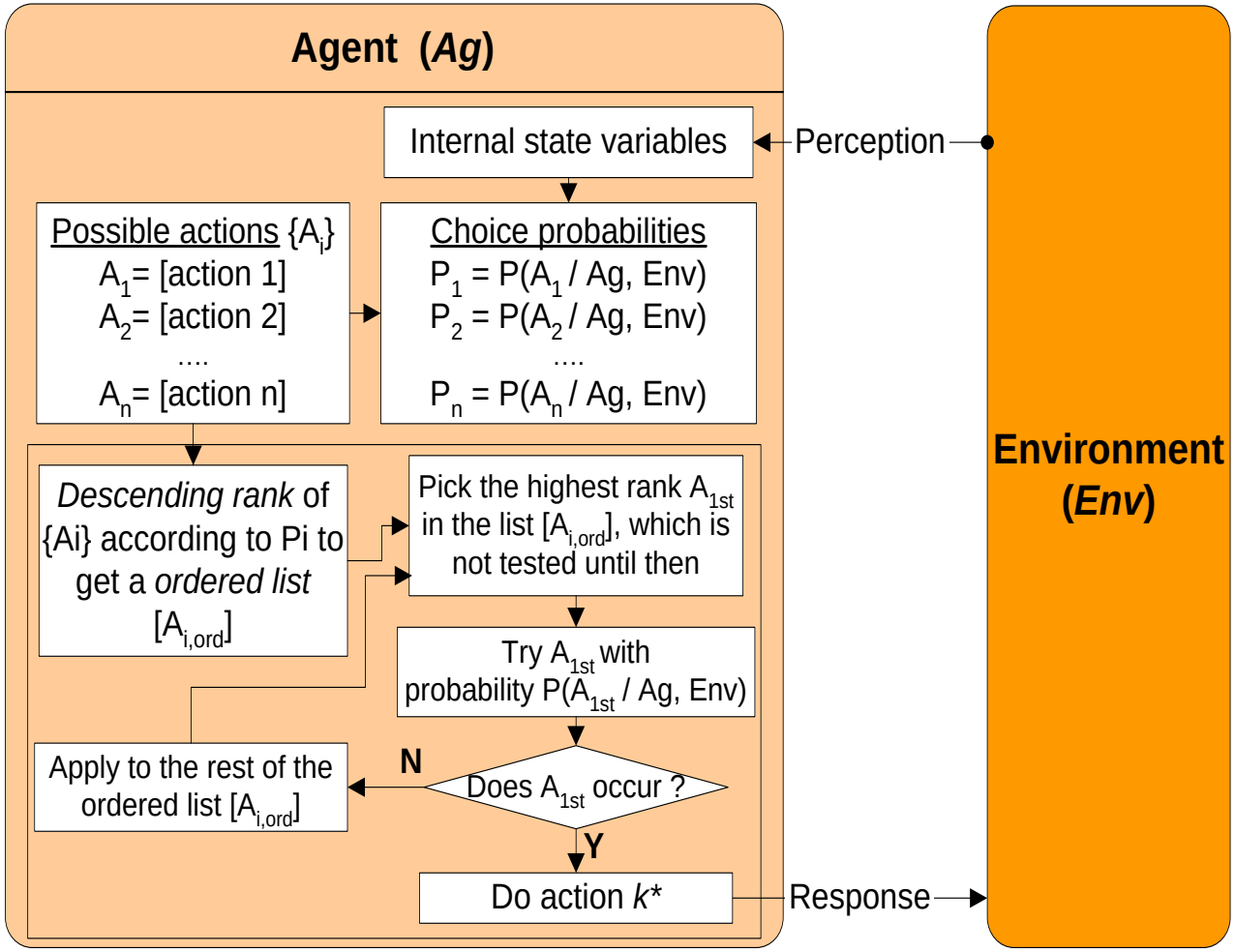
- Society High uncertainty + low aspiration (high satisfaction): other behavior likely to be: repletion (routines), imitation (to similar peers and surroundings)

Source: Jager et al. (2000); Le et al. (2012)

Bounded-rational decision-making: an example

What does this algorithm tell?

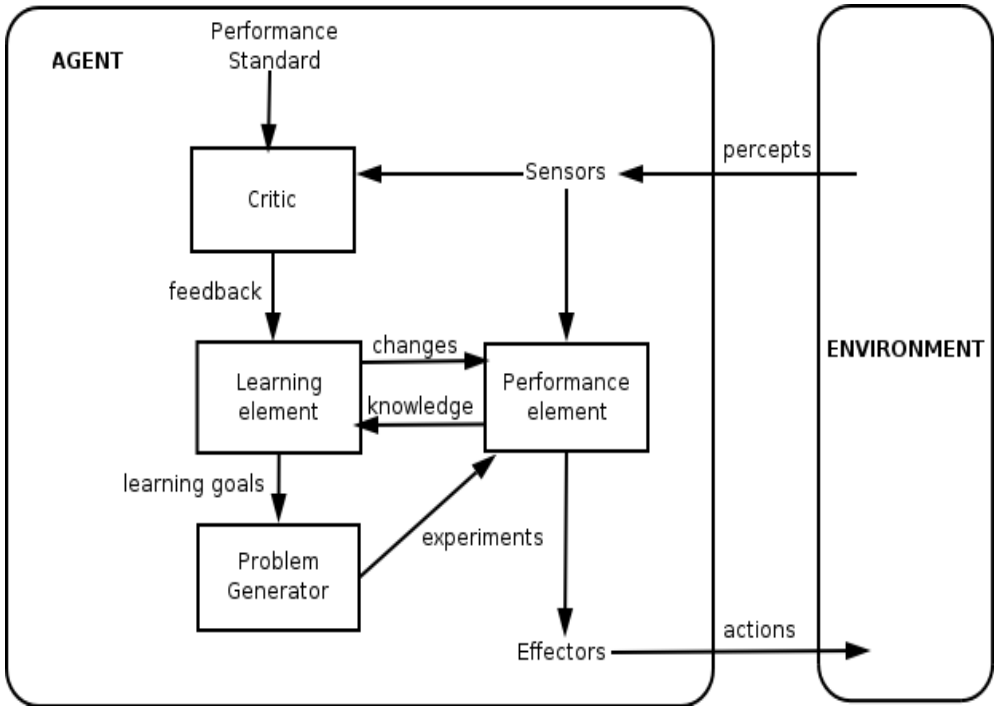
- The highest chance that the agent selects the alternative with maximal utility.
- Some chance that the agent doesn't make such an optimal choice.



Source: Le (2005), modified from Benenson & Torrens (2004)

Learning/adapting decision-making

- Agents have abilities to analyze themselves in terms of behavior, error and success.
- Adjust behavior to improve future performance
- Used techniques: genetic algorithm, neutral network, etc.



Social interactions in agent‘s decision-making

- In the real-world there are social relations among agents, which cause inter-dependences between their behaviors

- Game theory, role-playing games are a good way to empirically capture and encode social interactions within MAS/ABM

- Topologies as a basis for social interactions
  - Neighborhood influence
  - Social network