The development of agent-based models for the institutional analysis of drinking water quality governance

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Objectives

1. To analyse the evolution of agricultural practices in water catchment areas
2. To study the impact of the characteristics of protection programs on water quality

Context

Figure 1: Water cathcment area (source: Agence de l'Eau Seine-Normandie)

► **Diffuse pollution from agricultural practices → major threat to water quality**.
► One option for the public policies: **promoting farming practices** protecting water quality.
► Protection program → **voluntary commitment** of farmers.

Methods

► **Agent-based modelling** Computational systems with autonomous entities with dynamic behavior (agent) who operate in an environment and interact with each other and with the environment.

► **Social-ecological systems frameworks** Conceptual framework developed to represent and study complex systems around natural resource management [1].
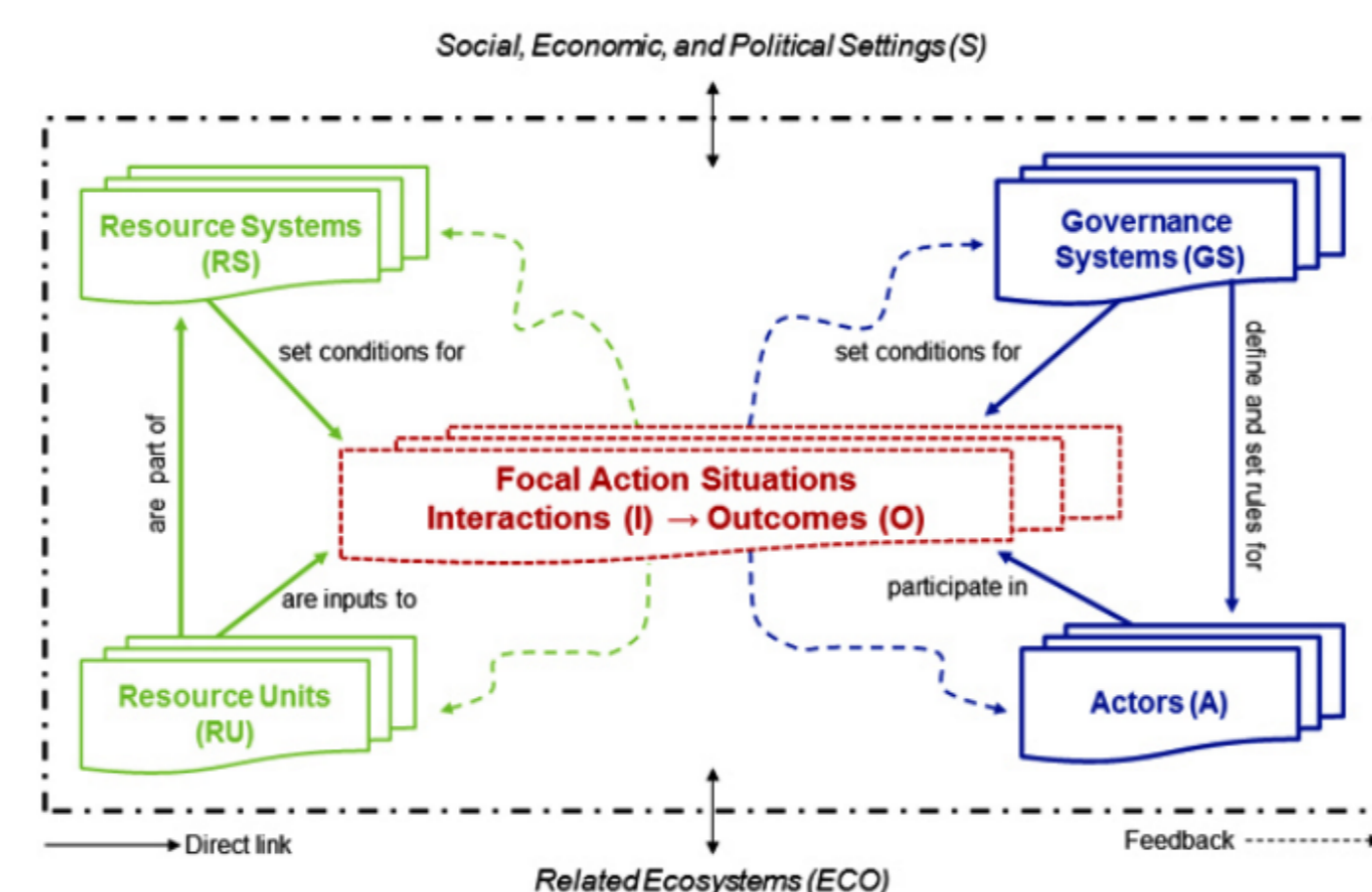

Figure 2: SES framework [1]

► **Theory of planned behaviour (TPB) [2]** Intention towards a behaviour is predicted by:
  ▷ *attitude towards behaviour*, judgment about the desirability of the behaviour and its consequences
  ▷ *subjective norm*, considerations about the influence and opinions of others on that behaviour
  ▷ *perceived behavioural control*, beliefs about the individual's ability to succeed in the behaviour.

Model description

► **Ressource system → Groundwater table**
  ▷ A water flow feeds (E) and exits (D) the groundwater. The concentration by polluting in water in mg/l (C) is used as a proxy to measure water quality.
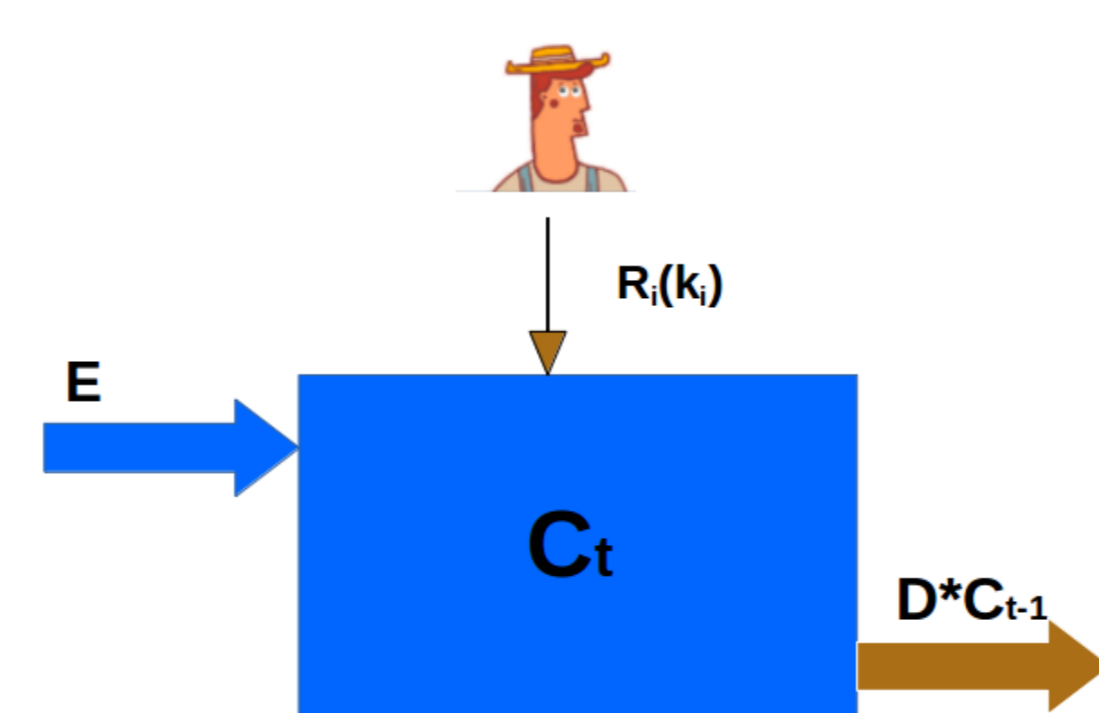

Figure 3: Representation of water and pollution flow

► **Actors system**
  ▷ 2 farming practices (k) with different quantities of input more or less polluting for the water ressource (R): *bio* and *conventional*.
  ▷ 2 agent types: *eco-friendly* and *economicus* with different attitudes' weigts.
  ▷ Behavior (B) [3]:

$$B = Att * \gamma_{Att} + SN * \gamma_{SN} + PC * \gamma_{PC}$$

where *Att* attitude towards a behaviour; *SN* subjective norm; *PC* perceived behavioural control; γ variable weighting.

► **Governance system**
  ▷ Protection program = combinaison of 2 measures
    ► measure 1: agri-environmental measure (financial compensation)
    ► measure 2: training measure

Simulation 1 - Results

Actors behaviour

► *Simulation*: Test of different weights of the variables affecting the intention of behaviour with a specific measure.
► *Results*: a) Results in terms of water quality and number of farmers changing their farming practice are differents. b) The higher the weight of subjective norm is, the lower the adherence of protection program is. c) Attitude influences agent types differently.
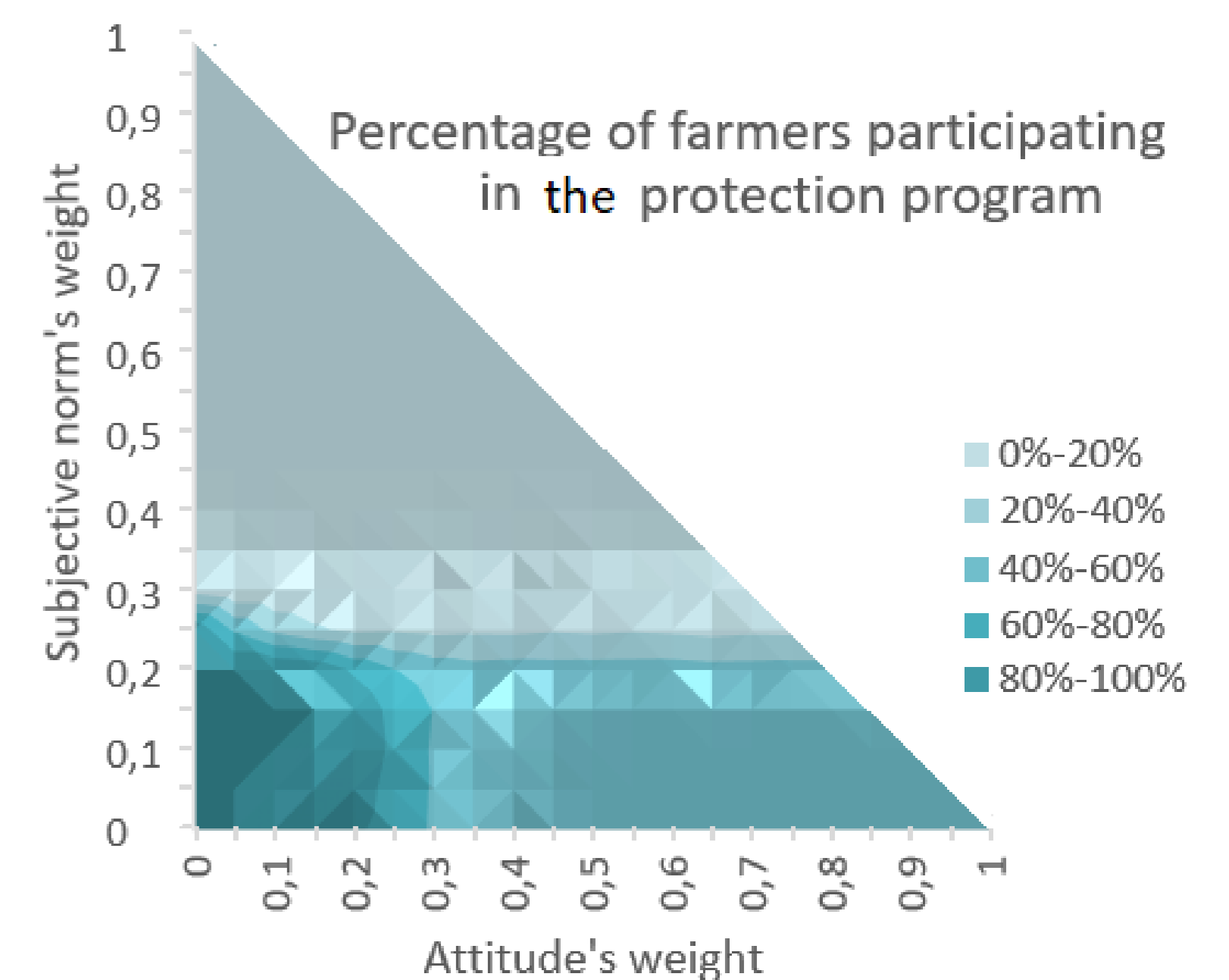

Figure 4: Percentage of farmers participating in the program depending on weight's variables of TPB

Simulation 2 - Results

Influence of the program's characteristics

► *Simulation*: With a set of weights, test of measures included in protecton programs.
► *Results*: a) The bigger subsidies or the level of training proposed, the higher the percentage of farmers participating in the program. b) Existence of a minimum levels. c) Different combinations of the two measures lead to the same result.
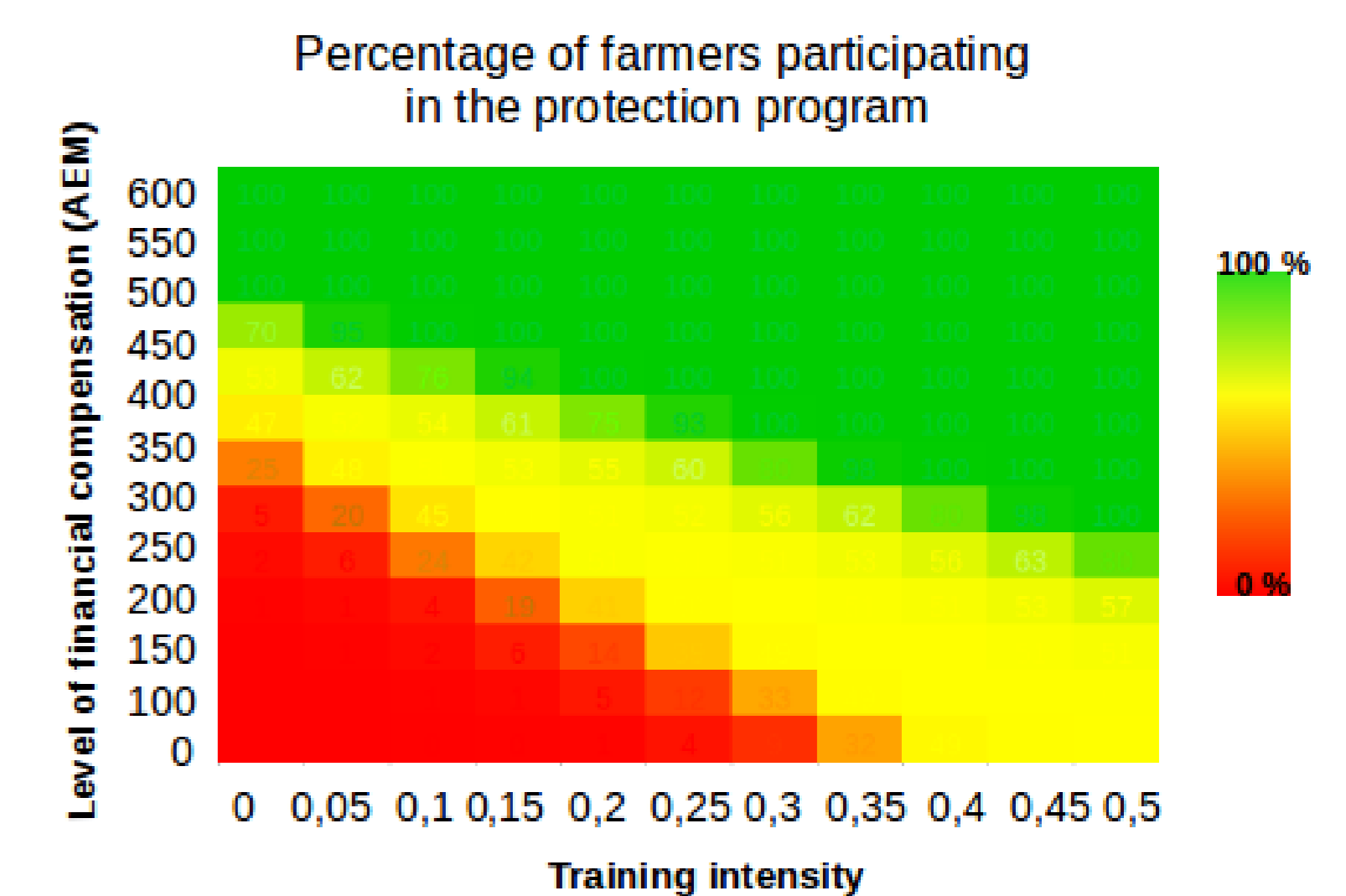

Figure 5: Percentage of farmers participating in the program depending the levels of measures' program

Conclusion

► This study allows us to understand how behavioural specifications influence farmers involvement and water quality results.
► In terms of public policy, this model enables us to highlight the trade-off between different measures.

References

1. **McGinnis, M. D., and E. Ostrom. 2014.** Social-Ecological System Framework: Initial Changes and Continuing Challenges. Ecology and Society 19 (2): 30. https://doi.org/10.5751/ES-06387-190230.
2. **Ajzen, I. 1991.** The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes 50: 179211.
3. **Beedell, J., and T. Rehman. 2000.** Using Social-Psychology Models to Understand Farmers Conservation Behaviour. Journal of Rural Studies 16.

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