Analysis of farmers’ decision-making in a context of multiple risks using modeling and experimental approaches

Stéphane Couture (INRAE, ECOSOCIO, MIAT, Toulouse).

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

INRAE

Colloque sur l'épidémiologie comportementale, Rennes, 31.05.2024

Outline of my presentation

1/

General introduction to the social and scientific context

Societal context: multiple risks

A farmer's activity is subject to a multitude of risks, of various kinds, interacting or cascading, dependent or independent.

Societal context: farmers' decision-making in a context of multiple risks

In a context of diverse risks and uncertainties and of global change, farmers' behavior in the face of diverse risks and uncertainties is heterogeneous. The fact that management behavior differs from one farmer to another raises many questions about the characterization and explanation of these differences.

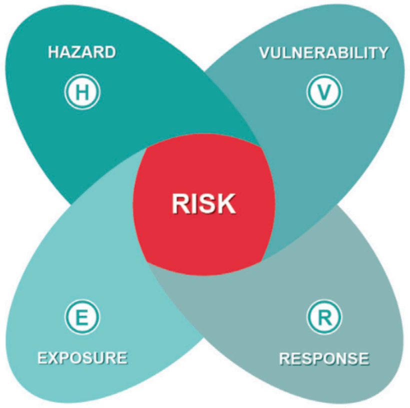
First: risk and its 3 initial components

Concept	Definition
Risk	Risk is defined as the possible consequences when something of value is at stake and there is uncertainty about the consequences. (IPCC, 2014).
Hazard	It is the possibility of a physical phenomenon or trend, natural or man-made, or of a physical impact, likely to lead to losses and damage.
Exposure	It is the presence of people, livelihoods, species or ecosystems, environmental resources and services, infrastructure elements or economic, social or cultural assets that are likely to suffer damage.
Vulnerability	It is the propensity or predisposition to suffer damage due to the occurrence of the hazard.

Flood, earthquake, fire, explosion, terrorism…

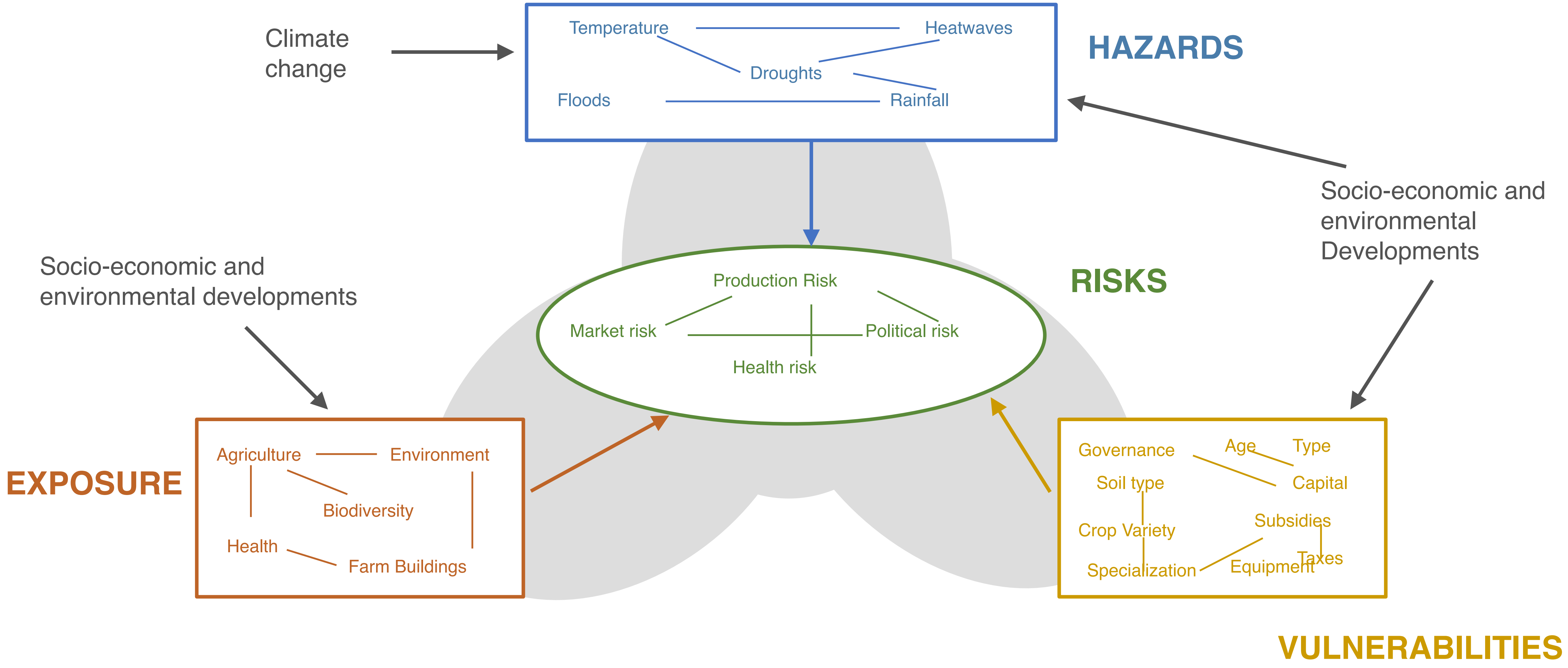
Population, agriculture, environment, socio-economic issues….

Economic, social, geographical, cultural, governmental and environmental factors….



Source : Adapted from Gallina et al. (2016), IPCC (2014), Simpson et al. (2021)

A diagram to illustrate the interactions of multi-risk applied to a simplified farmer's production activity



Scientific context: a wide range of approaches and disciplines

- There are a **host of methods** for tackling multi-hazard problems (Curt, 2021; Terzi et al., 2019).
- With **various fields of application** such as climatic, industrial, natural and technological risks.....

- **Statistical, mathematical and computer modeling methods** such as probabilistic (Bayesian networks) and statistical methods, agent-based models, systemic dynamic models, decision trees, graph theory and geographic information systems......
- But there are also more **hybrid approaches**, such as multi-criteria analysis, serious games, surveys and feedback systems.......

Scientific context: a wide range of studies about behavioral agricultural economics

Two common conceptual frameworks in behavioural agricultural economics:

- The conceptual framework of **Dessart et al. (2019)** : Dessart, F. J., Barreiro-Hurlé, J., & Van Bavel, R. (2019). Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review. European Review of Agricultural Economics, 46(3), 417-471.

=> **very general framework on psychological and cognitive factors**

- The conceptual framework of **Sitkin et Pablo (1992)** taken by **Villaris et al. (2021)** : Sitkin, S. B., & Pablo, A. L. (1992). Reconceptualizing the determinants of risk behavior. Academy of management review, 17(1), 9-38 ; Villacis, A. H., Alwang, J. R., & Barrera, V. (2021). Linking risk preferences and risk perceptions of climate change: A prospect theory approach. Agricultural Economics, 52(5), 863-877.

=> a framework **close to our problem.**

The conceptual framework of Dessart et al. (2019)

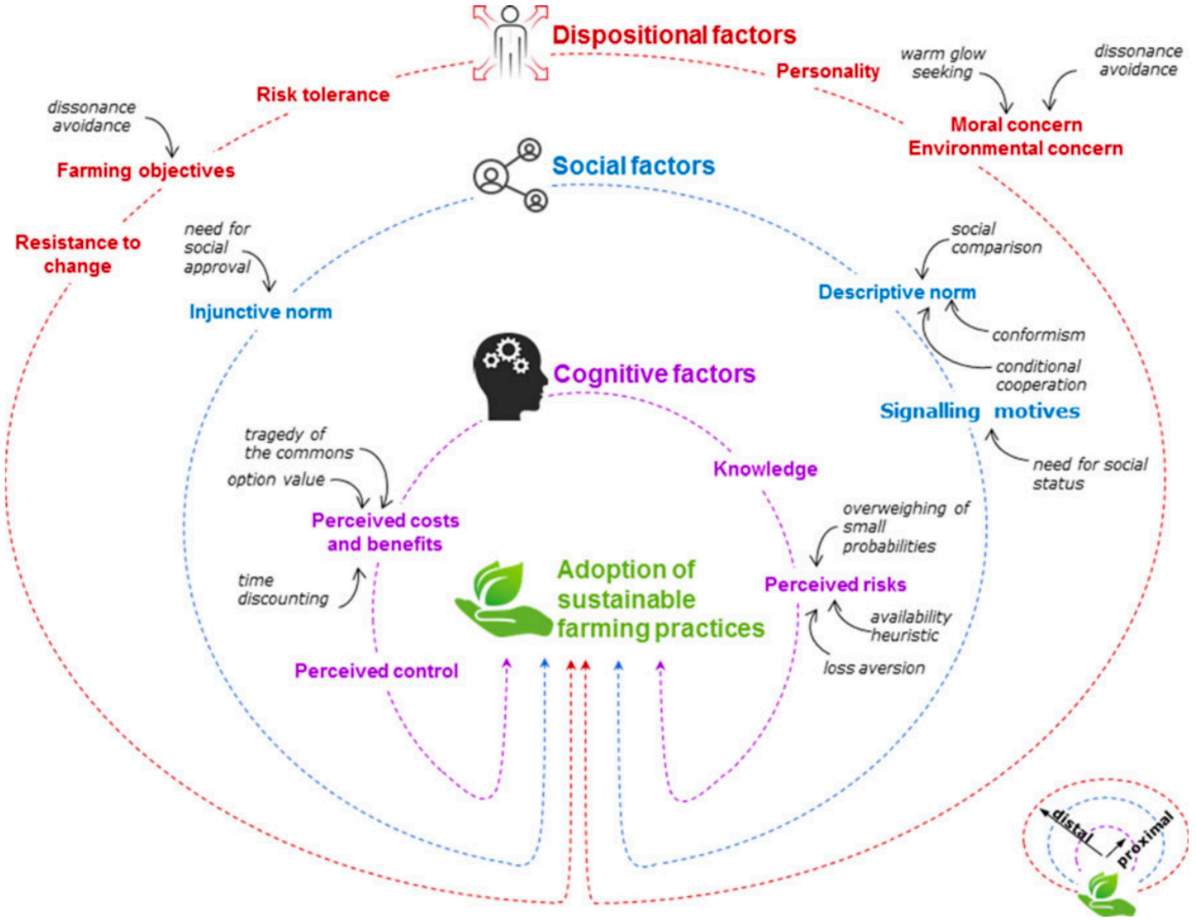
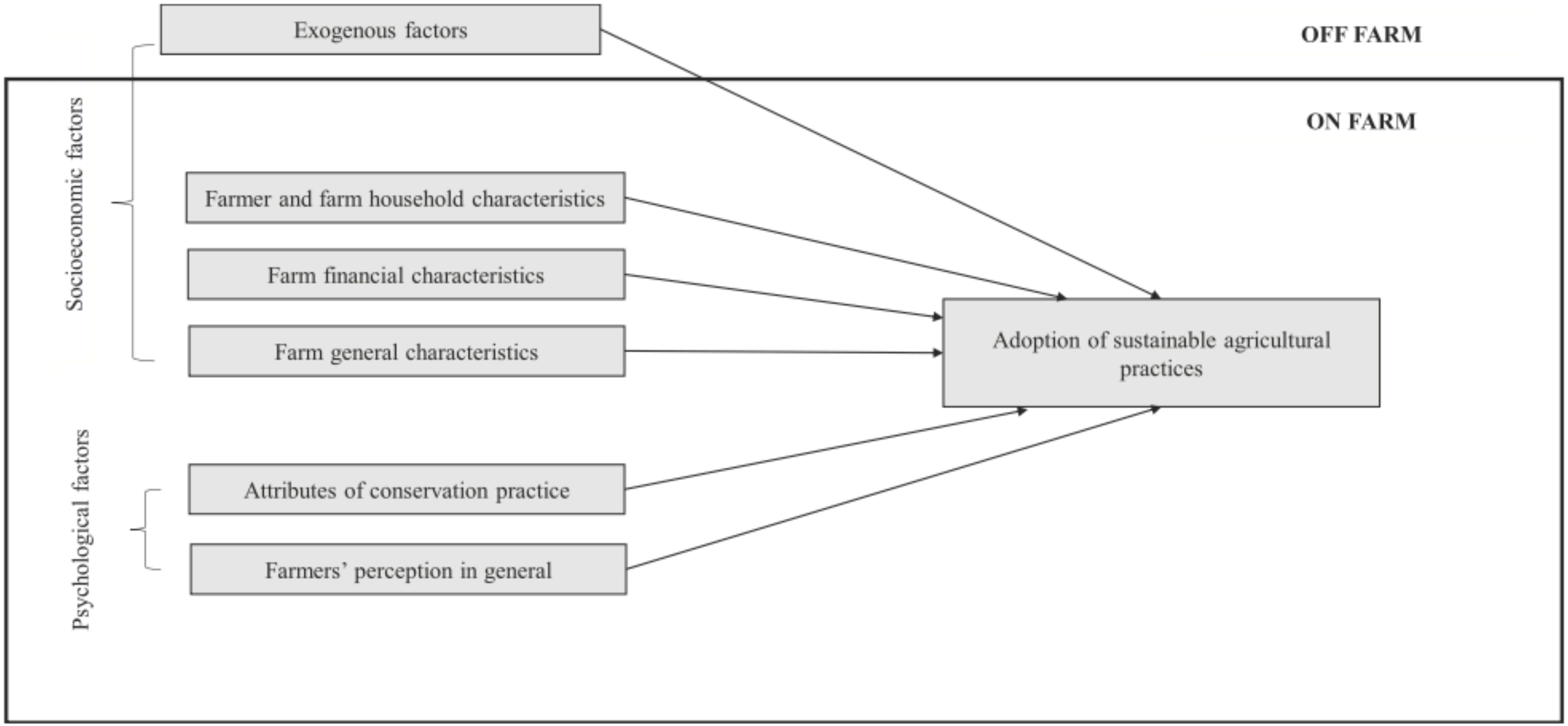


Fig. 1. An integrated framework of behavioural factors affecting farmers' adoption of environmentally sustainable practices. Mechanisms and biases in italics. Within each cluster, behavioural factors are not necessarily situated at the same distance (proximal-distal) to the adoption of environmentally sustainable practices.

The conceptual framework of Sitkin et Pablo (1992)

FIGURE 1
Reconceptualized Model of the Determinants of Risk Behavior

In addition, the conceptual framework of Foguesatto, C. R., Borges, J. A. R., & Machado, J. A. D. (2020). A review and some reflections on farmers' adoption of sustainable agricultural practices worldwide. Science of the total environment, 729, 138831.



2/

What is our problem?

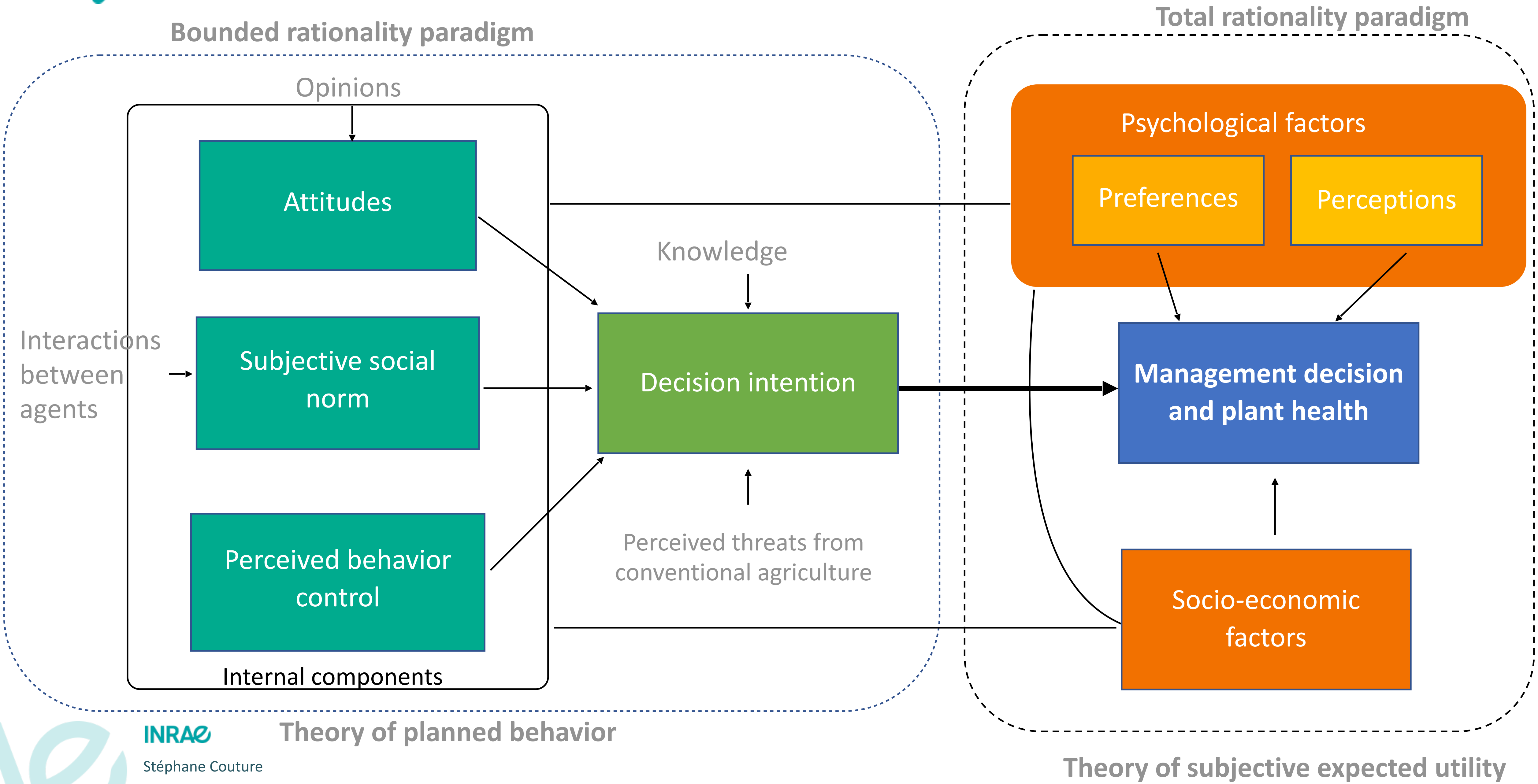
The issue here:

The heterogeneity of the behavior observed and the decisions taken by farmers can be explained by socio-economic factors but also by unobservable psychological and cognitive factors; the same applies to their decision-making process leading to their observed choices.

3/

The conceptual framework for this issue

A possible conceptual framework for our analysis



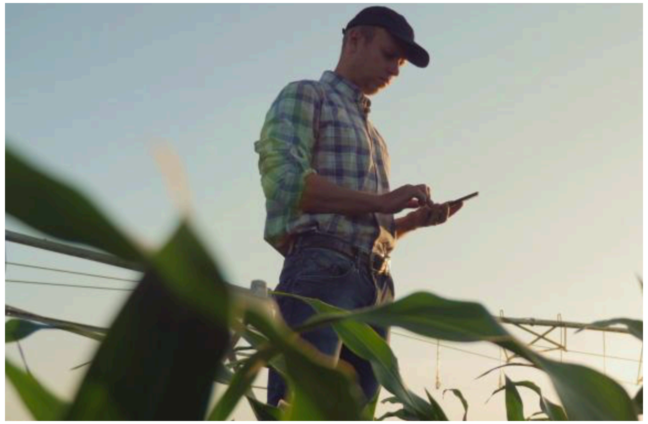
4/

Three illustrations of farmer choice and plant health

1/ Management model and plant health: information on pest pressure: estimating its economic value and impact on pesticide use

- **Scientific publication in Theory and Decision** (Couture S., Lemarié S., Teyssier S., Toquebeuf P. (2023). The value of information under ambiguity: a theoretical and experimental study on pest management in agriculture), and **site news** « *L'information sur la pression de bioagresseurs* »

  - **Information** on the risk of pest attack is generally recognized as being useful in making decisions on pesticide use.
  - However, assessments of the **economic value of such information** and its impact on pesticide use are still rare.

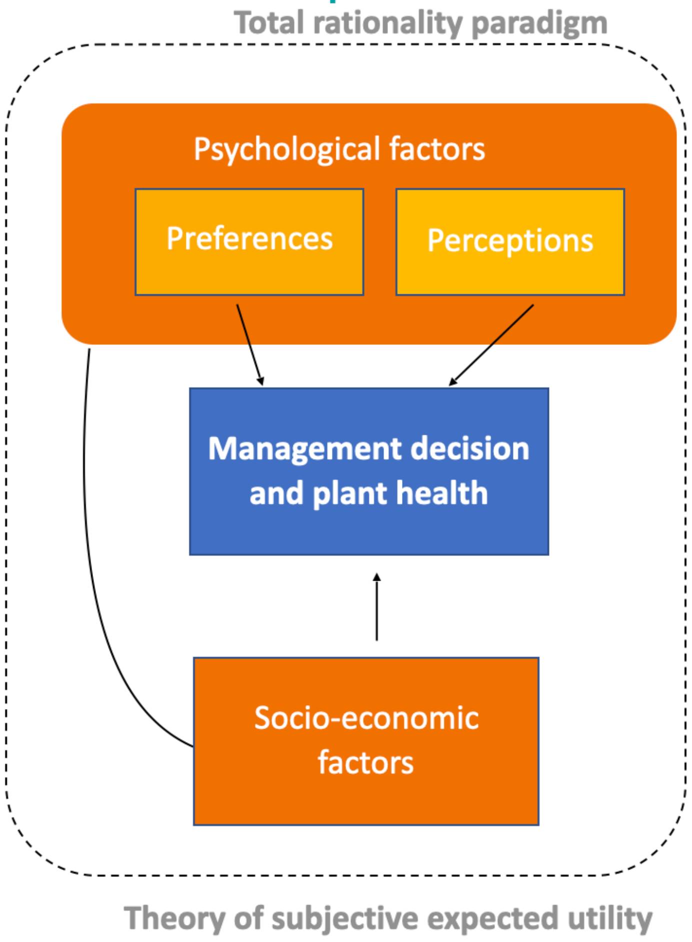


Scientific approach and targeted part of the conceptual framework

Scientific approach:

- Theoretical study: analytical model of behavior under ambiguity and lack of knowledge of risk: theoretical predictions of behavior.
- Survey protocol and experiments with 84 farmers and students.

The targeted part of the conceptual framework



Scientific approach: model and survey

Static analytical model of processing behavior under ambiguity, integrating risk and ambiguity preferences

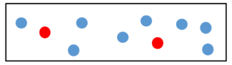
We consider an ambiguous context in which the farmer only knows that the probability of loss, p, lies in a certain interval $\mathcal{P} = [p_{min}, p_{max}]$. Indeed, as pest-related information is often based on experts judgement, it is common to represent ambiguity by probabilities intervals. In this context, the risk and ambiguity preferences of the farmer will be represented by an α-MEU functional[2] $V(.)$ over the final wealth $w_f(.)$ defined by:

$$V(w_f(x)) = \alpha E_{p_{max}} U(w_f(x)) + (1-\alpha) E_{p_{min}} U(w_f(x)), \quad (1)$$

Experimental design: contextualized experimental economics protocol:

- Measurement of preferences
- Treatment decisions in different scenarios

The urn will be composed as follows:



Your economic gains per hectare will be presented according to the table below.

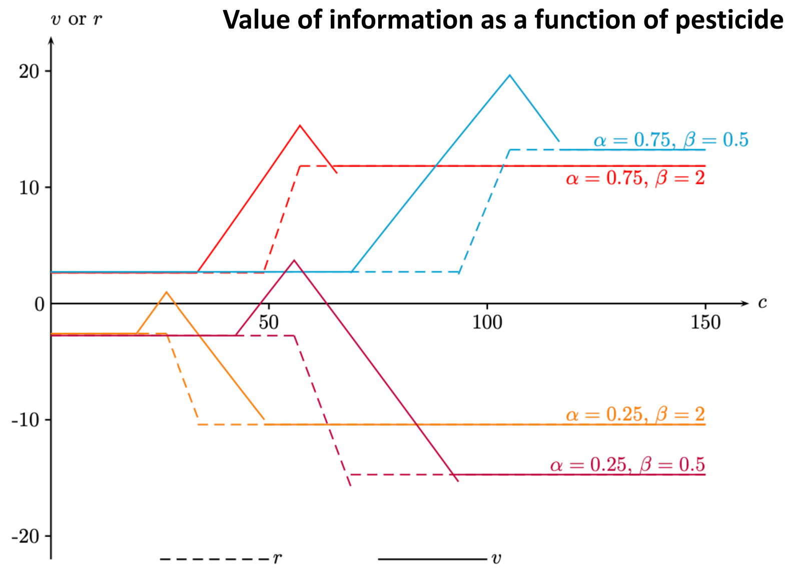
Without treatment		YOUR DECISION		With treatment	
Gain if no attack (if draw ●)	Gain if attack (if draw ●)	Not to treat	Treat	Gain if no attack (if draw ●)	Gain if attack (if draw ●)
380 €	110 €			360 €	306 €
380 €	110 €			350 €	296 €
380 €	110 €			340 €	286 €
380 €	110 €			330 €	276 €
380 €	110 €			320 €	266 €
380 €	110 €			310 €	256 €
380 €	110 €			300 €	246 €
380 €	110 €			290 €	236 €
380 €	110 €			280 €	226 €
380 €	110 €			270 €	216 €
380 €	110 €			260 €	206 €
380 €	110 €			250 €	196 €
380 €	110 €			240 €	186 €
380 €	110 €			230 €	176 €

Some illustrative results

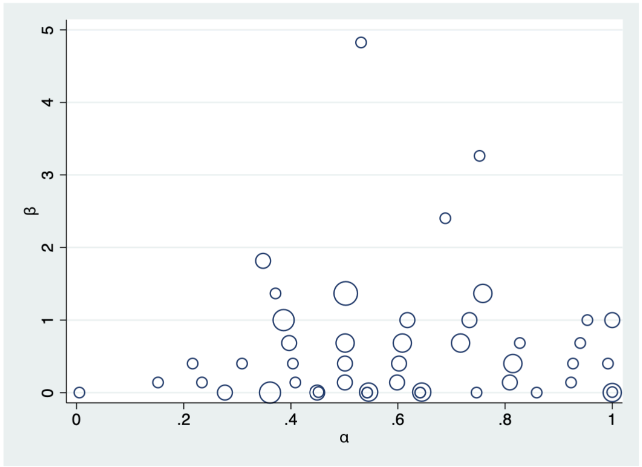
- **Providing information reduces the ambiguity** faced by farmers. For example, the publication of a BSV gives a farmer a better idea of the pressure of bio-aggressors in her plots.
- Information has value if the farmer shows an **aversion to ambiguity**.
- Information can reduce the use of a pesticide if its price is **intermediate**.

These results highlight the need to take account of the **behavioral factors** that influence decisions on whether or not to use pesticides.

Value of information as a function of pesticide cost



Joint distributions of risk and ambiguity preferences



2/ Data and experiments on plant health and behavior: the weight of psychological factors for statistical analysis

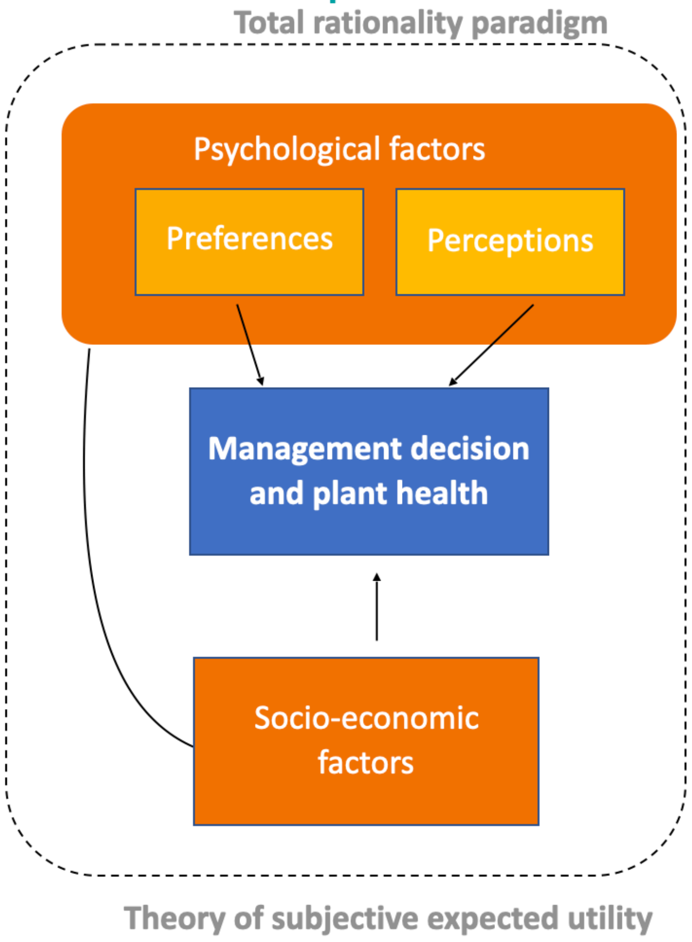
- Objective: to explore the **factors** that may explain the heterogeneity of agricultural practices observed in field crops: personal characteristics of the farmer, characteristics of the farm, preferences with regard to risk and uncertainty, individual perceptions, and sources of information, resulting from a decision-making process faced with disease risks.
- **Interdisciplinary collaboration** with 3 funded research projects, past (COCODIV, MP SUMCROP), current (SESRISKS, MP XRISQUES and PAPETEE, Plan Ecophyto II)

Scientific approach and targeted part of the conceptual framework

Scientific approach:

- Conceptual approach: study of links between risk perceptions, risk preferences, and socio-economic factors
- Survey protocol and experiments with farmers

The targeted part of the conceptual framework



Some illustrative results

- **Heterogeneity of risk preferences and risk perceptions**
- **Risk preferences** are a significant predictor of farmers' treatment behavior in the face of disease risks.

These results confirm the need to take account of the **behavioral factors** that influence decisions on whether or not to use pesticides.

Figure 1: Distribution of the risk aversion coefficients of the 119 farmers involved in the experiment. A and B show results of the two lottery tasks. C, D and E show results of self-assessment. Green shows *risk aversion* preferences, blue *risk lover* preferences and grey *risk neutral* preferences.

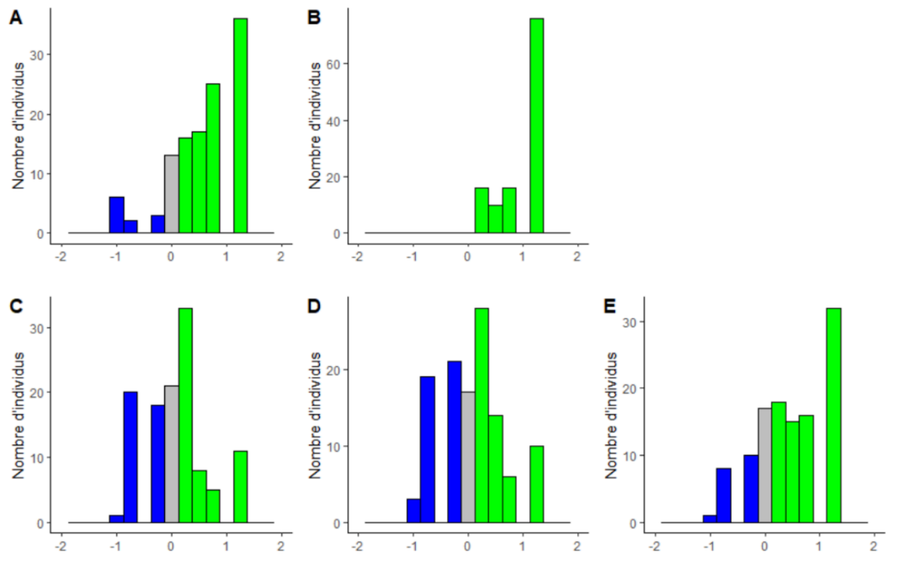
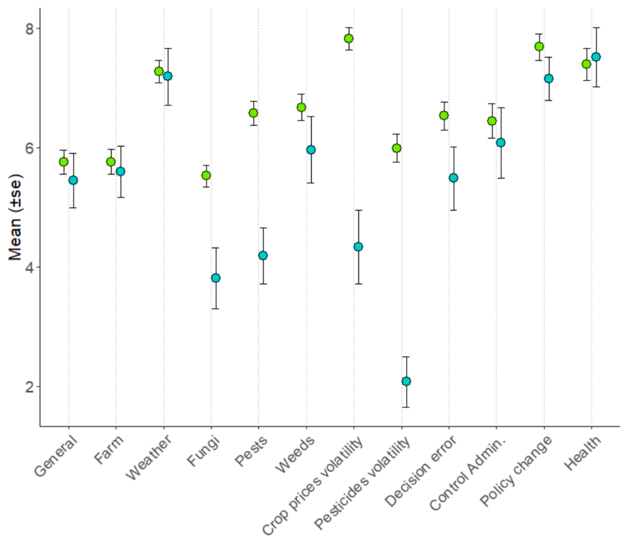


Table 9: Determinants of chemical weeding (CF only)

VARIABLES	*ANOVA*			*Number of Observations*	*R² (%)*
	DF	*F VALUE*	*Pr(>F)*		
		Model of herbicide TFI			
Crop Type	3	2.537.	0.059	141	2.62
Weed Abundance	1	6.009*	0.016		
Crop Type x Weed Abundance	3	0.157	0.925		
LT1	1	1.496	0.223		
SA2	1	0.135	0.713		
RISKWEED	1	0.043	0.836		
		Model of herbicide AI			
Crop Type	3	4.304**	0.006	141	11.17
Weed Abundance	1	8.150**	0.005		
Crop Type x Weed Abundance	3	0.417	0.741		
LT1	1	7.661**	0.006		
SA2	1	0.030	0.863		
RISKWEED	1	0.056	0.813		

OLS regressions with conventional fields only. Analysis of Variance Table (Anova Type II). ***, **, *, ., for significant at 0.1, 1, 5 and 10%.

Figure 2: Farmers' risk perception. Risk perception was evaluated using a 9-point scale. Dots show means and arrows standard deviations. Colours indicate the farming system: green for conventional farming and blue for organic farming.



3/ Better representing the dynamics of innovation diffusion using agent-based simulation and formal argumentation: application to water use and the adoption of communicating water meters

Objective: To highlight the impact of interpersonal relationships on the dynamics of innovation adoption and diffusion.

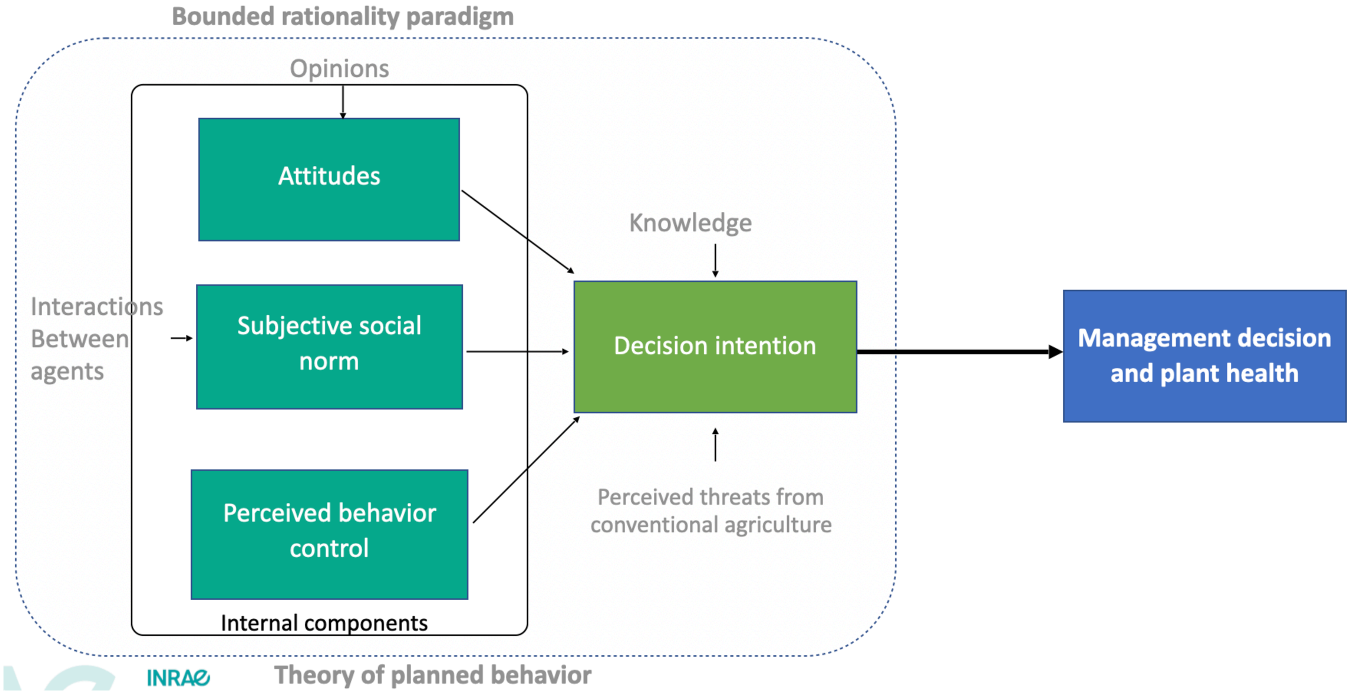
Scientific approach and targeted part of the conceptual framework

Scientific apporach:

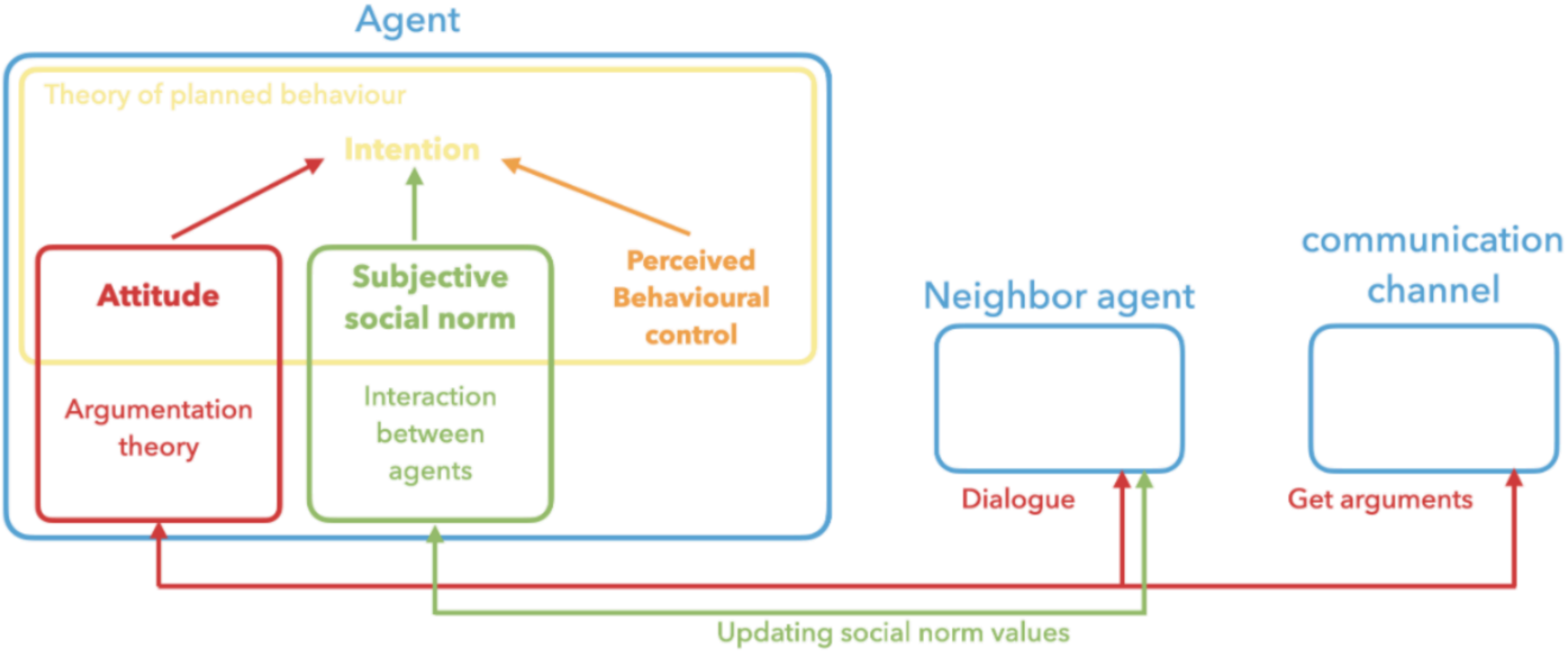
- Agent-based simulation: Model of innovation diffusion, called MIDAO (Model of Innovation Diffusion with Argumentative Opinion)

- Survey protocol and farmer surveys

The part of the conceptual framework targeted in this study

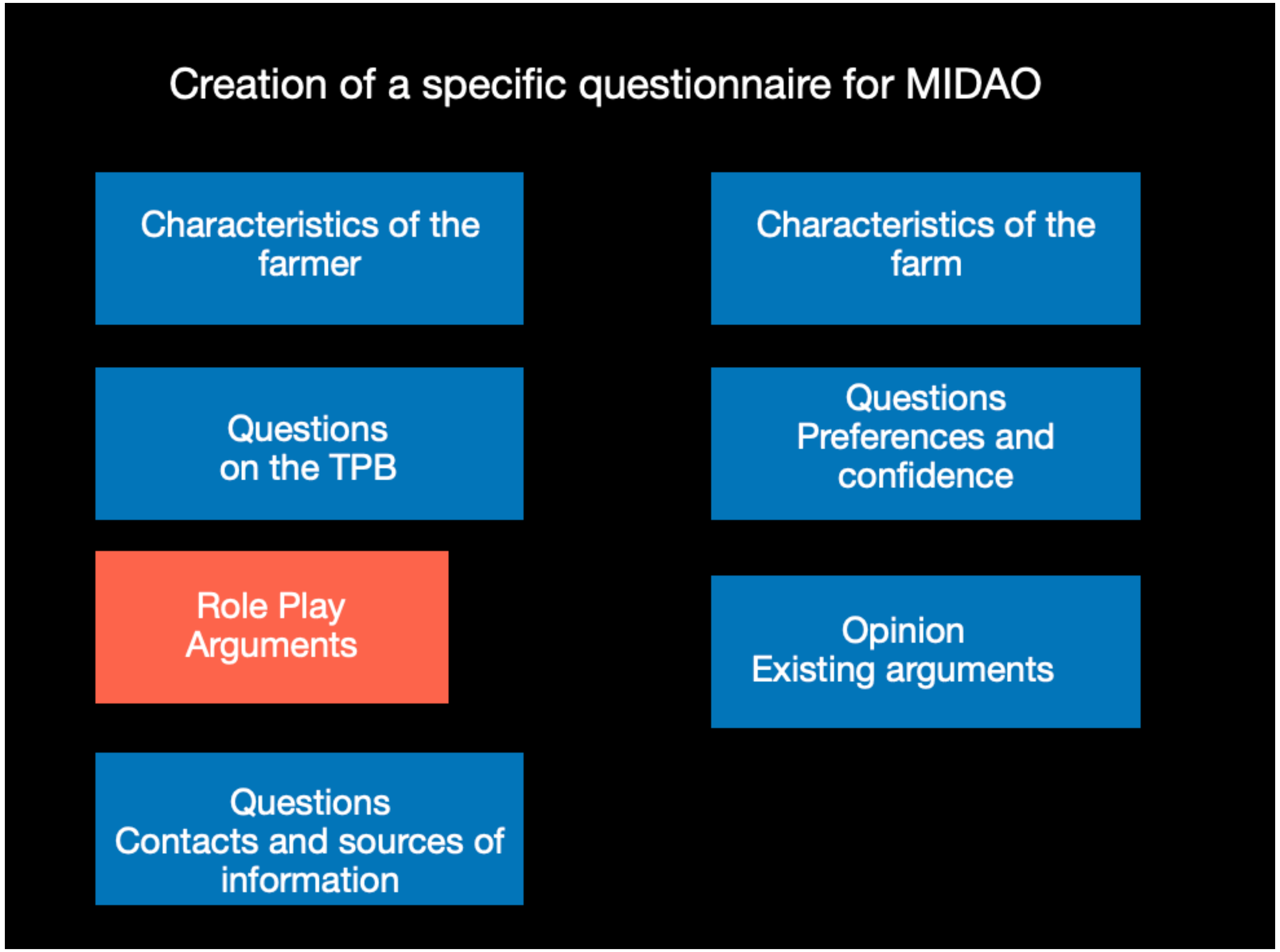


Architecture of the simulation model

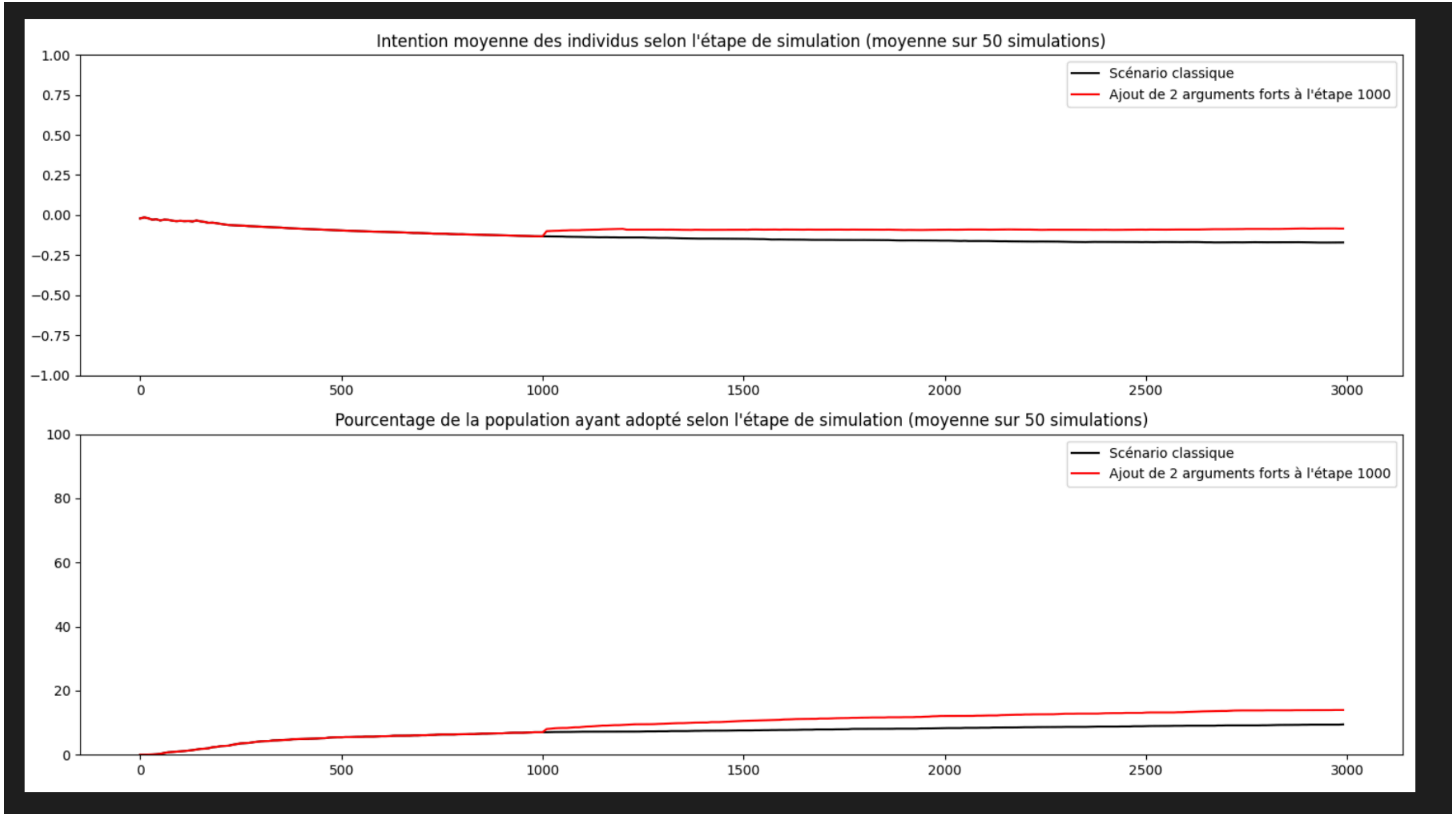


Investigation protocol: Propose an approach for using MIDAO in a practical context

- Field data collection
- Data processing to feed the model
- Using MIDAO to obtain results from communicating water meters



Some illustrative results



Conclusion

Weight of behavioral and socio-economic factors in farmers' behaviors.

Fundamental interdisciplinary collaboration.

Diversity of methods and approaches mixing modeling and experimentation drawn from SHS approaches.

Application framework for the issue of multiple risks and plant health.

Thank you for your attention

Stéphane Couture
stephane.couture@inrae.fr

METAPROGRAMME XRISQUES INRAE

Representation, Analysis and Management of Multiple Risks and Uncertainties affecting Food Systems, Agroecosystems and Populations

https://xrisques.hub.inrae.fr/