IPM design and assessment

Jean-Noël Aubertot (INRA)

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Outline

- Conceptual considerations
- Overview of methods to design and assess IPM-based cropping systems
- Identification of methodological challenges and future research pathways

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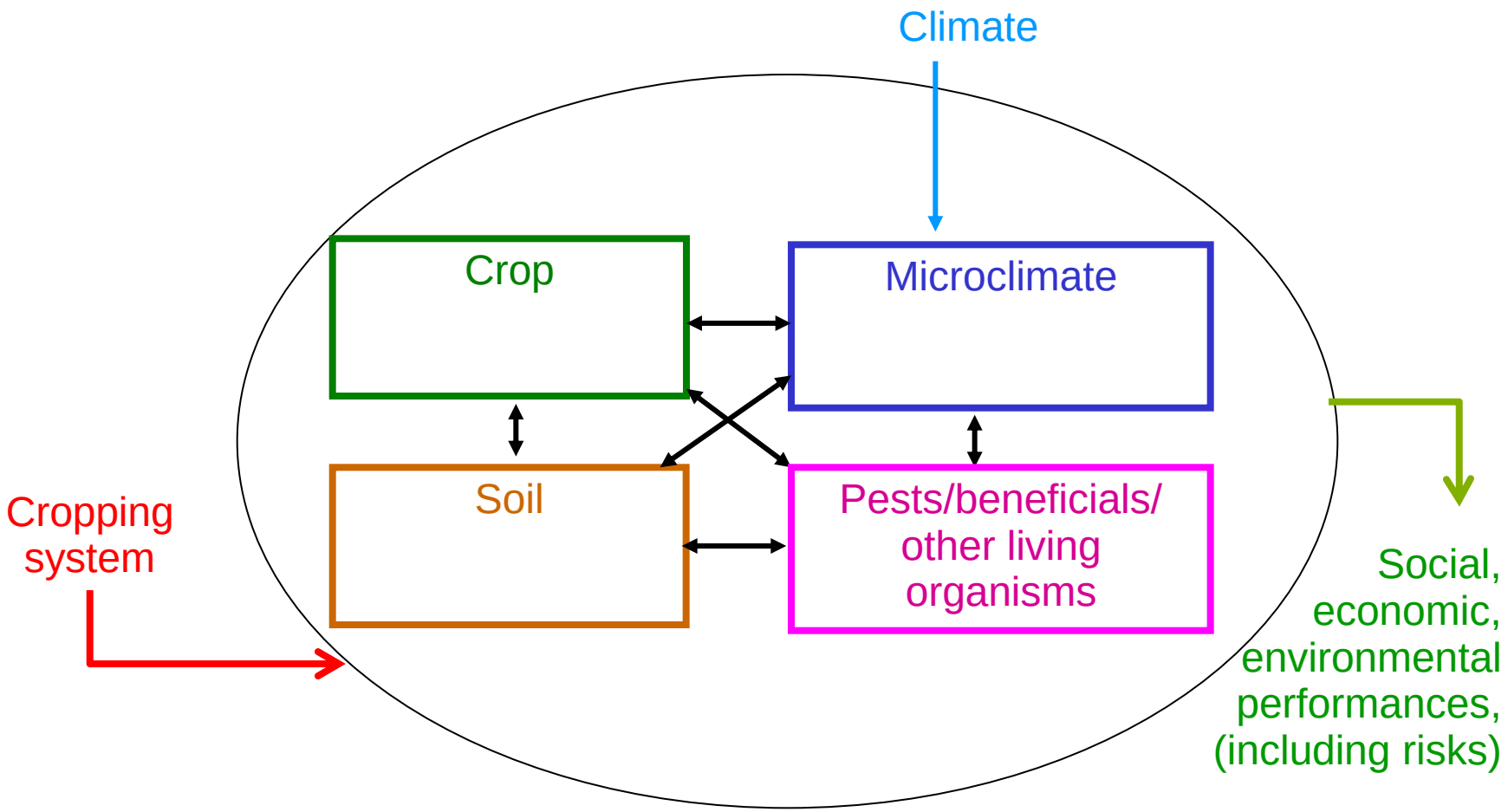
Simplified representation of an agroecosystem



Lescourret and Aubertot (2013)
PURE 2nd Annual meeting, Riva del Garda, Italy

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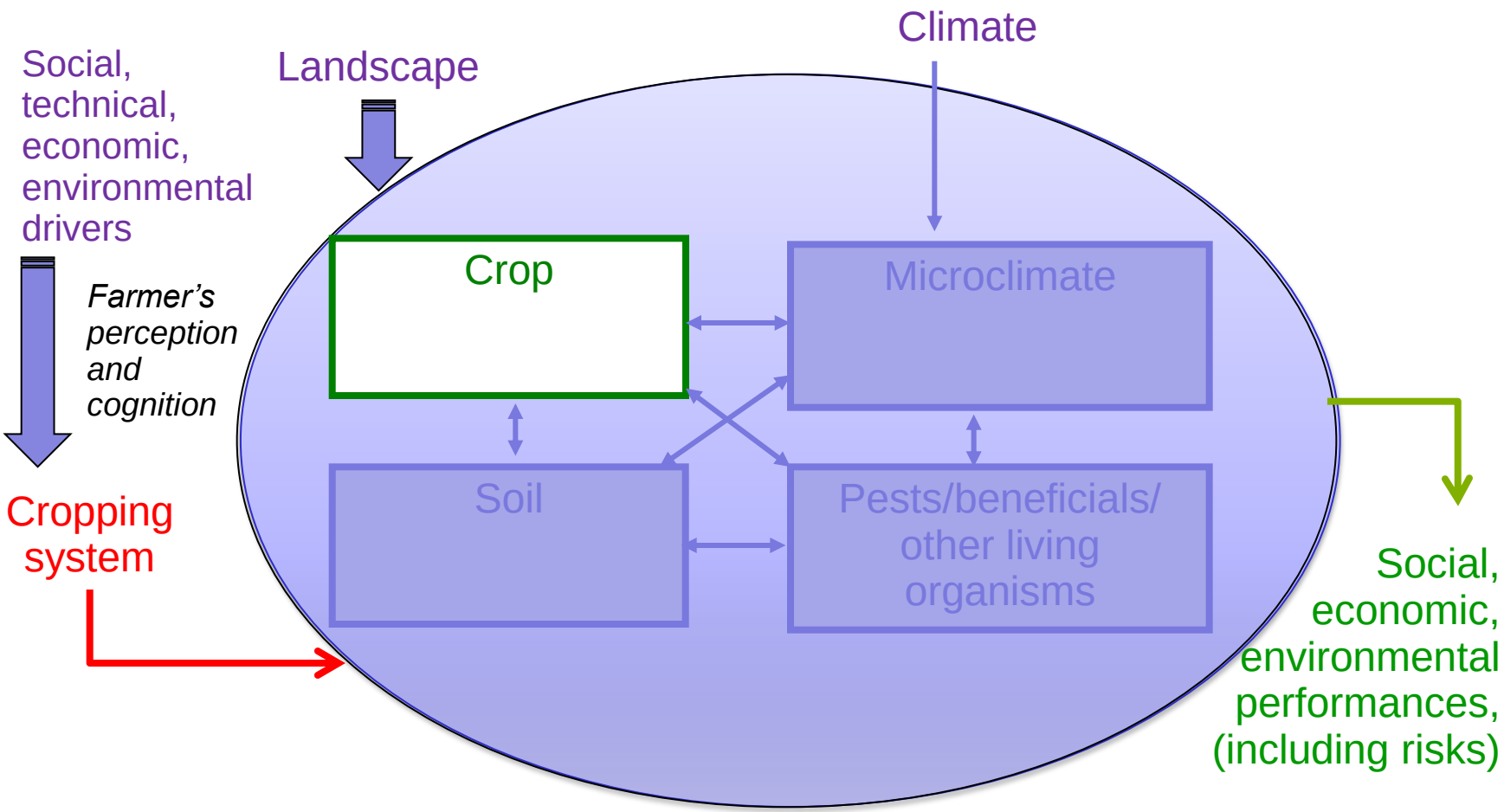


Performances = f(cropping system, production situation)

Lescourret and Aubertot (2013)
PURE 2nd Annual meeting, Riva del Garda, Italy

The concept of production situation

Production situation: physical, chemical and biological components, except for the crop, of a given field (or agroecosystem) and its environment, as well as socio-economic drivers that affect farmer's decisions (adapted from Breman and de Wit, 1983; Aubertot and Robin, 2013).

The concept of cropping system

1. Crop management or management practices: logical and ordered combination of techniques on a plot to achieve an agricultural production (Sebillotte 1974 – synthesis in Doré et al, 2006)

The concept of cropping system

1. Crop management or management practices
2. From crop management to cropping systems: a sequence and/or a spatial combination of crops and the corresponding technical operations, involving not only the crops themselves, but also between-crop periods with bare soil or a plant cover (Boiffin et al, 2001)

   Can be extended to semi-natural habitats (field margin, woodlots in landscape…)

The concept of cropping system

1. Crop management or management practices
2. From crop management to cropping systems
3. Cropping systems and decision processes are coupled

IPM: an old, polysemic, yet alive and kicking concept

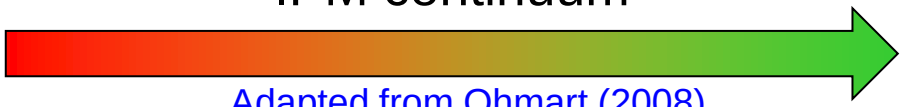
~~Intelligent Pesticide Management~~

IPM is a sustainable approach to managing pests by combining biological, genetic, physical, cultural and chemical tools in a way that minimises economic, environmental and health risks.

Adapted from ENDURE (2008)

Rational Pesticide Use + another control method

IPM continuum



Adapted from Ohmart (2008)

Ultimate IPM (pesticide-free cropping systems)

Cf. Session ”IPM guidelines” (Alaphilippe, 14.01.15); http://www.ipmnet.org/ipmdefinitions/

IPM: a nested concept…

Brent and Atkin (1987)

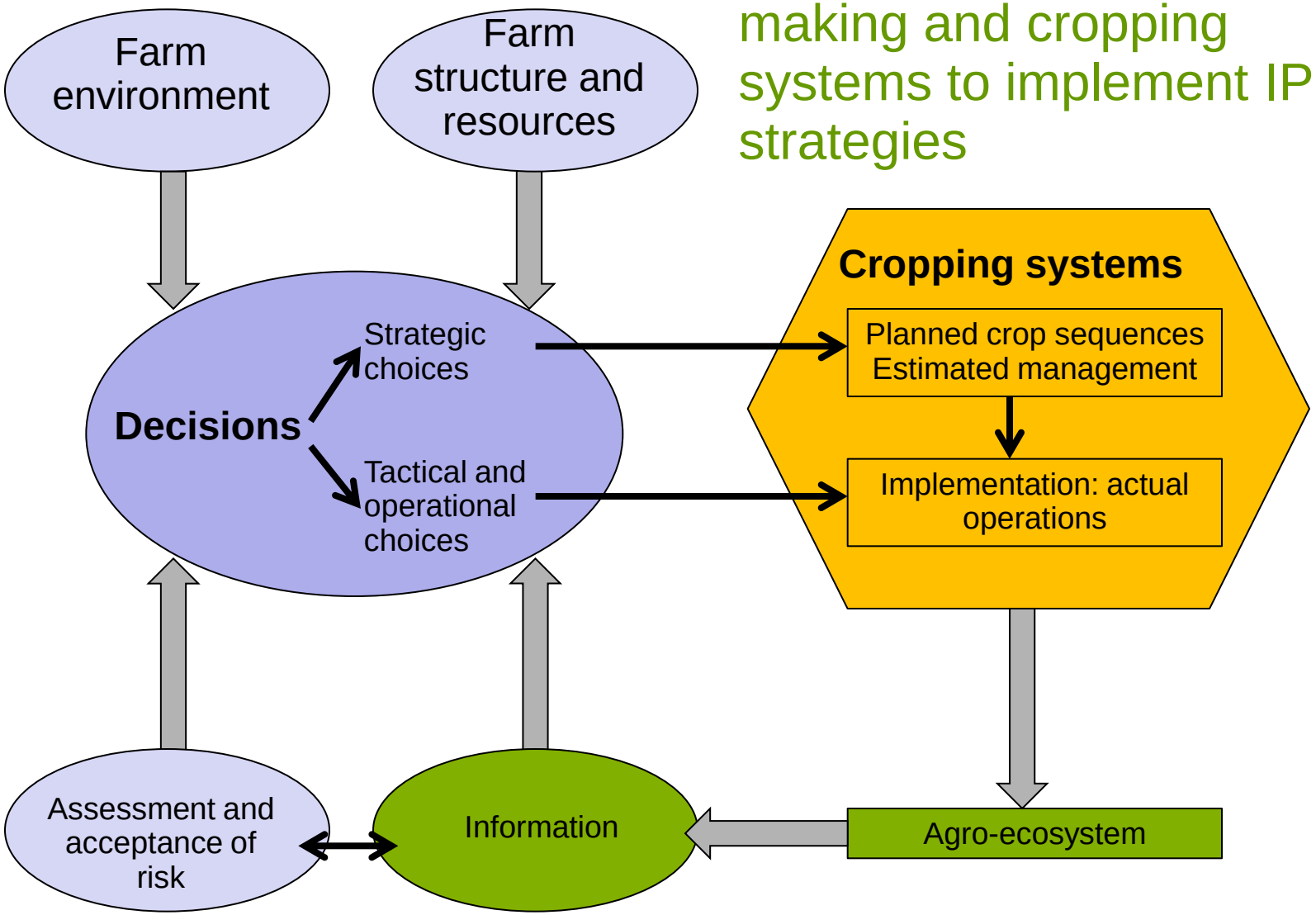
Stern et al (1959)

Heitefuss (1989)

El Titi et al (1993)

Katz (1984)

The coupling of decision making and cropping systems to implement IPM strategies



Boiffin et al, 2001

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Prototyping IPM solutions using expert knowledge and rule-based experiments (co-innovation in a given production situation)

Elementary IPM components

Promising IPM-based cropping systems

Co-design

Virtual prototyping during workshops

Benchmark of cropping system performances

Multi-criteria assessment

Elementary IPM components

Innovative IPM-based cropping systems

Advices
Training
Demonstration

Co-design

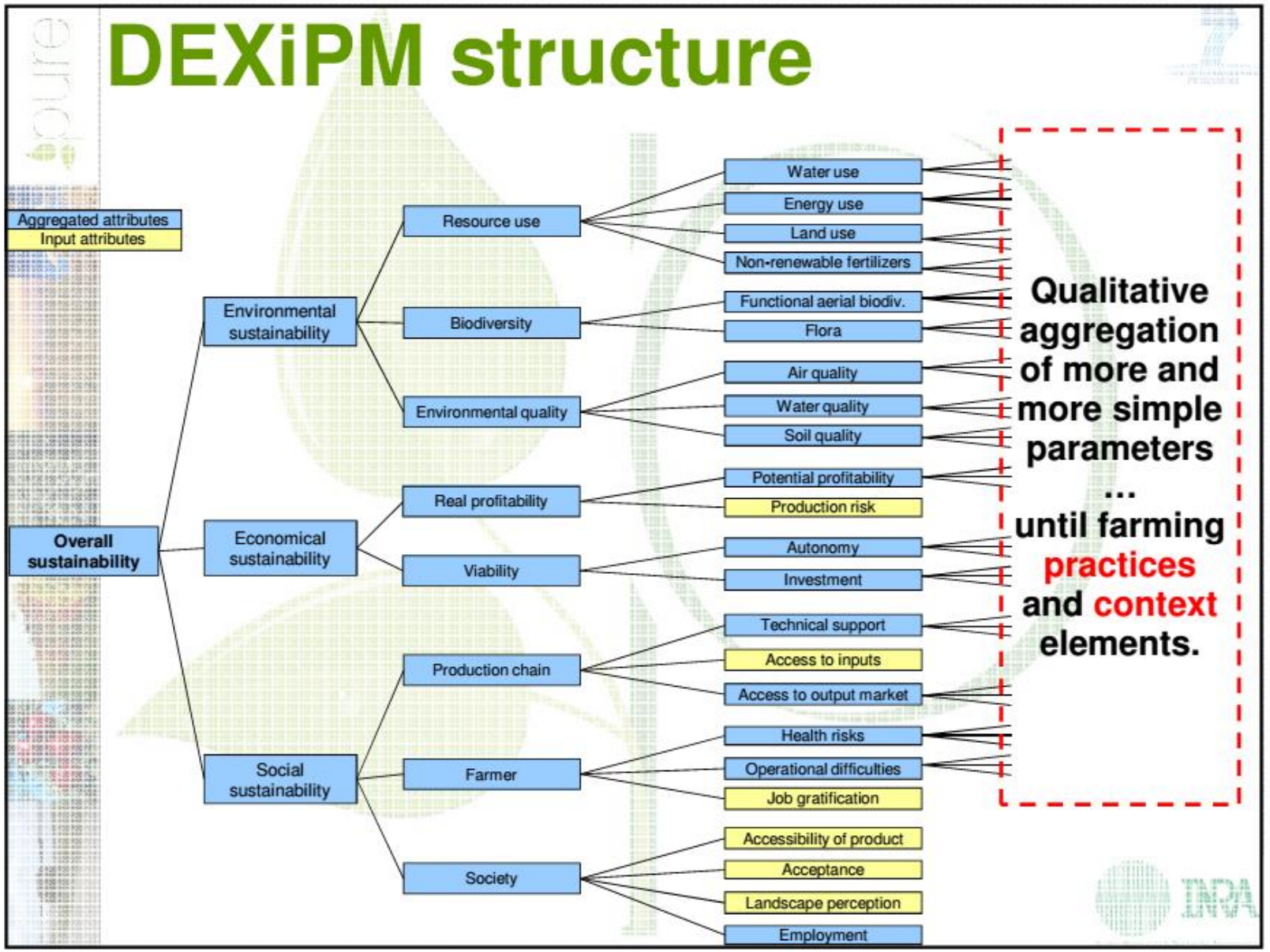
Field experiment

Experiment set-up

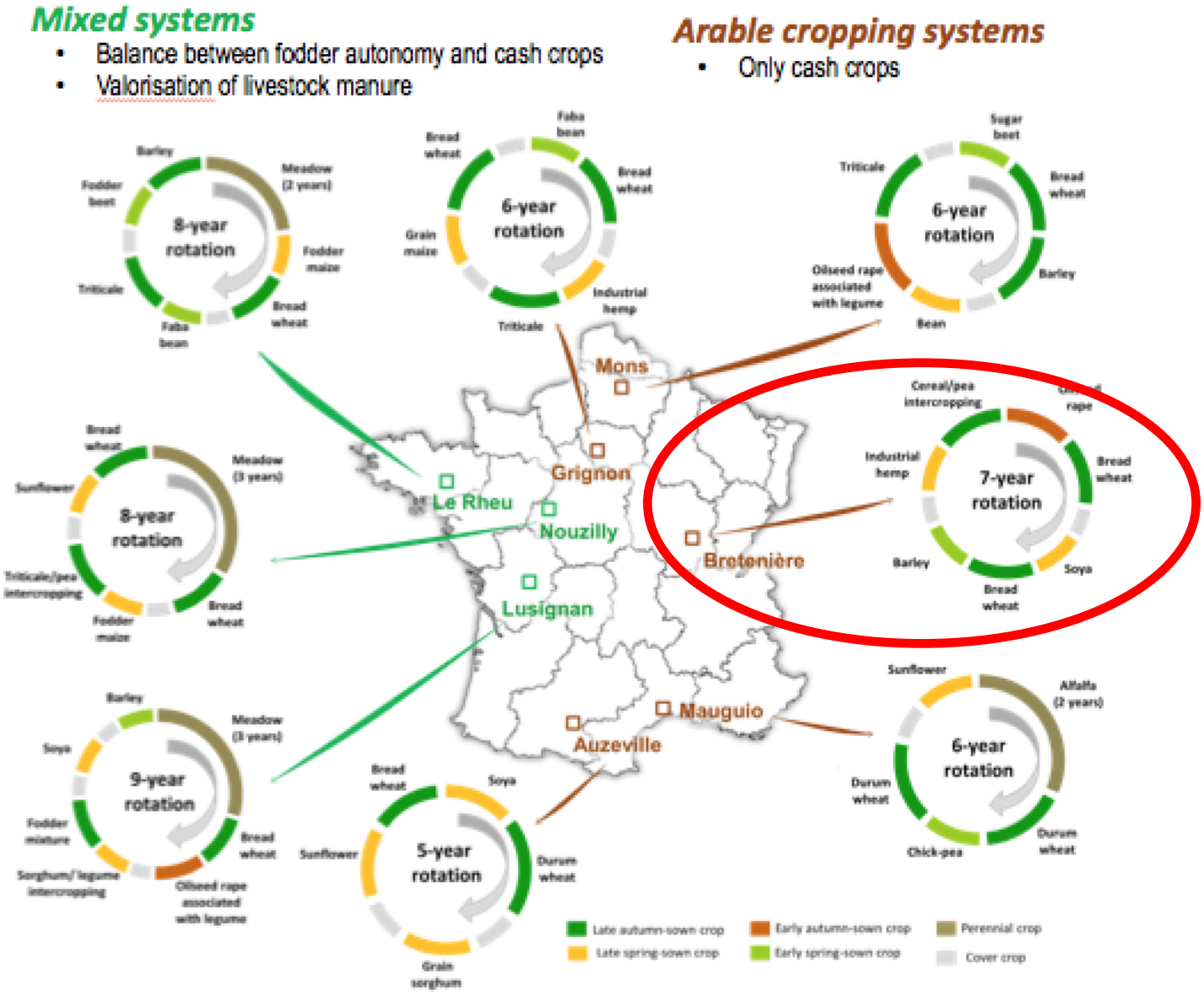
Observations/measure ments

Adapted from Lançon et al. (2008)

Multicriteria assessment of IPM solutions. Alaphilippe et al (P9), Colnenne-David et al (25), Gary et al (P28), Métral et al (P29), + «Tools for IPM design and assessment» session (Angevin et al)



An example of an IPM system experiment: the Bretegnière experiment of the RésoPest network (pesticide-free cropping systems, Cellier et al, Poster 56)



(in red : cultural control ; in blue : genetic control; in green : physical control ; in orange : biological control)






Competitive crop

Variety(ies) of barley resistant to diseases and lodging / variety(ies) of peas resistant to lodging and frost. Mechanical weeding in autumn if possible, and spring

Ploughing

False seedbed

High sowing density. cultivar mixture, Tolerant to Phoma, including 10% of an earlier cultivar. Mechanical weeding in autumn and spring. Contans® if risk of sclerotinia.

Barley / pea intercrops

Oilseed rape

False seedbed

Late sowing, high sowing density. cultivar mixture, tolerant to diseases. Mechanical weeding in autumn if possible, and spring.

Bread wheat

Cover crop

Ploughing

False seedbed

Soya (or sunflower)

Hardy crop (sunflower in case of high weed infestation)

2 strategies (soya): sowing with large space between rows or sowing in high density with close rows. Mechanical weeding, including hoeing. Contans® if risk of sclerotinia.

Bread wheat

Early sowing, large space between row. Resistant variety. Mechanical weeding in autumn if possible, and spring, including hoeing.

In case of high weed infestation, no cover crop and soil tillage to control them.

Barley

Crop less sensitive to pests than winter barley

Cultivar tolerant to diseases. Mechanical weeding.

Cover crop

Industrial hemp

False seedbed

Ploughing

Competitive and hardy crop

Early autumn-sown crop

Late autumn-sown crop

Early spring-sown crop

Late spring-sown crop

Harrowing of wheat sown in two twin-lines with an interrow of 25 cm

Comparison between «analytical» and «system» field experiments

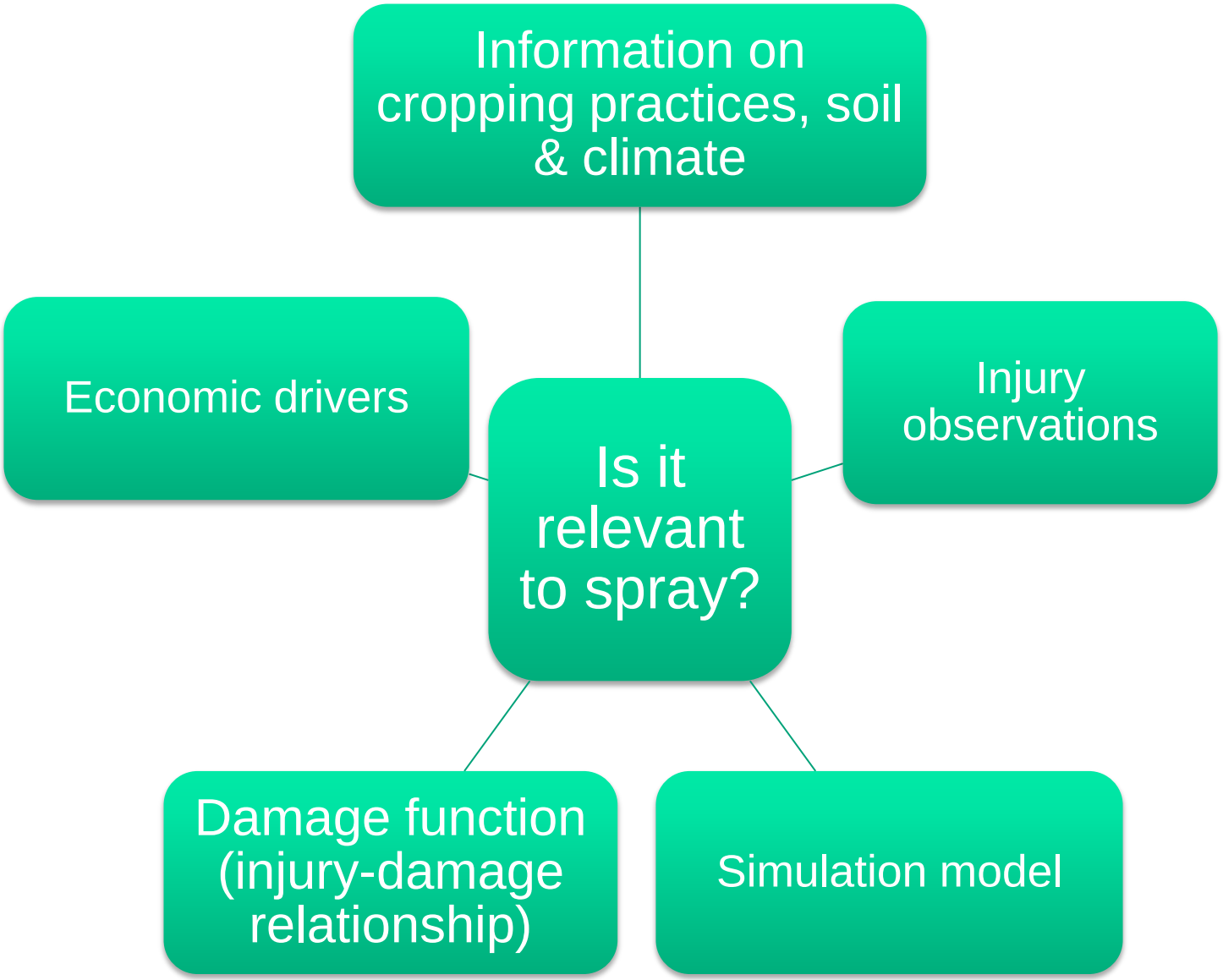
	Analytical experiments	System experiments
Objective	To test an hypothesis on the effects of one cropping practice, or at most of a couple of cropping practices in interaction, *ceteris paribus*	To test whether given systems can reach multicriteria objectives and/or compare their respective performances
N° of monitored variables	+	+++
Spatial scale	1-*ca* 1000 m²	500-*ca* 5000 m²
Temporal scale	Cropping season, usually repeated 2 or 3 years	Several rotations, usually a minimum of 10 years (arable and perennial crops)
Advantages	- Experimental designs are usually statistically powerful enough with regards to the objectives - Enables to isolate the effects of a given practice -Easily comprehensible experimental network	- Enables to provide references for entire cropping systems on a long term basis - Enables to consider cumulative effects - Can embed analytical experiments
Drawbacks	- Limited domains of validity with regards to cropping practices (e.g. experiments for cultivar registration) - Do not take into account interactions with the rest of cropping practices - References sometimes difficult to use to design innovative cropping systems	- More tedious, higher investment in time and money - Experimental designs often with limited statistical power - The expertise of the experimenters are confounded with the tested systems

Lescourret and Aubertot, 2012 (PURE EXCOM)

IPM design using models

- DSS for one decision (usually pesticide application)

General conceptual framework of DSS for Rational Pesticide Use



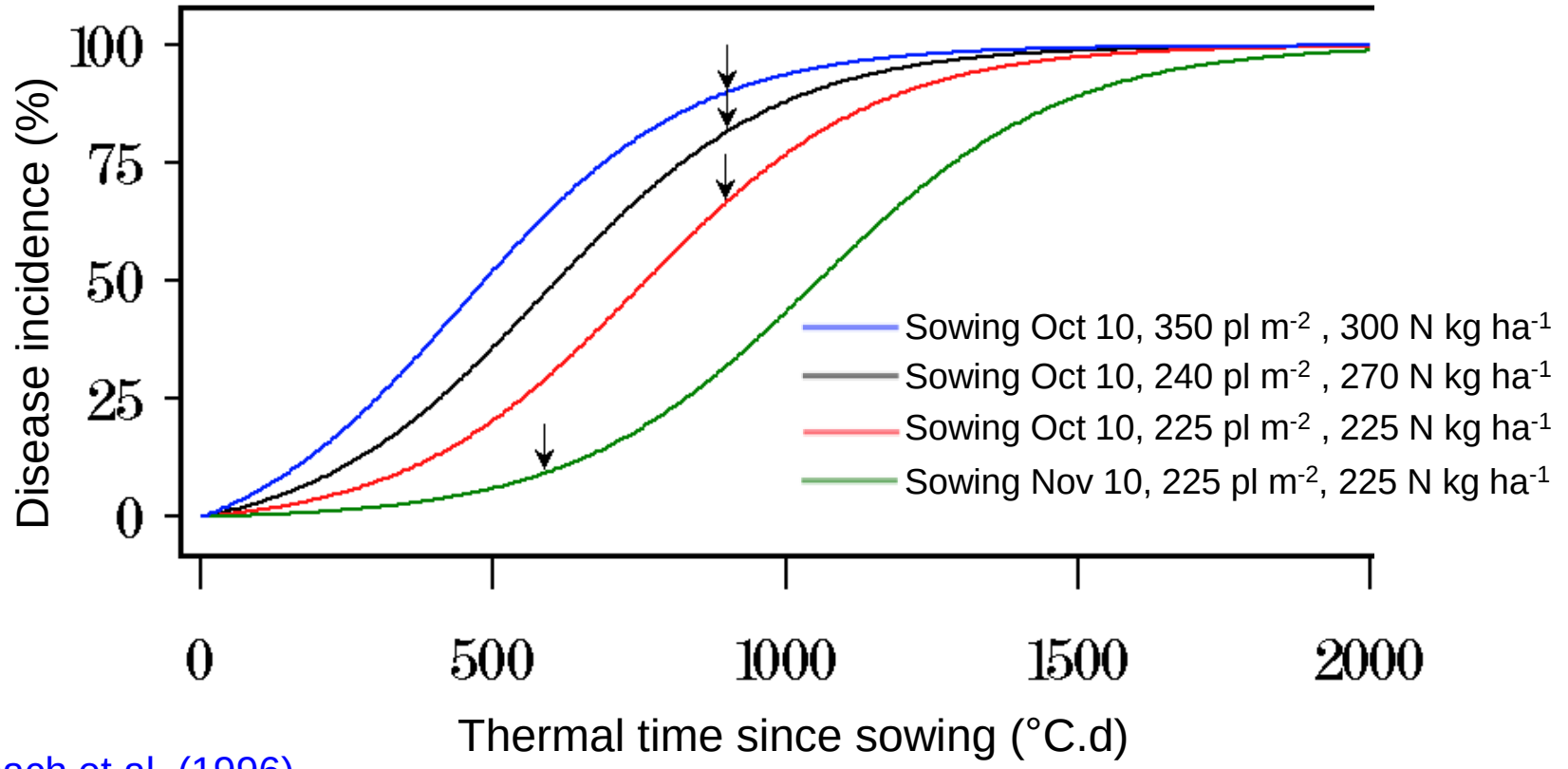
IPM design using models

- DSS for one decision (usually pesticide application)
- Simulation models to compare crop management options

IPM design using models

$$\frac{di}{dt} = k_1 p(n - i) + k_2 i(n - i)$$

Take-all on wheat

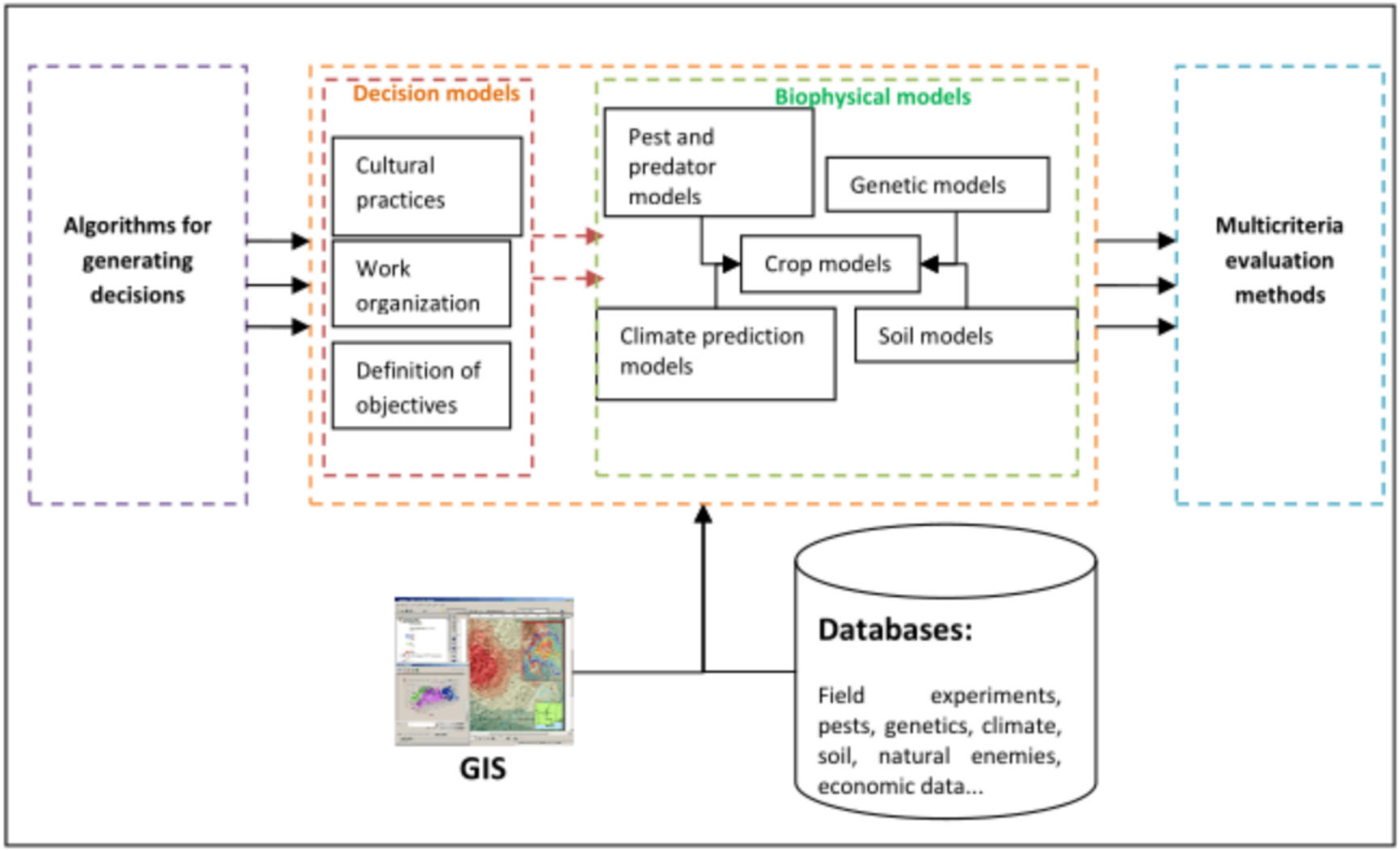


Colbach et al. (1996)

IPM design using models

- DSS for one decision (usually pesticide application)
- Simulations to compare crop management options
- Optimisation of IPM-based cropping systems

IPM design using models. Optimisation 1/2

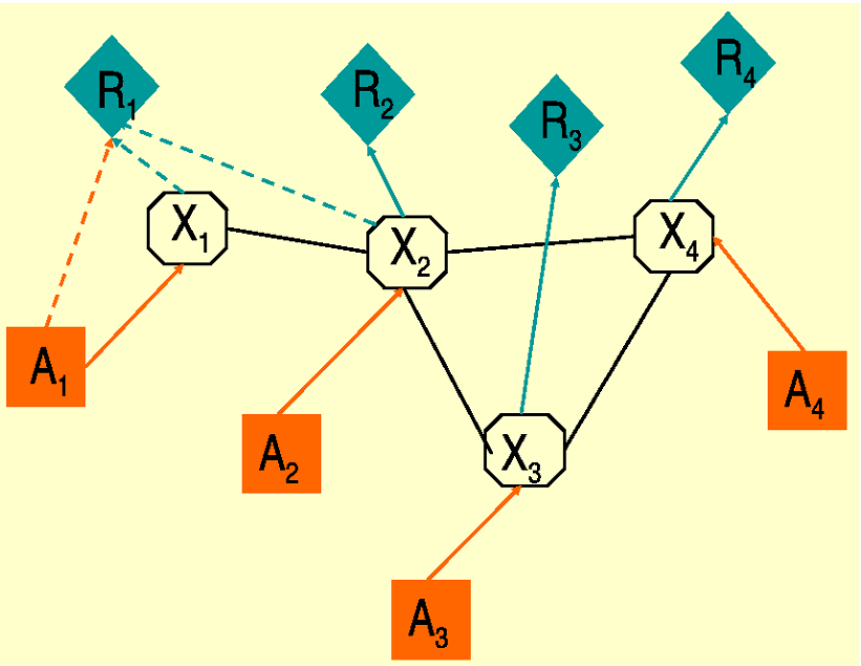


Ould Sidi and Lescourret (2011)

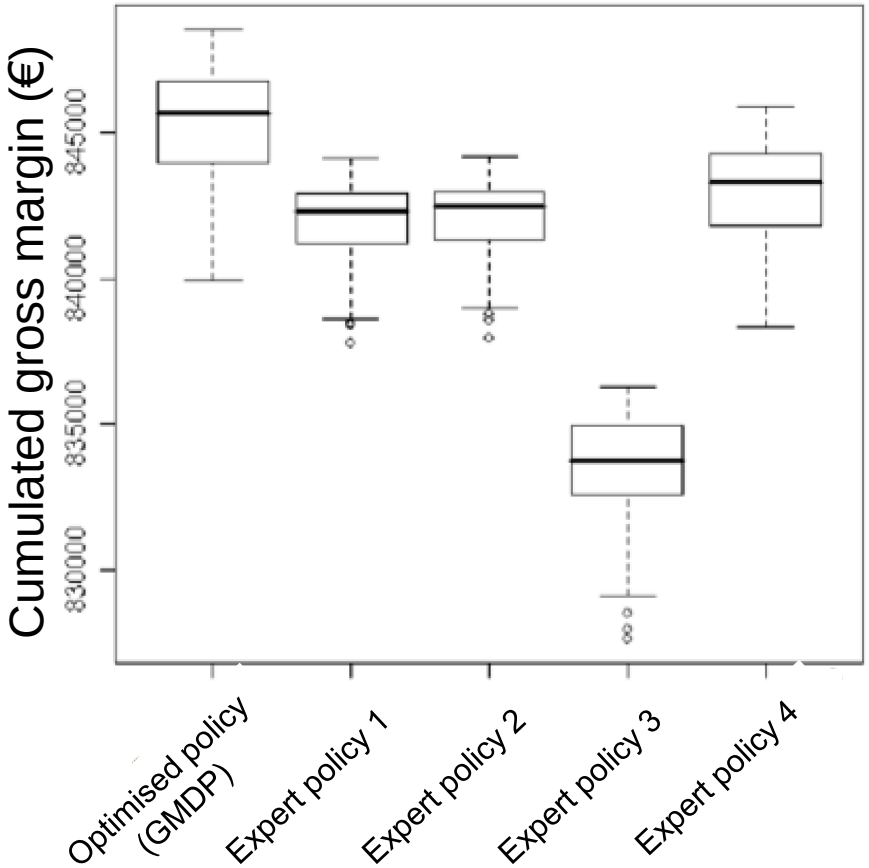
IPM design using models. Optimisation 2/2

How to enhance the durability of cultivar resistance against phoma stem canker (*Leptosphaeria maculans/ L Biglobosa*) on oilseed rape using ploughing?

Graph-based Markov Decision Process



2 landscapes*50 initial states*100 simulations (30 year trajectories)



Tixier et al. (2013)

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Methodological challenges

- Need for innovations in elementary components of IPM (several specific sessions and many posters)
- Need for more extensive data to describe interactions between cropping systems and productions situations leading to ecosystem services of agroecosystems
- Need for renewed modelling approaches to handle higher levels of complexity
- Better match between academic research and practical needs for end-users

Perspectives

2 statements from JE Jensens (VFL) and W Rossing (WU), Co-innovation session (14.01.15):

« PURE IPM-entry point did not work for farmers who think systemically »

- Make changes in our conceptual models (e.g. Lamanda et al, 2012)

« Linear approach is inappropriate for complex innovation »

- Need for co-innovation processes taking advantage of multiple expert knowledge to design IPM-based cropping systems aiming to reach a set of objectives in a given production situation (cf. Stephy guide, MS Petit, Market place)

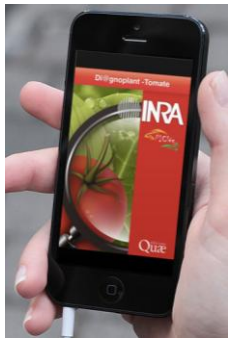
Perspectives

- Stronger articulation between reductionist and holistic approaches

  - Objectives of reductionist (analytical) and holistic research (synthetical) research programs should be harmonised at the earliest stages; expert knowledge and dataset should better be combined

- Better integration of biophysical, socio-economic sciences, Information and Communication Technology

  - Co-innovation processes, participatory sciences, participatory modelling



http://ephytia.inra.fr

Perspectives

- Implementation of IPM-based cropping systems implies to address higher levels of complexity
  - New methods needed to characterise agroecosystems (e.g. metabarcoding, qualitative scouting)
  - Renewal of modelling approaches (cf. sessions « Tools for IPM design and assessment», « Integrated management of pest evolution »)

Qualitative expert knowledge- based modelling without mathematics (Robin and Aubertot, Poster 57)