Soil resource, at the core of competitiveness and sustainability issues in agriculture: An economic approach

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2. Competitiveness, productivity and sustainability of farms: the role of soil quality
3. Soil quality: negatively and positively affected by farming practices
4. Economic approach of soil quality: a review
5. Bioeconomic Modelling
6. Conclusion

Introduction

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  - 2050 $\rightarrow$ 9 billion people

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  ⇒ Worldwide scale: political and social stability and equity issues
  ⇒ National scale: competitiveness and economic growth issues
  (Tilman et al, 2002)

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- **How French farms can position themselves ?**
- **Do soil conservation practices propose suitable answers ?**

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- Soil resource → **Soil conservation practices**:
  - Less soil disturbance
  - Soil cover
  - Crop rotation

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Farming practices	Impact of practices on soil quality	Impact of soil quality on productivity	References

Examples of interactions between agricultural practices, soil quality and crop production

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Tillage practices	Erosion (+)	(-)	Richard et al (2001)
	Soil porosity (-)	(+)	Carter (1992), Ekeberg and Riley (1997), Richard et al (2001)
	Soil Organic Carbon (SOC) (-)	(?)	Blevins et al (1983), Astier et al (2006)
	Decrease in soil fauna and flora	(-) pests ; (+) auxiliaries	Kladivko (2001), Verhulst et al (2010)

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	Soil structure (+)	(+)	Denef et al (2002)
	Soil porosity	(+)	Verhulst et al (2010)
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Fertilizers	SOC (+)	(+)	Verhulst et al (2010)
	Soil acidity (+)	(-)	Verhulst et al (2010), Shukla, Lal and Ebinger (2006)

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- Applications of soil quality optimal control models
  Segarra and Taylor (1987), Smith et al (2000), Yirga and Hassan (2010)
  → Soil quality as an **endogenous** variable
  → One or several dimensions of soil quality

- Integrating **biophysical models** within an optimization model
  Louhichi, Flichman and Zekri (1999), Belcher, Boehm and Fulton (2004), Schreinemachers (2006), Quang, Schreinemachers and Berger (2010)

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- Originality of our approach
  - Theoretical framework adopting an agronomic approach within an economic framework
  - Objective of the model

Theoretical framework

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Determine what is the **role of soil quality in the farm profitability and sustainability**, whether it is **optimal for farmers to maintain or increase their soil quality** when maximizing their farms profitability in a sustainable way, and if so in which extend ?

Theoretical bioeconomic control model

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Management intensity
(chemical input use, $m(t)$)

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Management intensity (chemical input use, $m(t)$)	Crop intensity (crop rotation, $u(t)$)

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Management intensity (chemical input use, $m(t)$)	Crop intensity (crop rotation, $u(t)$)	Crop residue $d(t)$

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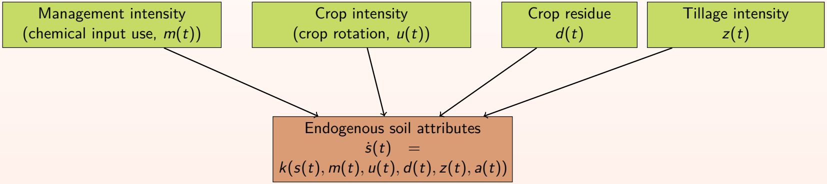
Management intensity (chemical input use, $m(t)$)	Crop intensity (crop rotation, $u(t)$)	Crop residue $d(t)$	Tillage intensity $z(t)$

Theoretical bioeconomic control model



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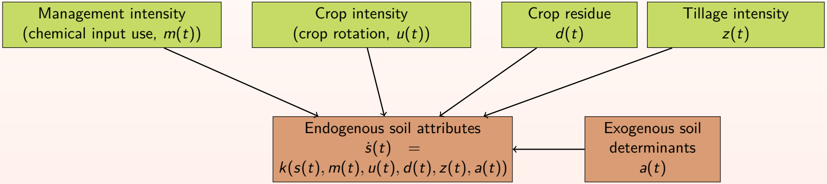

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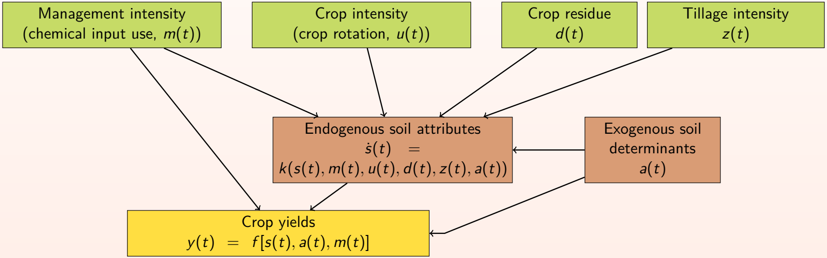

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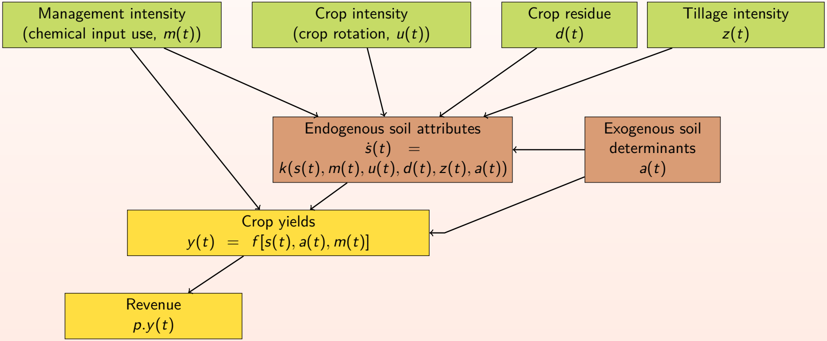

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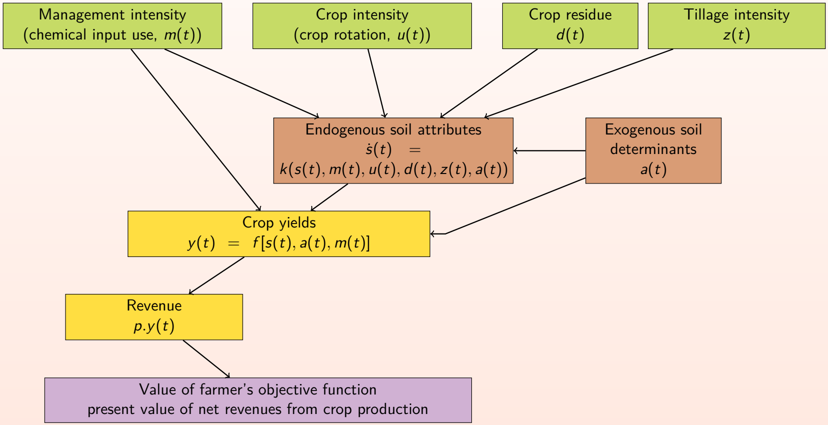

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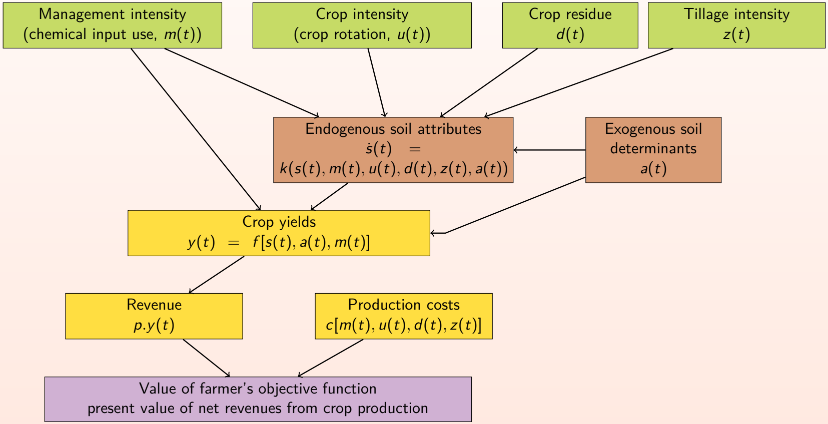

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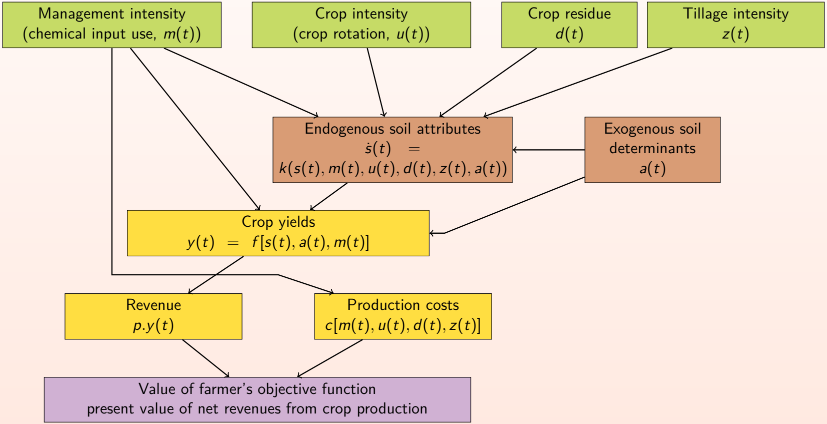

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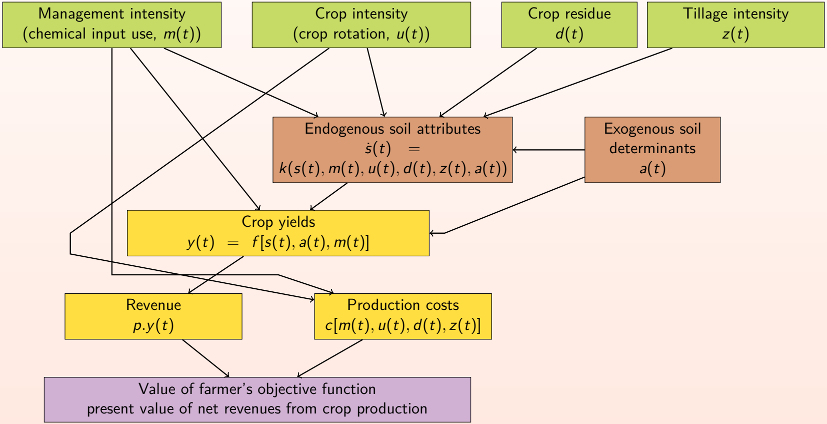

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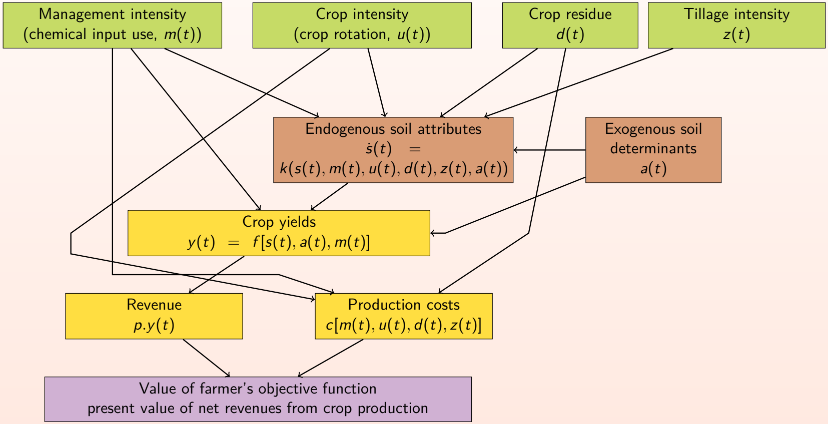

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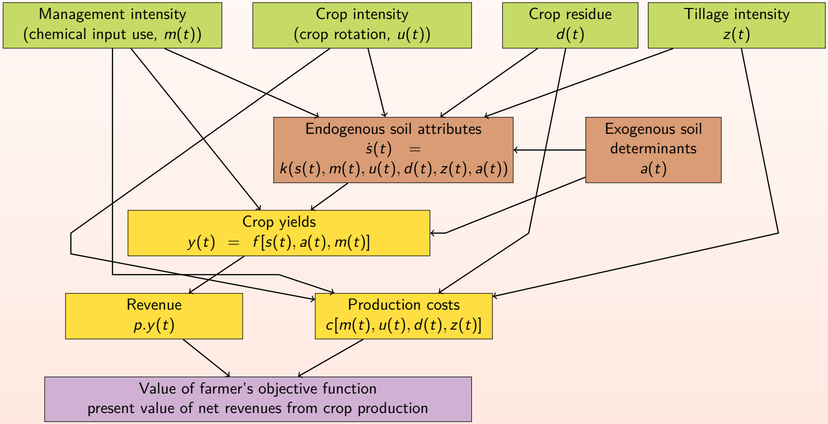

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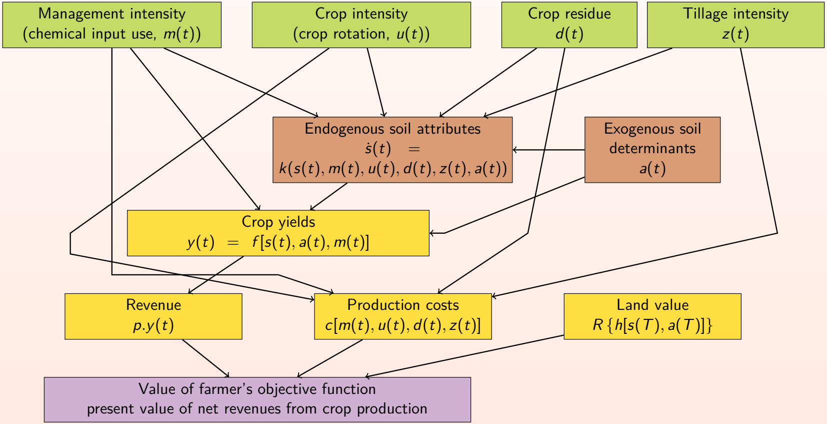

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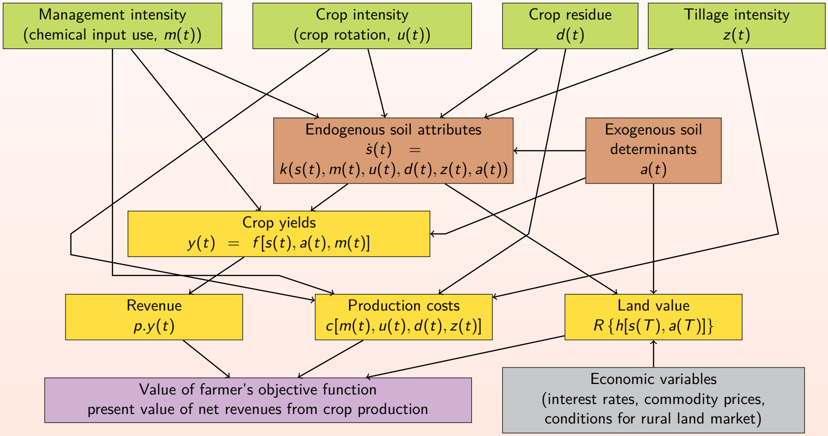

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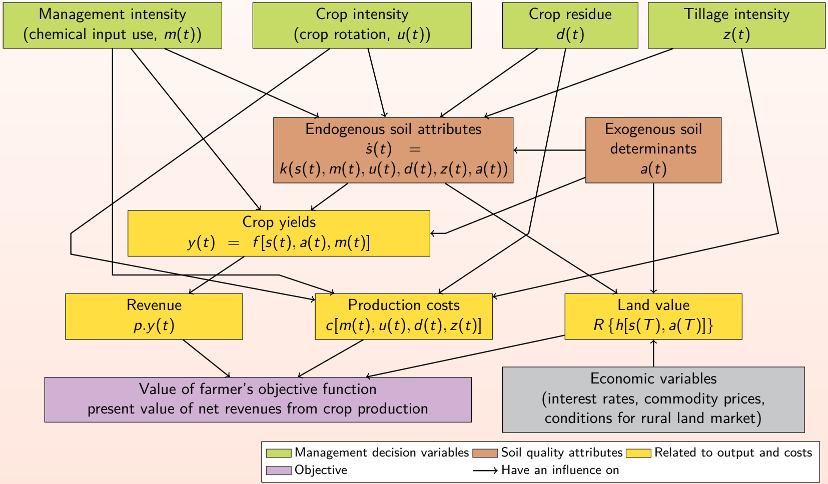

Production function

Crop production per hectare $y(t)$ is such that:

$$y(t) = f[s(t), m(t), a(t)] \tag{1}$$

[1]We denote by $f_{x_i} = \partial f(\ldots, x_i, \ldots)/\partial x_i$ the partial derivative of any function f with respect to x_i and by $f_{x_i x_j}$ the partial derivatives at the second order.

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This function is $C^{(2)}$ (twice continuously differentiable) and satisfies the following assumptions [1]:

$$f_s > 0, f_m > 0, f_{ss} < 0, f_{mm} < 0 \tag{2}$$

$$f_{sm} \gtreqless 0, f_{ss}f_{mm} - (f_{sm})^2 > 0 \tag{3}$$

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Soil quality function

Endogenous soil attributes motion over time depends on management practices:

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Maximisation problem

$$\underset{u,z,m,d}{\text{Max}} \int_0^T e^{-rt}[pf(s(t),m(t),a(t)) - c_1 m(t) - c_2 z(t) - c_3 u(t) - c_4 d(t)]dt + e^{-rT} R\{h(s(T),a(T))\} \tag{9}$$

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subject to: $\dot{s}(t) = k(s(t), m(t), u(t), d(t), z(t), a(t))$ Soil quality motion (10)

$s(0) = s_0$ Initial soil endogenous quality (11)

$0 \leq z(t) \leq 1$ Bounds on tillage intensity (12)

$0 \leq u(t) \leq 1$ Bounds on crop intensity (13)

$0 \leq d(t) \leq d_{max}$ Bounds on crop residues (14)

$0 \leq m(t) \leq m_{max}$ Bounds on management intensity (15)

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Thank you.