



An holistic systemic approach embedded with ecosystem services values: Assessing the resilience of cereal farms in groundwater overexploitation in Maghreb region

Kleftodimos, G.⁽¹⁾, Zaatra, A. ⁽¹⁾ Requier-Desjardins, M. ⁽¹⁾, Bellhouchette H. ⁽¹⁾

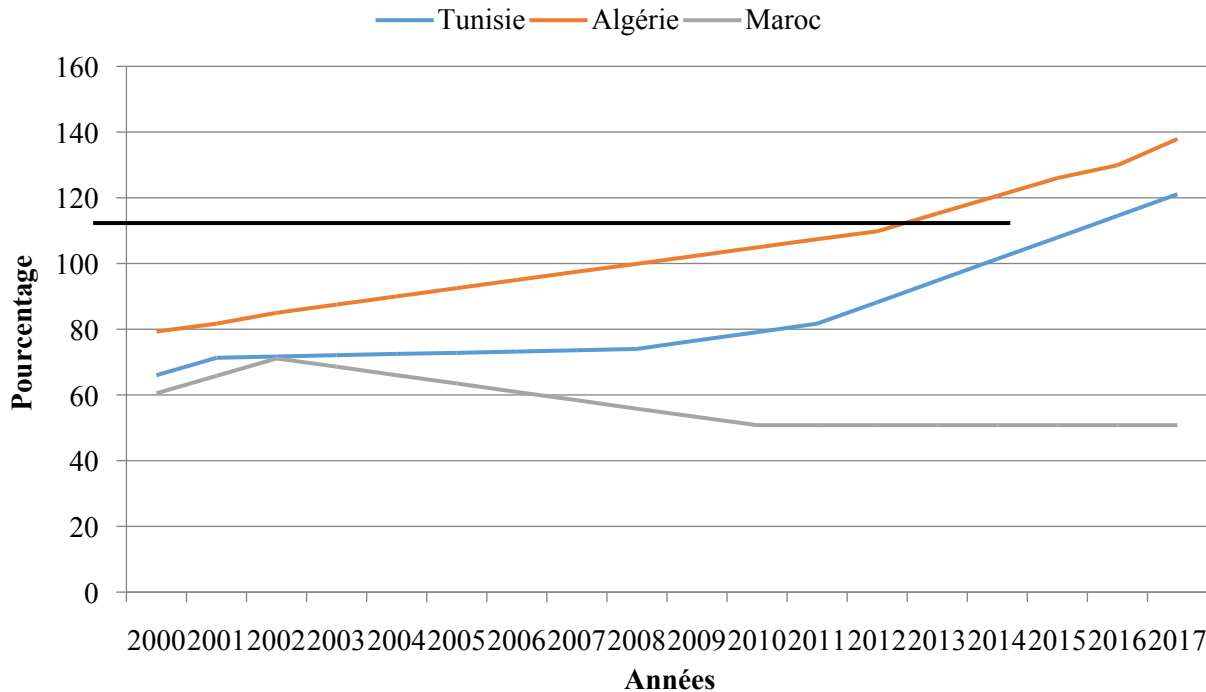
kleftodimos@iamm.fr

(1) Institut Agronomique Méditerranéen de Montpellier (IAMM), Montpellier, France



Context

Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (%) in the Maghreb



Source: [United Nations \(2020\)](#)

- ❑ The water resources of the Maghreb countries are well known, but limited, irregular and fragile.
- ❑ Unsustainable consumption and overexploitation of surface and groundwater resources are already contributing to water shortages and threatening long-term sustainable development.
- ❑ Indeed, agriculture accounts for two-thirds of water withdrawals in the Mediterranean basin.
- ❑ Increasing water scarcity in Maghreb countries is expected to have significant negative impacts on food production and affect the types of crops grown.

Research questions

- ❑ What would be the impact of overexploitation on agricultural activity?
- ❑ What would be the state of the agricultural sector if this overexploitation did not exist?
- ❑ What actions could be implemented to restore the balance in the aquifers without penalizing farmers?
- The objective of this study is to carry out an economic valuation of the overexploitation of groundwater in the Maghreb region in order to raise awareness among political decision-makers and put in place coherent mitigation policies.

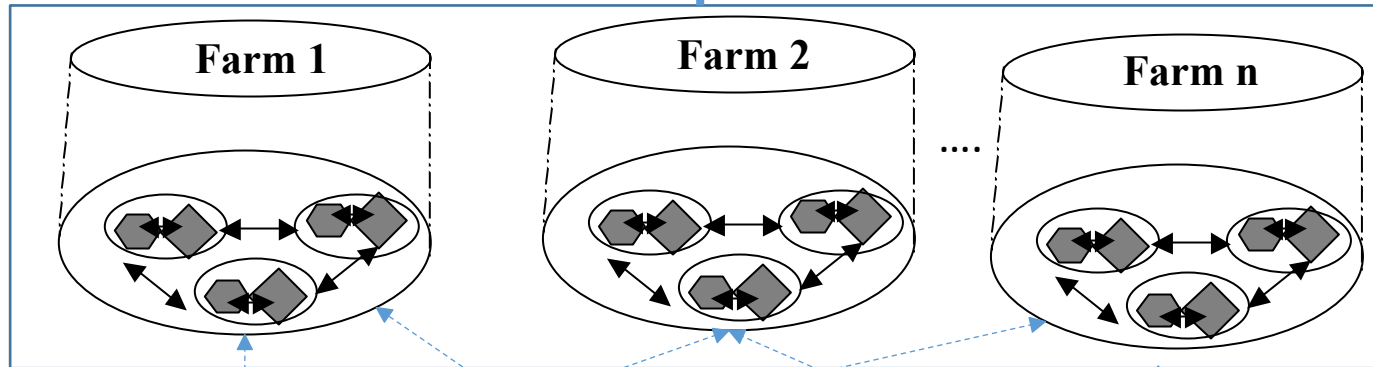
The system approach to define « activity concept » and select « representative farms »



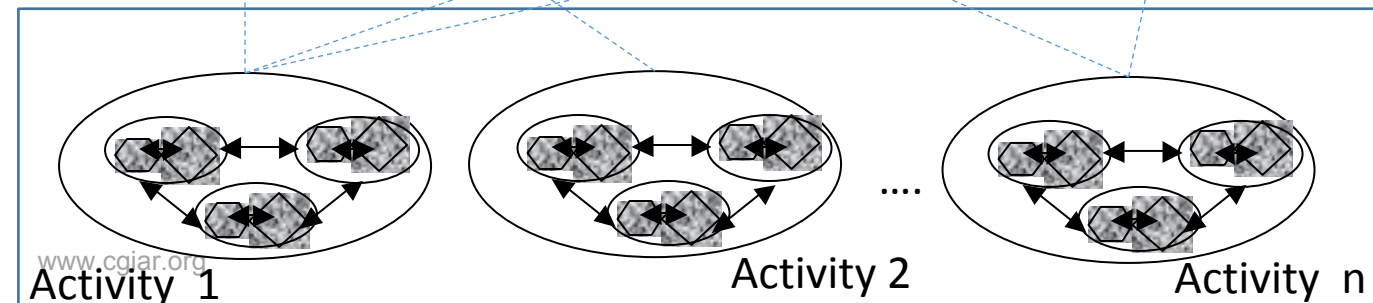
Region

- Aggregation of the impacts by weighting by number or area.
- Simulate the interaction between farm types taking into account market and resource exchanges

Farms



Fields



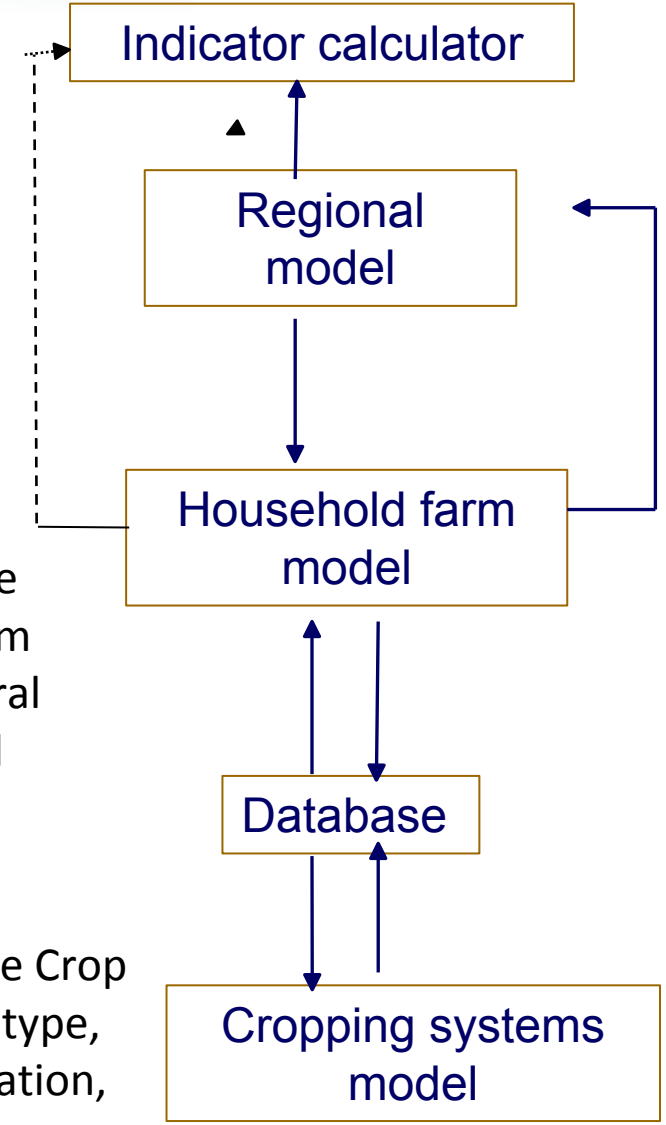
Indicator calculator

Regional model

Household farm model

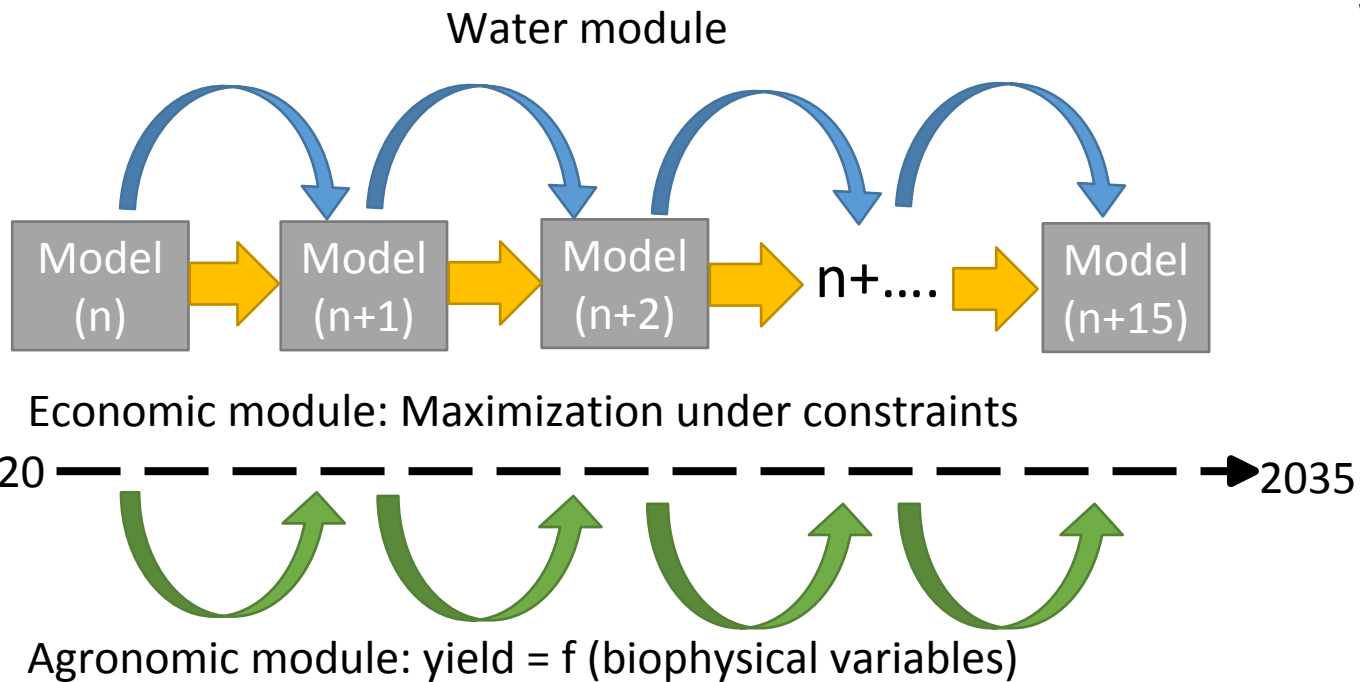
Database

Cropping systems model



DAHBSIM Model

Dynamic model that spans a 15-year series



➤ Objective function

$$U = \sum mb(t) - \sum (PHI \times ETRev(t))$$

Where :

- mb(t) : gross margin for year t ;
- PHI : risk coefficient
- ETRev : standard deviation of income

☐ Constraints

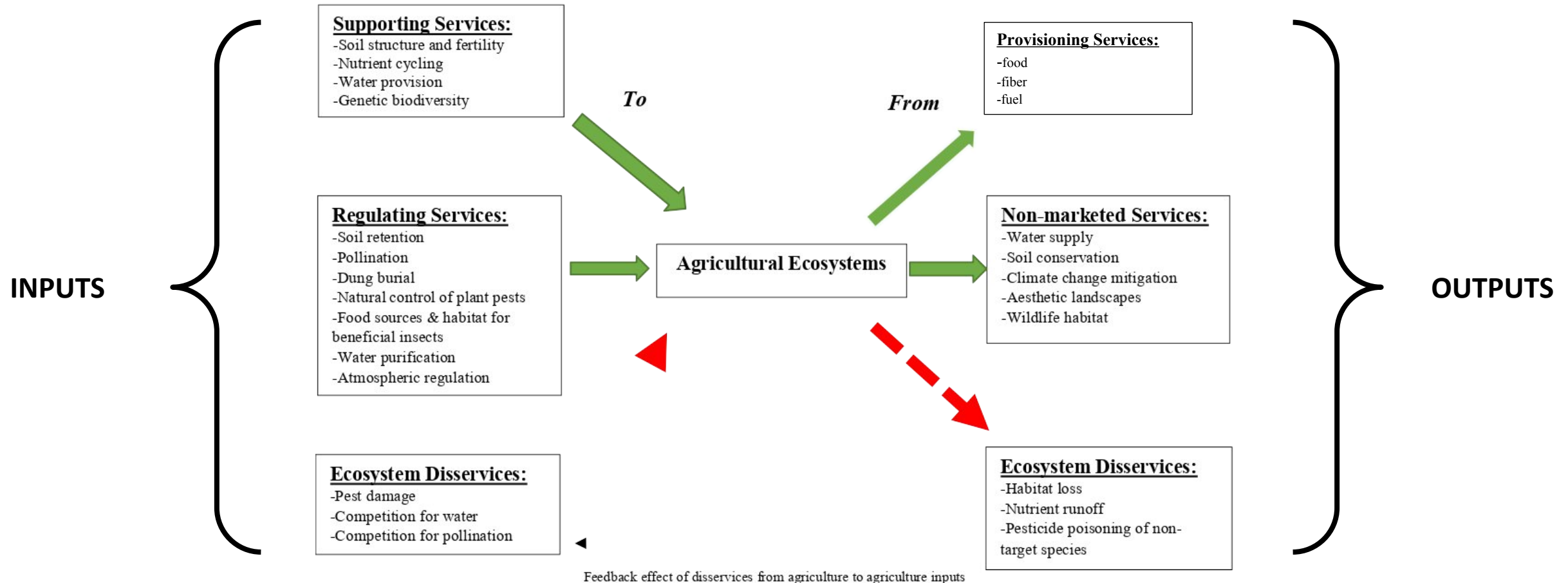
- Land
- Investments
- Agronomic constraints (rotation, ...)
- Labor
- **Water use**

Ecosystem Services and Human Welfare

- We define ecosystem services as the benefits that humans utilize directly or indirectly (Fisher et al., 2009).
- Agricultural activity relies on ecosystem services in order to produce an important variety of goods and services.
- However, it generates a high number of externalities which affects the provision of these services.

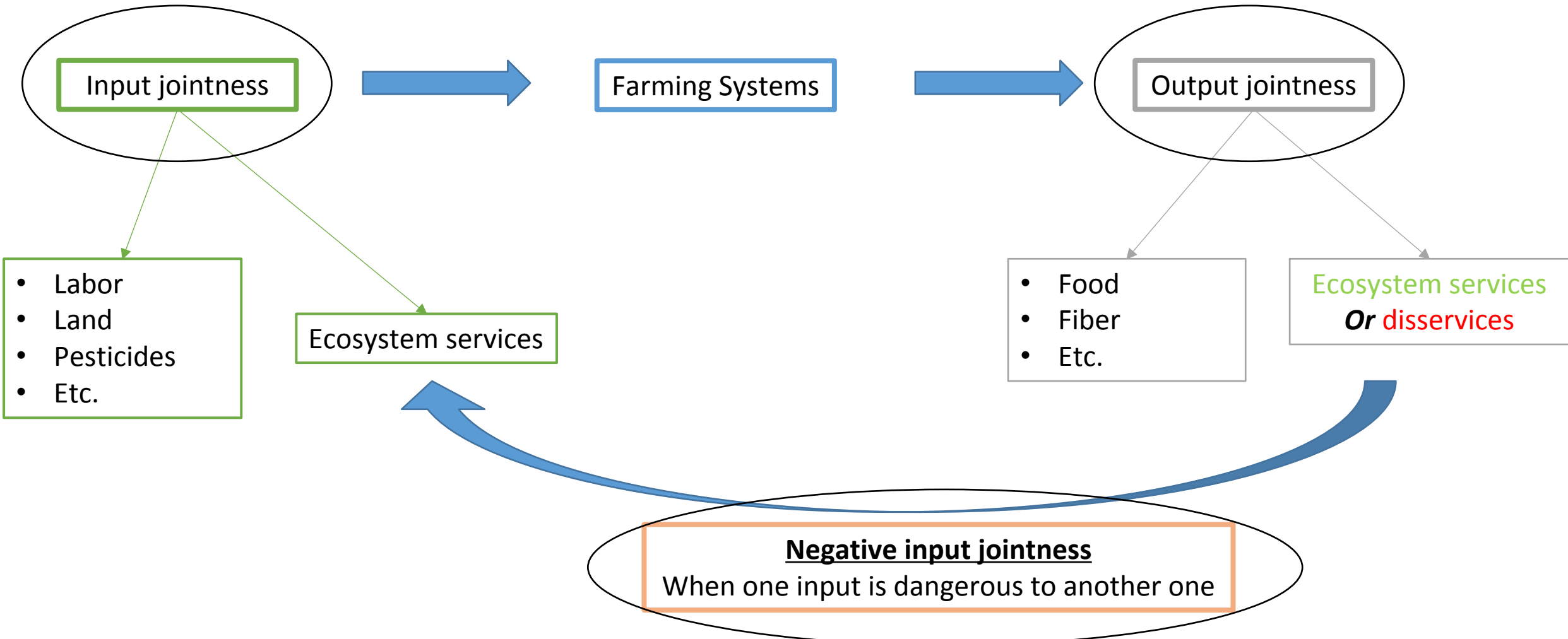
Ecosystem services and disservices to and from agriculture

Ecosystem services and disservices to and from agriculture

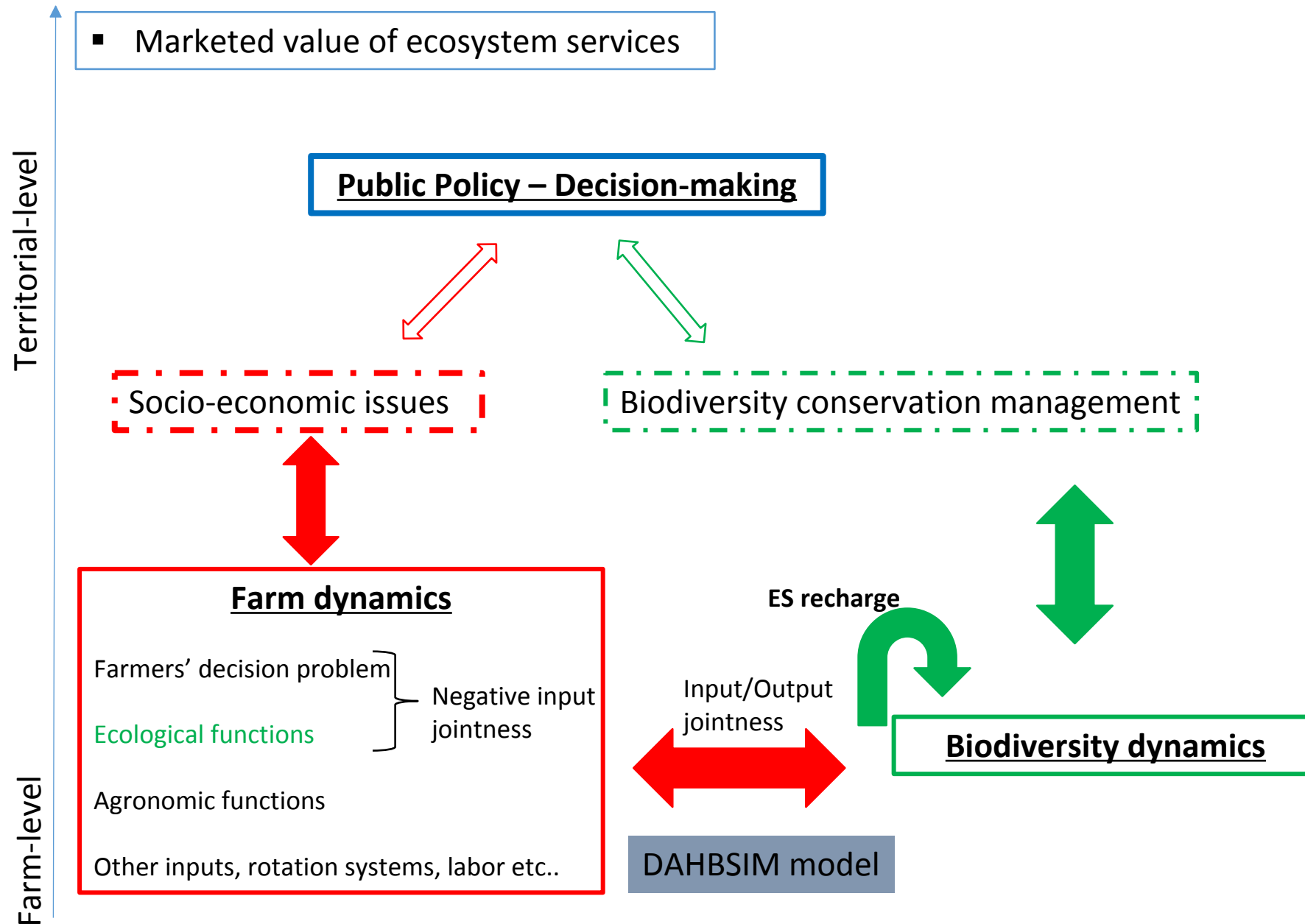


The integration of jointness to farmer decision problem:

- Ⓟ Capture the marketed values of ES
- Ⓟ Important from policy perspective



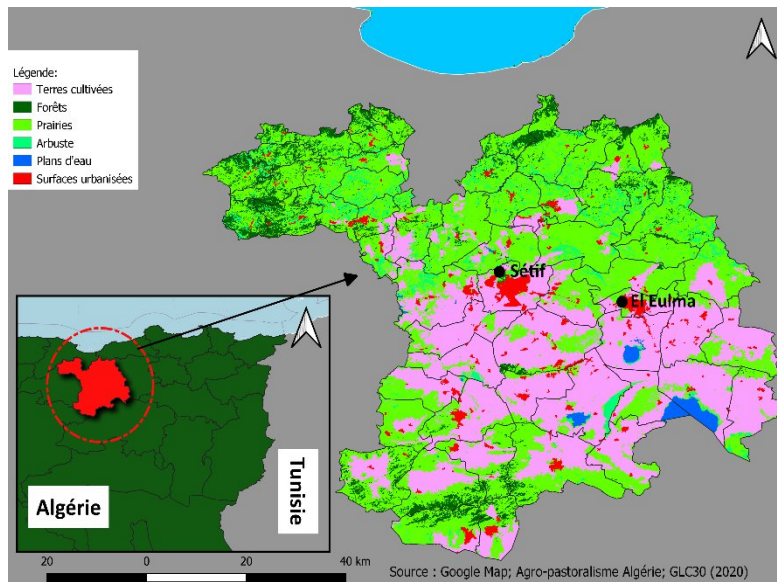
Conceptual framework



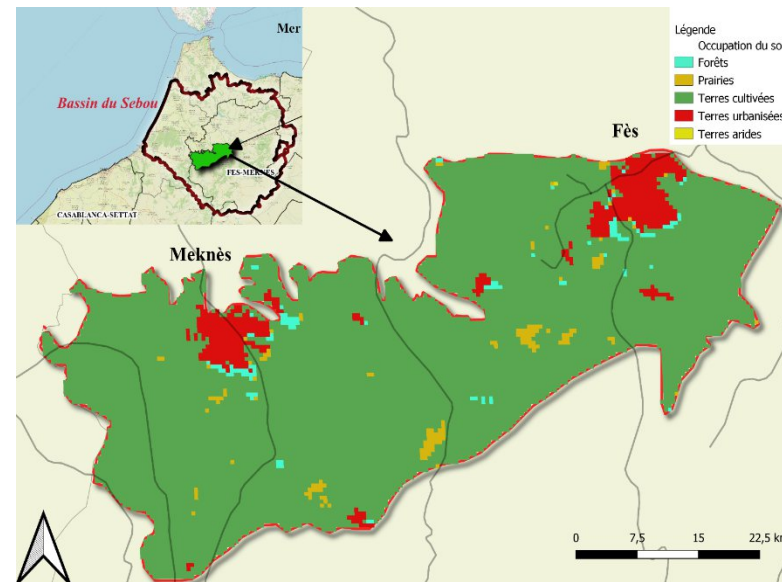
Case studies

❑ 3 case studies in the Maghreb region (Tunisia, Algeria and Morocco)

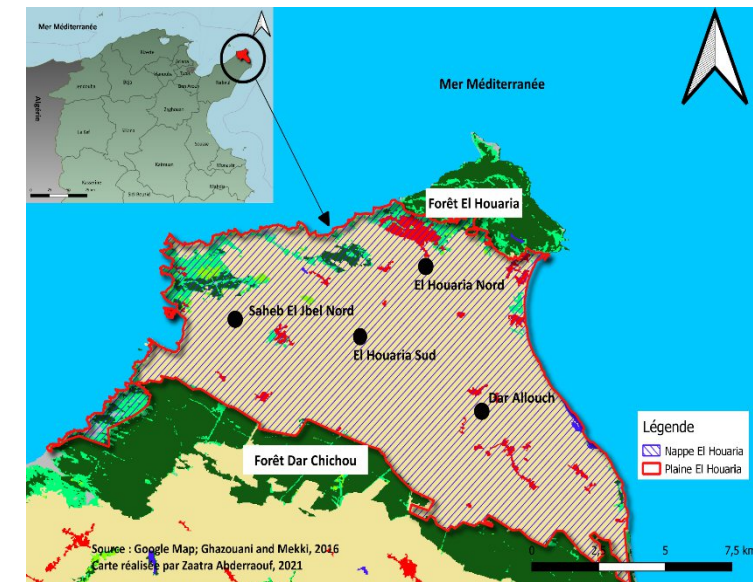
❑ Plains with significant agricultural production that depend mainly on groundwater.



Sétif Plain (Algeria)



Saïss Plain (Morocco)



El-Houaria Plain (Tunisia)

General results

- In Morocco, the results show that the cost of aquifer overexploitation is significantly higher than the cost of groundwater restoration
- In Tunisia this is a strategic moment to intervene
- In Algeria a change in the access to water policy may change dramatically the situation.

Indicators	Overall cost of annual average overexploitation			Overall cost of the average annual restoration		
	Morocco (Saïs plain)	Tunisia (El-Houaria plain)	Algeria (Sétif plain)	Morocco (Saïs plain)	Tunisia (El-Houaria plain)	Algeria (Sétif plain)
Water cost (€)	+ 614,384.000	+ 847,495	+296,802.46	+ 465,582,000	+ 847,495	+493,200.87
Farmers gross margin (€)	- 10,568,794	- 333,690	-	- 65,771,048	- 349,973	1,165,483.13