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Joël Aubin, Aurélie Wilfart, Killian Chary, Syndhia Mathé, Hélène Rey-Valette. Emergy accounting as an assessment tool of ecological intensification: application to pond farming in France. 5th international ecosummit- Ecological sustainability, Aug 2016, Montpellier, France. hal-04146891

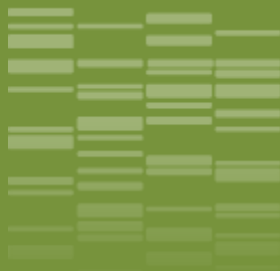
HAL Id: hal-04146891

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Submitted on 30 Jun 2023

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Emergy accounting as an assessment tool of ecological intensification: application to pond farming in France

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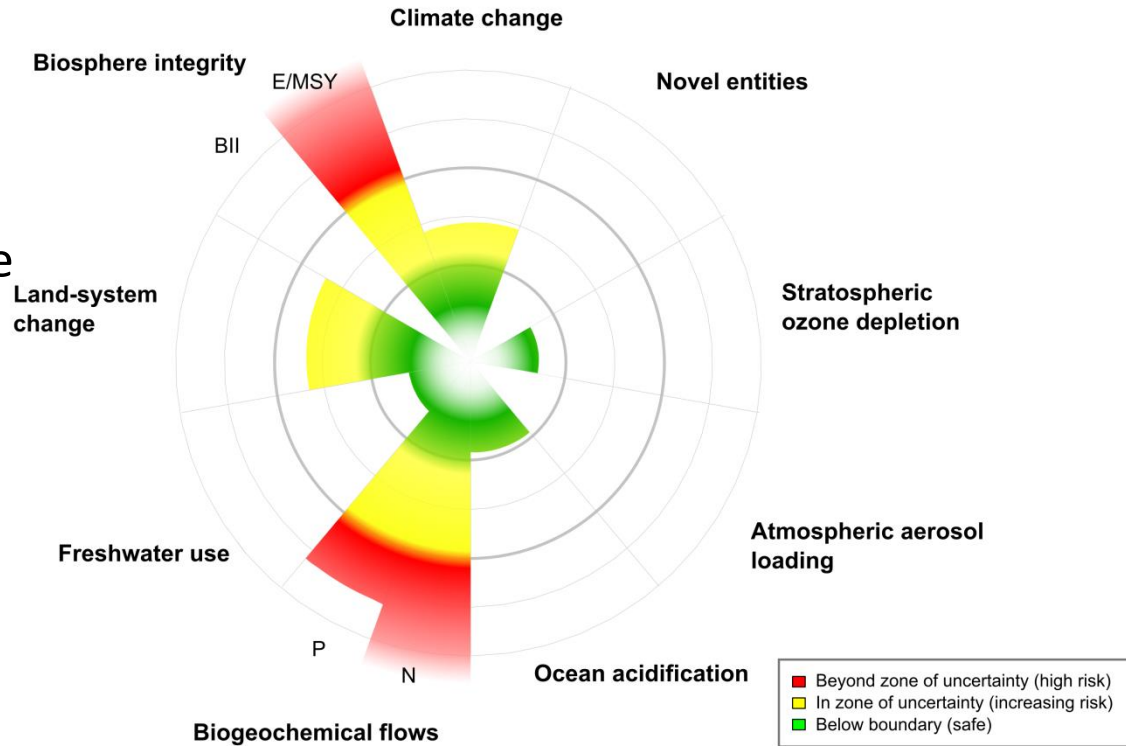
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Context

- 9 billion inhabitants in 2050
- An increase in food demand
- Food transition towards more meat consumption
- An increase on natural resources, lands, water, biodiversity pressures
- Overpass of ecosystems carrying capacity



Changes in food production paradigm



Steffen et al. (2015)

Ecological intensification of agriculture

- Use of biological regulation to manage agro-ecosystems, at field, farm and landscape scales (Doré et al., 2011)
- Increase the system efficiency using ecology's levers (Griffon, 2010)
- Integrating context-appropriate bundles of ecosystem services into crop production systems (Bommarco e tal., 2013)



Integrating agroecology principles and ecosystem services framework
in agricultural systems

In order to :







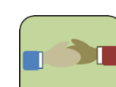
- Maintain/increase production levels
- Decrease the dependence on artificial inputs
- Respect the fragile resources
- Decrease pollutant emissions

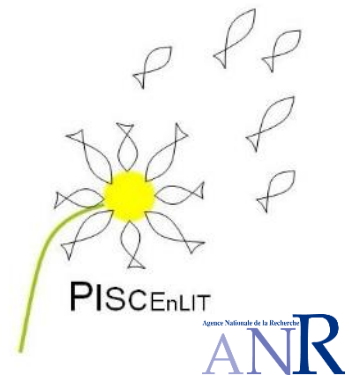
Applied to
aquaculture
systems



**Pas sur
de la garder**

Objectives to refine and apply ecological intensification

-  - Increase autonomy
-  - Improve efficiency
-  - Functions complementarity and integration
-  - Diversification of ecosystem services
-  - Inclusion of know how, local knowledge
-  - Improve territorial integration
-  - Involvement of stakeholders



Ecosystem services adapted to ponds from MEA (2005)



Support

- Primary production
 - Fauna and flora protection
- Habitat and refuge
- Plant multiplication
 - Nutrient cycling



Provisioning

- Food
- Fresh water
- Combustible/Fuel
- Fiber
- Genetic resources
- Biochemistry, medicine, pharmacology
- Ornamental resources
- Fertilizer

Ecosystem Services

Cultural

- Spiritual
- Inspiration
- Education
- Recreation
- Attractivity



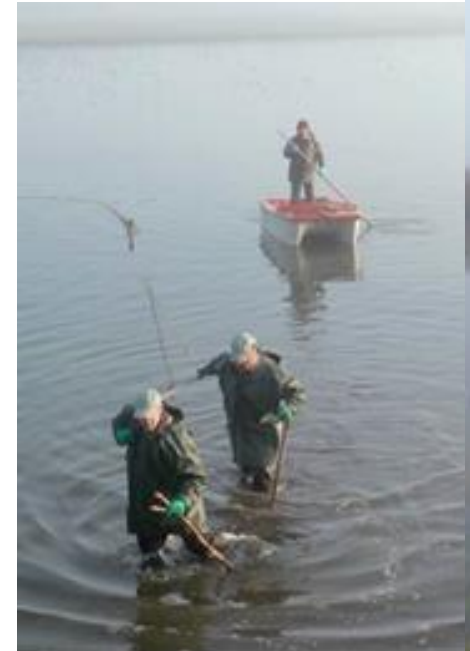
Regulation

- Climate
- Hydrology
- Protection against natural hazards
- Pollution control and depollution
- Regulation of erosion
- Biologic regulation
- Disease regulation



Issues of pond aquaculture sector in France

- A patrimonial activity (from Middle Age)
- A component of the landscape
- A low fish productivity (200 kg/ha/year)
- A decline of the fish production
- Controversial interactions with the environment
- Multiple use by different actors: fish production, recreational, hunting, angling, water reservoir, protected wetlands and biodiversity conservation...



Emergy accounting framework

Celle-ci ou la suivante?

Inputs and services

Adapted from (Cavalett et al., 2006)

Total Emergy (Y)			
Nature contribution (I)		Feedback from economy (F)	
Renewable resources from nature (R)	Non renewable resources from nature (N)	Material (M)	Services (S)
		Renewable materials and energy (M_R)	Non-Renewable materials and energy (M_N)



Methodology: Emergy accounting

Emergy Indicators:

Transformity
 $Tr = Y/Energy$

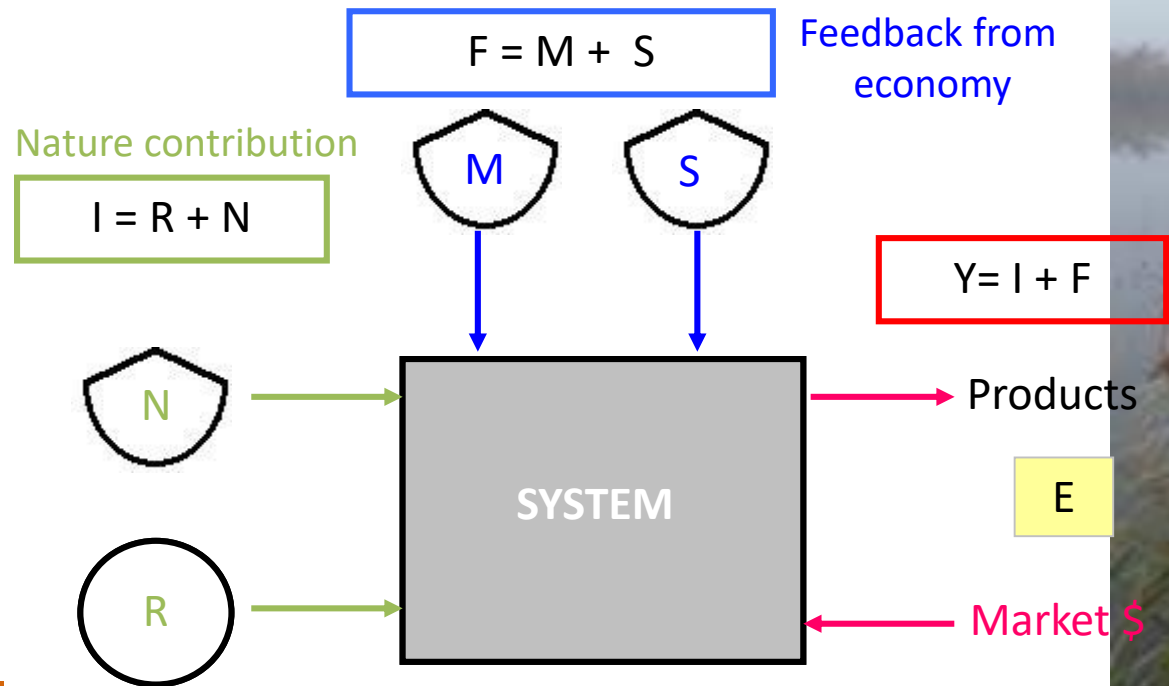
Renewability
 $\%R = 100(R/Y)$

Emergy yield ratio
 $EYR = Y/F$

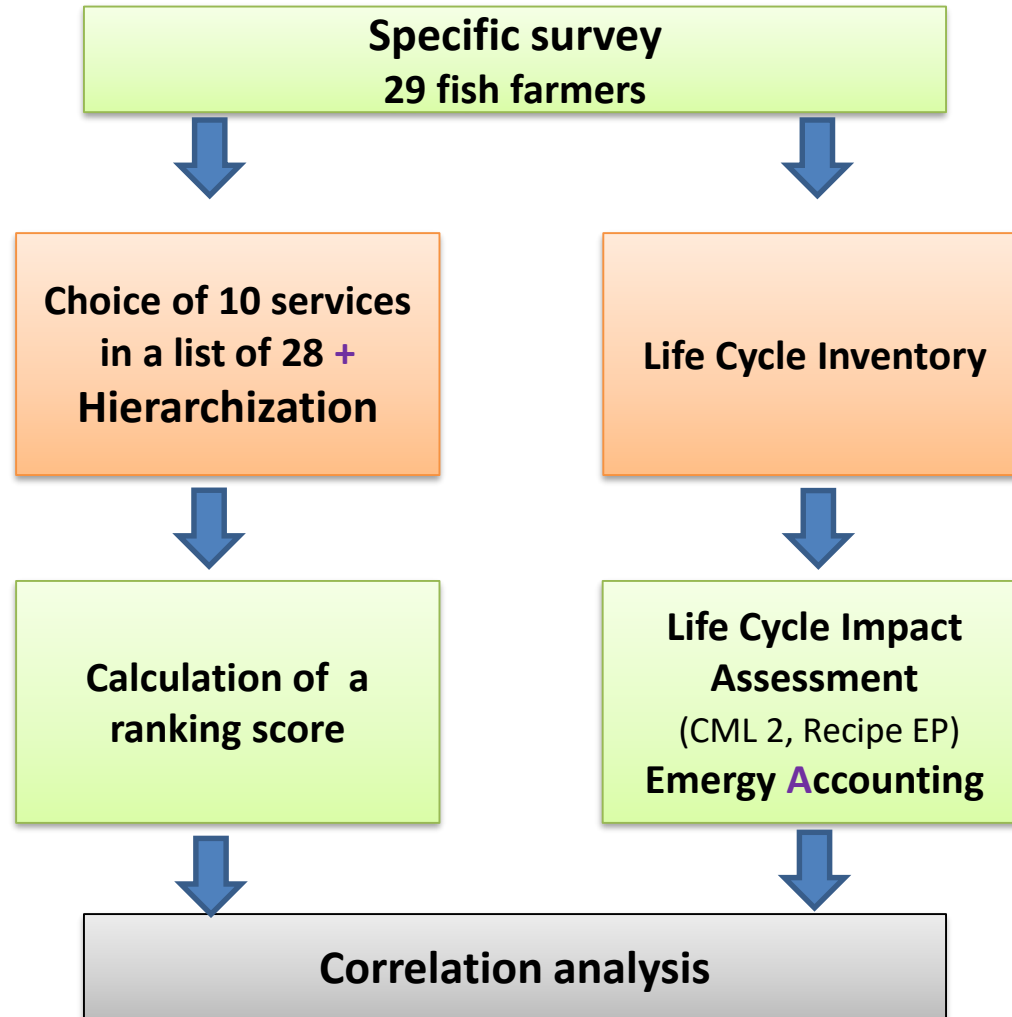
Emergy investment ratio
 $EIR = F/I$

Environmental loading ratio
 $ELR = (F+N)/R$

Emergy index of sustainability
 $EIS = EYR/ELR$



Methodology



Emergy Accounting framework

Total Emergy (Y)						
Nature contribution (I)			Feedback from economy (F)			
Renewable resources from nature (R)		Non renewable resources from nature (N)	Material (M)		Services (S)	
			Renewable materials and energy (M_R)	Non-Renewable materials and energy (M_N)	Renewable services (S_R)	Non-Renewable services (S_N)

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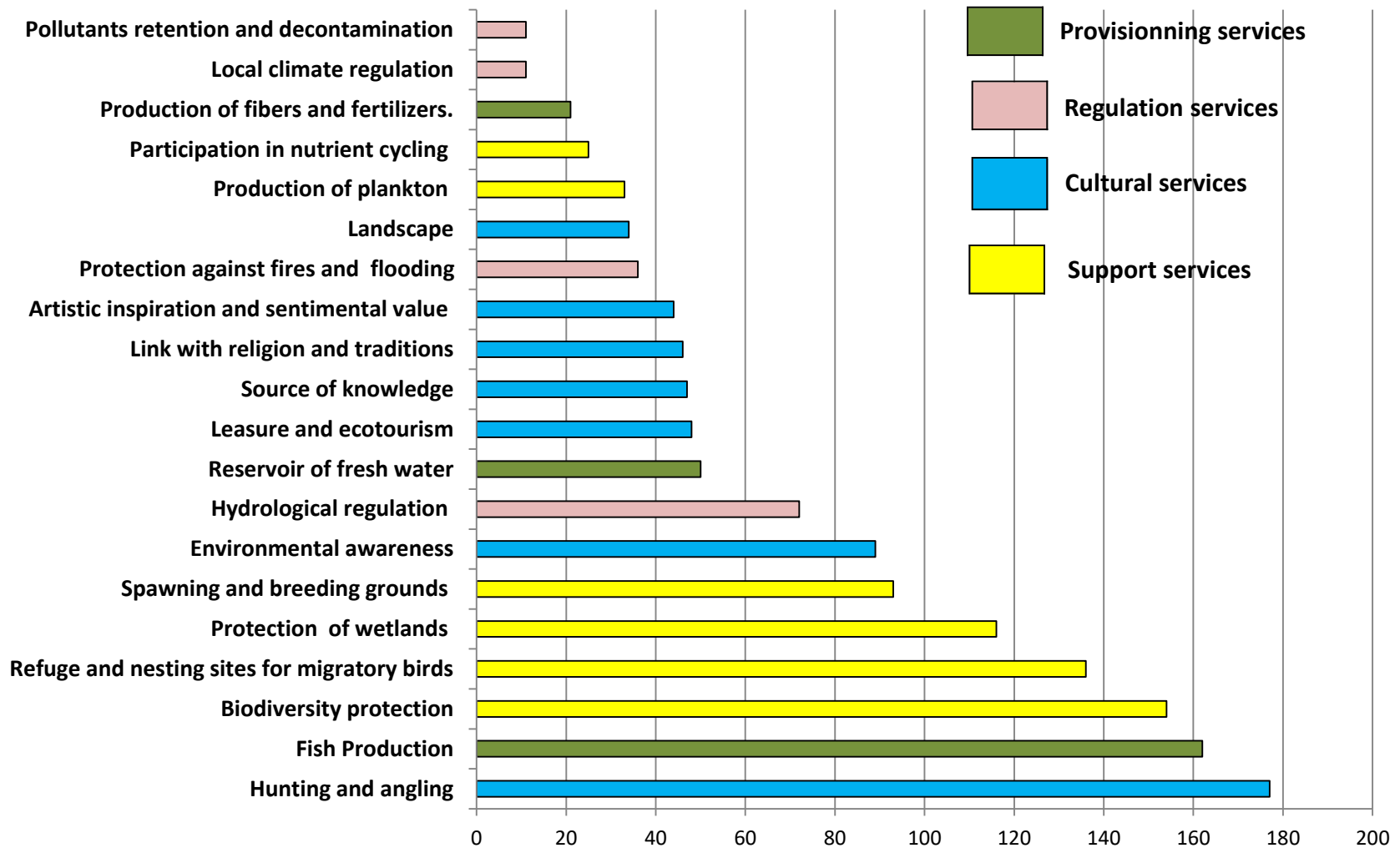
Studied areas :

2 polyculture ponds areas in France

- **Brenne** : « land of thousand ponds », Natural Regional Parc involved in bird protection
- **Lorraine**: dam ponds spread out in the agriculture area in a Natural Regional Parc

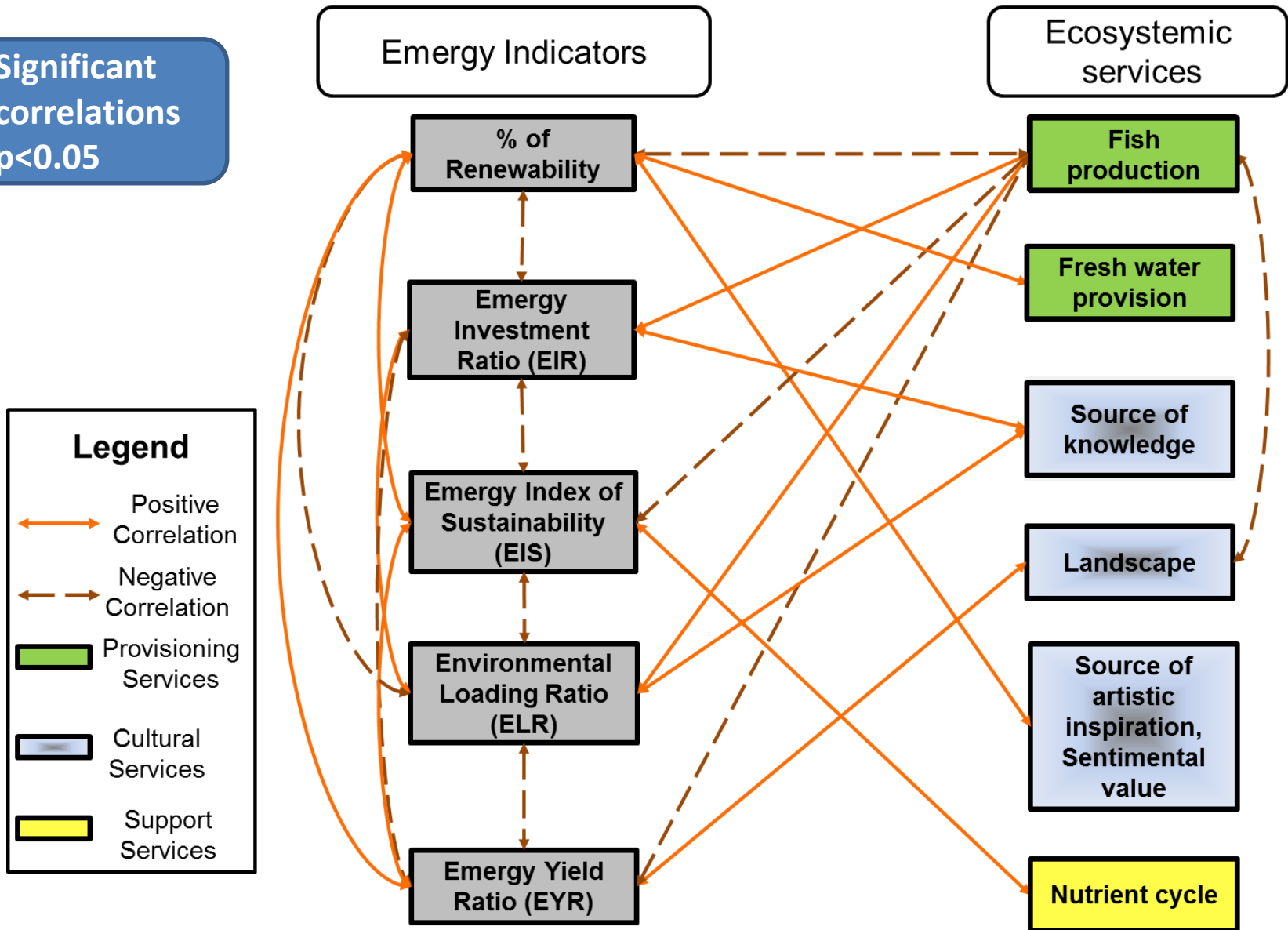


Scores of services perception by farmers



Emergy indicators & E. Services correlations

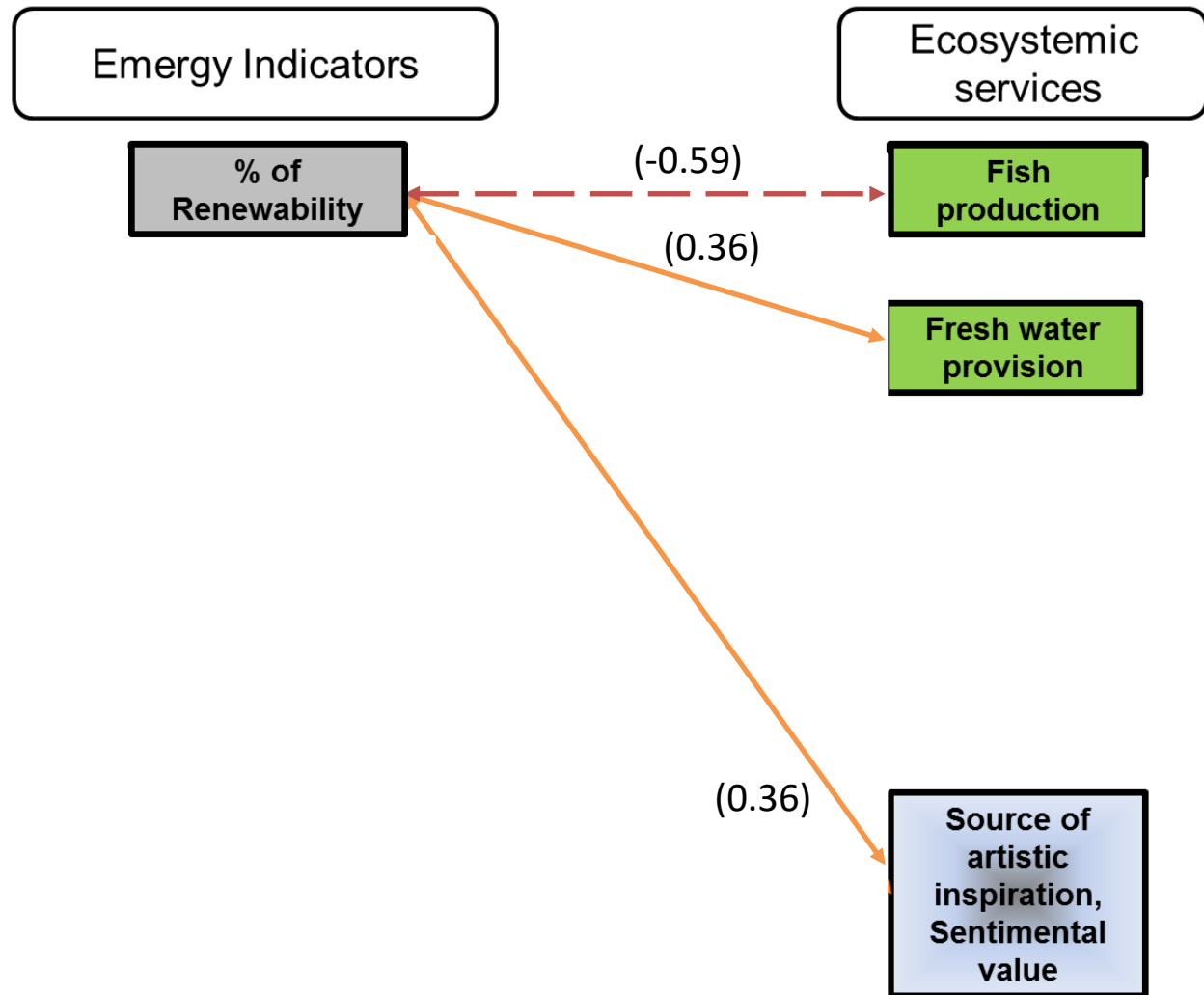
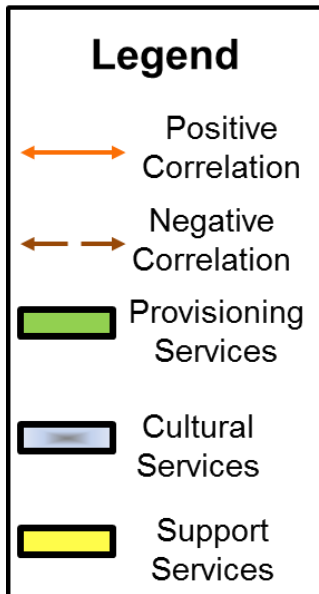
Significant correlations $p < 0.05$



Emergy indicators & E. Services correlations

Significant correlations
 $p < 0.05$

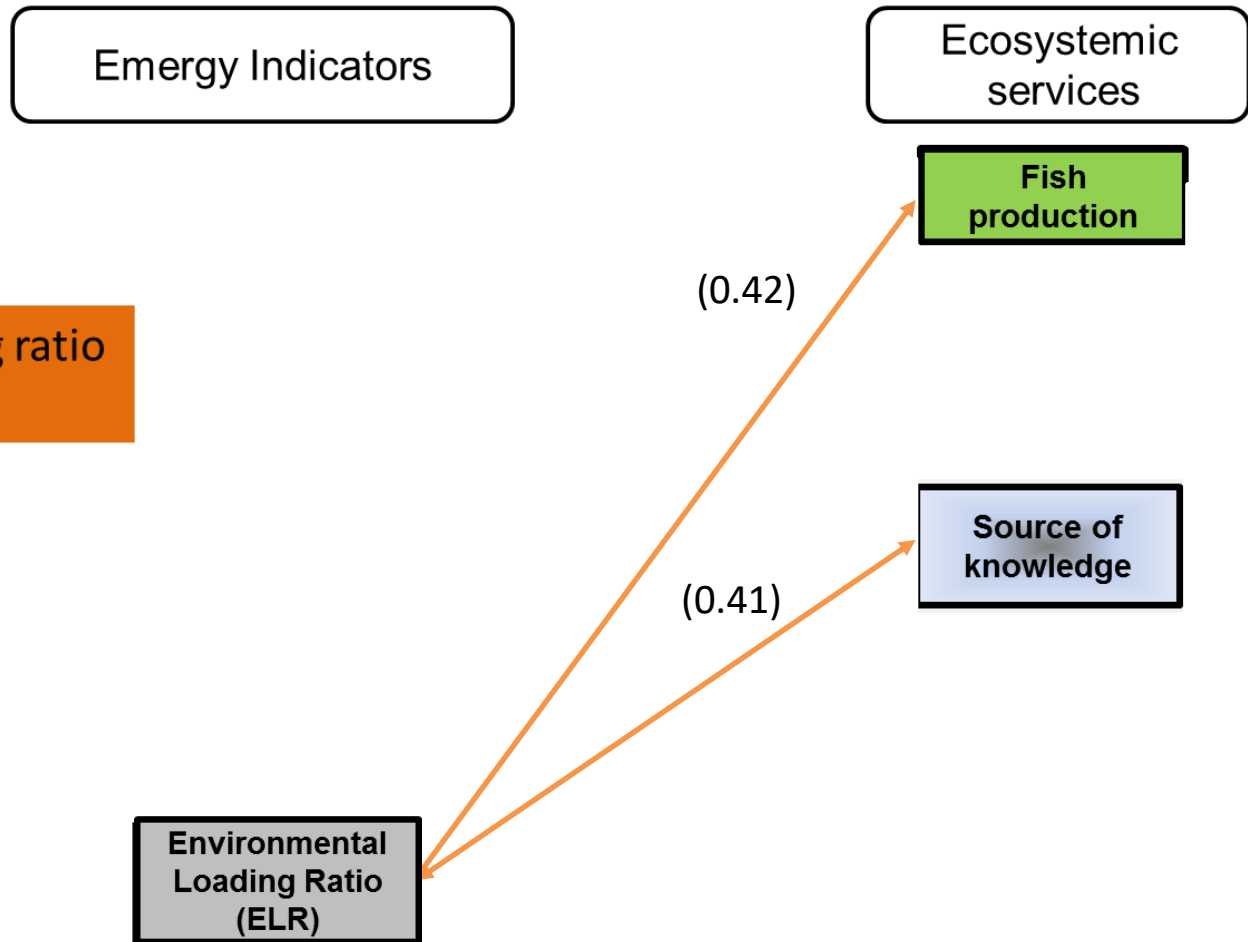
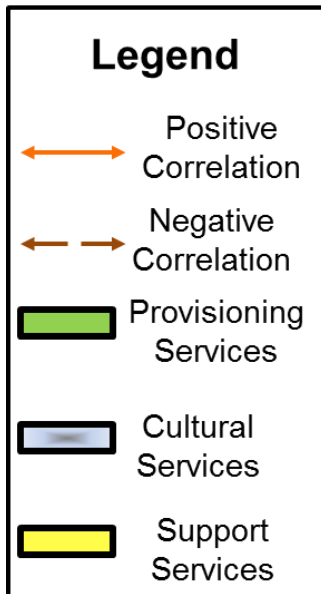
Renewability
 $\%R = 100(R/Y)$



Emergy indicators & E. Services correlations

Significant correlations
 $p < 0.05$

Environmental loading ratio
 $ELR = (F+N)/R$



Discussion

- LCA is sensitive to yields (tonne fish/ha) and technical inputs use
- Emergy accounting reflects more natural inputs use
- There are correlations between perception of services by fish farmers and environmental assessment indicators, but they are weak.
- A correlation doesn't mean that you can use the environmental indicators as a direct measurement of ecosystem services
- The observed correlations are explained by:
 - the inclusion of natural resources in the productive system
 - the attention paid to provisioning, support, regulation or cultural services.
- It reflects a proper consistency between the production objectives, the environmental profile and the perception of the environment by the farmers

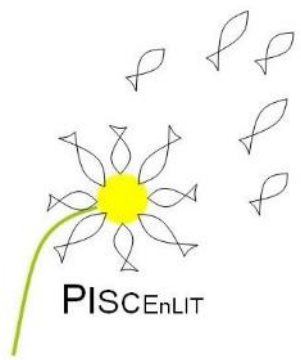
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Conclusion

- The assessment of energy flows by Emergy accounting permits to characterise the ecological efficiency and the dependence to economy/natural resources
- This study is a step towards joint studies including ecosystem services perception and environmental impacts in ecological intensive systems
- Results highlight the need to initiate integrated management of ecosystems by taking into account perceived values and uses of services and impact assessment of the activities



Agence Nationale de la Recherche
ANR

ANR/AIRD Systerra II Project
04 January 2010 – 03 January 2013

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