Why livestock farming systems are complex objects

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Session18. Modelling complexity in LFS to address trade-offs and synergies for efficiency

Why this question ?

- New challenges for livestock production
  - Climate change
  - Food security
  - Globalization
  - Sustainability
  - Competition for natural resources
  - Animal health and welfare
  - Biodiversity preservation
  - …

⏩ not a series of independent issues but a set of entangled issues

Why this is not simple ?

- Multiple dimensions of livestock farming systems (LFS) to be put into perspective
- Scale of approach enlarged from a local focus to a holistic view on agro-ecosystem functioning at territory level

⏩ an intricate set of dimensions and scales

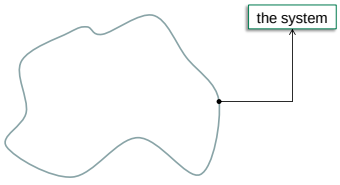
What is complexity ?

- Main hallmark of a complex object
  - Organization of its components within a network of interrelationships
  - Emergence of properties of the whole that are more than the properties of the parts

⏩ Complicated is the opposite of simple
Complex is the opposite of intelligible

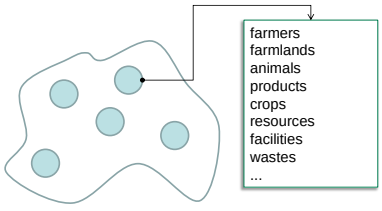
What is a LFS ?

- something



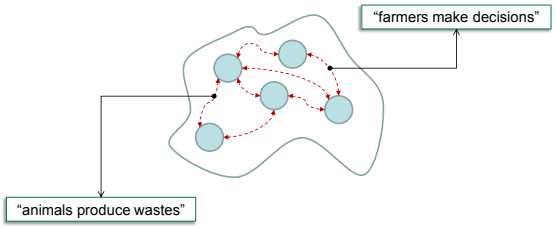
What is a LFS ?

- something composed of many things



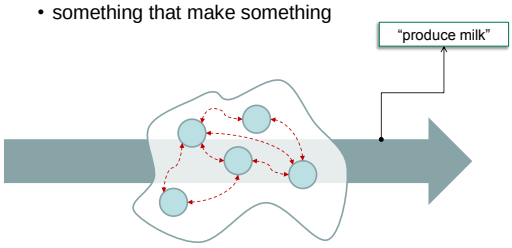
What is a LFS ?

- something organized in a network of relationships



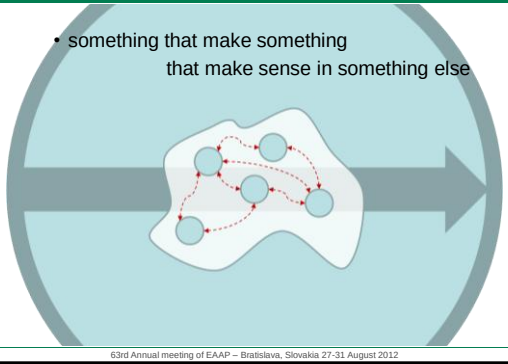
What is a LFS ?

- something that make something



What is a LFS ?

- something that make something
  that make sense in something else



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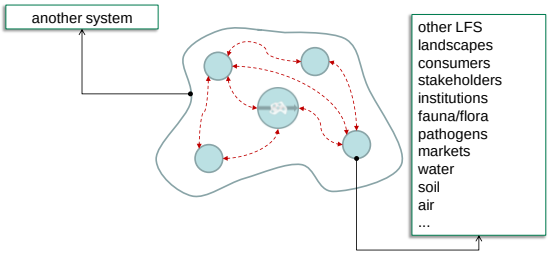
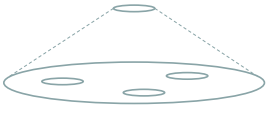


What is a LFS ?

- a system

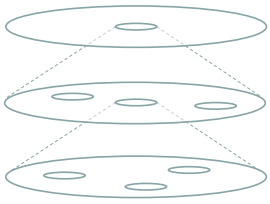
What is a LFS ?

- a system made of lower systems



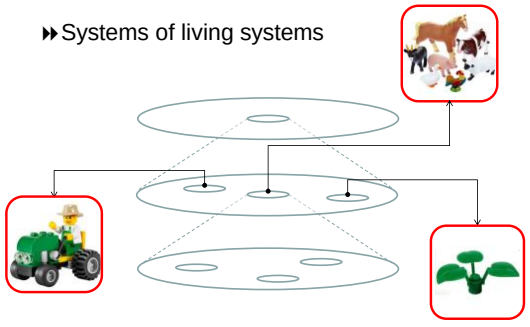
What is a LFS ?

- a system made of lower systems incorporated in an upper system

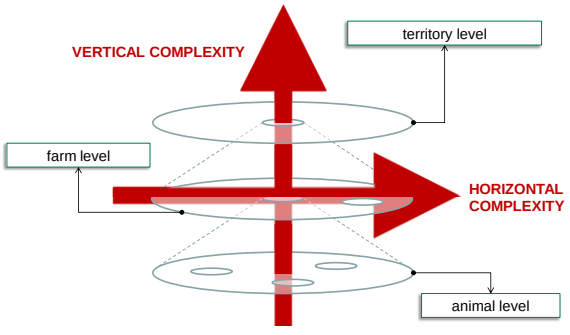


Why LFS are complex ?

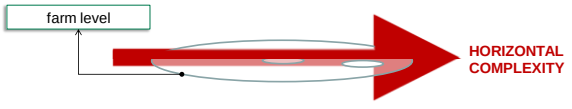
- Systems of living systems



How LFS are complex ?

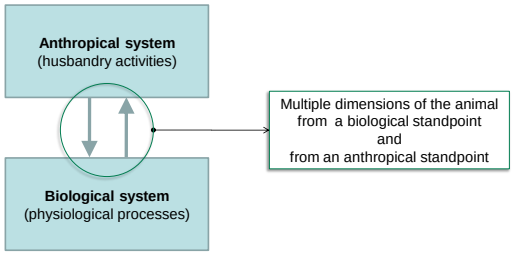


Horizontal complexity ?

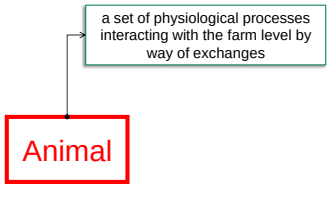


Cross linkage

- Classical view of the LFS



Biological stanpoint



Physiological processes

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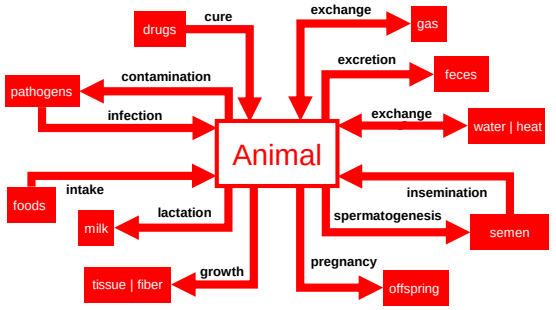
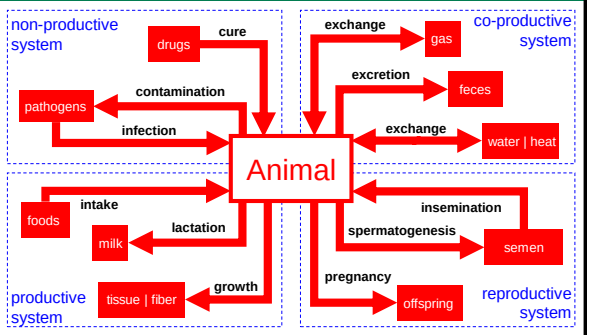


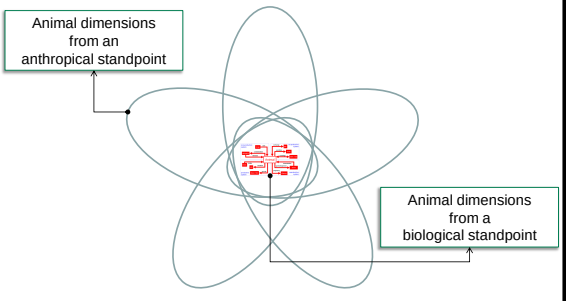
Biological dimensions

20



Husbandry activities

21



Anthropical dimensions

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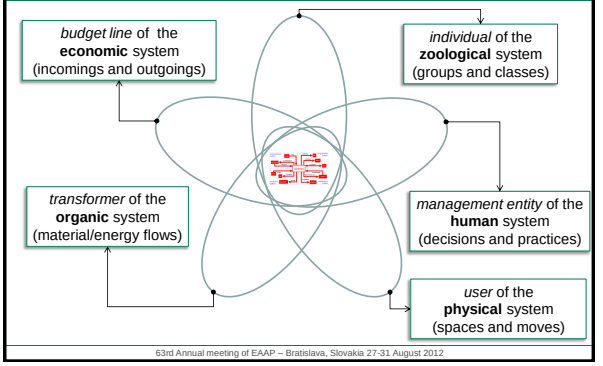
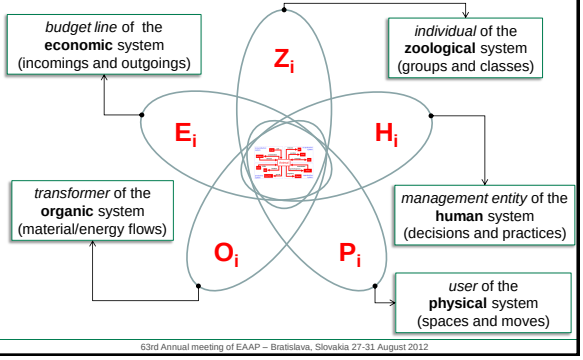


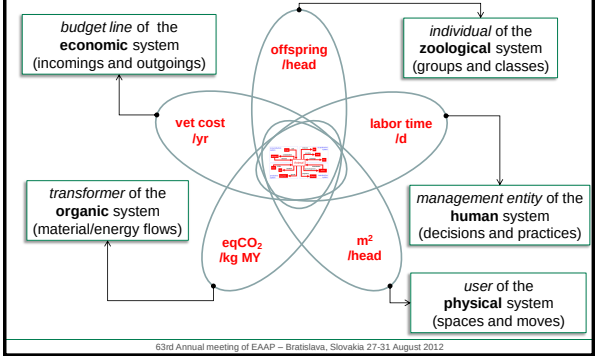
Variables

23

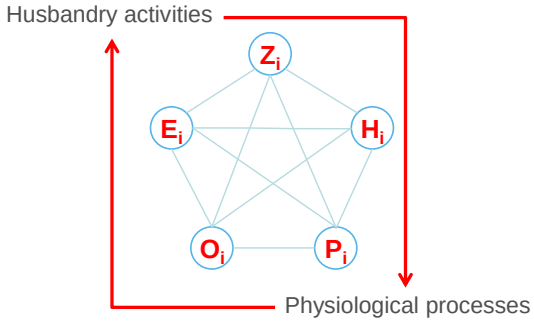


Variables

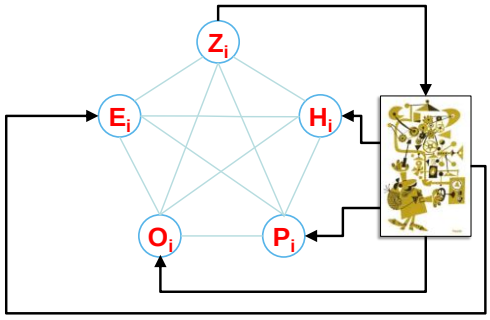
24



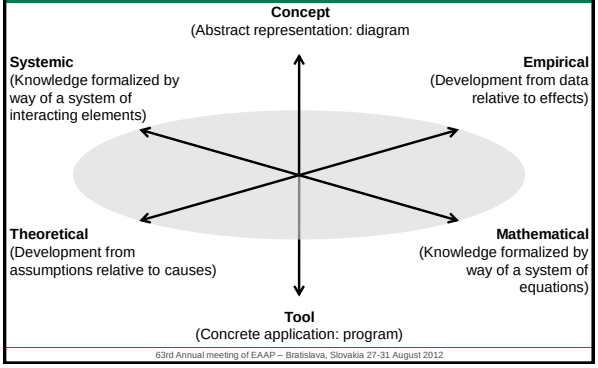
LFS functioning



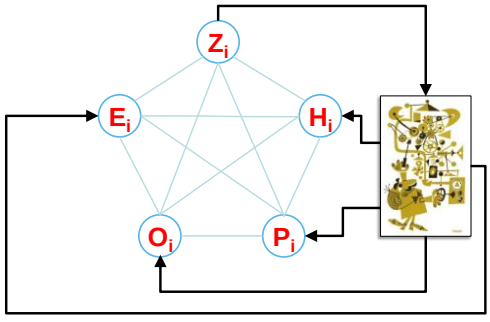
Modelling



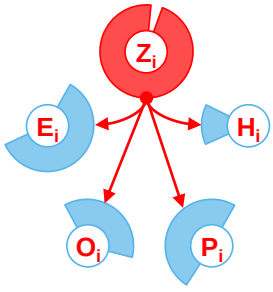
Models



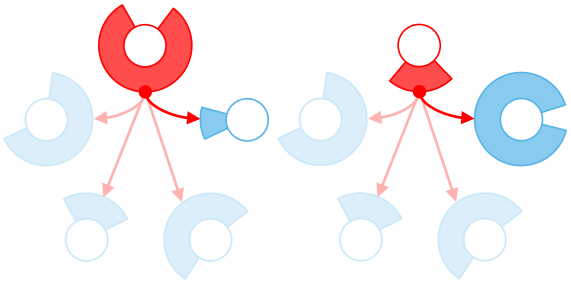
Modelling



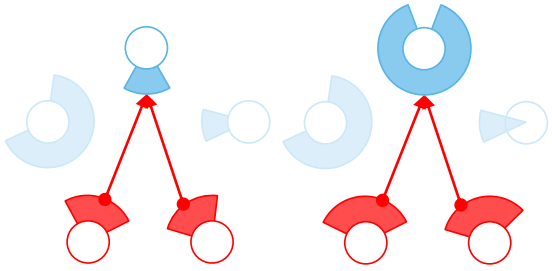
Technical options



Trade-offs

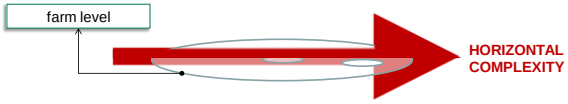


Synergies

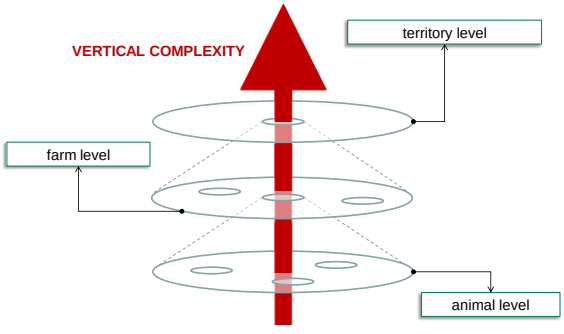


So what ?

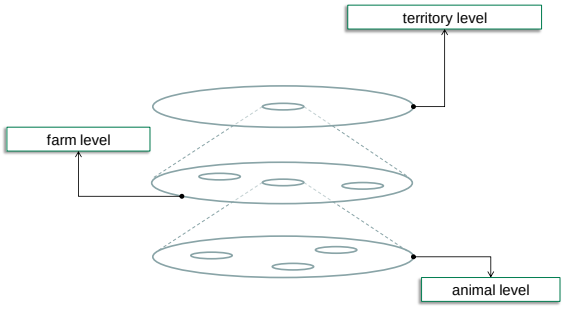
- Useful to
  - focus on interactions
  - mix standpoints



Vertical complexity ?



Hierarchical organization



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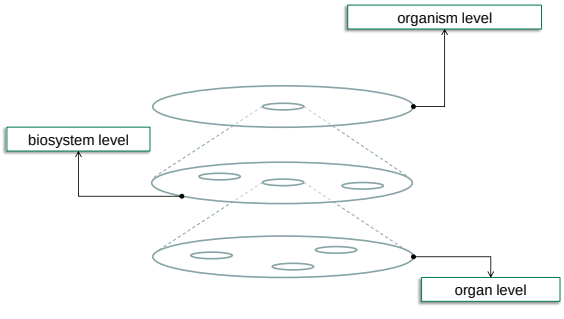

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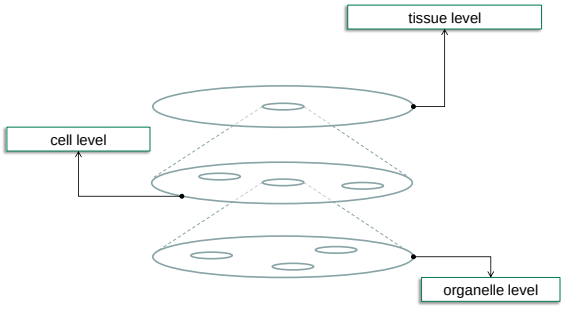
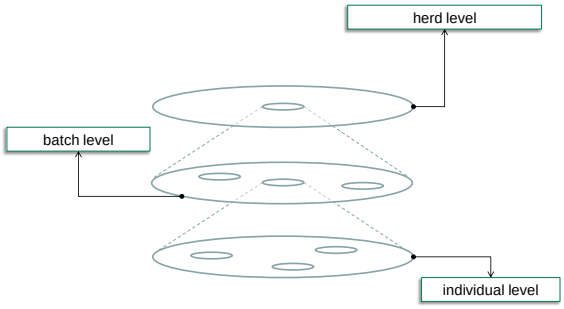
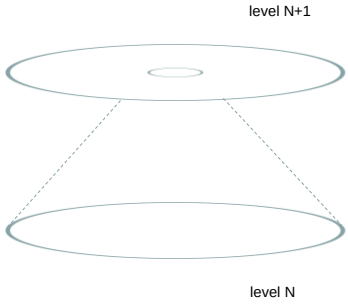


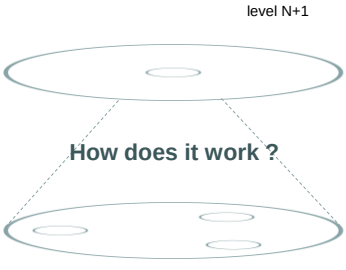
Hierarchical organization



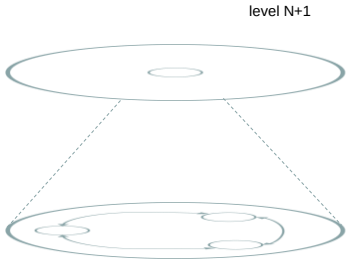
Elementary pattern



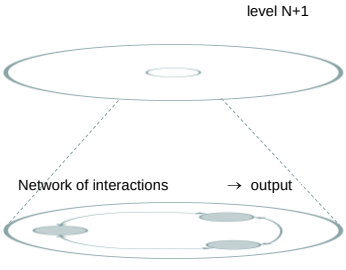
Physical view



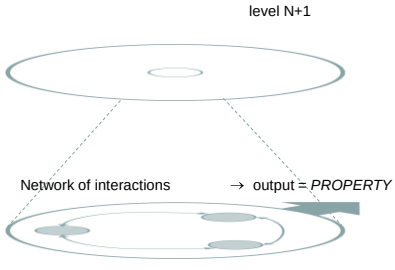
Interactions @ N



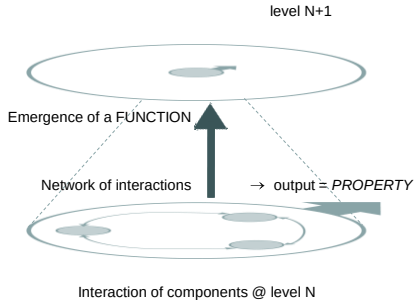
Network of interactions



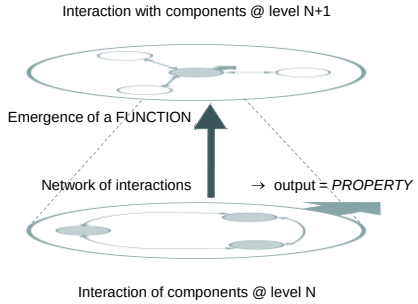
Output property



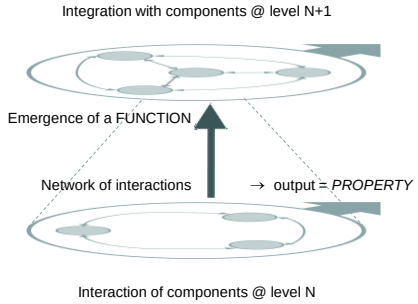
Emerging function



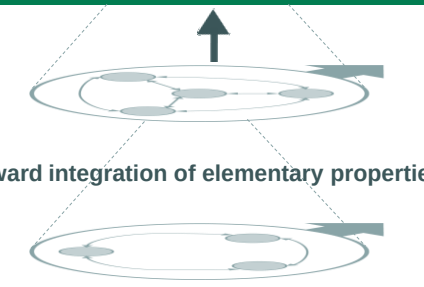
Interaction @ N+1



Functional emergence



Upwards



Functionnal emergence

From the interaction between
humans, animals and plants
emerge at the
farm
level the
production
function integrated in the
food supply
process at the
territory
level

Functionnal emergence

From the interaction between
reproductive, endocrine and metabolic biosystems
emerge at the
organism
level the
reproduction
function integrated in the
perenity
process at the
species
level

Functionnal emergence

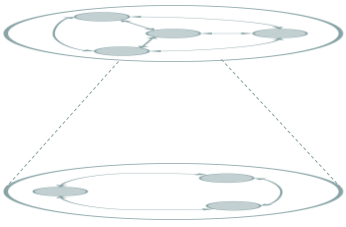
From the interaction between
nucleus, reticulum, mitochondria and golgi apparatus
emerge at the
lactocyte
level the
milk casein secretion
function integrated in the
lactation
process at the
mammary gland
level

So what ?

- Generic view from property to function that can be applied at any level
- Useful to
  - Consider the underlying elementary properties
  - Consider the meaning of the function in the upper level

Interaction @ N+1

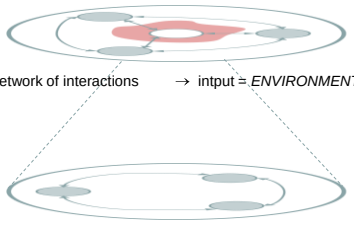
Interaction of components @ level N+1



level N

Input environment

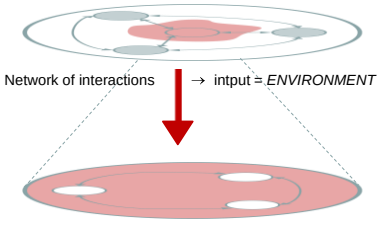
Interaction of components @ level N+1



level N

Interactions @ N

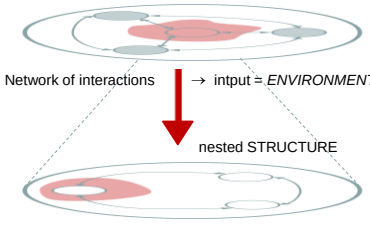
Interaction of components @ level N+1



Interaction with components @ level N

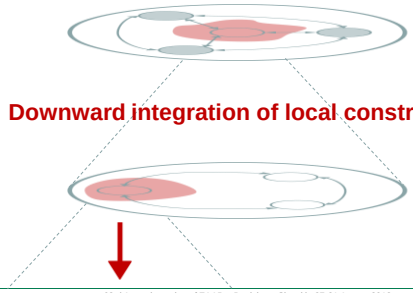
Structural immersion

Interaction of components @ level N+1



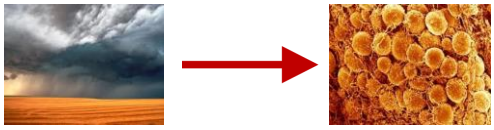
Interaction with components @ level N

Downwards



Structural immersion

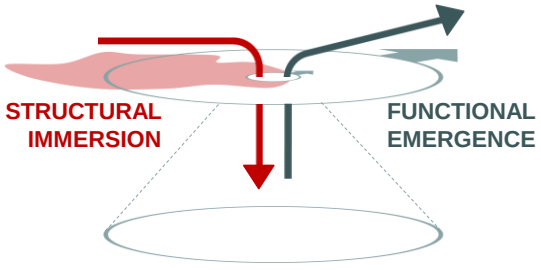
- Climatic conditions at territory level
  - Nutritional practice at the farm level
    - Exchanges at the animal level
      - Homeostasis at the biosystem level
        - » Nutrient supply at the organ level
          - » Hormonal signal at the tissue level
            - » Regulation factors at the cell level
              - » …



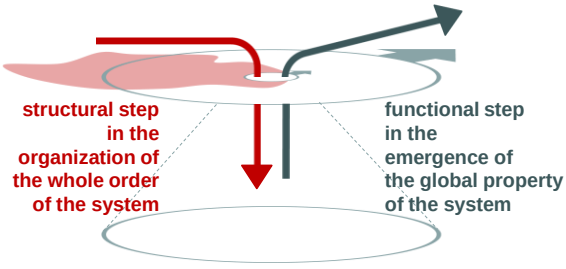
So what ?

- Just a fact: the nesting of structures spread environmental constraints
- Useful to
  - Consider environmental effects level by level
  - Consider properties (adaptation, robustness, flexibility, resilience,…) at each level of organization

Vertical complexity



Step of complexity



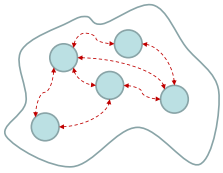
Synergies

Trade-offs

- Positive effects at one level can be associated with negative effects at other levels
- *cf.* Puillet *et al., 2012. ibid.*

Conclusion

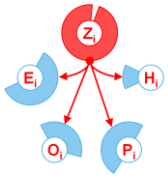
- How to address complexity of LFS ?
  - Think system



- Interactions are more important than parts

Conclusion

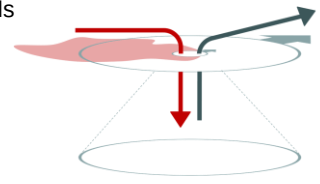
- How to address complexity of LFS ?
  - Draw schemes



- The task of decomplixify is to give insights

Conclusion

- How to address complexity of LFS ?
  - Make models



- All are wrong but some are useful

Thank you for your attention

"In theory, there is no difference between theory and practice.
But, in practice, there is."

Jan L. A. van de Snepscheut