Agricultural systems by design

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INITIATIVE FOR DESIGN IN AGRIFOOD SYSTEMS

Agricultural systems by design

Keynote

Transitioning to sustainable agri-food systems: going beyond the systems rhetoric

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The call for a systems approach in agricultural and food sciences

Why?

Agri-food sector is central to addressing urgent societal challenges

Agri-food systems face wicked problems

Agri-food systems are dynamic and complex

Science is questioned and under pressure to provide actionable solutions, at scale

➔ *Systems approach is needed*

as opposed to reductionist, technology-centered approach

For what?

Enabling transitions to agri-food systems that are sustainable and resilient now and in the future

The danger of a “systems rhetoric”

Trend of “systems washing” and calls for system transformation

-> Dilute the value of systems science

-> Few reports on actual implementation of systems approach

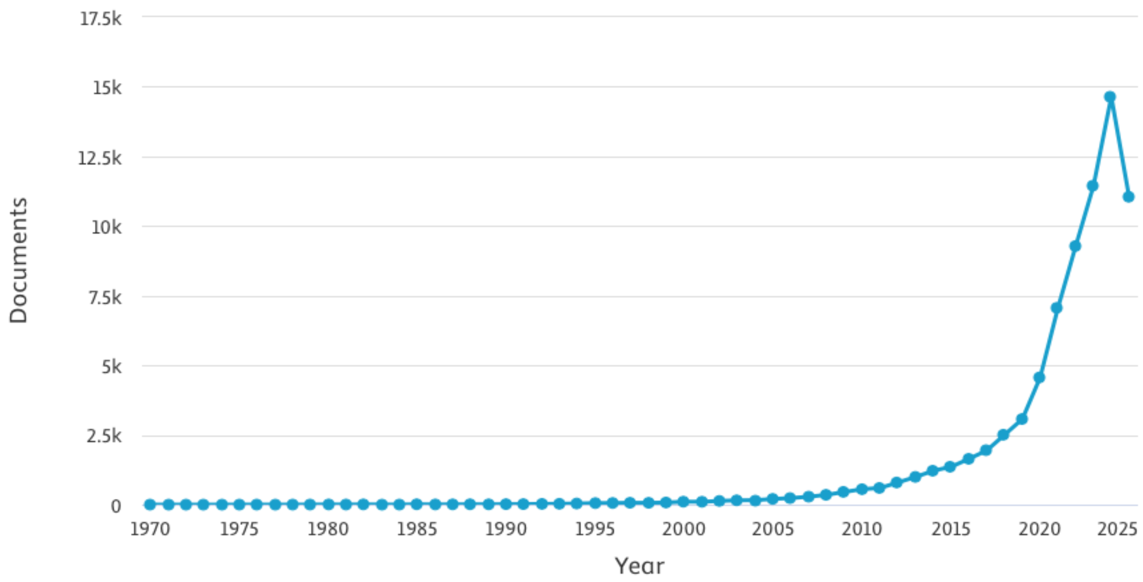
-> Fewer reports on the outcomes of systems approaches

Systems science may be perceived as unclear, fuzzy, hard to define

-> Systems science programs may be discontinued

-> Shift back to techno-fixes

Scopus search: [food system] AND [transform]*



Agricultural systems by design

How to go beyond the rhetoric?

Avoid that systems-based approaches and systems science are framed as the magic solution to all major challenges in the agri-food sector.

1. Situate systemic agricultural sciences
2. Show value of systems approach in agricultural science
3. Articulate the role of the agricultural scientist in sustainability transitions
4. Fight institutional barriers
5. Capacity building and sharing

1. Situate systemic agricultural sciences

1. A brief history of systems agronomy
2. The spectrum in systems science

1.1 Brief history of systems agronomy

Liebig (1840) -> 1960-1970s: “classical” agronomy

- Technological focus; one problem -> one solution
- Goal of increasing production and input efficiency => green revolution
- Rise of advisory systems, focused on each technology independently

1970s-90s: Farming systems research

- Originates from concerns over environmental damage, limits of one-size-fits-all approach
- Involvement of farmers; recognition of farmers’ agency => participatory methods
- Sustainability pillars: economic, social, environmental aspects => emergence of interdisciplinarity

Contemporary changes: broadening to agri-food systems

- Originates from increasing urgency of challenges + limits of supply-driven focus
- Involvement of different actors beyond farmers => emergence of transdisciplinarity

1.1 Brief history of systems agronomy

Broadening of scope

- Spatial scale : field > farm > landscape > community > national > global
- Actors: farmers > value chain actors > food system actors
- Innovations: technological -> systemic innovations, socio-technical innovation bundles -> coupled innovations

Development of **approaches and methods**

- Reductionist > holistic, interdisciplinary > transdisciplinary
- On-station experiments, crop modelling > on-farm experiments, tailoring of options > model coupling, multi-actor engagement

Development of **role of the agronomist**

- Knowledge generation > knowledge brokering > partner in the co-design process
- Acknowledgement that research(er) is not objective, and influencing the process

➔ *As agronomy is defined by its goals, it is constantly evolving and renewing itself as a discipline*

➔ *Agronomists need to be equipped for the new roles, new methods and interdisciplinary nature*

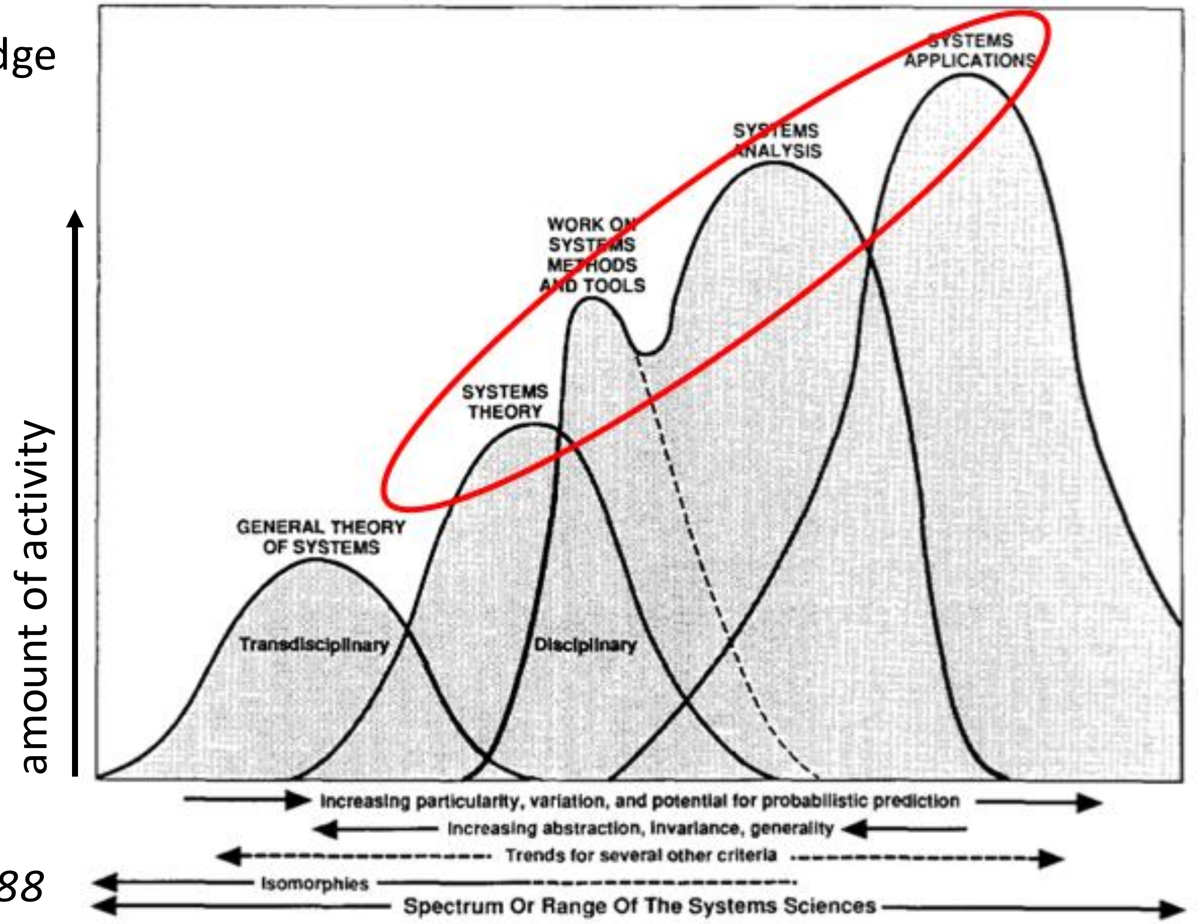
1.2 The spectrum in systems science

Definition: Systems science is a broad class of [analytical] approaches that aim to uncover the behaviour of complex systems. (Carey, 2015)

Systems movement: counterbalance and complement to centuries of outstanding reductionist work

Many separate specialties, but common framework of knowledge

Spectrum of systems approaches and goals



Troncale, 1988

2. Showing the value of a systems approach

Learn from success and failure

Systematic assessment:

- Describe system science elements
- Describe research process
- Document results

System Science Elements	Research process	Results

2. Showing the value of a systems approach

Generic knowledge

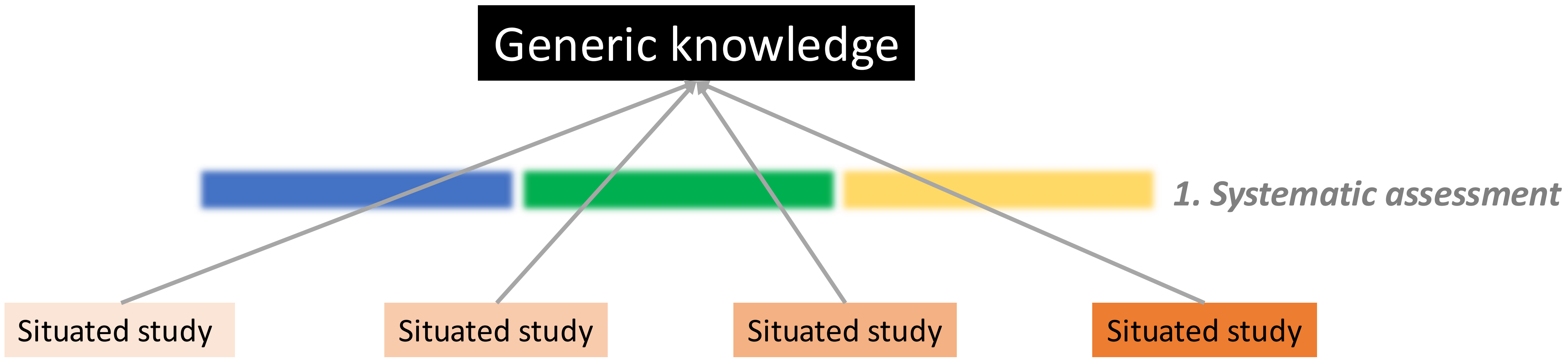
Situated study

Situated study

Situated study

Situated study

2. Showing the value of a systems approach



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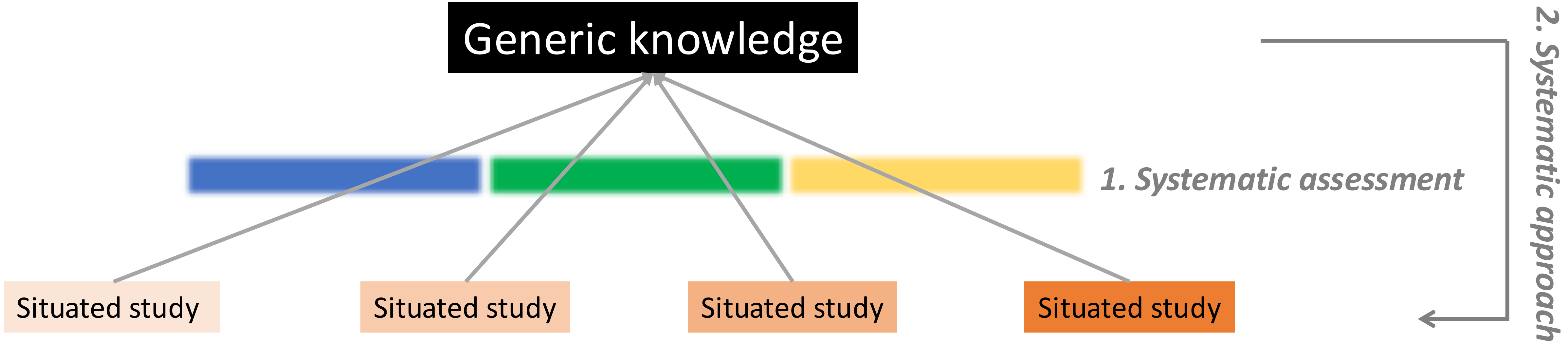

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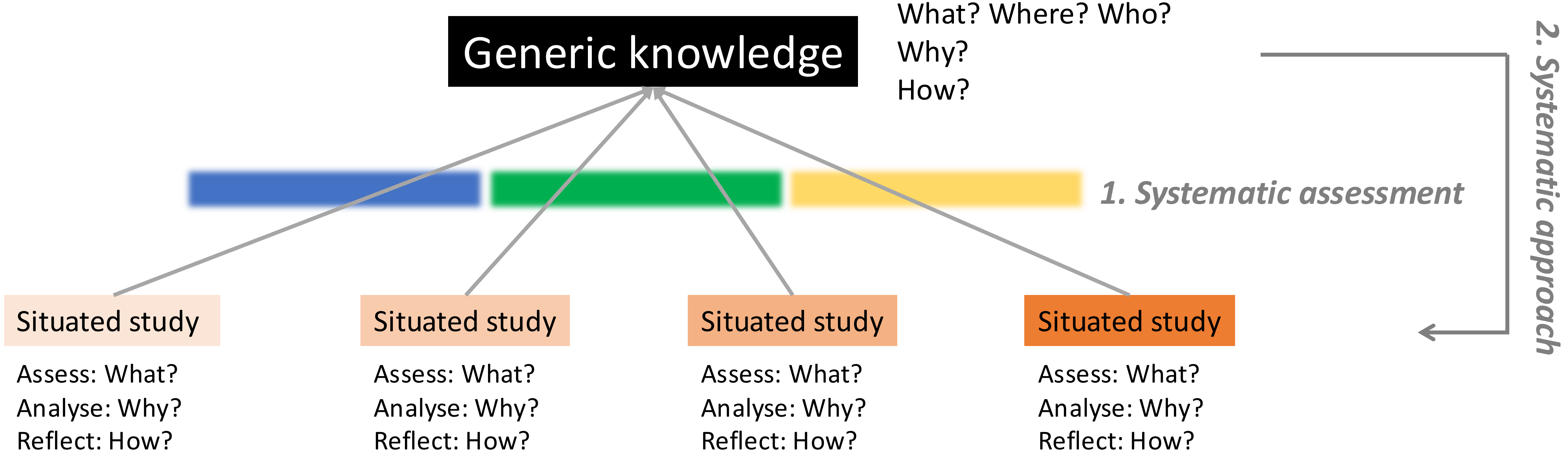


2.1 Application of the framework

Case study – Agro-ecological intensification in southern Mali

12-year project, ended in 2024

System Science Elements	Research process	Results

2.1 Application of the framework

System Science Elements | Research process | Results

Case study – AEI in Mali

Define system and its components

Mixed-crop livestock system

Cereals, legumes, cotton

Different farm types

Entry point: agro-ecological intensification

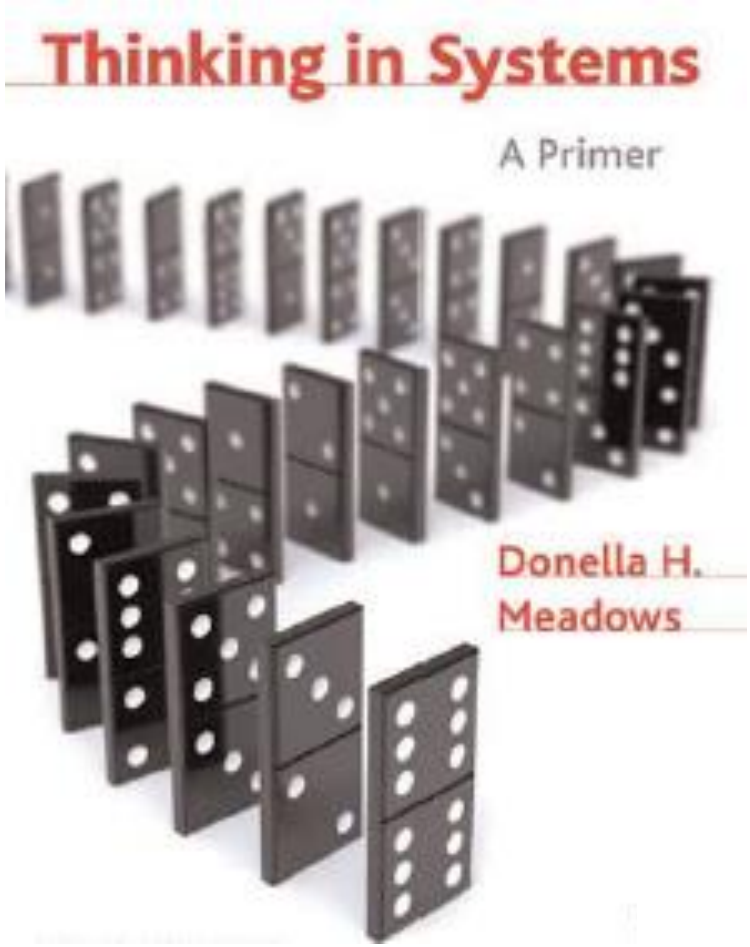
Aims

- Agricultural productivity
- Food security
- Livelihoods
- Healthy ecosystems




System features

The object of systems science, the system and/or the systemic innovation, is not predefined – it depends on the problem & the context



But, some common system features:

- Boundary and components
- Interactions, feedbacks
- Non-linearity, emergent behaviour
- Hierarchies
- Endogenous/exogenous factors
- Stocks and flows
- Path dependency, lock-ins

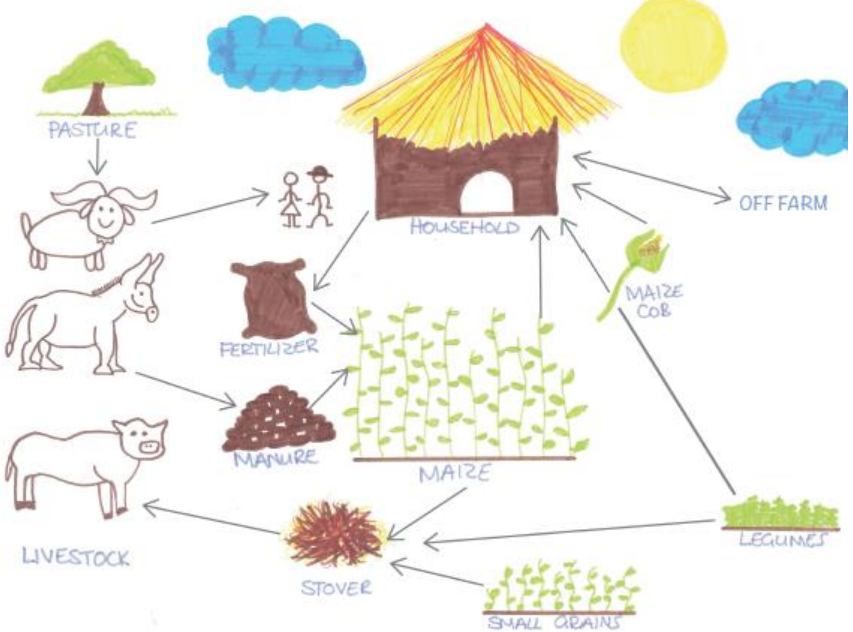
Case study – AEI in Mali

Scale levels

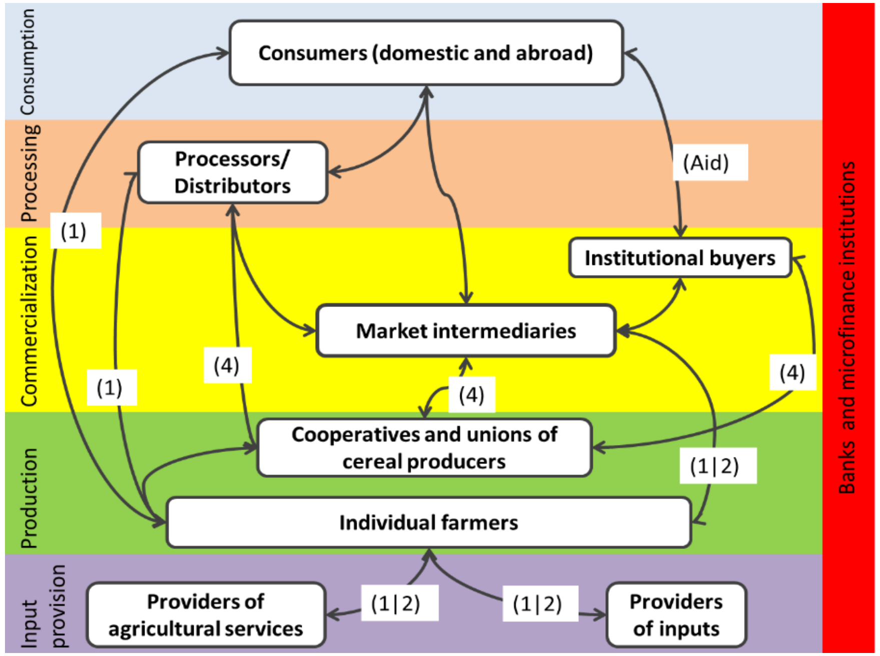
- Spatial / Organizational

Field

Farm



Value chain



System Science Elements

Case study – AEI in Mali

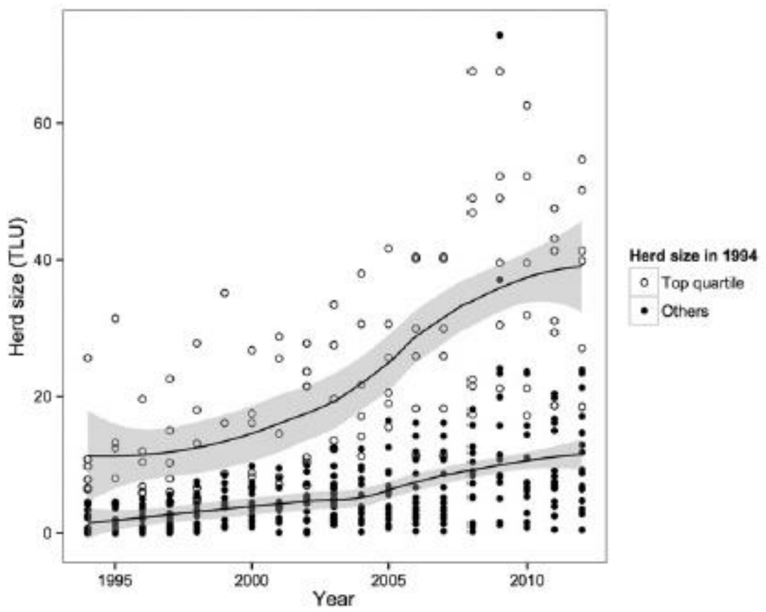
Scale levels

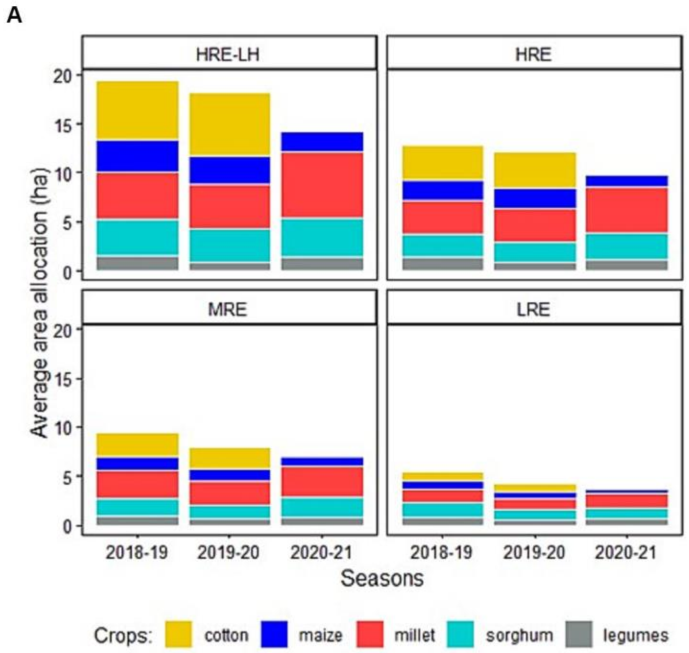
- Spatial / Organizational
- Temporal

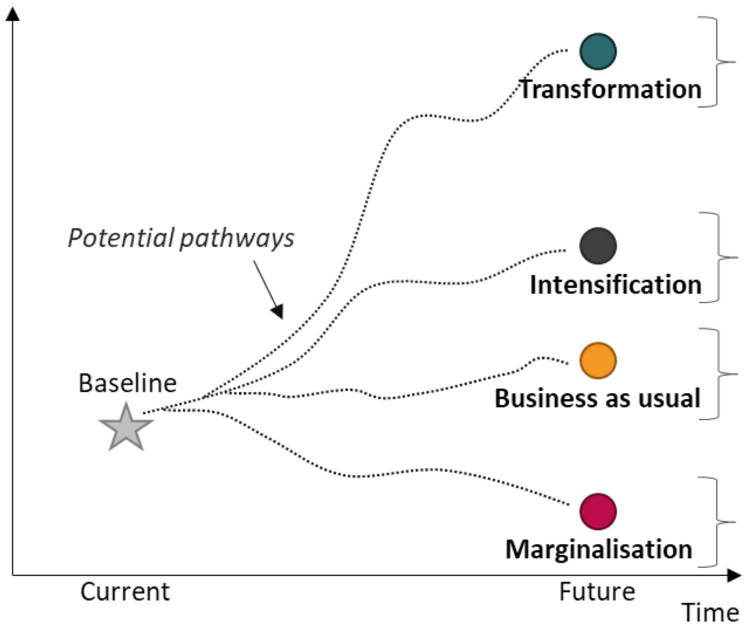
Historical

Current

Future







System Science Elements

Case study – AEI in Mali

Interdisciplinarity

- Disciplines: agronomy, economics, soil science, livestock science, marketing studies
- Sustainability dimensions & goals
  - SDG1, 2, 5, 13, 15
- Trade-offs
  - Income, food self-sufficiency, labour
  - Soil nutrient balances, GHG emissions, biodiversity
- Systemic innovations

sheep fattening

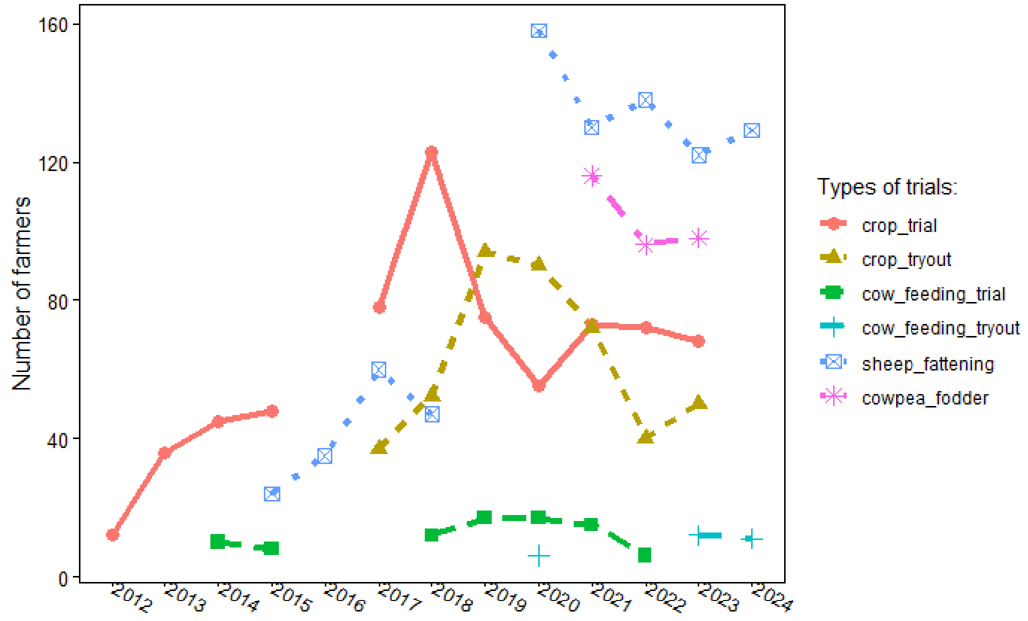
feed production

revolving fund

Case study – AEI in Mali

Transdisciplinarity

- Stakeholder involvement
  - Actors: farmers, development & extension agents, value chain actors
  - Farmer research network; on-farm experimentation
  - Multi-actor workshops and platforms

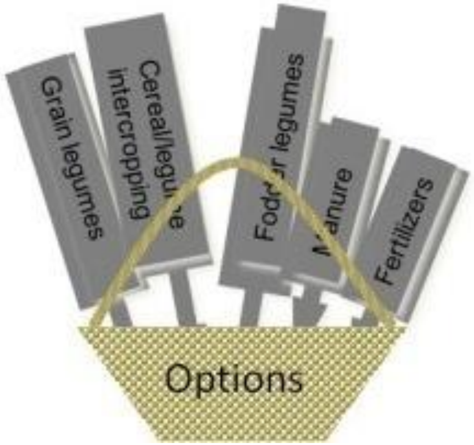


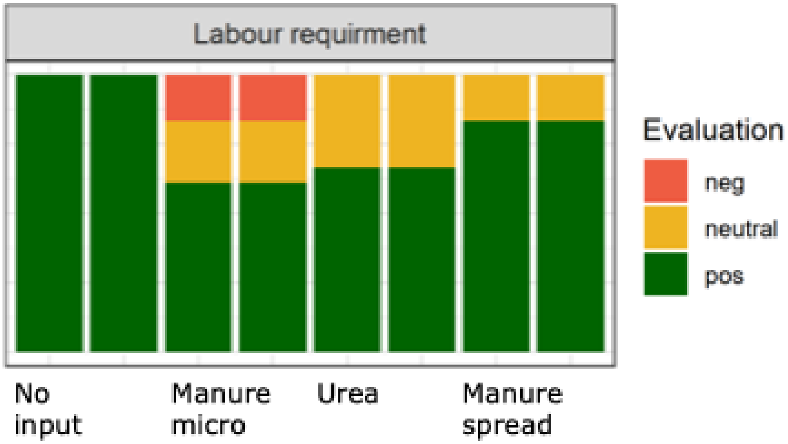
System Science Elements

Case study – AEI in Mali

Transdisciplinarity

- Stakeholder involvement
- Knowledge integration
  - Scientific: baskets of options, experimental design, assessment frameworks
  - Experiential knowledge: assessment of practices
  - Local farmer knowledge: practice adjustment





System Science Elements

Case study – AEI in Mali

Transdisciplinarity

- Stakeholder involvement
- Knowledge integration
- Researcher role
    - Bring in outside information and innovations
    - Facilitation: assessment process
    - Brokering: actor dialogue and negotation
    - Partner in co-learning

System Science Elements

2.1 Application of the framework

System Science Elements

System features

Scale levels
- spatial/organizational
- temporal

Interdisciplinarity

Transdisciplinarity

2.1 Application of the framework

System Science Elements

Research process

Results

Case study – AEI in Mali

Epistemological position

- Research from within
    - Knowledge on the how ("transformative knowledge")
- Distant research
    - Knowledge on the what, where, for whom (knowledge on the system and the change)

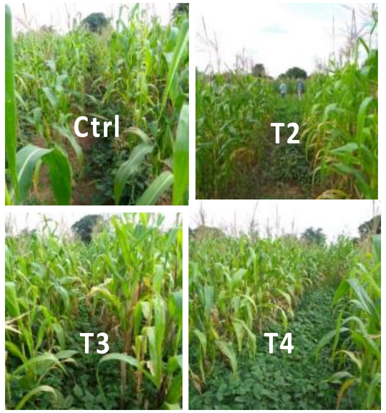
Case study – AEI in Mali

Epistemological position

Research process

- Cycles of diagnose, explore, test, assess

Diagnosis



On-farm trials

Farmers' field day

Co-learning &
co-designing AEI options

Farm planning and value chain negotiations

Feedback and planning sessions

Research process

Case study – AEI in Mali

Epistemological position

Research process

Combination of methods

Modelling & scenario analysis

Various crop and livestock options
- experimental trials
- demonstration trials
- farmer try-outs

Value chain analysis

Detailed farm monitoring

Multicriteria analysis
Focus group discussions

Research process

Approaches, methods and tools

Broad range of methods and tools

Advantages:

- Fit for purpose
- Innovation in method development

Risks:

- Hard to benchmark best practice
- Difficult to maintain scientific rigour
- Getting lost

Approaches, methods and tools

Taxonomy of methods

1. Five main pillars

- Define: system features, such as components, boundary, interactions
- Analyse: system functioning and behaviour
- Assess: system performance
- Design: systemic innovation or improved system
- Test: try out and evaluate new options

2. Hard -> soft methods

3. First -> second-order science

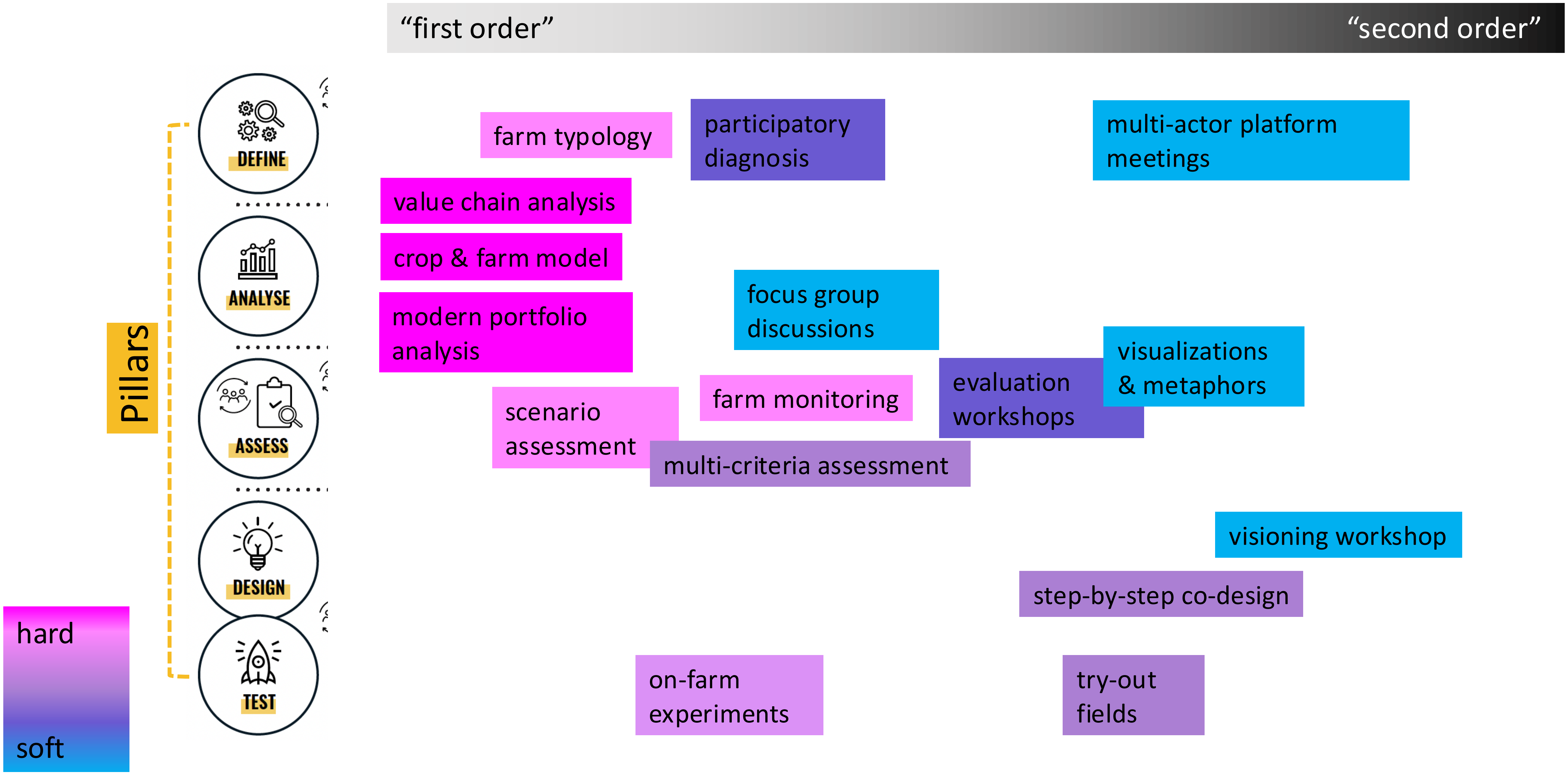
Taxonomy of methods

"first order" "second order"

hard

soft

Taxonomy of methods



2.1 Application of the framework

Research process

Epistemological position

Research process

Methods

~taxonomy

2.1 Application of the framework

System Science Elements

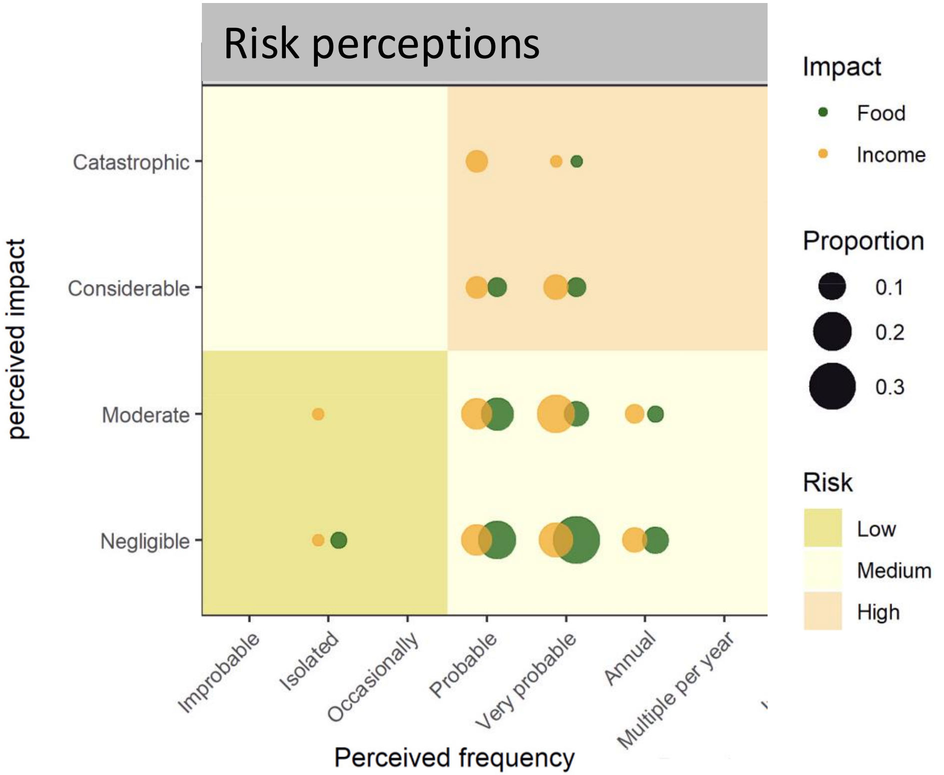
Research process

Results

Case study – AEI in Mali

Outputs

- Analytical knowledge (what, why)
  - System functioning
  - Systemic solutions
  - Actor behaviour
    - Risk perceptions



Seasonality

Months	Jun–Sept	Oct–Jan	Feb–May
Climate events	rains	dry/cold	dry/hot
Periods	cropping	harvest	post-harvest
Labour demand for cropping	medium	high	low
Food availability	low	high	medium
Fodder availability	medium	high	low
Cash availability	low	medium	medium

Results

Case study – AEI in Mali

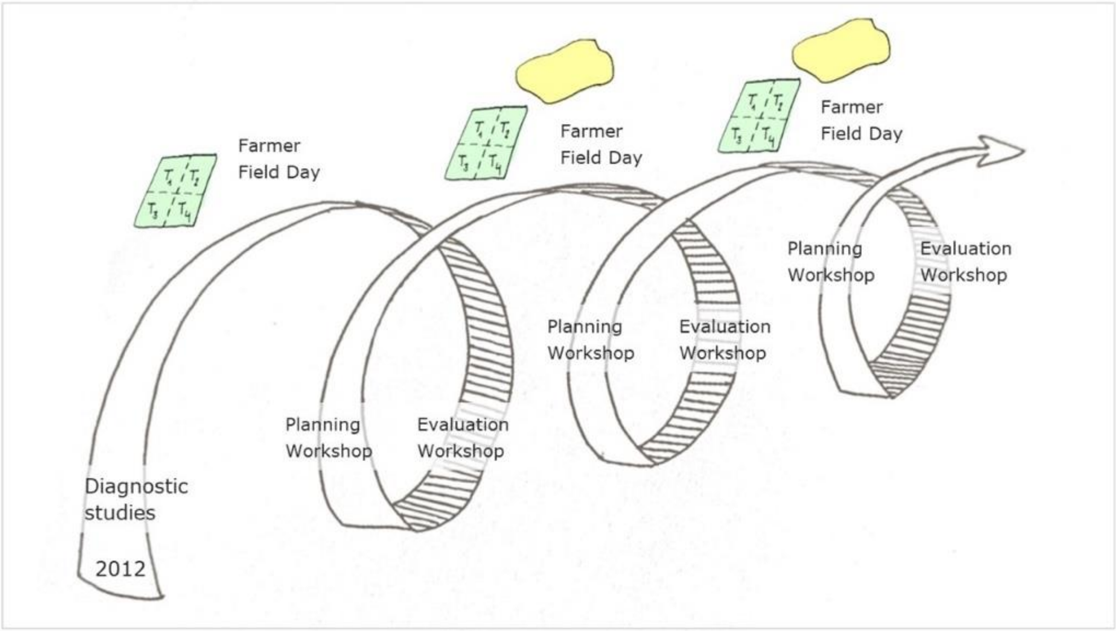
Outputs

- Analytical knowledge (what, why)
- Transformative knowledge (how)

  Farmer research networks => actionable knowledge

  - Represent farmer diversity
  - Collaborative networks
  - Rigorous and locally-relevant research

A.



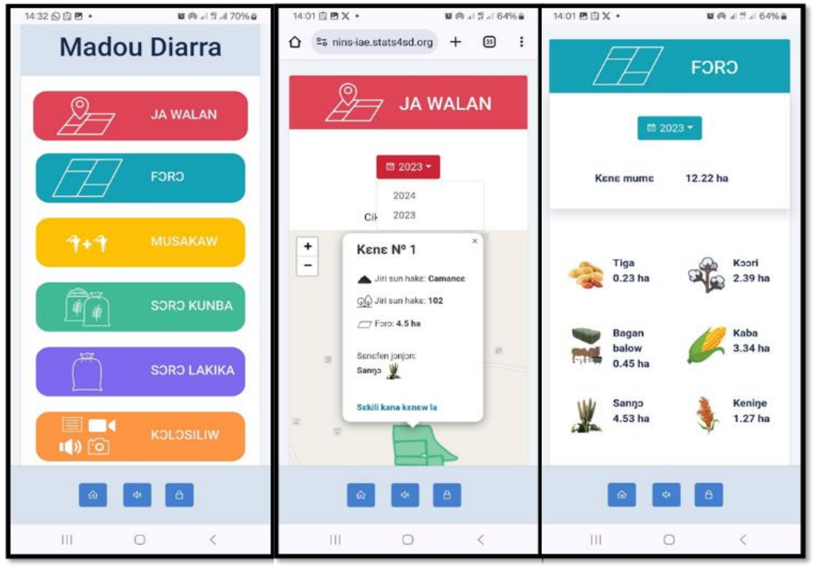
B.

	ON-FARM TRIAL		TRY-OUT FIELD
Objective	**Test SI options at plot level**	Promising options	**Follow-up crop management to assess farmers' adaptation of options**
Design	Researchers based on farmers' ideas		Farmer
Inputs	Researchers provide		Farmer
Analysis	Researchers and farmers		Researchers and farmers

Case study – AEI in Mali

Outputs

- Tools and methods
  - Decision support tool based on planning, monitoring and evaluation
  - Farm model for scenario assessment
  - Visualization and metaphors in communication



Results

Case study – AEI in Mali

Outcomes => transition indicators

- Learning
  - Farmers: experiential learning
  - Researchers: broadening of scope
- Attitude
  - Farmers: testing and adapting
  - Researchers: integration of farmers' knowledge and other disciplines
- Uptake
  - Farmers: AEI practices, record keeping, planning
  - Researchers: tools and methods
- Capacity
  - Farmers: multi-criteria evaluation
  - Researchers: facilitate dialogue, communicate
- Empowerment
  - Farmers: female farmers running sheep fattening group ; joint selling of produce
  - Researchers: local and young leadership development

2.1 Application of the framework

Results

Outputs

- Analytical knowledge
- Transformative knowledge
- Tools and methods

Outcomes

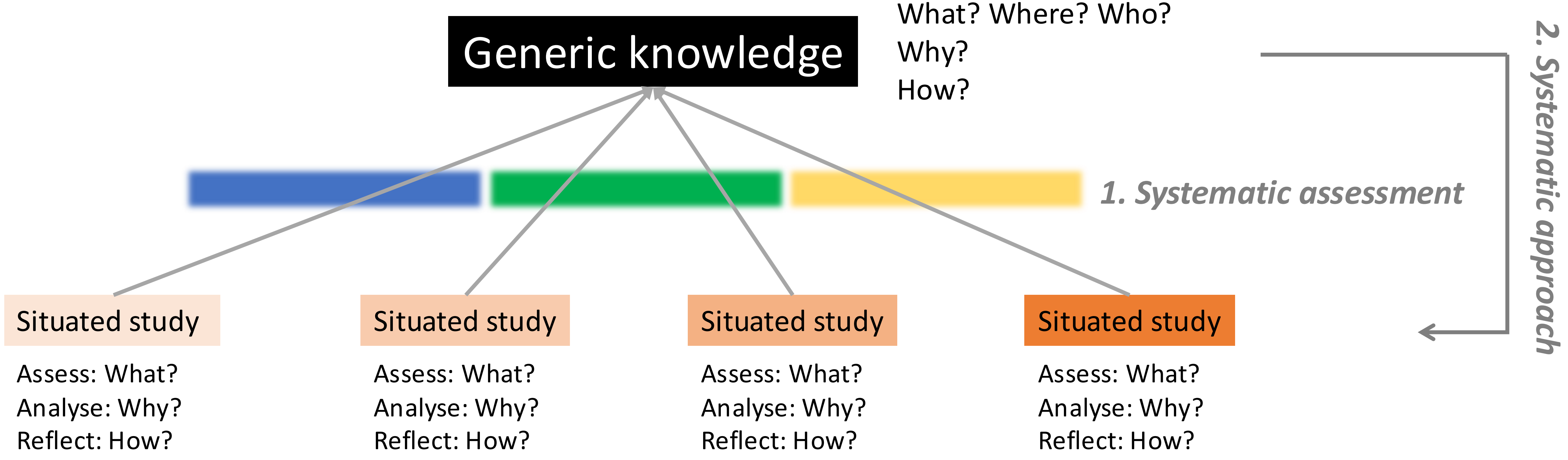
- Learning
- Attitude
- Uptake
- Capacity
- Empowerment

2.1 Application of the framework

System Science Elements	Research process	Results
System features	Epistemological position	Outputs - Analytical knowledge - Transformative knowledge - Tools and methods
Scale levels - spatial/organizational - temporal	Research process	
Interdisciplinarity	Methods ~ taxonomy	Outcomes - Learning - Attitude - Uptake - Capacity - Empowerment
Transdisciplinarity		

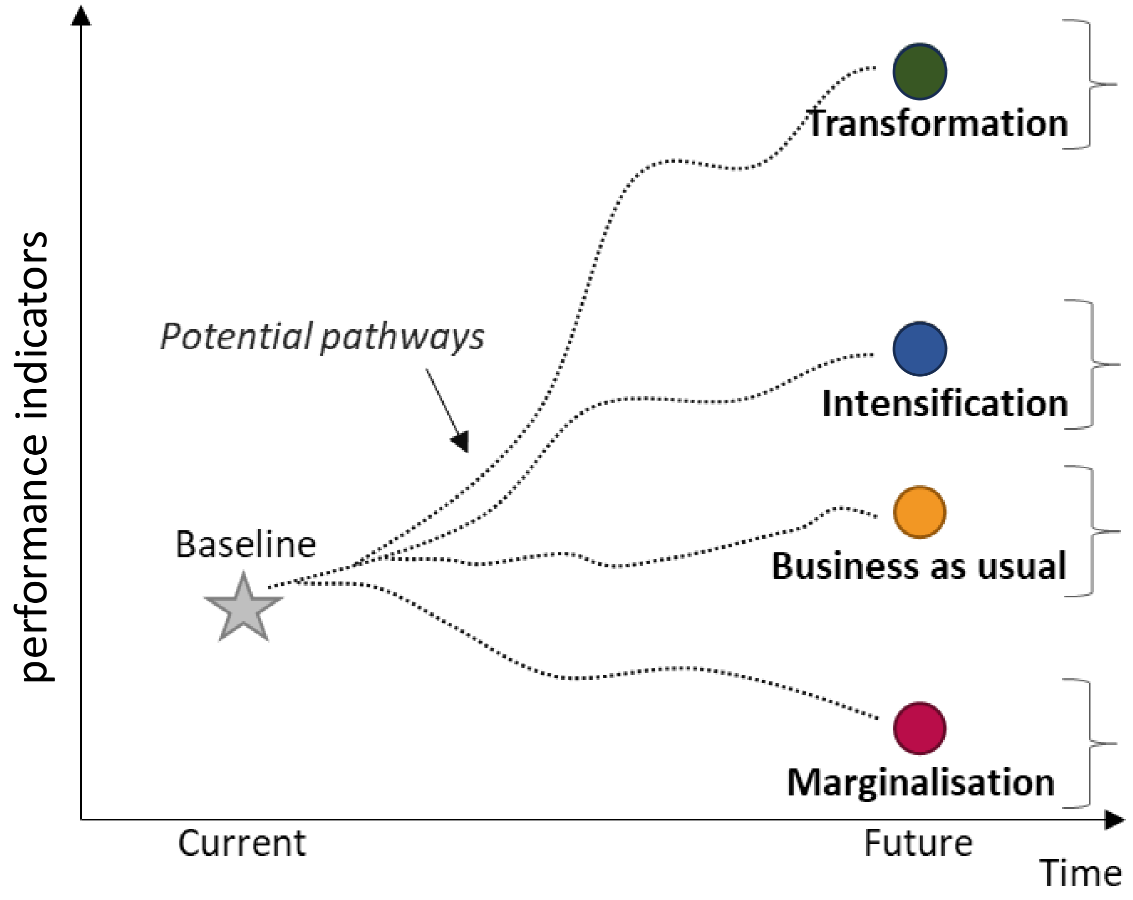
Agricultural systems by design

2.2 Generic knowledge



2.2 Generic knowledge

Generic knowledge on the **what & why**



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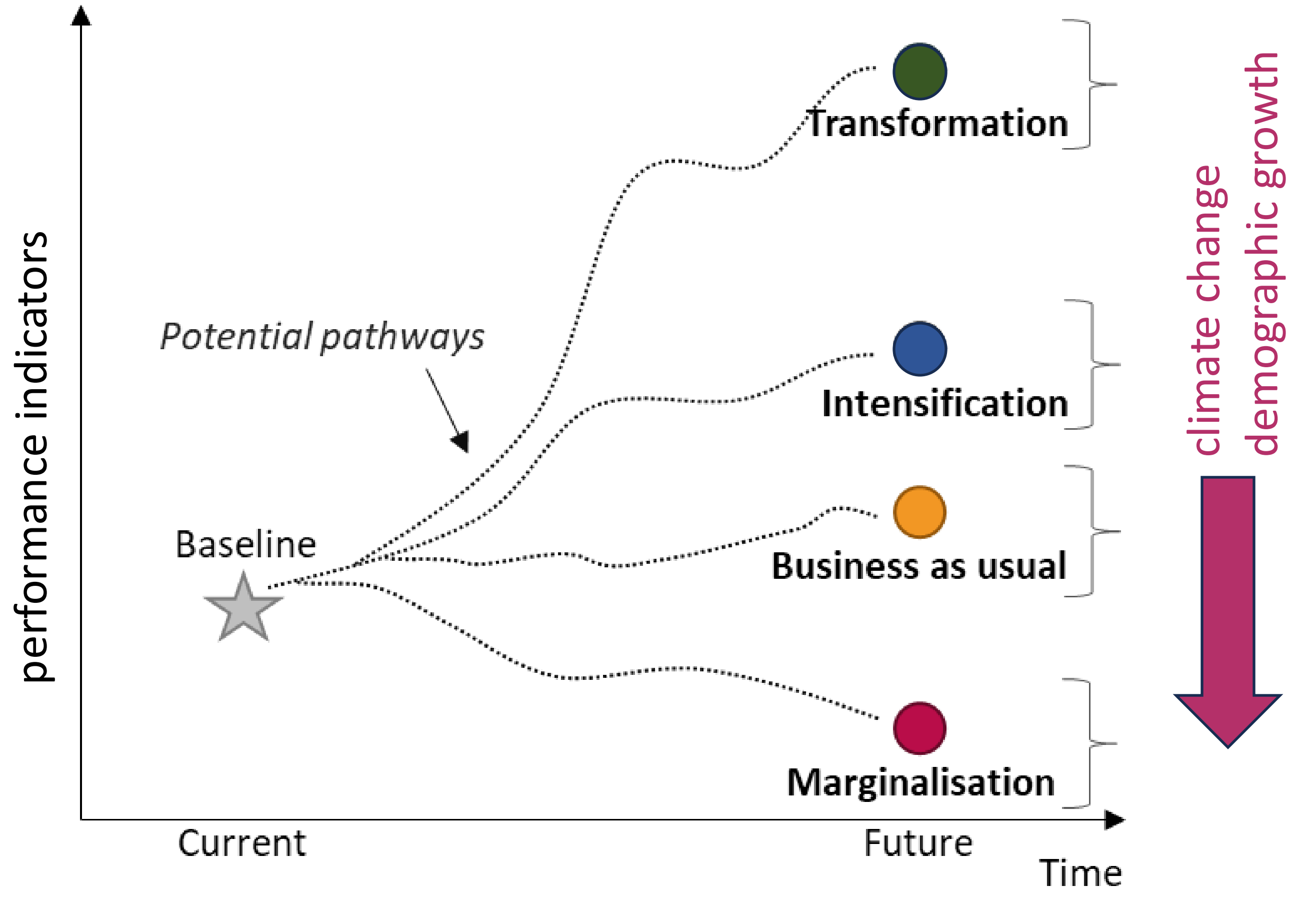

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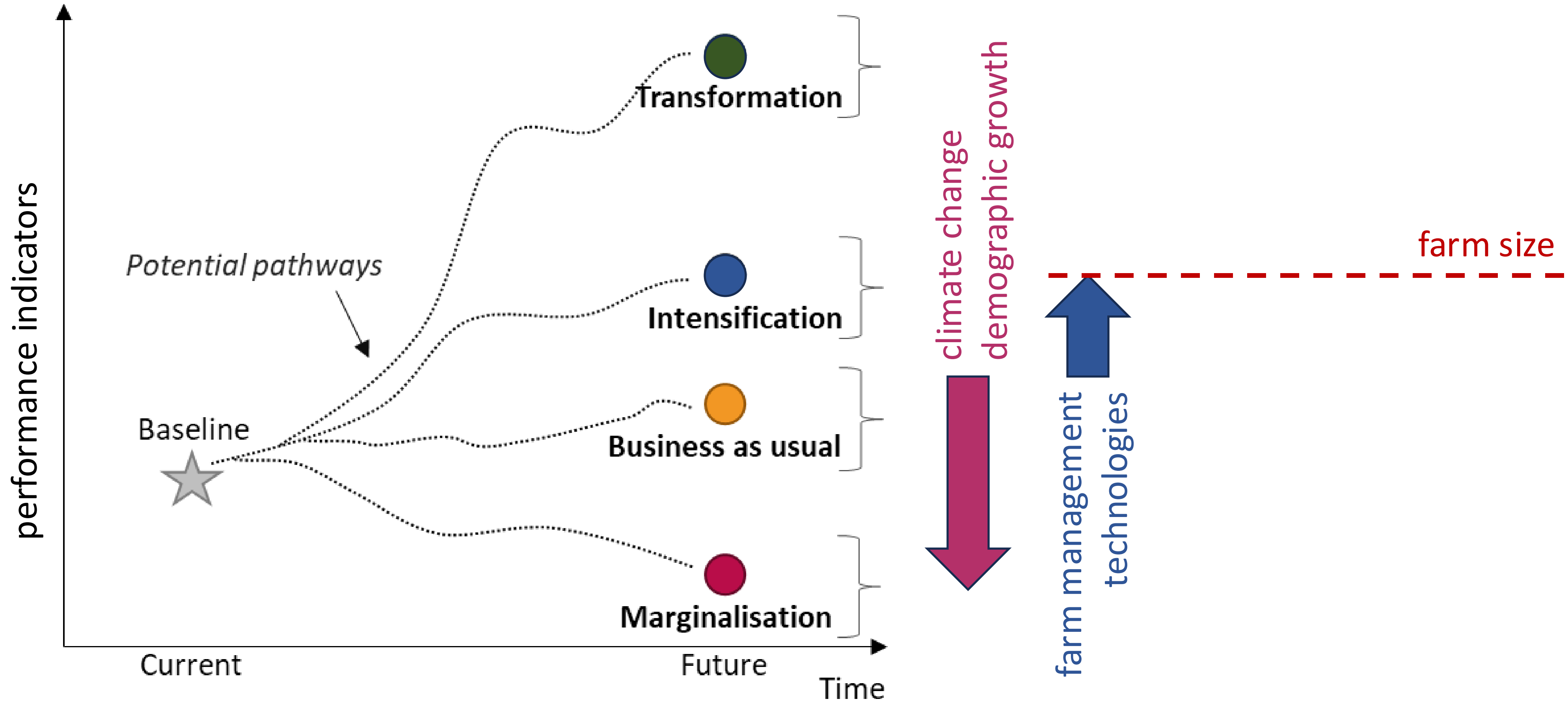

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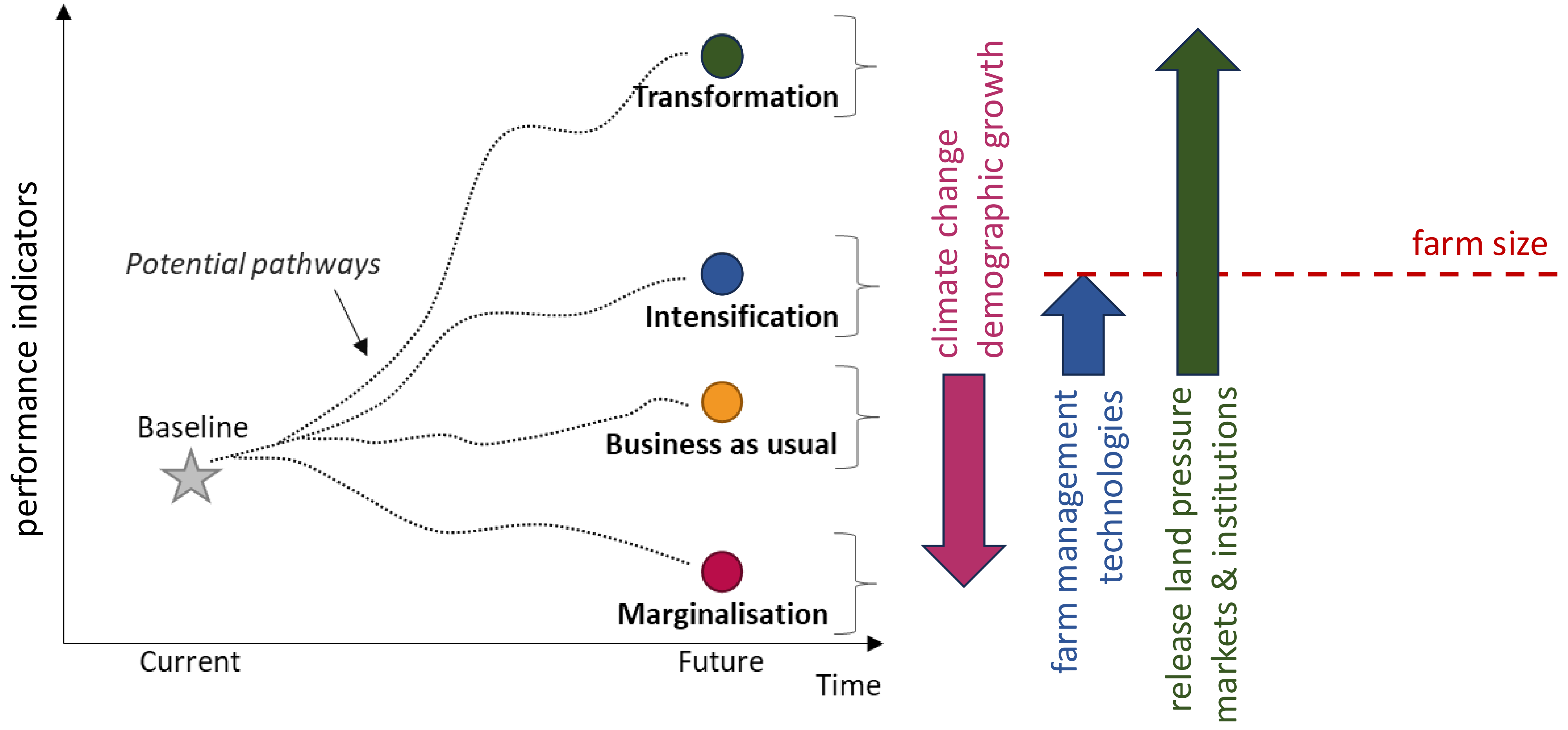


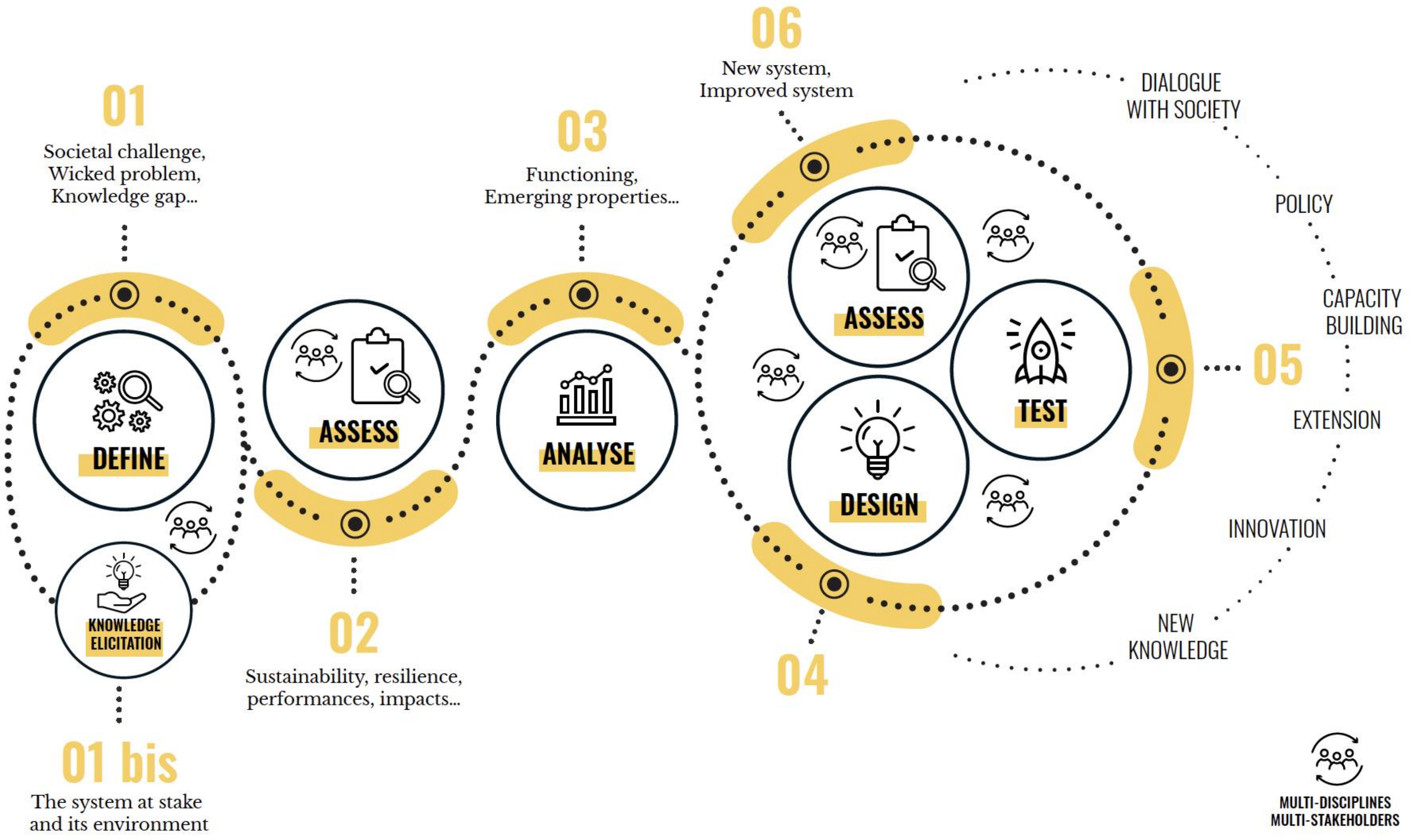
2.2 Generic knowledge

Generic knowledge on the **how**

No prescribed approach, but when transition is the objective:

- Combination of pillars in adaptive research processes
- Action step in real world
- Link to societal actors

MULTI-DISCIPLINES
MULTI-STAKEHOLDERS



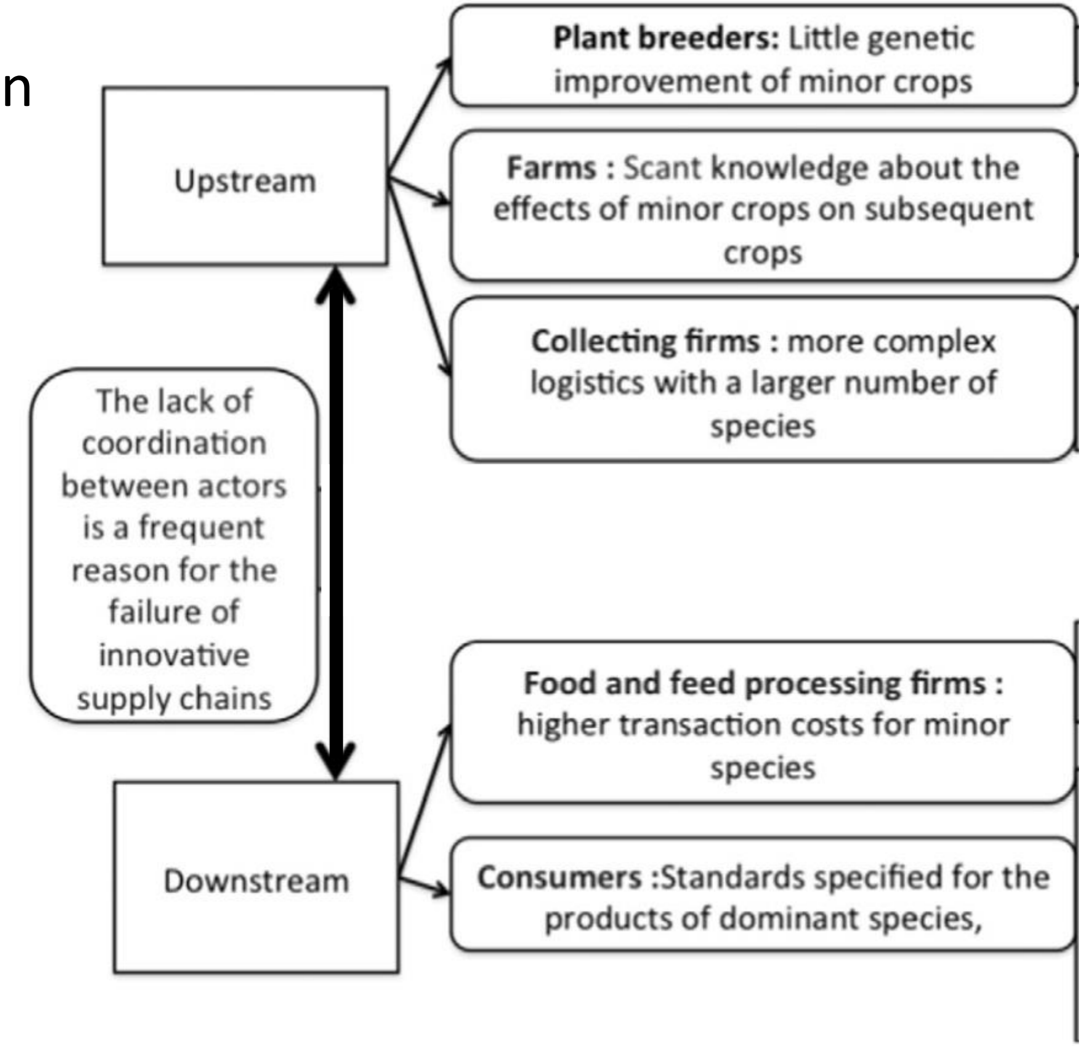
3. The role of the agricultural scientist in sustainability transitions

Agriculture as a typical systems science at crossroads of technical, social and ecological considerations

The agricultural scientist as the orchestra conductor

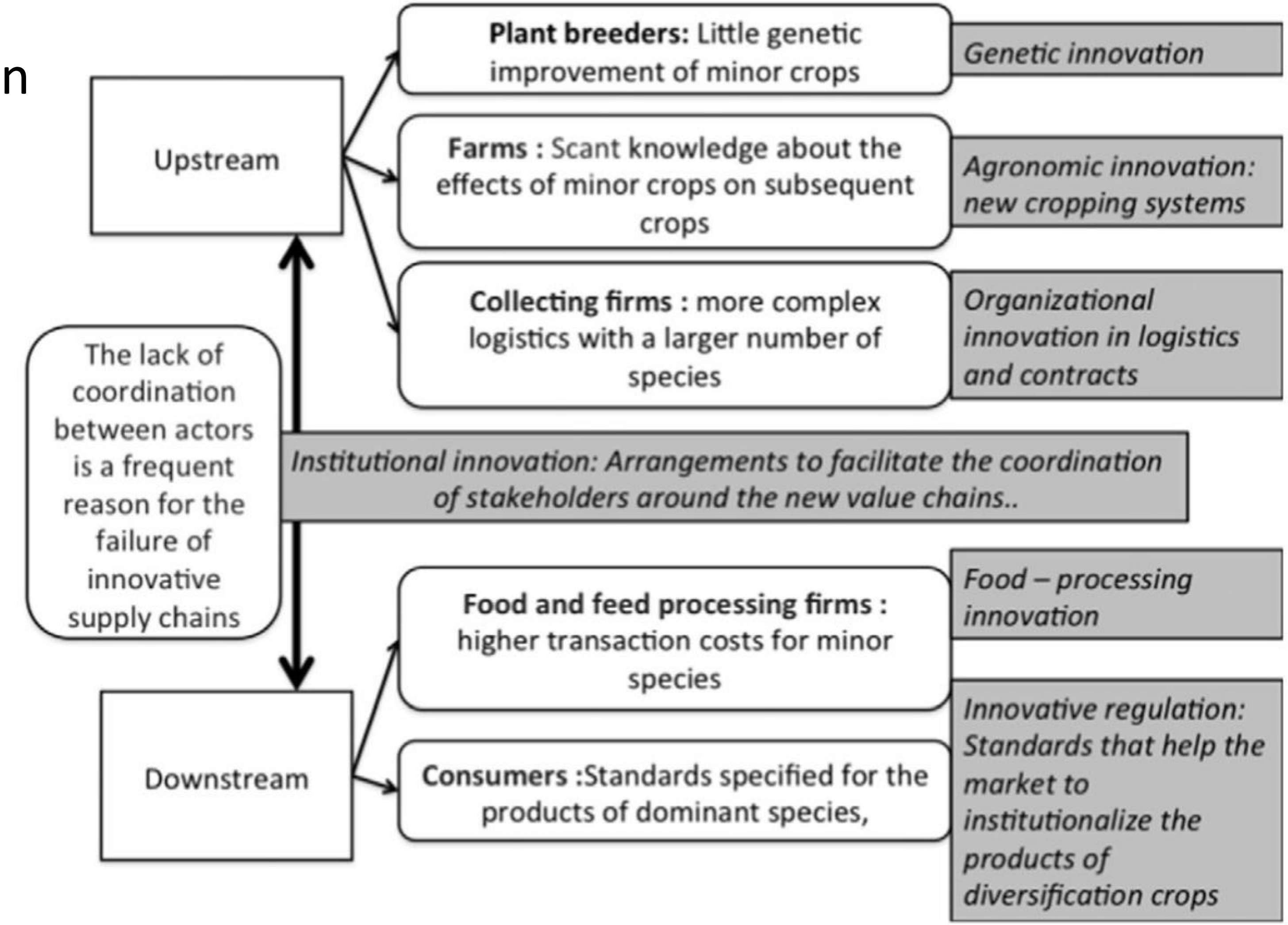
3. The role of the agricultural scientist in sustainability transitions

Example of crop diversification



3. The role of the agricultural scientist in sustainability transitions

Example of crop diversification



Genetic innnovation

Strategic alliance with a breeder working on minor crops, to consider specific criteria

Agronomic innovations: lentil-wheat intercrops to increase wheat protein content while decreasing environmental impacts

Innovation in advisory: design of a tool for analytical accounting taking into account multi-year results

Organisationnal innovation : a new service to support farmers in adopting intercropping

Commercial innovations: bagging, delivery service for local consumers

Technical innovations: grain sorting management at the collecting step

4. Fighting institutional barriers

Removing lock-ins for impactful systemic approaches

- Scientific and education tradition of reductionist, disciplinary approaches
- Recognition and reward system in academia
- Organization of societal actors
- Sectoral asymmetry: systems approach mostly in research

➢ *Be aware of lock-ins, also in our own institutes*

➢ *Search for allies, across institutional and sectoral borders*

➢ *Form inter- & transdisciplinary teams*

➢ *Lobby for funding and policy attention*

5. Capacity building and sharing

T-shaped skills

- Disciplinary grounding
- Ability to connect across disciplines and with society

Equip researchers and students with systems science skills, knowledge

- Theoretical learning
- Experiential learning: embedding in real-world setting, action-research

Integrate systems science elements

- In curricula
- In life-long learning for practitioners

5. Capacity building and sharing

Community of practice

Conclusions: How to go beyond the systems rhetoric?

Ensure that systems science can effectively address challenges in the agri-food sector and contribute to transitions towards sustainability.

An invitation to all of you to think along and

1. Sharpen our position in the systems sciences spectrum
2. Enrich our theoretical frameworks to generate insights
3. Reflect on our roles
4. Demolish system lock-ins
5. Share experience in systems science