Transition to agroecology: insights from a foresight study on European pesticide-free agriculture in 2050

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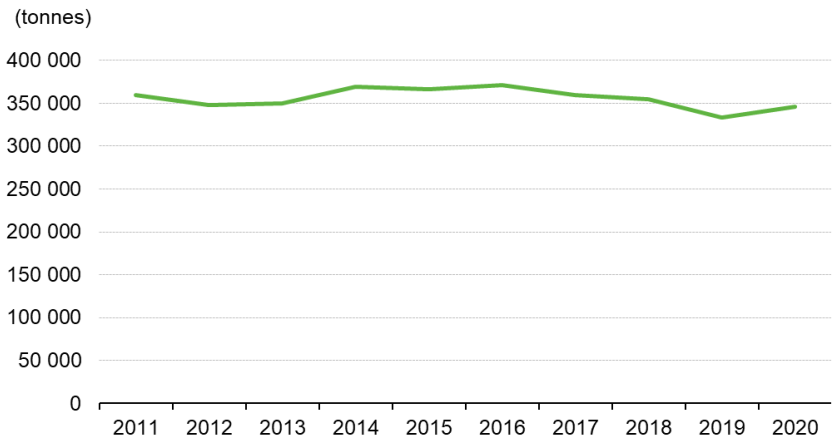
What is the problem with chemical pesticides, and why there is a need to develop Agroecology?

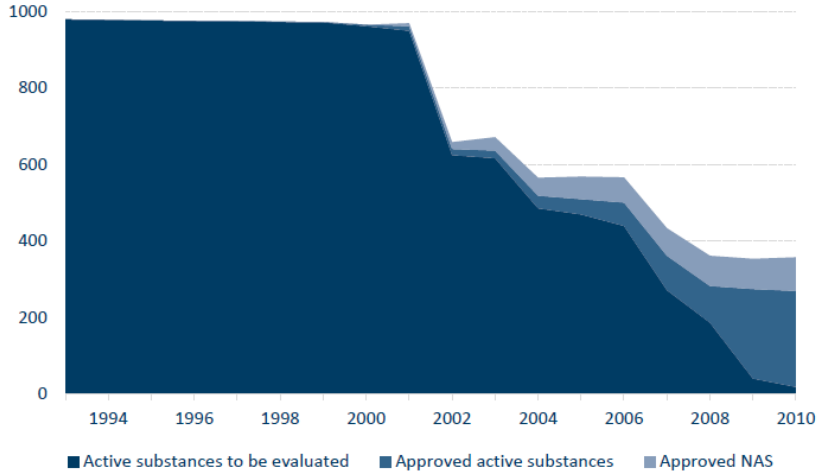
- Chemical pesticides are **key elements of crop protection**: improving and stabilising yields and the quality of agricultural products. Conventional cropping systems **strongly depend** on chemical pesticides.
- Increasing **genetic resistance** observed in species targeted by pesticides (herbicides, insecticides, fungicides, bactericides) (Aubertot et al., 2005; Ravigné et al., 2021) leading to an « **arms race** »
- Negative impact of chemical pesticides on:
  - **environment** (water, soil, air) and **biodiversity** (Leenhart et al., 2022; Rigal et al., 2023; Pisa et al., 2021; Sanchez-Bayo et Wyckhuys, 2019; Hallmann et al., 2017)
  - and **human health** (EAA, 2023; HBM4EU, 2022; Teysseire et al., 2021; Inserm, 2021; Mostafalou and Abdollahi 2013)

Limited impacts of pesticide reduction policies in the EU (2011-2020)



Note: The EU data do not take into account confidential values. They represent < 1 % of the total sales over the entire time series. *Source:* Eurostat (online data code: aei_fm_salpest09)

Decrease in the number of available active substances in the EU (1993-2010)



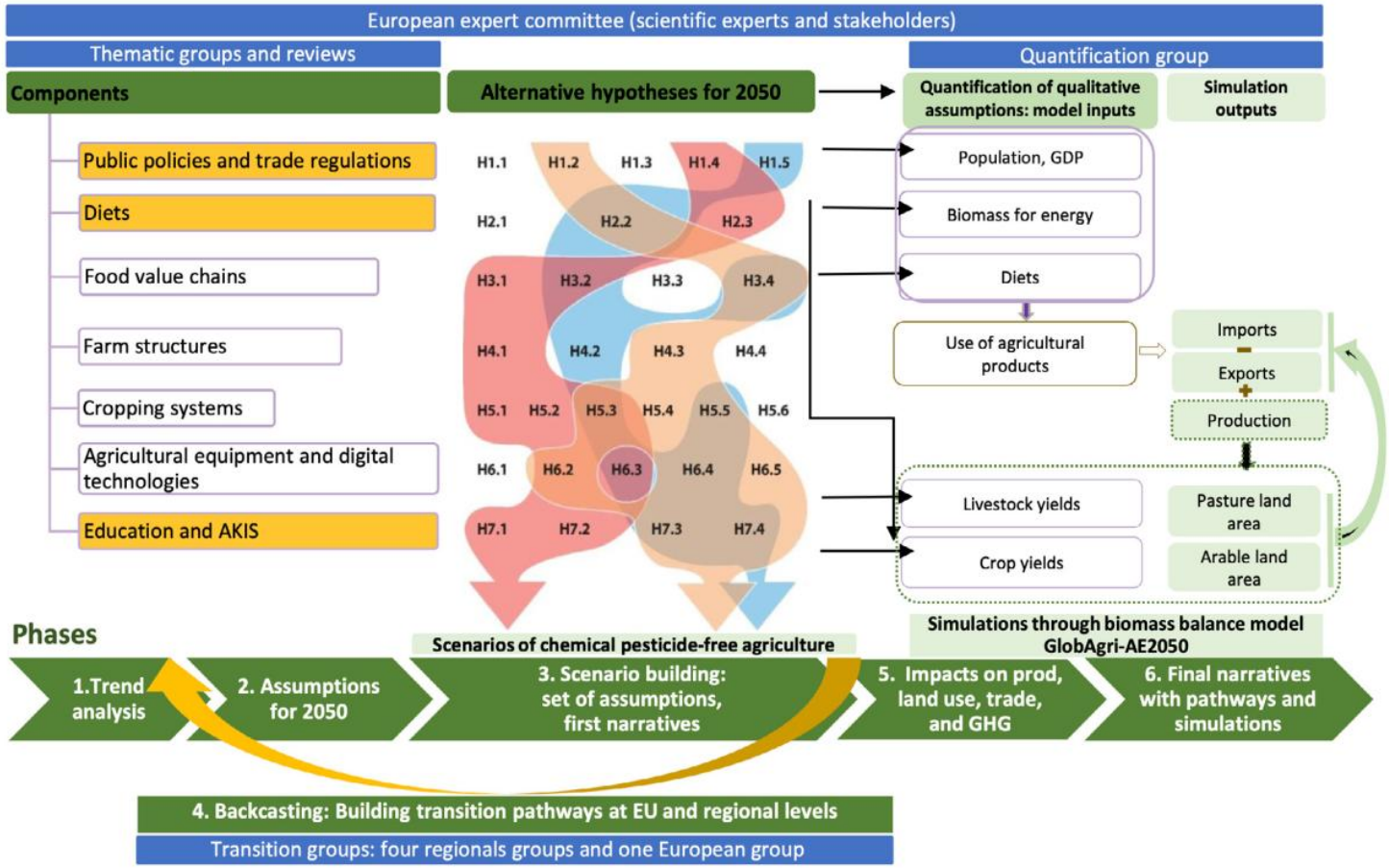
Source: European Commission

Why a foresight on European chemical pesticide-free agriculture in 2050?

- The limited impacts of past policies in terms of pesticide use justify **a change in the approach of innovation in cropping systems** (Jacquet et al., 2021):
  - A **paradigm shift** in research from an **incremental approach** aiming at reducing pesticide use
  - to a **disruptive approach** aiming at building cropping systems without chemical pesticides
- **Explore the possibility of chemical pesticide-free agriculture in 2050 at EU level** and propose **transition pathways to achieve these scenarios**
  - A foresight study supported by the **French national priority research programme (PRP) 'Growing and Protecting crops Differently'**, and linked (through case studies) to the **European Research Alliance 'Towards Chemical Pesticide-free Agriculture'**
  - Scenarios and transitions pathways for pesticide-free agriculture in Europe

- *Chemical pesticides correspond to synthetic pesticides and mineral pesticides that have a negative impact on environment and human health.*
- *Summary and full report (640p) online in English:*
  https://www.inrae.fr/en/news/european-pesticide-free-agriculture-2050
  https://www.inrae.fr/sites/default/files/pdf/European%20Pesticide-Free%20Agriculture-Foresight-report-INRAE_08-11-23w.pdf

An original foresight method mixing scenario planning, modelling and backcasting

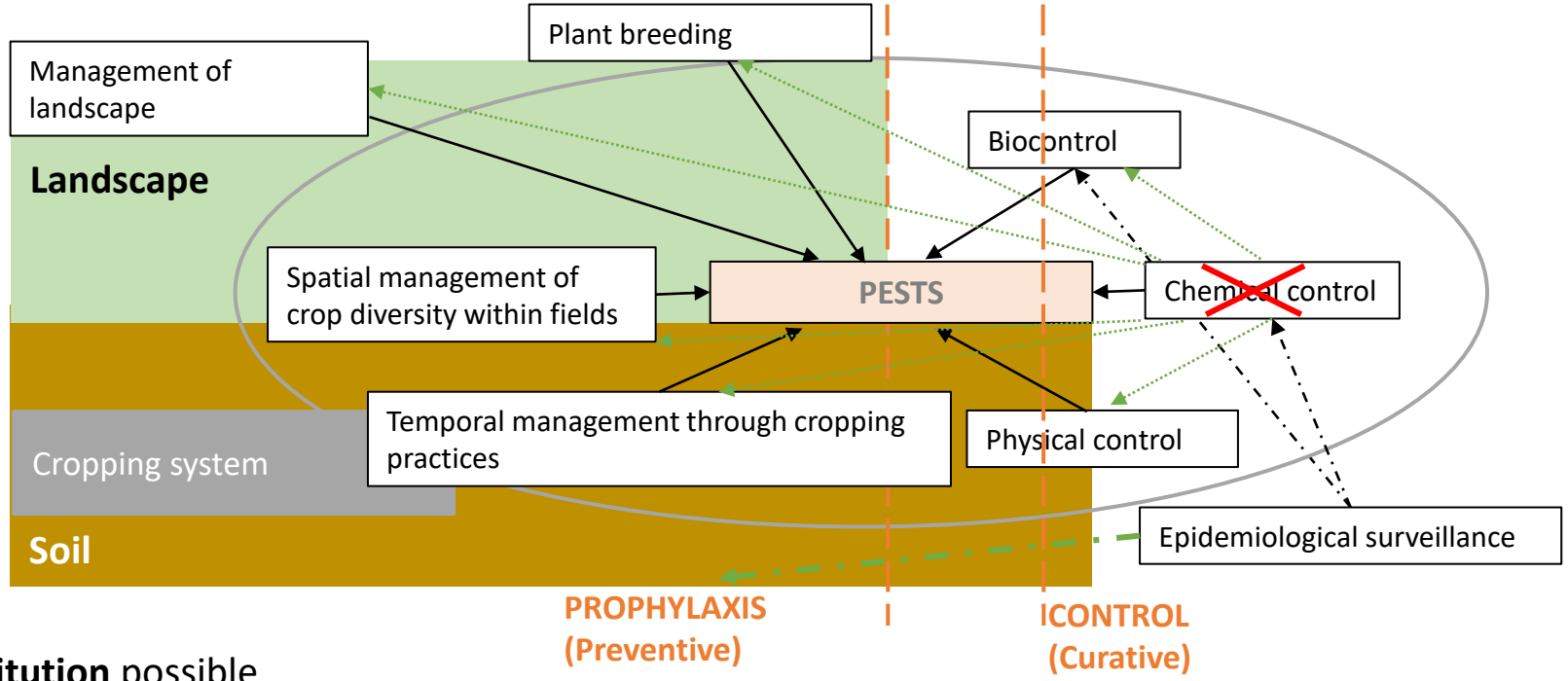


- 2 years project
- A dedicated project team
- 144 European experts mobilised in a European expert committee and thematic experts groups

Three results:

- **Three scenarios and their transition pathways**
- **A quantitative assessment of the impacts of the scenarios**
- **Four case studies in 4 EU regions (Finland, France, Italy, Romania)**

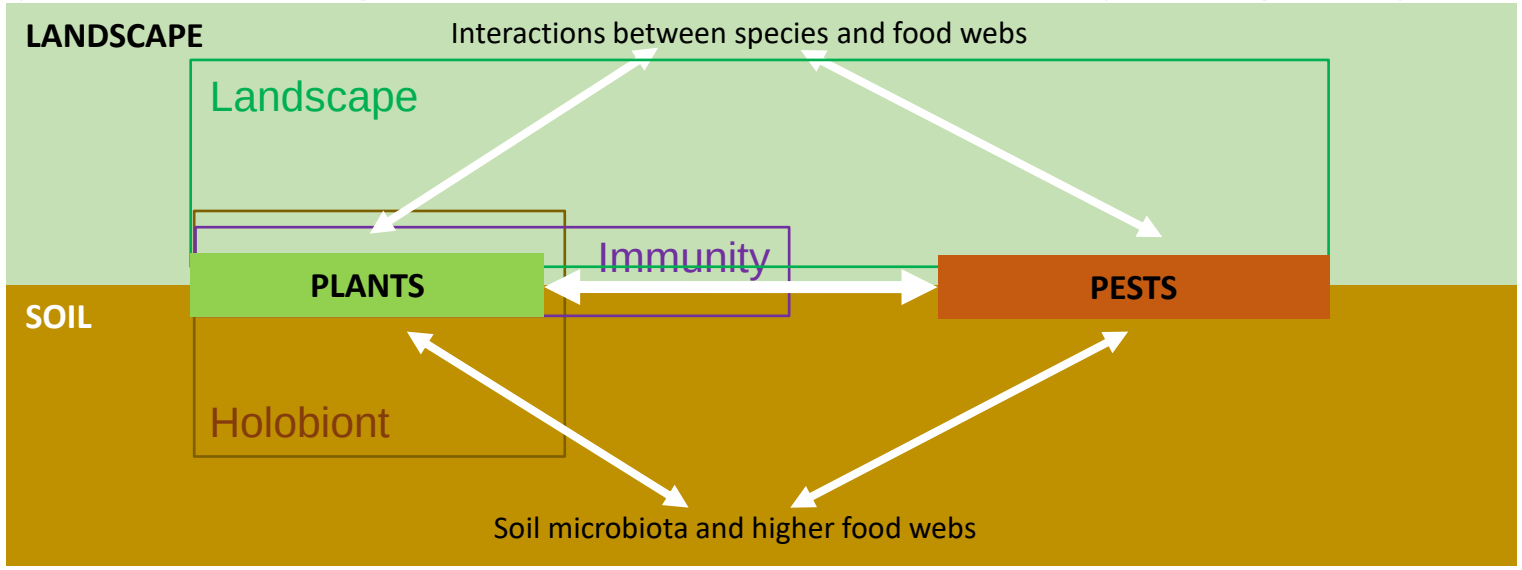
What strategies for chemical pesticide-free crop protection in 2050?



1. **No simple substitution** possible
2. A need for a **redesign** of cropping systems
3. A shift from a **curative** strategy against pests to a **preventive** strategy (anticipation of pests)
4. Developing tools for **monitoring pests** and the environment
5. Reinforcing **biological regulations** in **soil** and **landscape**
   - **Need to mobilise agroecological principles** (including principles of **organic agriculture**)

→ Agroecological principles are key elements to move towards pesticide-free cropping systems.

Three disruptive strategies of chemical pesticide-free crop protection in 2050 by mobilising research fronts and expert groups



Strengthening the **immunity** of cultivated plants

By using plant defence stimulators, biostimulants, biocontrol (Zhang et al., 2020), plant breeding (resistant varieties), by reinforcing interactions with microbiota, other crops and plant services (Lannou et al., 2021)

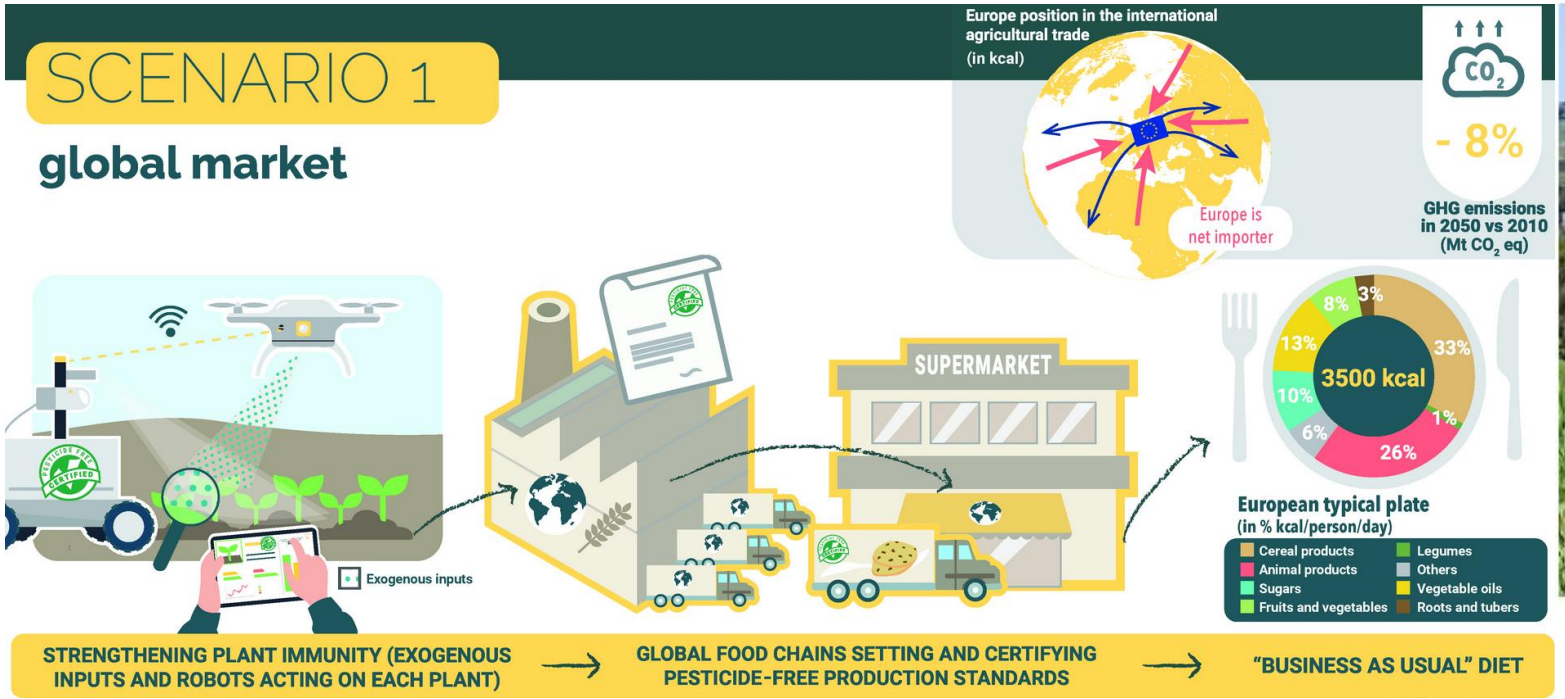
Managing the crop **holobiont** by strengthening **host microbiota interaction**

By developing microbial biodiversity, in order to strengthen the adaptability of the holobiont and the functions of microbiota (Tosi et al., 2020;; Simon *et al.*, 2019), by modulating the existing microbiome through agricultural practices, crop choice, inoculations of microorganisms (Berg et al, 2021) and plant breeding (Wallenstein, 2017)

Designing **complex and diversified landscapes** adapted to local contexts and their evolution

Promoting biological regulations by increasing biodiversity and agrobiodiversity over space and time, building complex landscapes with 20% of the land with semi-natural habitats (Garibaldi et al., 2021; Tscharntke et al., 2021), a changeable mosaic of diversified crops (Alignier at al, 2020; Sirami et al, 2020), and crop diversification at plot level (Tibi et al., 2022; Thomine et al., 2022), and through plant breeding

Scenario 1 (S1) : Global and European food chains based on digital technologies and plant immunity for a pesticide-free food market



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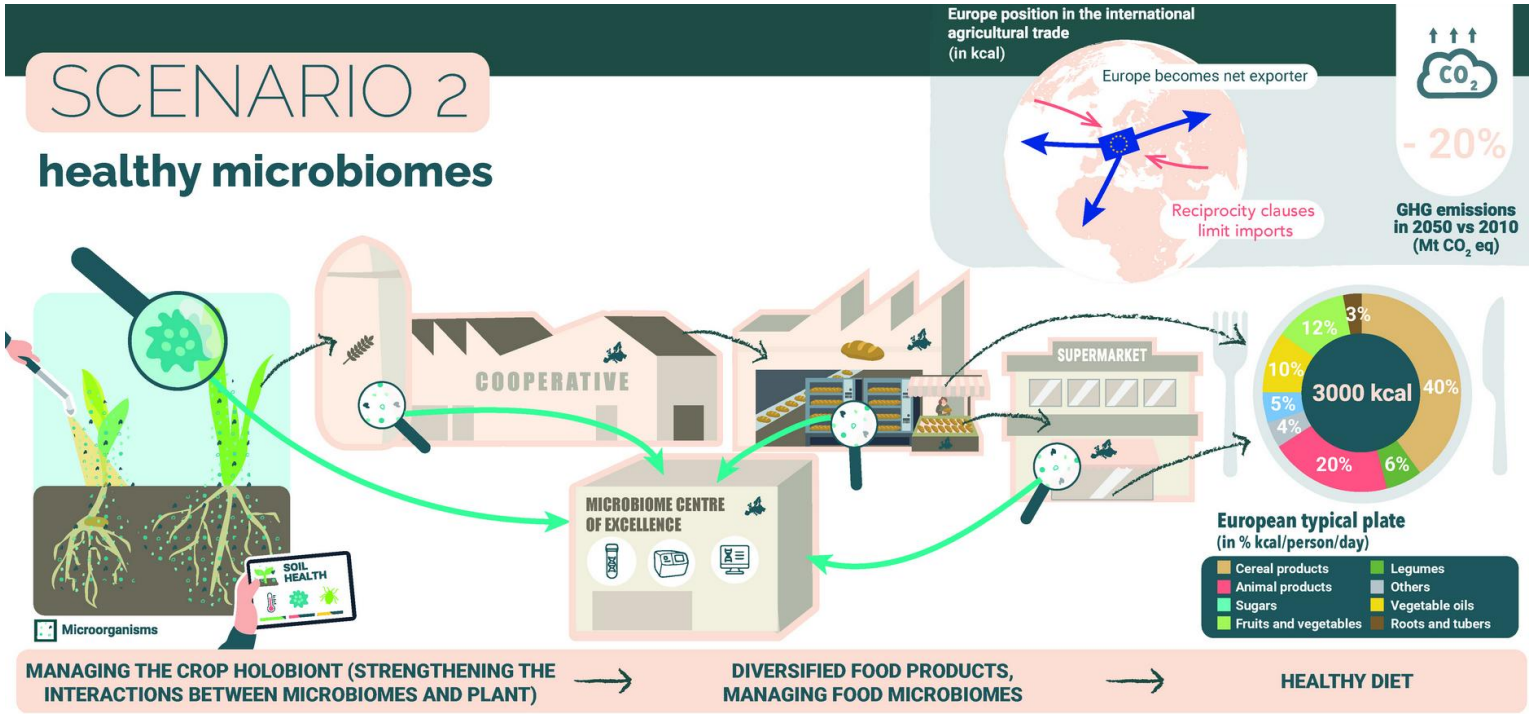
Durum wheat production in Toscany (Italy) in 2050

- Global food chains
- Private certifications and international standards for pesticide-free production
- Specialisation and financiarisation of farm structures
- Tools for monitoring pests and individual plant health in the plot
- Robots acting on each plant
- Reinforcing plant immunity through biocontrol and plant defence stimulators
- BAU Diets

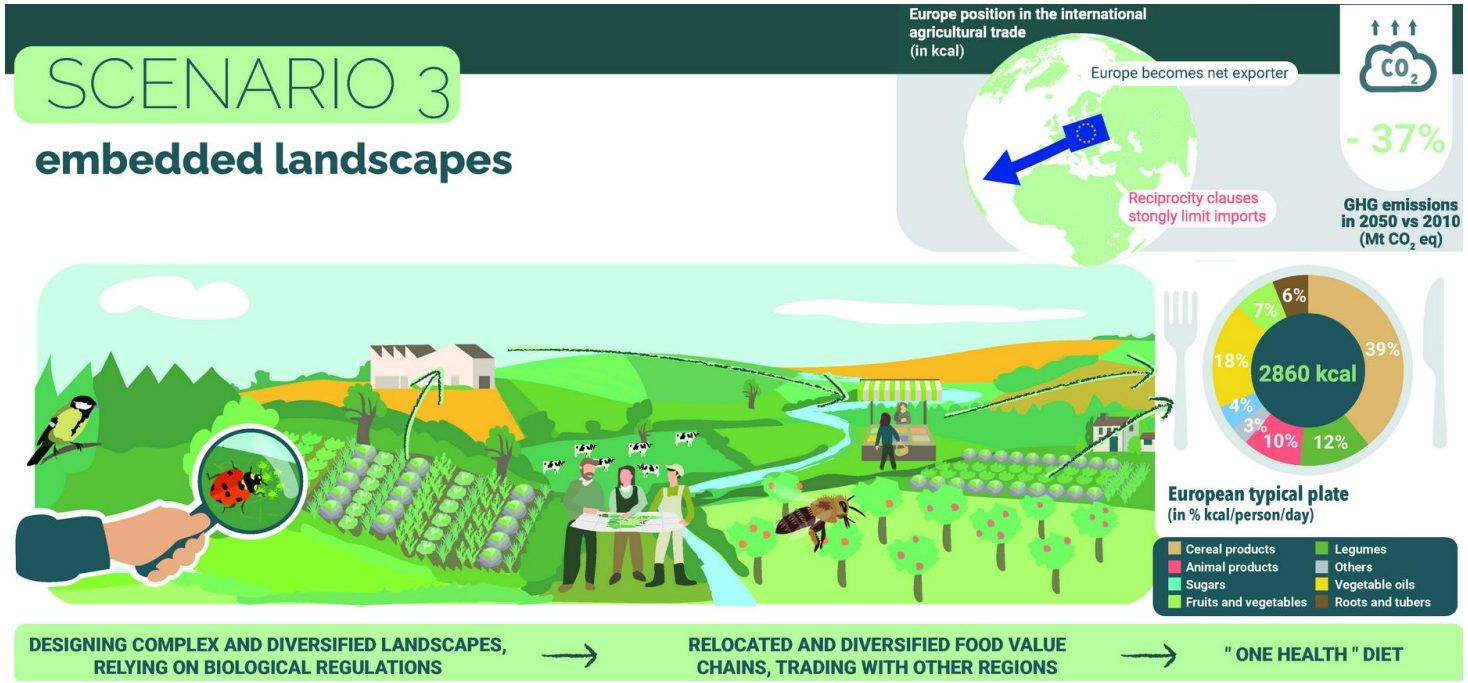
Scenario 2 (S2) : European food chains based on plant holobiont, soil and food microbiomes for healthy foods and diets



Vegetable production in South-East Romania in 2050

- Consumer demand for healthy foods
- European value chains without chemical pesticides
- Impact on the whole food system
- Monitoring of microbiomes: soil, plant, food storage and processing, and final food product
- Crop diversification to respond to the target of healthy diets
- Reinforcing interactions between host plants and microorganisms (management of the holobiont) for crop protection
- Transition to healthy diet, more diversified diets: less calories, less animal products and sugar, more fruits and vegetable, more pulses, diversified cereals

Scenario 3 (S3) : Complex and diversified landscapes and regional food chains for a One Health European food system



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Cereals and oilseeds production in South Finland in 2050

© IVBD

Wine production in Bergerac-Duras (France) in 2050

- Territorial and regional food value chains
- Food protecting human health and environment (One Health)
- UE transition towards One Health approach
- Territorial coordination to reinforce biological regulation (landscape) and relocate value chains
- Complex landscapes with 20% of land dedicated to semi-natural habitats
- Adaptation of the mosaic of crops to the issues of crop protection, temporal diversification of crops
- Monitoring of the environment and anticipation of pests
- Transition to healthy and sustainable diets: less calories, less animal food and more pulses, less sugar

Building transition pathways at regional level based on the European scenarios

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S1
Durum wheat production in Toscany (Italy) in 2050

© Tudor Stanciu

S2
Vegetable production in South-East Romania in 2050

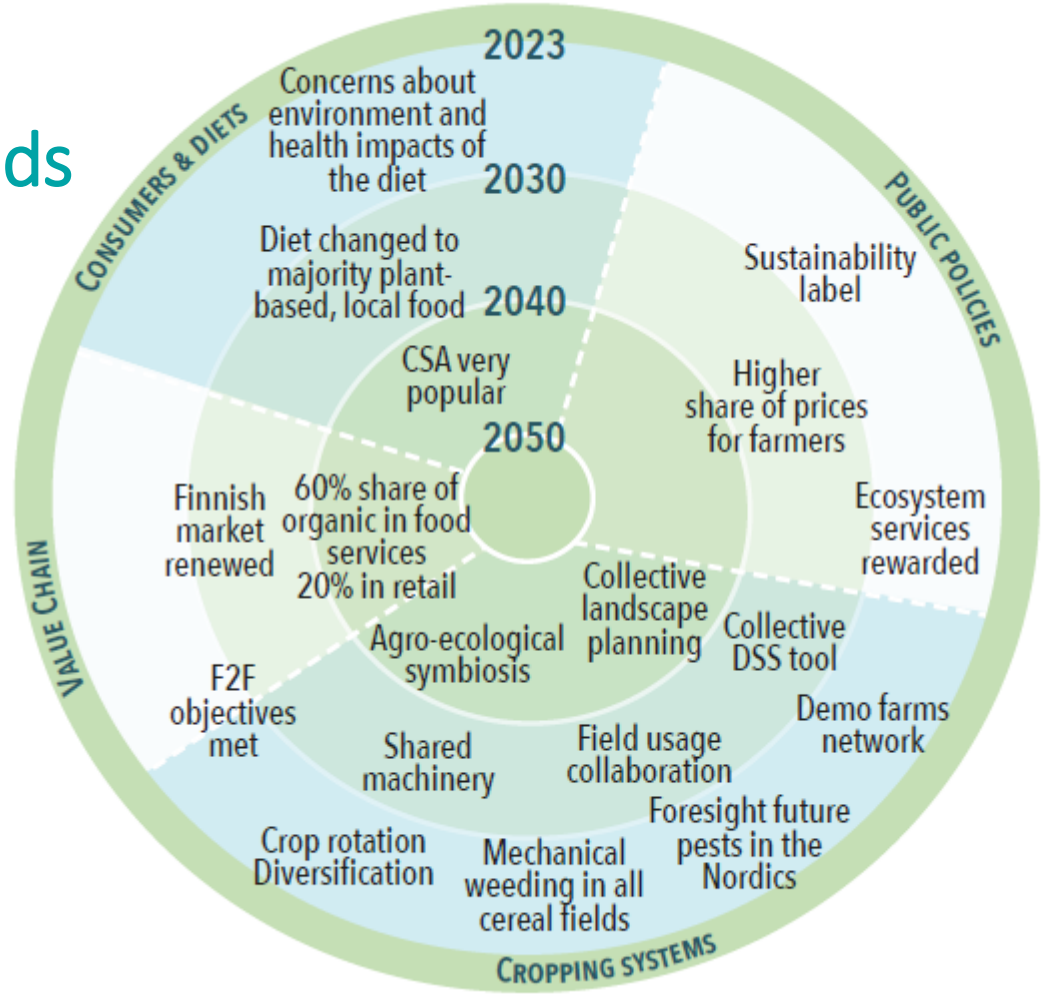
© IVBD

S3
Cereals and oilseeds production in South Finland in 2050

S3
Wine production in Bergerac-Duras (France) in 2050

- Testing the European scenarios at regional level with local stakeholders
- Inspiring and promoting changes with local stakeholders: common vision and theory of change by building a transition pathway, multi-actor and integrative vision, formulating the first steps of a collective strategy of change

Transition pathway for South Finland & cereals and oilseeds



Key transition steps : Finnish consumers concerns about the impact of their diets on the environment trigger changes in the food value chain: the share of organic products increases, and the food market evolves towards more diversity of local products. Finnish consumers support the transition of local agriculture, which evolves progressively towards increased **organic farming**, **diversification of cereals, oilseeds and legumes productions**. Transition in the cropping systems goes by sharing best practices through demo farm network, payments for ecosystem services, fairer share of food prices for farmers, and an **increased collaboration** between farmers and local actors, up until the **implementation of agro-ecological symbiosis**.

CSA : community supported agriculture ; F2F : farm to fork ; DSS : decision support system

S3

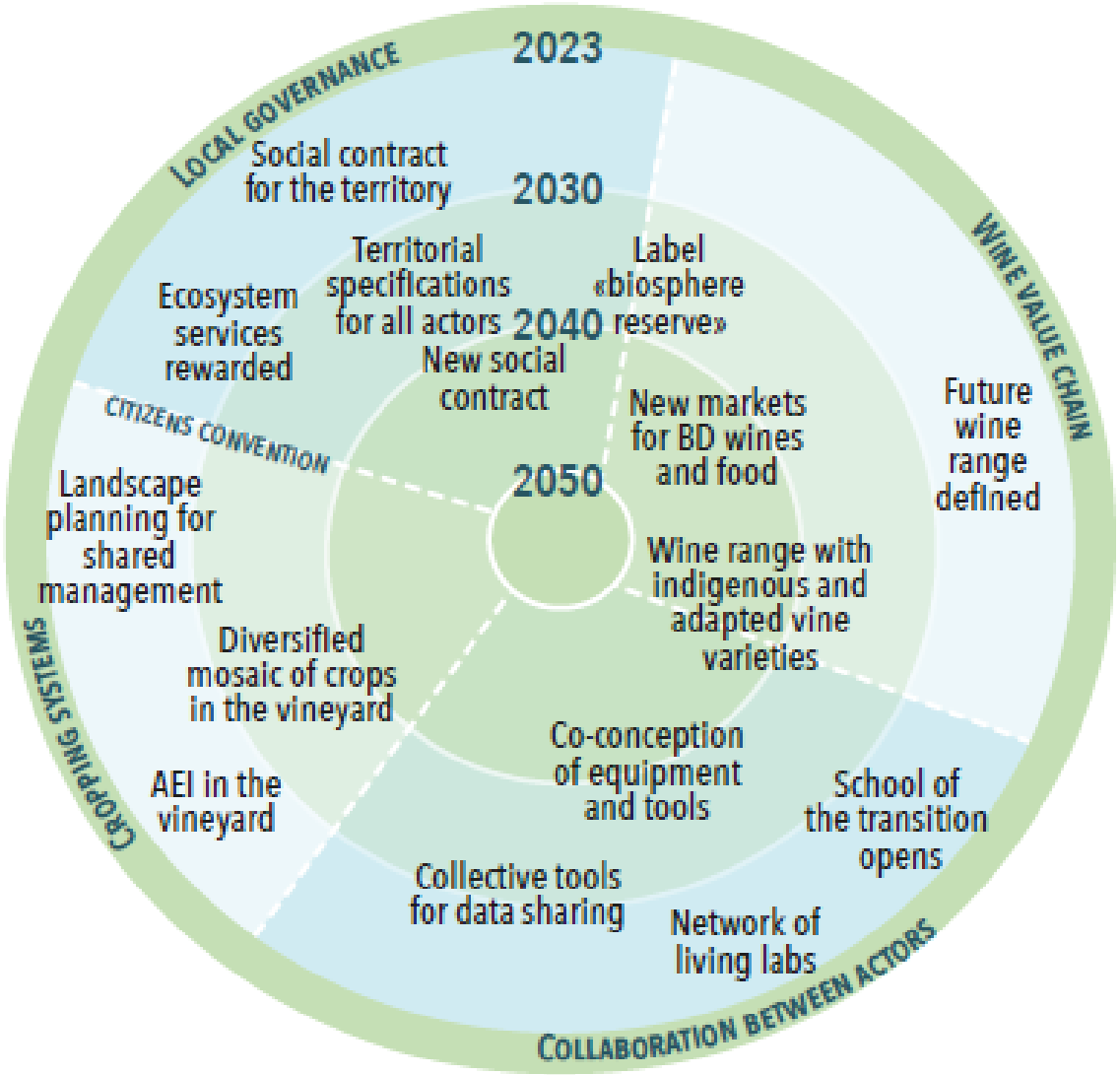
South Finland & cereals and oilseeds

Transition pathway for Bergerac Duras & wine (France)

Bergerac Duras & wine

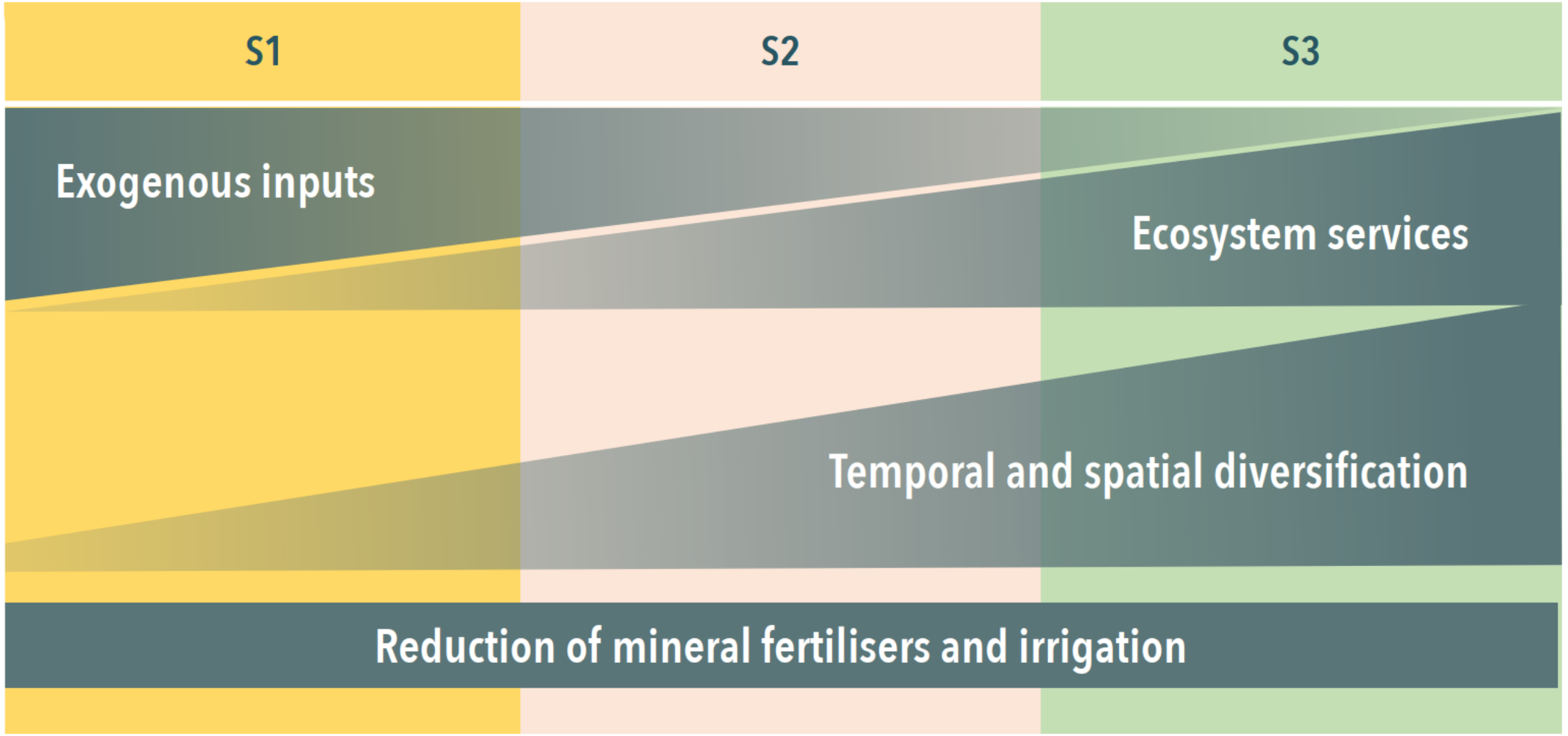
Key transition steps : The transition starts with a common agroecological project put through by local actors, followed by the set up of a participatory governance around the social contract of the territory. It organizes the transition, the landscape planning, the fundings including the payment of ecosystem services. A citizen convention monitors and gives inputs all along the transition. Actors increasingly cooperate, share knowledge, practices, results of experiments, and co-develop solutions towards the same goal: the « biosphere reserve » certification for the territory. It opens new markets for the Bergerac Duras renewed wine range and for the diversified local food products.

AEI : agro-ecological infrastructure ; BD : Bergerac Duras

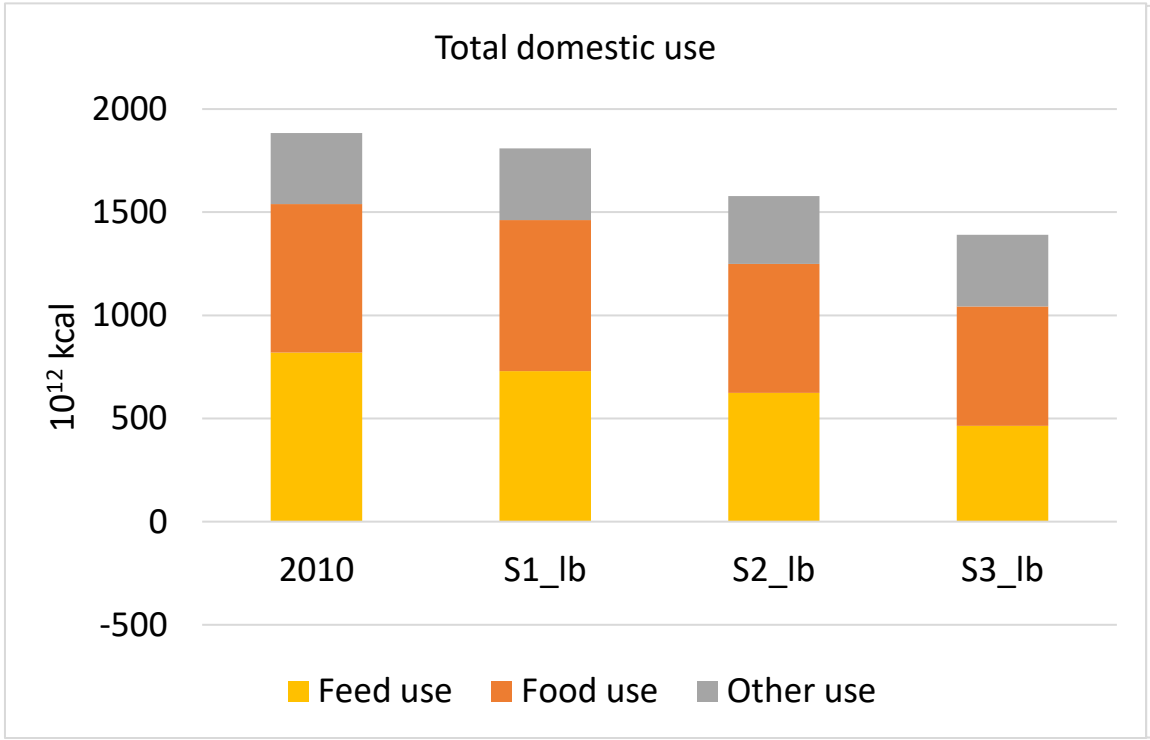


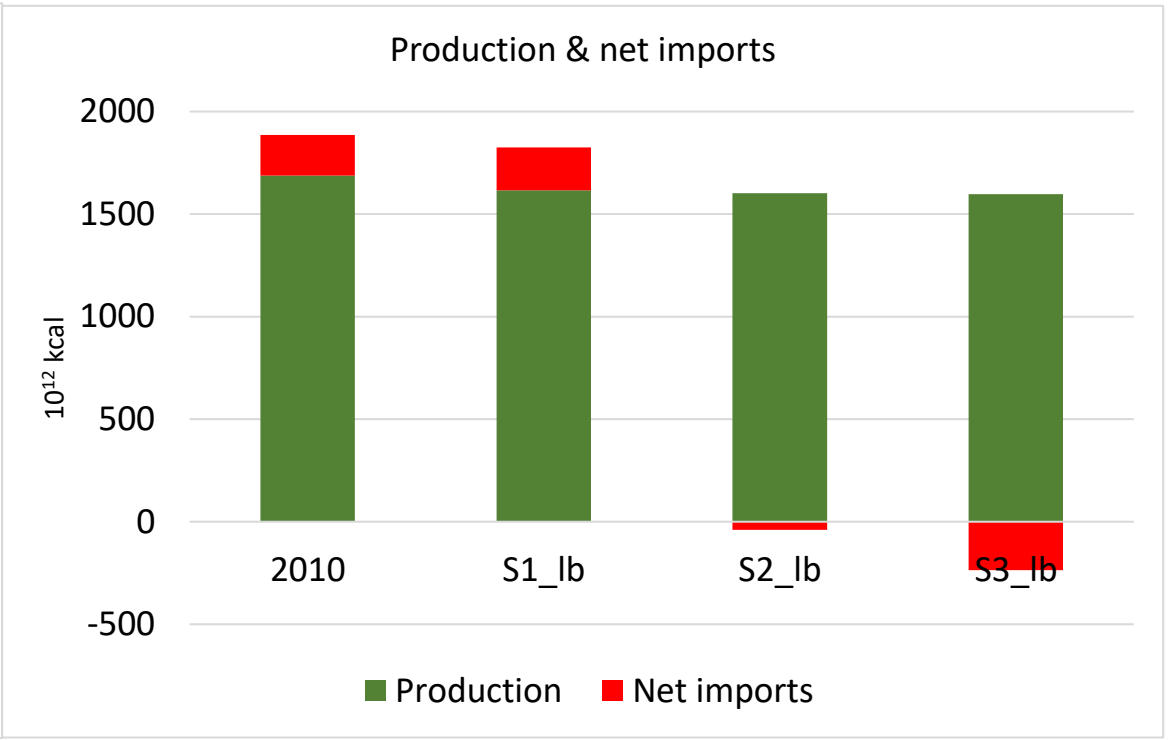
Managing pests by increasing biodiversity and agrobiodiversity: towards agroecological cropping systems

Characteristics of the cropping systems in the three scenarios (S1, S2, S3)



How does the 3 scenarios impact domestic use, production and net imports in Europe?

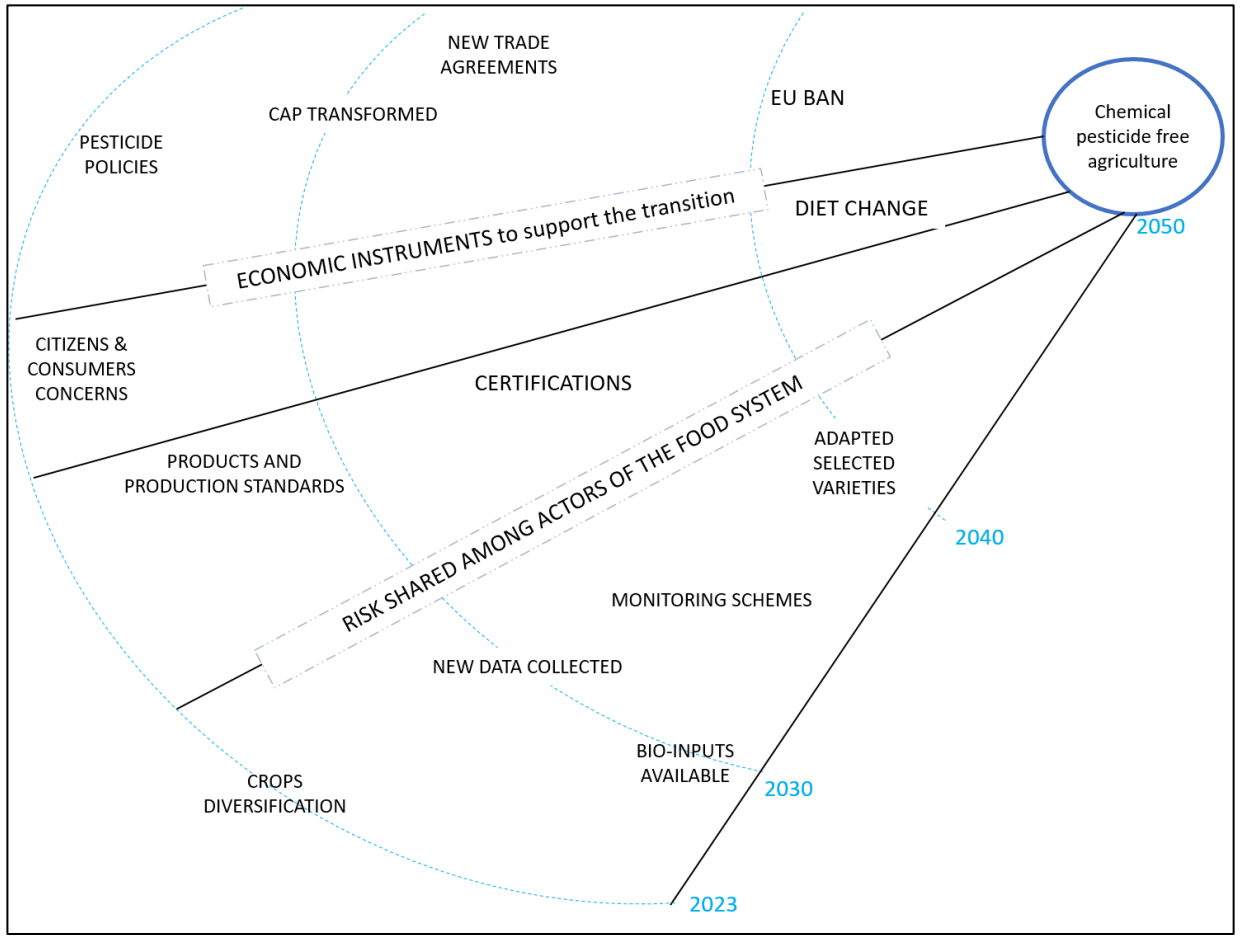




Resource-use balance in "2010" and in 2050 in S1, S2 and S3 (10^{12} kcal)

→ Two scenarios have a positive impact on the European agricultural trade balance in calories

Is there a highway to support the transition towards European chemical pesticide-free agriculture by 2050?



Robust elements of a transition pathway towards pesticide-free agriculture

In all the scenarios, **strong and coordinated measures** are required for a successful transition:

- Key role of **consumers**, citizens and inhabitants in the transition. Concerns about impacts of chemical pesticides. **Shift of their dietary patterns (S2 and S3).**
- **Mix of public policies**: **regulatory policies** for reducing and ultimately banning chemical pesticides, **sectoral policies for supporting farmers transition**, **environment policies**, **food and nutrition policies** to **support transition to healthy diets (S2 and S3).**
- New **trade agreements** with non-European partners in order to develop a pesticide-free European market.
- New **production standards**, enabling the **certification** of productions, and their valorisation through food **labels.**
- Mechanisms for **sharing the risks** among the different actors involved in the value chain through market contracts, or in the territory.
- Agricultural, knowledge and innovation systems for knowledge **creation and co-conception** with farmers, of pesticide-free cropping systems (inc. **Living labs**).

Public policies conducive for a transition towards chemical pesticide-free agriculture in EU by 2050

	Public policy supporting the transition towards « pesticide-free »	**Agricultural** policy	**Trade** policy
S1	Iterative pesticide reduction targets set in the law	Enhanced conditionality of payments to the compliance with pesticide reduction and pesticide-free targets	Towards a global harmonisation of rules on chemical pesticides, in line with WTO, *Codex alimentarius*
S2	A **holistic policy on food systems**, integrating measures related to pesticides and also to nutrition and health	**Integrated to the holistic food system policy**, oriented towards nutrition and health goals	**Bilateral trade agreements** including mirror or reciprocity clauses related to pesticides use and nutrition/health criteria for food entering the EU market
S3	**Territorial and participatory cross-sectoral policies (One health)**	**Payments for ecosystem services** provided by all actors including farmers, within a territory	**Mirror or reciprocity clauses** in trade agreements related to pesticides use and one health standards

Main issues for a transition to Agroecology in 2050

- **2 scenarios out of 3 are based on agroecology**. With co-benefits: Both improving nutrition and health, environment (biodiversity and water), GHG emissions, European food sovereignty
- A plurality of pesticide-free cropping systems in 2050 (holobiont, microbiome, landscape redesign): Opening new avenues for research (eg. soil microbiota, monitoring) and co-conception. Biological regulations at the soil, crop and landscape levels should be favoured, as preventive actions.
- **Conditions for a robust transition**:
  - **Engaging all the actors of the food system, farmers and beyond**, including actors of the value chain (storage, processing and retailing). Agroecological value chains.
  - Key role of consumers and **dietary changes** in transition (towards more plant-based diets)
  - **A mix of coherent public policies**: Cross-sectoral, holistic, integrated policies beyond agricultural policies to support the transition
  - **Risk sharing among actors** for supporting the risk of experimentation during the transition, **co-conception** of technologies and cropping systems, and **transformations** in the **upstream and downstream sectors** of agriculture
- Backcasting the scenarios at a regional level: A way of **engaging stakeholders in building a vision of a territorial transition**, prioritizing actions
- But **a need to build a conducive environment** (ie. more stability) for the transition, and to define the role of organic sector in the transition towards agroecology (OF as a prototype, a value chain, a market…)

Thank for your attention

More information on the foresight including summaries, videos and **full report (640p)** available at:

https://www.inrae.fr/en/news/european-pesticide-free-agriculture-2050

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Knowledge and technologies needs to support the disruptive strategies in crop protection by 2050

Strengthening the immunity of cultivated plants (S1)

- Existing knowledge on molecular mechanisms of action and on partial resistance to pests (plant defence stimulators, service plants, or flash UV-C)
- Knowledge needs to cover the interactions between the various levers to stimulate plant immunity, identify plant immunity markers, and map resistance genes to the main pests

Managing the crop holobiont by strengthening host microbiota interaction (S2)

- Existing knowledge on mycorrhization, and tools for assessment of the genetic diversity and the detection of microorganism
- Knowledge needs to better understand the link between a specific microbial community structure and its functional traits, identify the microbial communities that are important for the different crops and their dynamics, and determine the ways to modulate the soil microorganisms

Designing complex and diversified landscapes adapted to local contexts and their evolution (S3)

- Existing knowledge on the principles and mechanisms linked to crop diversification and landscape design
- Knowledge needs on modelling tools for anticipating the quantitative impacts of crop diversification and semi-natural habitats on biological regulations and the quantitative impacts of pests on crops as well as working out solutions for perennial crops