Directorate for Collective Scientific Assessment, Foresight and Advanced studies (DEPE)

Sant'Anna Scuola Universitaria Superiore Pisa

CASE STUDY REPORT

TUSCANY
Durum wheat sector

Building transition pathways towards Chemical Pesticide-Free agriculture in 2050

Case study conducted as part of the foresight European Chemical Pesticide-Free Agriculture in 2050

RÉPUBLIQUE FRANÇAISE
Liberté Égalité Fraternité

FRANCE 2030

anr

INRAE

GROWING PROTECTING *differently*

Authors: Claire Meunier, Olivier Mora, Stefano Carlesi, Giovanni Pecchioni

Contact: Claire Meunier, claire.meunier@inrae.fr

Director of publication: Guy RICHARD, Director for Collective Scientific Assessment, Foresight and Advanced Studies (DEPE)

This report is a supplementary material of the foresight report
Mora O. (coord.), Berne J.-A., Drouet J.-L., Le Mouël C., Meunier C. (with the contribution of Forslund A., Kieffer V., Paresys L.) (2023). European Chemical Pesticide-Free Agriculture in 2050. Foresight Report, INRAE (France), 643p. https://dx.doi.org/10.17180/ca9n-2p17

All publications related to the foresight study are available on INRAE website:
https://www.inrae.fr/en/news/european-pesticide-free-agriculture-2050

This document is the report of the case study Chemical Pesticide-Free Durum wheat production in Tuscany by 2050. It has been conducted as part of the foresight European Chemical Pesticide-Free Agriculture in 2050 commissioned and financed by the French Priority Research Program "Growing and Protecting crops Differently". This foresight study was conducted by INRAE's Directorate for Collective Scientific Assessment, Foresight and Advanced Studies (DEPE).

Version 1 filed on 2023, December 20th

Table of content

I. Objectives of the case study

The Tuscany durum wheat case study is one of the four regional case studies conducted as part of the foresight European Chemical Pesticide-Free Agriculture 2050. The European foresight study was run within the French Priority Research Program (PRP) 'Growing and Protecting crops Differently', and in connection with the European Research Alliance 'Towards a Chemical Pesticide-Free Agriculture'. It produced three European scenarios, with their transition pathways and quantitative impact assessment. The full report of the European foresight is available here: https://hal.inrae.fr/hal-04231124.

From one of the European scenarios, the Tuscany case study aims at building a scenario of chemical pesticide-free durum wheat production in 2050, and at working with local actors on a transition pathway to achieve this desirable scenario. The Tuscany scenario is therefore based on one of the European scenarios of chemical pesticide-free agriculture, and illustrates it in a specific region, on a specific crop and cropping system & for a specific and a specific sector and value chain. It is also a way to check, with local experts, the plausibility, coherence, and clarity of the generic hypotheses identified at European level, and the feasibility to translate them into a specific context.

In this report we cover three topics that has been addressed in the case study:

- an analysis of the major trends of the agricultural system in the region considered.

- the definition of a common vision of a desirable future, that is the scenario of a chemical pesticide-free durum wheat production in Tuscany.

- the building of the transition pathways to get to this desirable future. Our primary objective is to elaborate transition pathways crafted and adopted by the group, that is a timeline from 2020 to 2050 of actions organized to reach milestones which altogether will make us achieve this desirable future.

II. Brief overview of Tuscany and the durum wheat sector

After a call for interest within the Experts' committee of the foresight, launched in December 2021, Paolo Barberi and his colleagues volunteered to participate in the case study. The case study on Tuscany was prepared with Stefano Carlesi and Giovanni Pecchioni, both researchers from the Group of Agroecology at the Center of Plant Sciences, Scuola Superiore Sant'Anna, Pisa, Italy.

Region chosen

The Tuscany Region (Regione Toscana in Italian; figure 1) is a region in central Italy with an area of about 23,000 square kilometers and a population of about 3.7 million inhabitants (ISTAT, 2017). The Region is surrounded and crossed by major mountain chains, has few (but fertile) plains, and the landscape is dominated by hilly country used for agriculture. Hills make up nearly two-thirds (66.5%) of the region's total area. Plains occupy 8.4% of the total area.

Sector chosen

Durum wheat production and its value chain was chosen for this case study. Durum wheat (*Triticum turgidum* subsp. *durum* (Desf.) Husnot) is one of the most essential cereal species and is cultivated worldwide, the largest producer being the European Union, where production and cultivation areas are concentrated in the Mediterranean basin. Italy is considered the leader of durum wheat production in Europe, with an average production of 4.26 million tons in the last decade (1.28 million ha growing area) (Xynias et al, 2020). 75% of the Italian durum wheat production is located in central Italy and the islands (Bianchi 1995). After cultivation, durum wheat is milled to produce durum wheat semolina, and then processed mainly into pasta. There are 3 main steps for pasta production: dosing and mixing (semolina and water), kneading and shaping (by extrusion or sheeting), and drying. Pasta products are then sold to consumers through various channels. Pasta is an important part of Italian people's diet, Italian people consume on average 23.1 kg pasta per year, followed by Tunisians, Venezuelans and Greeks (Bresciani *et al.*, 2022).

Figure 1: Map of Tuscany

III. Method and process

III.1- Backcasting definition and application to the foresight study

In order to build the transition pathways, we chose the backcasting methodology. This backcasting method is combined with the exploratory scenarios.

Backcasting approach is a method that consists of analyzing, backward from a desirable future that is considered as an end-point, the actions (innovations, public policies…) that need to be taken to reach that future. It is a normative method, first described by Robinson in the 80's to work on energy transitions: *"working backwards from a particular future endpoint to the present, to determine what measures would be required to reach that future"* (Robinson, 1982).

The backcasting method is particularly appropriate to our study since it allows addressing long term and complex issues, where the dominant trends are part of the problem, involving many aspects of society as well as technological or organizational innovations, public policies and change. By breaking down the future into small steps, it contributes to making scenarios plausible and feasible, and to listing the various steps necessary to achieve them (Dreborg, *1996*).

The backcasting exercise methodology we propose is inspired from previous foresight studies that have used this approach (Kok *et al.,* 2011*;* Hines *et al.,* 2019), that we have adapted to our study and purpose.

III.2- Organization of the work - Calendar of activities

A "regionalization" meeting was organized on March 22nd. It gathered the Tuscany case study coordinators – Stefano and Giovanni – and members of the foresight team Olivier and Claire. Its aims were to (1) select the "desirable scenario" and (2) to translate its European hypotheses into hypotheses adapted to the local situation and crop studied.

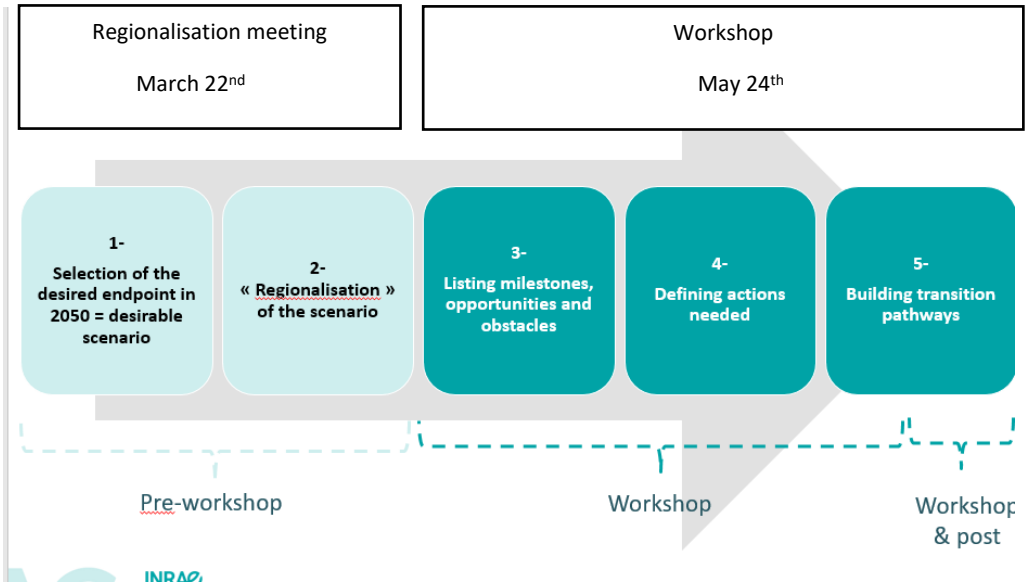
Then, a narrative of regionalization of the scenario for Tuscany was built through email exchanges in April-May.

Finally, the participatory workshop to elaborate transition pathways for durum wheat in Tuscany happened on May 24th, in Pisa. It gathered 17 participants in addition to the case study coordinators.

III.3- Methodology followed in the case study: overview of the different steps

Figure 2 summarizes the process we followed in each of the case study, also valid for the Tuscany case study. The five steps are further detailed below. Steps 1 and 2 happened in March 2022. The process and template were prepared by Olivier Mora and Claire Meunier; the preparatory work and the retrospective analysis were done by Stefano Carlesi and Giovanni Pecchioni; the "regionalization meeting" gathered all four contributors together. Steps 3, 4 and 5 happened during a one day workshop organized by the regional coordinators Stefano Carlesi and Giovanni Pecchioni.

Figure 2: Process followed in the case study



Step 1: Definition of the desired endpoint in 2050: selection of the desirable scenario

For each of the regional workshop, the experts selected one of the 3 exploratory scenarios developed with the foresight expert committee.

The regional coordinators, with the support of the foresight team, chose the most relevant scenario. To select the scenario, the regional coordinators, supported by the foresight team, looked for the most relevant scenario for the region, crop and value chain studied. Several criteria could be used, such as the adaptability of the scenario, its plausibility in the specific context of the region and the crop, and its attractiveness for the regional stakeholders.

Step 2: Definition of the desired endpoint in 2050: « regionalisation » of the scenario

The selected desirable scenario was adapted to the cropping systems, the farms structures, the value chain and the region considered, in order to make it more tangible and to define a specific endpoint for the region considered. The regionalized scenario translates the generic hypotheses of each component of the system into specific hypotheses fitting with the region considered.

In order to regionalize the selected scenario, we first identified the past and current regional dynamics of cropping systems, food value chains and local area. Scientific literature, grey literature, outreach to researchers or stakeholders were used to inform this step (table 1).

- In this **retrospective analysis**, we identified trends, weak signals, and ruptures for each of the components: local cropping systems, local food chains and local area.

Table 1: Example of « component value chain table » summarizing past and current dynamics

Definition of the food value chain and its main indicators
How does the food value chain look like for the crop considered? What are its main characteristics: main actors, organisation, main products, economic data, consumers' attitudes
Retrospective analysis of the food value chain
What have been the past evolutions (10 last years)? Who are the key actors involved in these changes?
Prospective
Which factors could influence the future evolution of the value chain? What are the trends? What are the weak signals? What are the possible ruptures?
References (scientific articles, grey literature, experts interviews…)

- We then **translated** and specified the generic hypotheses in 2050 from the **desirable scenario into regional hypotheses** linked to regional dynamics.

This was done by referring to the morphological table for the desirable scenario chosen, and by asking, for each hypothesis for each component: What does this hypothesis mean for the region and crop considered?

The regionalization of the scenario was done during a dedicated meeting gathering the regional coordinators of each region and the foresight team. Its outcome was a regionalized scenario, in the form of a morphological table and a narrative.

One-day workshop in Pisa, Tuscany, on May 24th, addressing steps 3,4 and 5

Step 3: Listing obstacles, opportunities and milestones

During the workshop, we began by listing obstacles, opportunities and milestones.

The objective of this part was to identify the key intermediate steps needed to be achieved, in order to reach the desired objectives, and issues and opportunities arising from them. Milestones, obstacles and opportunities were discussed for each of the components of the system and their hypothesis, linking to the desirable scenario and its morphological table.

*Milestones are defined as the main steps from the desirable future to the present, or a future event that signals the progression towards our desirable future (*Van Vliet and Kok*,* 2013*;* Bengston *et al.,* 2020; Hines *et al.,* 2019*). Milestones can for example be a 50% reduction in the use of chemical pesticide by farmers in the region in 10 years.*

Obstacles are for example: lack of resources, or organization of crop protection services, alternative biocontrol solutions not known to all, lack of financial incentives for transitioning, perceived risks of transition etc….

Opportunities are favorable changes that are in favour of a transition towards pesticide-free agriculture (for example, consumers willing to buy pesticide-free products).

Obstacles, opportunities and milestones are identified out of the regionalized scenario. They are discussed for each of its components: agricultural equipments and digital technologies, crop systems, farm structures, food value chain, diet.

Step 4: Defining actions needed

In this step the group discussed which initiatives are needed to reach these milestones, overcome obstacles, and/or make use of opportunities.

*An action is defined as a concrete initiative that take advantage of an opportunity, or reduce the likelihood of or prevent from an obstacle (*Bengston *et al., 2020).*

Actions can be a regulation, a policy instrument, a research program, an education program, a communication campaign, a monitoring, a technological solution, capacity building …

Actions can be, for example, a decision by a mayor to only buy pesticide-free products in the school canteens, a new combination of living microorganisms introduced in the market as a biocontrol solution, increasing the plants resistance to pests; a local NGO campaign to sensitize the population on biodiversity preservation.

The actions must be as specific as possible, and answer the typical questions:

*Why: obstacle overcome, opportunity seized.
*What: type of actions.
*When, and How long.
*by Who: actors involved and their roles.

Step 5: Building transition pathways

Milestones and actions were articulated in the backcasting timeline, in order to build transition pathways. We showed how each action on a component of the system will interact with other actions on other component of the system.

The various actions and milestones were organized in order to identify strands of connected actions and milestones that could ultimately form the transition pathway.

IV. Retrospective analysis – durum wheat production and value chain in Tuscany

In order to conduct the retrospective analysis, a template table was provided to the regional coordinators, listing the different *components* of the foresight and their *variables*. The retrospective analysis aimed at identifying past, current trends and possible future evolutions.

For each component, the following questions were asked:
- What have been the past evolutions (during the last 10 years)?
- Who are the key actors involved in these changes?
- Which factors could influence the future evolution of the component?
- What are the main trends?

- What are the weak signals?
- What are the possible ruptures?

The Tuscany case study coordinators completed the retrospective analysis template ahead of the regionalization meeting, based on their knowledge and experience. They also questioned farmers within their network, through questionnaire and informal talks, between October and December 2021. In parallel the foresight team conducted a short literature review (non exhaustive) using WOS[1], documents from the European Commission (EC, 2020) and foresight operations conducted in Tuscany (Arcury *et al.*, 2022).

The table was then shared and discussed during the regionalization meeting, that gathered Stefano Carlesi, Giovanni Pecchioni and members of the foresight team Olivier Mora and Claire Meunier. The detailed outcome of this discussion is presented in the next pages (tables 2, 3, 4, 5) and a summary of the main trends identified is presented below.

IV.1- Major trends identified on durum wheat cropping system

In cereals systems there is currently an orientation towards specialized system, with a narrowing amount of crop choices between durum wheat, common wheat, sunflower, maize, sorghum, soyabean, faba bean, few pulses such as chickpea, or most rarely alfalfa or Trifolium. The crop sequence varies generally from 2 to 4-5. Because of climate change, crops choices have decreased over the past years and moved to crops with less water needs (ie switch from maize to sorghum) (Nassi o Di Nasso *et al.*, 2011; Pecchioni *et al.*, 2020). Also, crops choices are limited due the increased presence of animals such as wild boars (Amici *et al.*, 2012). In the future, we foresee this trend to continue with less crops available and specialization increasing still. Organic farming is more interested in mixed cropping (Leoni *et al.*, 2022).

Varietal choice for durum has evolved towards selection of resistant cultivars to the main fungi. It has also evolved to rediscover old cultivated varieties (CV) that increase durum wheat quality, and are valorized with consumers. In the future selection will continue to evolved towards development of CV that are both resistant and tolerant to fungi diseases (De Vita *et al*., 2007; Lazzaro *et al.*, 2018;).

The main pests affecting durum wheat production are weed, fungi (Fusarium, Septoria and Puccinia), and, more recently, insects. Pest management practices include use of herbicides and fungicides, with resistant issues developing especially for weed management (Scarabel *et al.*, 2020). Alternative pest management is increasing. They include longer crop rotation and forage availability, intercropping, cover crop, mulching (Adeux *et al.*, 2019; Antichi *et al.*, 2022). Against weed, mechanical management is developing, with an interest from farmers to invest in machinery, robotisation.

There is a trend towards reduction of use of synthetic fertilizers because of energy costs increasing. After years of no-till and reduced tillage, there is an increased interest in ploughing to control resistant weeds, at soil preparation.

IV.2- Major trends identified on durum wheat food value chain

Durum wheat is mainly processed into pasta. It is the main source of carbohydrate in Italians' diet. Pasta consumption has slightly reduced over the past 10 years, due to concerns over gluten health

[1] WOS query « tuscany AND cereal » conducted in February 2022, limited to « topics », generated 33 results, 7 of which were selected based on abstracts.

impacts. In future, there could be an increase in the consumption of minor cereals, and of specific varieties, triggered by consumers increased interest in these products. Consumers expect more and more quality for pasta products, linked to gluten and presence of residues of pesticides (like glyphosate). This explains the development of certifications and labels promoting high quality pasta, organic (which currently represents 8% of total production). In future, this trend should continue with even more importance to local production, diversification of pasta products towards no pesticides residues, healthy products (raw pasta…) and organic growth. Italy exports around 50% of its pasta production to mainly Europe and the US, and also imports wheat from abroad even if these are decreasing. In the future, exports of Tuscany production could even increase.

IV.3- Major trends identified on agricultural equipments and digital technologies in Tuscany farms

There is currently a medium penetration rate of innovations and digital technologies in Tuscany farms, that are still transitioning to digitalized agriculture. The 10% farms have access to Real Time Kinematic (RTK), mapping and Decision Support Systems (DSS), that were absent 10 years ago. In future, digitalization – automated machinery, drones, … - should spread among more and more farms, provided that blockers on costs and technology accessibility are removed, and that farmers get convinced and trust their benefits.

IV.4- Major trends identified on Tuscany farm structures

The size of farms has increased over the past 10 years, and number of farms have decreased. Average farm size is around 200 ha (from 30 to up to 500 ha), with probably a stable trend in future years on average, with 2 possible (parallel) evolutions:
- younger farmers starting with smaller capital and farms and a much more differentiated product range,
- selling of farms to capital investing firms, with an aggregation to larger farms.

Farms have specialized strongly over the past years, with a polarization of animal production and cereal production. There is currently a niche development of smaller size and differentiated new farms.

The source of capital is and should remain private mainly, with public subsidies focusing on specific targeted investments.

Table 2: Retrospective of cropping systems for durum wheat in Tuscany

CROPPING SYSTEMS	*CURRENT SITUATION*	*PAST TRENDS*	*FUTURE TRENDS*
		What have been the past evolutions (10 last years)? *Who are the key actors involved in these changes?*	*Which factors could influence the future evolution of the cropping system?* *What are the trends?* *What are the weak signals?* *What are the possible ruptures*
System characteristics: orientation, choice of crops and crop sequences	Orientation is manly specialized system, narrow amount of crop choice (Durum wheat, common wheat, sunflower, maize, sorghum, soyabean, faba bean, few pulse chickpeas, or most rarely forage as alfa alfa or Trifolium both annual or poliannual) in cereal specialized crop system. Crop sequence from 2 to 4-5	new crops, with less water needs seeded as sorghum instead of maize, increasing surface of soja been and pulse, less forage crops. In general, less crops available due to environmental limits as climate change and noxious wild animal as pigeon wild boards crowns	less crops available, risk of specialization. Interest on mixed crop on organic farming
Varietal choice	in theory quite a good amount of varietal choice, not always available for both durum and Common wheat, anyway enlarging.	selection of resistant cultivar to main fungi problems + re-discover old CV to increase quality, marketing recognizability, competition on weeds, but more exposed to disease susceptibility	Selection on both resistant and tolerant to fungi disease. More competitive cv.
Pest management : Main pests, weeds, pathogens Main plant protection products used Alternative solutions to replace PPP	Weeds: Lolium sp.; Fungi: Fusarium graminearum; Septoria spp. Puccinia spp. Few insects: Halyomorpha (emerging). Herbicide and fungicide. Main alternative in weed management are based on longer crip rotation and forage availability, intercropping, cover crop, mulch, mechanical treatment. against fungi, resistant or tolerant CV.	some new pest emerging (insects) rust spreading, weed becoming resistant to main available principles, and less available pesticide molecules. New machinery for post emergency mechanical management available	Increasing interest in developing new machinery to reduce or eliminate herbicide application, robotization far to be applied, some map developed to manage spraying more efficient, few utilized
Fertilisation	PK pre seeding; 150 N, manly urea; few organic animal manure available, green manure manly on spring crops	tendency to decrease the amount to increase efficiency, keeping production high	reduction of synthetic fertilizer due to increasing costs of energy
Management of water resources and irrigation	no irrigation on cereal	no irrigation on cereal	no irrigation on cereal
Tillage and soil management	manly reduced tillage, depending on soil, from no till (few) to some farms going back to ploughing	increasing area on ploughing to control herbicide resistant weeds as Lolium sp., after a long (15-20yrs) increasing no till and reduced tillage	new machinery available to control resistant weeds, at soil preparation time- but reducing tillage and oil consumption

Table 3: Retrospective analysis of food value chain and diet in Tuscany

FOOD VALUE CHAIN	CURRENT SITUATION	PAST TRENDS	FUTURE TRENDS
Type of food products	Durum wheat: Pasta; Common wheat: flour and bread	Stable	stable
Food consumption patterns - place of the product in people diet	in Italy: the main source of carbohydrates (100 kg pro capita yearly)	little reduction in consumption - 13% in 10 yrs., manly related to more attention to gluten consumption	more space in market for minor cereal and specific CV,
Consumers attitudes and expectations towards the products	Expectation on Pasta and bread quality is high and increasing. Attention to CV varieties even for consumer.	increased a lot the attention to old varieties, gluten quality, residues presence (Glyphosate on Canadian wheat)	more attention on specific CV, attention on gluten quality. Increasing attention on protein content.
Main actors in the value chain (storage, primary processors, food and drink manufacturer, retailer, food services…), organisation and governance		Durum wheat production 4 M t; import 30-40%; Pasta producer (3,4 M T) export 50%.	
Information to consumers (labels, certifications, traceability, …)	pasta, many producers are investing in labels (marketing) for recognizability of wheat source, CV, quality, for bread making and flour more attention on CV and old varieties but on little nice. Organic pasta and bread have a constant increase and occupies around 8% of total consumption	label quality certification increased constantly in the last 10 years, consumers attention to healthier products, higher market availability to buy higher quality product for higher price, in particular national product, low pesticide residues, organic.	more attention on internal production, reduction of pesticide residues, increase of healthy product, raw pasta and bread, organic product,
Technologies used to sort, store, process and/or preserve food products	sorting: density and shape at harvest and post harvest. Storing is made at farm or at storage centre. Processing is manly done on cylinder mill, some stone mile for niche production.	pretty stable not great innovation; some nice of new attention on milling industries on stone.	
Spatial scale : activities at local, national, European, outside Europe	value chain is strongly integrated at national level, few chains 100% Tuscan. 30 40% import of wheat from aboard (even extra UE). 50% exports, manly to UE and US	slow trend in decreasing import of wheat and increasing export of products	more attention to national production, reduction on dependency from import

Table 4: Retrospective analysis of agricultural equipments and digital technologies in Tuscany

AGRICULTURAL EQUIPMENTS AND DIGITAL TECHS	*CURRENT SITUATION*	*PAST TRENDS*	*FUTURE TRENDS*
Observation and modelling systems	DSS private company available (Main is HORTA); RTK given by new machinery in the top 10% farm	the actual situation is pretty new no RTK or DSS was common 10 years ago	increasing level of informatic alphabetization, on new generation, weak signals are manly from old age of farmers. And new generation not so keen in starting agricultural activities. Anyway, new generation of famers, more digital alphabetized could take more profit from the digital innovations available.
Specific equipment	new equipment, using prescription maps are available for seeding, sparing and distribute. As for mapping soil and yield. In particular new machinery for change seeding patterns or manage weeds post emerging, are of particular interest, anyway the availability among real far rate still scarce.	specific equipment development was implemented by both machine producers as tractors.	increasing interest on automated machinery, drones, ad precision farming is clearly developing. Not sure how fast those innovation would be implemented in farms
Innovation dynamics	medium penetration, still age of passage from an old agriculture to modern digitalized agriculture. More update farm has RTK, mapping and DSS, but are the top 10%. Consultancy is pretty common, related to input buying. Poor public consultancy.	increased the number of farms with RTK, and DSS (manly absent 10 years ago).	slow but constant trends in increasing digitalization spreading. Anyway, high cost and high technology capability may lack in some farm. Still farmer not confident, and risk perception on dependency on technology provider.

Table 5: Retrospective analysis of farm structures in Tuscany

FARM STRUCTURES	CURRENT SITUATION	PAST TRENDS	FUTURE TRENDS
Governance of farm structures	Mainly private	stable trend	stable trend
Size of farms	Average around 200 ha (from 30 to up to 500 ha)	enlarging surface, reduction in number	probably a stable trend. Aging farmer, low profitability are making new generation less prone to continue their farm activities, so farm are sold and aggregated to larger farms. Some new trend in younger farmers, but starting with smaller capital, smaller farms and much more differentiated production. a really small niche, anyway very open to organic farming and digitalization.
Labour force (family, sole holder, external to family, ...)	family or sole manly (low labour intensive, high mechanization)	reduction of labour force	new generation less willing to work in family farm. Smaller families, older farmer.
Source of capital	private + bank loan+ public subsidies for innovation at % of new investment	public subsidies for specific investment gave important asset for increasing independency on market	increasing presence of big conglomerate of capital investing in land (Bon fiche Ferrarese e.g.); public subsidies for una tantum investments, private capital still main source.
Type of farms (specialized, mixed, livestock, permanent crop, …)	Specialized manly	strong specialization, reduction of mixed farms, polarization of animal production and cereal production.	some new farm, smaller size more differentiated are developing, but still a niche
Access to new technologies (digitalisation, machinery, breeding, consultants, …)	medium penetration, still age of passage from an old agriculture to modern digitalized agriculture. More update farm has RTK, mapping and DSS, but are the top 10%. Consultancy is pretty common, related to input buying. Poor public consultancy.	increased the number of farms with RTK, and DSS (manly absent 10 years ago).	slow but constant trends in increasing digitalization spreading. Anyway, high cost and high technology capability may lack in some farm. Still farmer not confident, and risk perception on dependency on technology provider.

V. "Regionalized" scenario in 2050

The regionalization of the scenario started during the "regionalization meeting", after the retrospective analysis presented in the previous section.

As second step, the regional coordinators chose the desirable scenario out of the three European scenarios. They chose the scenario number 1 (S1) « **Global and European food value chains for pesticide-free food markets**". The main reasons for this choice are the current trends in terms of specialization and increased size of farms, development of digital tools, and the distribution market for pasta (50% export and increasing consumption of pasta globally). Scenario number 3 (S3) "Territorial and regional coordination, complex and diversified landscapes for a one health food system" was another option, given the ongoing trend of more diversified and smaller farms. However, the scenario "Global and European food value chains for pesticide-free food markets" seemed to correspond more to the major trends in Tuscany for farm structures and market development opportunities.

Finally, a brainstorming session enabled to translate the hypotheses of the European pesticide-free agriculture scenario "Global and European food value chains for pesticide-free food markets" into hypotheses specific to the Tuscan case study. For this last part, we organized a klaxoon session to gather insights on how the European hypotheses would translate in Tuscany for the durum wheat sector, for each of the four components. The board was divided into four areas representing the four components: cropping systems, food value chain, agricultural equipments, and farm structures. Generic hypotheses of the components were described on the left-hand side of the board, and participants posted suggestions of hypotheses (practices / status / organizations) adapted to the situation in Tuscany in 2050. On the right-hand side, we posted a list of questions to help in the idea generation.

Figure 3 shows an example for cropping systems. The ideas proposed are in the yellow sticky notes (Appendix II presents the klaxon board delivered during this session). Table 6 lists all the ideas generated during this session.

Figure 3: Example of the idea generation process used for gathering hypotheses adapted to Tuscany and durum wheat production in 2050.

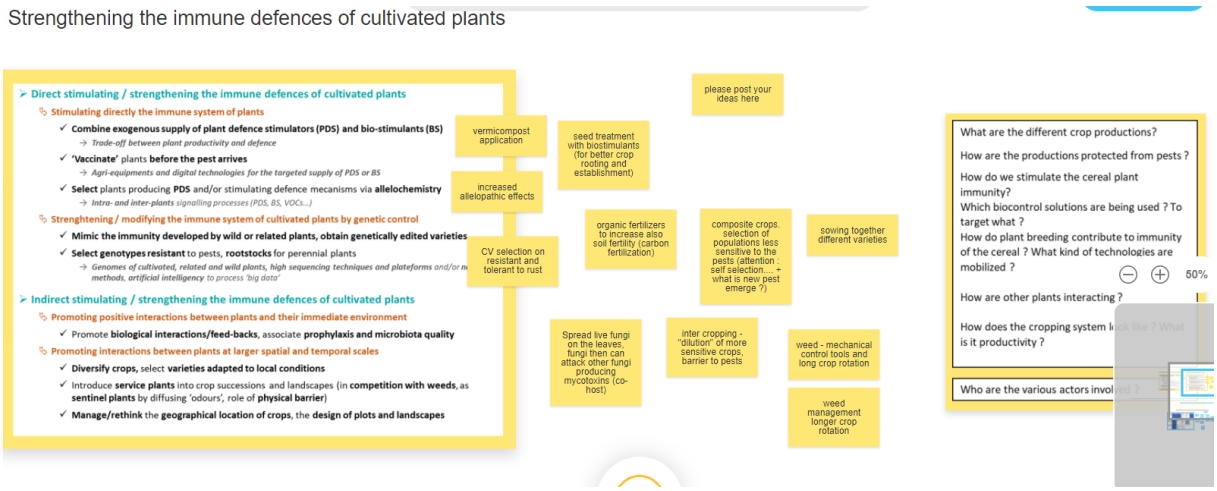


Table 6: List of ideas generated during the brainstorming session on hypotheses for 2050

Cropping systems	**Food value chain and diets**	**Agricultural equipments and digital technologies**	**Farm structures**
vermicompost application	durum wheat and pasta	living labs	family farms remain present
increased allelopathic effects	sorter for seeds, for both crops and quality to allow mix crop and mix CV	user friendly technologies	mix situation between family owned company and stock company
CV selection on resistant and tolerant to rust	consumer's trust on product information would be higher if information come from 3rd parties / independent from the producers of the food	user-friendly tech, lose few time, save time. Big surface to manage	pasta producers own the agricultural lands to control the crop production (have bought abandoned farms)
seed treatment with biostimulants (for better crop rooting and establishment)	independent (public or not) to trace the absence of pesticide residues	save time technologies to manage quickly large surfaces	some banks invest in agri lands
organic fertilizers to increase also soil fertility (carbon fertilization)	data provided: absence of pesticides, pesticide residues	tractor = station driven by the farmer, and connected to other equipments, to autonomous robots nearby	land price is pretty high, lot of capital needed to buy lend, that anyway produce few revenue
Spread live fungi on the leaves, fungi then can attack other fungi producing mycotoxins (co-host)	blockchain technology to trace back to the producer of pasta, durum wheat, origin of the wheat, link to "terroir"	easy control on new tools	Giving up agricultural lands
inter cropping - "dilution" of more sensitive crops, barrier to pests	link product with land and territory (block chain)	reliable predictive modelling for pests	the most professional family farms may rent land for a good price from farm going out of the market and make profit from land, increasing innovation

Table 6 (continued) :

Cropping systems	Food value chain and diets	Agricultural equipments and digital technologies	Farm structures
composite crops. selection of populations less sensitive to the pests (attention: self selection. + what is new pest emerge ?)	pasta is exported in Asia that is now the main consumer	predictive modelling can help AI may increase reliability	family farms remain competitive, taken by young farmers, more access to information, to new technologies, field trials + other sources of incomes (solar panels, side activities)
sowing together different varieties	Italian pasta producers have factories outside Italy	DSS tool services recommended by 3rd parties (public or pasta producers)	family farms rent lands at low price to 10% top innovative large farms
weed - mechanical control tools and long crop rotation	old varieties are now integrated in high value chain production	type of information provided by DSS: seeding time, when to apply fertilizers, which and how much biocontrol solutions...	
weed management longer crop rotation	top quality pasta value chain with durum wheat locally produced with old varieties	interoperability between drones, sensors, DSS and robots	
		more efficiency of preventive methods through monitoring tools, AI	
		data property of all these data ? Farmers should have the right to choose which and how to share the data gathered on their fields Public ownership of the data	
		laws regulates property of data gathered on farm lands	

Building the narrative for a pesticide-free durum wheat agriculture in Tuscany in 2050

Based on the regional hypotheses generated during the regionalization workshop, the foresight team prepared a first version of the regional scenario: a narrative describing the durum wheat production and sector in 2050, without chemical pesticides. In this first version, we highlighted some missing points to get a coherent and clear narrative, and we shared it with the coordinators of the Tuscany case study, in order to have their inputs on (1) the coherence of the scenario with the local situation and crop studies, and (2) the missing parts.

Main points of discussion and additional elements brought to the scenario:

-the value chain in 2050 for pasta was clarified: "*re-fashioned old equipment in the pasta factories with simpler materials integrated in highly automized and digitally controlled production lines*"

-the agricultural equipments and how the digitalization helps farmers work in 2050: *"The use of precision farming is spread and almost all the equipment used for the main operation, from sowing to mechanical weeding until harvesting, are satellite-guided (Isobus etc). Most of the agricultural area is*

under production even if the number of farms is decreased and their size and working capacity is higher".

- discussion about the "chemical pesticide free" standard: is it a market standard (adopted by all actors voluntarily), or is it a regulatory ban? We agreed to keep it as a market standard.

- clarification about the seed varieties used in 2050: seed that are resistant and tolerant to rust, plants that are selected to produce plant defense stimulators for increased allelopathic effects. These also include the use of old varieties with a higher gluten digestibility.

- additional elements related to the fertilization in 2050: application of vermicompost *to fill the gap of the lack of manure in many areas where animal husbandry almost disappeared. The use of mineral nitrogen is limited, especially the one produced from fossil fuels, and the use of organic and organic-mineral complex fertilizer are commonly used. Other fertilizers coming from different byproducts are used instead of the common mineral fertilizers*.

Final Tuscany scenario

Generic scenario: Global and European food value chains for pesticide-free food markets

Tuscany exports its know-how and high quality, pesticide-free durum wheat products on the international food markets.

In Tuscany in 2050 durum wheat is produced without chemical pesticide, in compliance with market standard in place in Europe, and using cutting edge technologies. Durum wheat is used for producing semolina and pasta, delivered to national, European and international markets. Indeed, the high quality reputation of Tuscan durum wheat has spread beyond Italy, and durum wheat processed products are very popular. Export market of Tuscan pasta is very developed in Europe, America, and have reached Asia. In addition to the standard pasta, premium pasta ranges valorize local Tuscan production, with old traditional durum wheat varieties, top quality taste and product attributes. They are produced using re-fashioned old equipment in the pasta factories with simpler materials integrated in highly automatized and digitally controlled production lines.

The main quality assets consumers are looking for are: Tuscan origin, absence of pesticides all across the food chain, seeds varieties, know-how of the Tuscan farmers and of the Italian food chain, but also the worldwide renowned Tuscan quality of life and terroir. Thanks to the blockchain[2] technology, pasta products are fully traceable throughout the supply chains, from the crop to the fork, in a secured, unmodifiable and transparent way. Consumers get access to information including the origin of the durum wheat, seed varieties used (including the use of old varieties with a higher gluten digestibility), agricultural inputs, processing steps, composition of the end product including proof of absence of pesticides. Durum wheat storage facilities are equipped with preventive solutions to avoid development of pests - particularly insects - without using chemical biocides. These include proper cleaning of the facilities, ventilation to reduce grain temperature, or fumigation techniques. To deal with variable quality of durum wheat, production facilities are equipped with seeds sorters that can select the durum wheat grains according to quality criteria, and mix different varieties together.

Durum wheat production happens in large and specialized farms in Tuscan plains. They are equipped with cutting edge technologies that allow farmers to work at very large scale without too much labor forces and with a high working speed, resources optimization and control. The use of precision farming is spread and almost all the equipment used for the main operation, from sowing to mechanical weeding until harvesting, are satellite-guided (Isobus etc). Most of the agricultural area is under production even if the number of farms has decreased. Farms size and working capacity are higher.

[2] A blockchain is a distributed database of records in the form of encrypted blocks, or a public ledger of all transactions or digital events that have been executed and shared among participating parties and can be verified at any time in the future (Antonucci et al, 2019)

Crops are protected from pests without using chemical pesticide. Against fungi, a combination of solutions are available to farmers, in order to strengthen the immune defenses of durum wheat plants. Genetic control is used to select cultivated varieties that are resistant and tolerant to rust, and plants are selected to produce plant defense stimulators for increased allelopathic effects. Seeds are coated with biostimulants for better crop rooting and establishment, or with beneficial microorganisms to induce resistance to fungal diseases caused by Fusarium species. Different varieties of wheat are sowed together in order to form composite crops, more resistant to fungi. Beneficial micro-organisms are spread as biocontrol solutions at various stages of its development, and competitive non-harmful fungi species are sprayed to compete with the species causing diseases. Biostimulants are also sprayed to make durum wheat stronger and more competitive with diseases. Weeds management measures to limit their development include longer crop rotation to break disease and pest cycles and inter cropping selection. Different sowing machines and techniques and highly efficient mechanical weeding equipment can solve the issue of weed-wheat competition. Mechanical control tools are used to destroy weeds and avoid them to go to seed. Application of vermicompost in the plot enriches the soil with beneficial plant growth hormones, nutrients, and beneficial microbes acting against pests, and fill the gap of the lack of manure in many areas where animal husbandry almost disappeared. The use of mineral nitrogen is limited, especially the one produced from fossil fuels, and the use of organic and organic-mineral complex fertilizer are commonly used. Other fertilizers coming from different byproducts are used instead of the common mineral fertilizers.

Farmers use user-friendly technologies to monitor pest developments on the plots and get advice on crop management options. They remain the decision makers, and are helped in their choices by the use of Decision Support System (DSS) tool services. They trust these tools as reliable source of advice on seeding time, fertilizers application time, pests development and use of biocontrol solutions These tools build upon artificial intelligence based on years of observations, and predictive modelling. They are connected with drones, sensors for real time detection of pests, analyse the relationship between pests, potential crop damage, and the efficacy of control measures. The precise application of targeted control decided by the farmer is executed with small autonomously navigating robots. Farmers remain the decision maker through a centralized station connected to the other equipment. These tools are co-developed and supported by different actors in living labs that gather farmers, researchers, digital tools developers, agroequipment providers, pasta producers. The use of remote platforms to communicate with farmers help the advisors to give real-time information to solve problems occurring in the fields. Laws regulate the property and use of these data to ensure proper ownership, access and use.

Table 7: Summary of the scenario for Tuscany and durum wheat production

	Hypothesis
Cropping systems	Durum wheat is protected from pests with solutions that strengthen the plants immune system. They include genetic control, use of biostimulants and of biocontrol solutions to protect against fungi. Mechanical weeding and longer crop rotation are used against weed-wheat competition. Organic and organic-mineral complex fertilizers, as well as fertilizers coming from different byproducts are commonly used.
Agricultural equipment and digital technologies	The use of precision farming is spread and almost all the equipment used for the main operation, from sowing to mechanical weeding until harvesting, are satellite-guided. Farmers are helped in their choices by the use of Decision Support System (DSS) tool services which build upon artificial intelligence based on years of observations, and predictive modelling.
Food value chain	Durum wheat is used for producing semolina and pasta, delivered to national, European and international markets (America, Asia), due to the high quality reputation of Tuscan production. Products include standard pasta and premium pasta ranges valorising local Tuscan production, with old traditional durum wheat varieties, top quality taste and product attributes
Farm structures	Tuscan farms are large and specialized. They are equipped with cutting edge technologies. They require limited labour forces.

VI Workshop to build the transition pathway

Pisa, May 24th, 2022

The facilitators of the workshop were Stefano Carlesi and Giovanni Pecchioni, Istituto di Scienze della Vita, Scuola Superiore Sant'Anna, Pisa, Italy, helped by Claire Meunier, INRAE Directorate for Expertise, Foresight and Advanced Studies.

VI.1- Participants

Participants were selected and invited by Giovanni Pecchioni. They are listed in table 8.

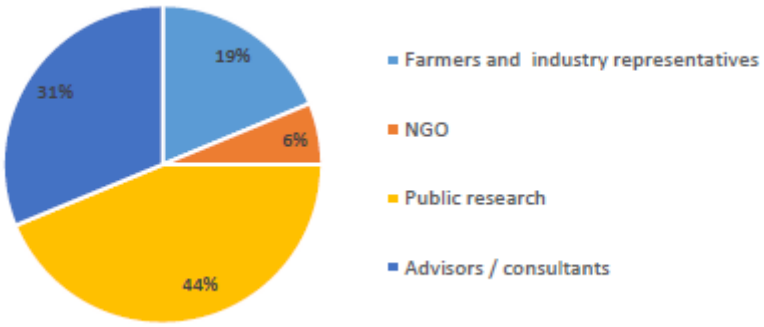
Table 8: List of participants

	Stakeholder	**Organization**	**Name**
1	Science	INRAE	**Claire Meunier**
2	Science	SSSA (Scuola Superiore Sant'Anna, Pisa)	**Stefano Carlesi**
3	Science	SSSA	**Giovanni Pecchioni**
4	Science	SSSA	**Paolo Barberi**
5	Science	SSSA	**Federico Leoni**
6	Science	SSSA	**Alberto Mantino**
7	Science	SSSA	Giaime Berti
8	Science	UNIPI (Università di Pisa)	Daniele Antichi
9	Science	UNIPI	Lorenzo Tramacere
10	Science	UNIPI	Christian Frasconi
11	Science	UNIPI	Marco Fontanelli
12	Technicians/consultants	Fondazione Seminare il Futuro	Federica Bigongiali
13	Technicians/consultants	AEDIT s.r.l. (Company developing ITC tools to support Integrated Pest Management, SSSA spin-off)	Iride Volpi
14	Technicians/consultants	ODAF Pisa, Lucca e Massa Carrara (Ordine dei Dottori Agronomi e Dottori Forestali)	Luigi Casanovi
15	Technicians/consultants	ODAF Pisa, Lucca e Massa Carrara (Ordine dei Dottori Agronomi e Dottori Forestali)	Giacomo Nardi
16	Technicians/consultants	ODAF Pisa, Lucca e Massa Carrara (Ordine dei Dottori Agronomi e Dottori Forestali)	Giovanni Ricottone
17	Cooperatives (farmers associations)	Terre dell'Etruria (Società Cooperativa Agricola tra Produttori)	Francesca Cupelli
18	Cooperatives (farmers associations)	Cooperativa L'Unitaria	Alessandro Bigi
19	Cooperatives (farmers associations)	Confcooperative FedAgriPesca Toscana	Stefano Gori
20	Consumers/NGOs	WWF Italia	Franco Ferroni

Profile of participants:

The workshop gathered a very diverse group of participants (figure 4), There was around 40% of academic scientists, 30% of advisors and technicians, and 20% farmers (cooperatives).

Figure 4: profile of participants



VI.2- Organisation of the workshop

The day of the workshop was divided into different sessions and activities, following the methodology presented in section III (table 9).

Table 9: Main sessions of the workshop

1-Presentation of participants, general introduction of the day
2-Presentation from Paolo Barberi
3-Presentation of the foresight study – context, objectives, method, scenarios
4-Presentation and discussion of the regionalized scenario
5-Identification of milestones, obstacles and opportunities
6-Identification of actions
7-Transition pathways - articulation of actions in a timeline
8-Conclusions, next steps

VI.3- Presentation from Paolo Barberi

Farm to Fork and Biodiversity strategies set 2030 objectives at European level, regarding pesticides reduction (-50% of use and risk of chemical pesticides) and regarding organic development (+30% increase in organic surface for land use). In Italy, if the current trend is followed, there will be 30% reduction in pesticide use in 2030, and 21% reduction of surface cultivated.

The agroecological transitions can be presented as a multiple steps approach which will share the system approach, the strong input reduction, the importance of the agrobiodiversity and the socio-cultural aspects (from Hill and McRae, 1995; Barberi, 2021). These steps will include:

- Precision farming (including use of biopesticides)
- IPM
- Conservation agriculture
- Organic agriculture
- Agroecology

The levels of IPM integration can have an increasing range of tactical components and levels of integration, going through a first level of integration with precision agriculture and cultural tactics, towards a higher level of IPM integration which comprehends also the use of crop-pest models and to reach the highest level of complexity which includes also the multicrop interactions, the agroecosystem processes and the landscape/regional aspects (from F. Norris, University of California, Davis USA).

Crop diversification using alternatives to glyphosate as an herbicide such as a real research case-study implemented in Pisa, Italy (Antichi *et al.*, 2022) includes:

- Durum wheat as previous crop
- Winter over crop (e.g. *Veccia vellutata*)
- Mechanical cover crop termination (roller crimper)
- No-till or direct sunflower seeding into a perennial grass or legume stand (sod seeding)

In this case study given, the legume cover crop (*Veccia vellutata*) devitalized mechanically with roller crimper allows to give 135 kg/ha of N (3-year average) to the soil. Moreover, the sunflower grain yield was 4-5 t DM/ha with no significative differences between the mechanical cover crop termination and the chemical cover crop termination at 100% and 50% glyphosate dose.

The mechanical cover crop termination (roller crimper) allowed also to cut the operational costs to 540 €/ha. The control sunflower cultivation without cover crop and the sunflower cultivation with chemical termination of cover crops resulted in higher operation costs of 583 €/ha and 600 €/ha respectively.

As a concluding remark, for the long-term sustainability and resilience of the agricultural landscapes, an effort to promote the diversity is needed, going from the field scale and the farm scale towards the landscape scale and the regional scale.

VI.4- Discussion points during the workshop

Feedback on the scenario

After a presentation of the scenario, each participants got a copy of it and read it in details, taking notes. The scenario was then discussed in two groups, in order to gather participants insights about their understanding of the scenario (*What are the key words from the scenario? For each of the components)*, the challenges they see (*What are the main challenges around the scenario?)*, its clarity (*How clear is the scenario on a scale from 1 to 5? What can be added to make it more explicit?).*

Each group discussed the whole scenario in sub-groups based on these 4 questions. The facilitators captured the various insights on paperboards, and then a participant debriefed in plenary.

After reading the scenario, both groups put forward keywords related to technologies (table 10): "**technology and innovation", « automation », « automation control », « DSS », « technology costs ».** They also both quoted « farm structures », »**large structured farms** ». They choose keywords related to cropping systems (« specialization ») and especially to breeding (« breeding », « old varieties »), to the supply chain « internationalisation for exports », « product processing », « pesticide free from farm to fork »). They also referred to transversal items such as « **economic sustainability** » of the scenario, the cooperation at various levels (« **horizontal and vertical cooperation** »), « **re-evaluating tradition** ».

Table 10: Keywords quoted after reading the scenario (in green are keywords quoted by both groups)

Group 1	***Group 2***
Specialization	Technology and innovation
Self-awareness	DSS
Supply chain or "death" (of the farms)	Internationalization for export
Automation	Vertical and horizontal cooperation
Breeding	Pesticide free products form farm to fork
Farm structure	Lowland (plains)
Re-evaluating tradition	Large structured farms
Economic sustainability	Old varieties
Internal areas[3]	
Automation control	
Product processing	
Artificial Intelligence	
Technology costs	

[3] in Italian "internal areas" means the areas with higher logistic problems, less developed, far from the communication facilities.

Main challenges of the scenario identified by group 1 and group 2

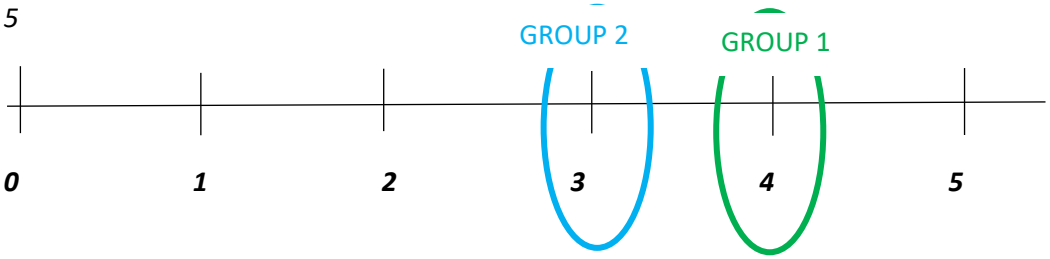
The participants identified several challenges linked to the scenario (table 11). They pointed out the need for education and AKIS for farmers but also for consumers. They also highlighted the rather 'poor' value chain of durum wheat in terms of added value. Without economic sustainability farmers will not be able to invest or experiment new practices. They questioned the importance of technology in the scenario: according to them, automation can pose some risks and will need to be controlled. These technologies also have a cost that may not be affordable to all. The question of traceability was raised as a challenge, linked to the necessary controls. The participants also had some questions about the value chain in terms of product availability to reach the international markets, and the capacity of raw product processing to meeting consumers demand. Finally, the question of 'internal areas', the hilly/mountains areas in Tuscany, was asked: what will these areas be like in 2050?

Table 11: Main challenges identified by group 1 and group 2 with the scenario

Group 1	***Group 2***
Automation: which are the risks and how to control it?	Structure of the food value chain
Without economic sustainability, no in-farm investments or experiments	Product availability (how much?)
Raw product processing and meeting offer/demand	Availability of genetic material (suitable varieties)
What do we do with internal areas? (policies and ideas for the hilly/mountain areas of the region)	Farmers' knowledge
	Consumers' knowledge
	Farmers' age
	Structure and dimension of the farms
	Technologies' cost
	Wheat is a "poor" value chain (in terms of added value)
	European/national/regional policies
	Traceability and verification/control
	Access to land property (or rent) to farm
	Training/technical assistance to farmers

Clarity of the scenario

Figure 5: clarity of the scenario as rated by participants from group 1 and group 2, on a scale from 0 to 5



Both groups considered that the scenario was pretty clearly described in the narrative (rated 3 and 4 out of 5; figure 5). However, they insisted that according to them the scenario was difficult to reach, too idealistic.

They suggested several additions in order to make it clearer. First, they recommended to discuss the status of the uplands (the so-called « colline », referring to the hilly inland areas of Tuscany) in 2050, since they are important part of the landscape in Tuscany. Currently, the "colline" landscapes are very attractive for the tourism; what will be their status in 2050? Both groups would also like the scenario to be completed with information about the future of small farms in the scenario. Indeed, the scenario focuses mainly on the specialization and increase of farm sizes; the evolution and status of small farms in 2050 should further be discussed.

The scenario talks a lot about export outside Tuscany and even internationally. Group 1 recommended that we also address the question of food sovereignty at local level, which is priority before export. Similarly, group 2 proposed to discuss how the competition on the international market will evolve by 2050, considering climate change, the evolution of the production capacities of the other countries…

Group 2 also suggested to complete the scenario by justifying the need for all the technologies used.

Group 1 suggested to consider the place for organic production in the transition towards the scenario.

VI.4- Building the transition pathway

VI.4.1- List of milestones, opportunities and obstacles, and actions

In the two groups, participants studied the scenario in order to identify first the obstacles and opportunities encountered in relation to achieving the Tuscany scenario in 2050, and the milestones required to reach the scenario. Group 1 worked on cropping systems and agricultural equipments components, group 2 worked on food value chain and farm structures components.

Then, in a second session, the same groups worked to define the key *actions* that are needed to reach the desirable future. Each group worked from the backcasting timeline, and, for each of the components, think of the actions needed to: (1) Overcome the obstacles; (2) Size the opportunities; (3) Reach the milestones.

The following tables (tables 12 to 15) present the translation of the participants' contribution to the workshop.

Table 12: List of milestones, obstacles and opportunities, and actions for food value chain

FOOD VALUE CHAIN	**2040**	**2035**	**2025**	**2025**	**2022-->2040**
Milestones	Logistic models using artificial intelligence (blockchain)	Strengthening (Shortening?) the food value chain: from producers to retailers locally planned (regional)	Certification and control labelling	Creation of a participative network on innovation	Contracts for risk compensation and dedicated financial tools
Obstacles	Lack of internet coverage, high costs	Competition on local scale	Rules for applying, higher control on production processes		Higher costs due to climate change
Opportunities	Transparency, planning	Using CAP payments for key investments	Increasing consumers' attention		Economic risk reduction for farms
Actions	Creating investments to promote a better internet network (*EU and Italian government*). *Italian government and Ministry of Education and Agriculture* to plan new technical school at the pace with the newest digital technologies in agriculture	Logistic platforms with the help of digitalization built with a bottom-up approach (starting from the farmers' needs and involving the consumers too)	A set of rules for the production to be set by the *Regional government*. Volunteer certification to ensure the revenues (*food industry and farmers*)	Creating a national AKIS system, free and public (*Italian government*). *University, Regional government and farmers (producers)* to organize a common innovation platform, built with collective contracts, incentives, de-taxations and so on. Creating a public office to organize the AKIS system.	CAP reform in 2028-2035-2042 (*EU and Italian government*) with the aim of protecting the durum wheat production (e.g. Durum wheat common market organization with the model of wine). Aggregate Offer, production planning (*from the industry to the farmers with the help of National and Regional governments*)

Table 13: List of milestones, obstacles and opportunities, and actions for cropping systems

CROPPING SYSTEMS	**2050**	**2040**	**2040**	**2030**	**2020-->2050**
Milestones	+ 1 point soil organic matter	50% of organic fertilizers (non-chemical origin)	Cover crops availability for different pedo-climatic contexts	Promoting biodiversity protection and enhancement planning: longer crop rotations, intercropping, agroforestry, cover crops and other measures	Breeding (from now to 2050 in a continuous process)
Actions	*University* to do research and give long-term data for solid scientific databases to help the policy makers. *Regional government* to write PAC Measures easier to be implemented and more rentable and liked by the farmers. *EU and Ministry of Agriculture* to write laws to promote the circularity/easiness of making the farming systems smarter.	Building a better law system and a lighter bureaucracy to stimulate the organic fertilisers market, with the aim of building a strong and rich circular fertilisers value chain good for all the actors. *Ministry of Agriculture and Ministry of Environment* to write better laws.	Promote the research and the innovation transfer on the cover crops. *University* to study and test on the long term, *farms networks and agronomists* to spread the innovation and to implement the innovations	Building a long-term and ambitious "national agriculture plan" to give fundings for research and for "innovation brokerage" to transfer the innovations. At Regional scale, farms networks (*Regional government*). *All the actors to be involved in the process*	Promote the research and the innovation transfer through a long-term and ambitious "national agriculture plan".

Table 14: List of milestones, obstacles and opportunities, and actions for agricultural equipments and digital technologies

AGRICULTURAL EQUIPMENTS AND DIGITAL TECHNOLOGIES	**2050**	**2030**	**2030**	**2025**	**2025**
Milestones	New professional role of the farmer	50% of arable land with precision agriculture	Simpler and integrated DSS (common language, common platforms)	Build a network of pilot farms and networks of farms for knowledge transfer	Incentives with de-taxation of equipment, input, technology
Actions	Create new roles of "innovation brokers" (agronomists, farmers, technicians) to deliver the innovations. *University and farmers' unions* to promote training and to spread the innovations. *EU* to finance and create these new figures	Collective organisation of innovative machineries trials, to let every type of farm to have access to the cutting-edge technologies. Agronomists professional organisation to do training among agronomists who spread the digitalisation in the farms. *Banks to give access to loans for young farmers.* Cooperatives/farms' networks *to buy, to lend or to have free trials of innovative machineries*	Connecting software specialists and specialists in agriculture. *EU* give funding to digitalisation projects. *Agronomists professional organisation* do training among agronomists who spread the digitalisation in the farms	Networks of farms to be built in a mix of public and private farms. Selection of the farms (*farmers' unions*), funding from the *Regional policy makers*, *farms* who want to be involved	Funding to research to set the standards; writing laws to promote investments in equipments (*Ministry of agriculture*)

Table 15: List of milestones, obstacles and opportunities, and actions for farm structures

FARM STRUCTURES	**2045**	**2040**	**2040**	**2035**	**2025-->2050**
Milestones	Export marketing plan (regional)	Farms' digitalization	Farmers generational turnover	Cooperative and networks structures for farms	Territorial public technical assistance (AKIS)
Obstacles					Lack of experienced teachers/technicians, conflict of interests with farmers' unions
Opportunities					Already an interest on CAP policies (measure 16)
Actions	Starting from the schools (public schools' canteens with local products). *EU and Regional government* to give funding (Operational groups and others) for food value chains integration and to promote the multi-actor approach	*See "logistic models" on food value chain*	Building politics for setting a higher life standard in the rural areas (services, attractivity and so on). *EU and Italian government* to write laws and set rules related to rural areas.	Building a reduced number of cooperatives to not leave the farmers alone to trade and to set farmers (aggregate the offer to have a higher commercial power). *Italian government* to write rules to promote the creation of these cooperatives, *farmers* to accept these new structures and make them effective	*See other plans written in agricultural equipments and food value chain*

VI.4.2- Discussion points about the milestones and actions

Group 1: working on components cropping systems and agricultural equipments/digital technologies

Breeding is very important all across the transition, to develop varieties with multiple tolerance to pests. It is a continuous process from now to 2050, supported by a long term and ambitious "national agriculture plan" to promote research and innovation transfer, funded by the national government.

By 2030, cropping systems have evolved in favor of **promoting biodiversity protection and enhancement planning**, with longer crop rotations, intercropping, agroforestry, and cover crops implementation. This is as an outcome of the "national agriculture plan" for research and for 'innovation brokerage' to transfer the innovations, including at regional scale through farms networks.

In 2040, use of **organic fertilizers** has increased to reach 50% of total fertilizers use, incentivized by public policies and regulations to stimulate the organic fertilizers market growth.

In 2050, in **Tuscany rate of soil organic matter** has increased by one point in comparison with its content in 2022, as an outcome of previous milestones, research programs, and Common Agriculture Policy (CAP) measures for easier farmers' adoption.

Use of agroequipment and digital technologies progress during the transition: very early in the transition, farmers' access to these technologies is facilitated by **de-taxation**. Research and innovation investments are supported by national regulations. A network is created to connect pilot farms with farms for knowledge transfer, funded by the region.

In 2030 a **Decision Support System tool** is adopted by farmers. It has been created by a joint work of software specialists and agriculture specialists, with EU funds to digitalization projects.

In 2030 50% of arable land is using **precision agriculture**. Farmers have been trained by agronomists, and financed by banks loans. Cooperatives have bought the machinery and lend it to farmers for free trials of innovative machines.

In 2050, there is a **new professional role for farmers as "innovation brokers**", who deliver innovations adapted to needs of Tuscany durum wheat production.

Group 2: working on components food value chain & diet, farm structures

The value chain and its actors are very important in the transition.

In 2050, Tuscany durum wheat is a fully integrated and structured sector.

As of now, contracts are implemented for farmers, to compensate for extra-costs due to the transition towards chemical pesticide free products, and due to climatic events. Management of risks is shared across the sector (economical risks, resources,).

Also, for creating a pesticide-free standard, market requires certification, information on labels, to valorize with consumers the 'premium' quality of Tuscany products. It will also require controls. A set of criteria is defined by the government (and EU ?). Certification is voluntary and is a way to ensure higher revenues for the farmers and the food industry.

Technical assistance must be developed a lot to deal with a much more complex system, oriented towards technologies, diversification, DSS… Diffusion of knowledge to the farmers. This is enabled by the creation of a participative network on innovation. This is a national AKIS system, free and public, gathering universities, farmers, producers, that organizes common innovation platforms, collective contracts, incentives for adoption of innovation, de-taxation, …

The aggregate offer is very important.

By 2040, logistics models using artificial intelligence are implemented, such as blockchain. They ensure full traceability from the crop to the fork. This is enabled by public investments to improve the internet network all across the region. Also, a technical school trains future experts in newest digital technologies in the whole food system.

Ultimately, there is a full integration of the whole sector, also including the supply chain (logistic),

VI.4.3- Transition pathway towards chemical pesticide-free durum wheat production in Tuscany

In the last session of the workshop, the two groups gathered in order to build the transition pathway. They were asked to organize chronologically the milestones and actions as identified in the previous sessions, and articulate them logically in the timeline. We did not split the system in components anymore but instead, at the reverse, each sub-group discussed first the link between the different milestones, and then the link to their related actions. A series of milestones connected together with their actions form a transition pathway.

Working simultaneously on all the components of the system, participants were asked to complete a blank backcasting timeline, starting from the milestone closest to 2050, and to discuss in the group which milestone – or which milestones - it is connected to. They repeated the task with other milestones until they reached year 2020. This provided a series of milestones connected together. Then they picked another milestone close to 2050, and repeated the exercise in order to build a second series.

In practice, a short group of people selected some milestones from the different components, and tried to articulate them on the backcasting timeline. The rest of participants looked at the timeline and were discussing or challenging the order proposed by the small group. They worked first on the general chronology, and then on the logic, i.e. the connection between the different milestones ("this milestones leads to this milestones, to these milestones….). It was an iterative process, as several attempts were necessary to build the connections between the milestones. When an agreement was reached on the connection between two milestones, one participant connected them with masking tape.

At the end of the session the group gathered around the pathway and the facilitators asked whether some additional milestones were needed. This allowed to re-organize slightly some milestones, but no other milestone was generated.

After the workshop, the transition pathway was translated and transcripted on an excel document (version 0 of the transition pathway). Then, this version was studied by the foresight team, considering the logic, and coherence with the scenario. This allowed to build a second version of the pathway, where:

- We reclassified with new colors the milestones related to public policies, governance, and education & AKIS;
- While keeping the order and year allocated for each milestone (and actions), we have re-organised the pathway to make it easier to read;
- We proposed to make some modifications to the milestones, in order to be closer to the scenario;

This revised version (appendix 4) of the pathway was shared with the Tuscany case study coordinators, and discussed during a meeting in September.

VI.5- Final version and narrative of the transition pathway towards chemical pesticide-free durum wheat production in Tuscany by 2050

The revised version of the transition pathway has been discussed with the Tuscany coordinators on September 12th, in order to get their overall feedback and complete it with pending questions.

- **Overall feedback from the Tuscany coordinators**

Tuscany coordinators considered that the transition pathway presented was clear, logical. They found that the outcomes of the workshop were fairly kept.

- **Discussion on how to include milestones "50% use of organic fertilizers" +1 point in soil organic matter content"**

These 2 milestones are important as part of the transition. They are linked to biodiversity enhancement, adoption of agro-ecological systems less dependent on chemical inputs (fertilizers and pesticides). Several actions can lead to these milestones, such as residues management of the durum wheat crops (wheat straws), longer crop rotations with introduction of crops such as alfalfa, use of pellets from manure (there will likely be only residual animal farms in Tuscany by 2050, but these pellets from manure could come from other regions in Italy). Based on these comments it was decided to connect the 2 milestones to the milestone linked to biodiversity.

- **Discussion on the role of precision farming in the transition**

The adoption of precision farming allows a more efficient use of pesticides. It also allows farmers to start thinking about other farming practices, test new solutions. Precision farming provides farmers with more capacity to manage their fields, with for example mapping of the soil, precision mechanical weeding, …. For this reason, it is an important milestone in the transition towards pesticide free durum wheat production. On the contrary, complete redesign strategies could face resistance from farmers as they require too big changes in their practices. It was therefore decided to add a milestone after the milestone on precision farming to clarify its role and impact in the transition.

- **Discussion on the articulation between private companies and public policies supporting the transition**

In the 2050 Tuscany scenario, an integrated durum wheat value chain dominates the pesticide free market with large actors (farmers – processors – retailers). In the transition, a majority of the actions proposed are financed by public funds, at regional (Tuscany), national (Italy) and EU levels. There was a discussion on the articulation between private and public initiatives within the transition. The outcome was that public policies put some incentives or even mandatory targets, then adopted and implemented by private organizations.

- **Discussion on the digitalization all along the transition**

Digitalization is core to the 2050 scenario and the transition pathway. There was a discussion on how to be more precise on the development and usefulness of these digitalization tools within the transition. To summarize, the development of digital tools for monitoring enable the collection of a lot of data each day, that can be compiled into big databases, for developing predictive models. With these predictive models based on artificial intelligence, Decision Support Systems are developed to advice farmers on the application of preventive methods. These DSS can be promoted by downstream actors such as durum wheat processors, who will contract with farmers provided that they use these tools. Ultimately, robots are able to act at each plant in order to provide the most accurate applications. It is important to note that farmers remain the decision makers on how to use these technologies, where to position them, etc… they manage the mobile applications, the DSS, the

positioning of the robots. Also, law must regulate property, access and use of all the data collected. The transition pathway will be completed according to this information.

The final version (figure 7) of the transition pathway has been shared with the workshop participants for inputs. A narrative accompanying the transition pathway has been prepared and is presented below, together with a summary version of the transition pathway in the form of a diagram (figure 6).

As of 2022, private food companies set standards for chemical pesticide free production and processing of durum wheat (sustainability commitments, goals, timings, …). In exchange for compliance with their production standards, food processors provide contracts for risk compensation to farmers. They join the participative innovation network created by the Italian government, that gathers farmers, producers and researchers. This network allows to build common innovation projects, to co-develop solutions such as the removal of pesticide use in grain storage units, and the transfer knowledge. This innovation network is connected to a farmers' network of pilot farms funded by the Tuscan region, that experiments solutions proposed in the innovation network.

Thanks to these networks and strong AKIS system in place, farmers adopt new practices towards less use of chemical pesticides, according to the standards set by private companies. From 2025, a long term and ambitious « national agriculture plan » provides fundings for research and innovation brokerage to farmers. An important breeding program is financed through this plan, and lasts all along the transition. New and traditional durum wheat varieties are issued out of this program and proposed to farmers. They combine several criteria and in particular a strengthened immunity allowing multiple tolerance to pests. They are also adapted / resilient to climate change (drought, extreme events). Also, cropping systems evolve to be more adapted to reduced chemical pesticide use, promoting biodiversity and the interactions between the cultivated plants and their environment. This includes the introduction of intercropping, agroforestry, and cover crops, after successful testing through the network of pilot farms. Also, longer crop rotations are implemented, including crops such as alfalfa, which, together with the increased use of organic fertilizers, and crop residue management, contribute to the restoration of soil health and increased percentage of soil organic matter. Alternative solutions to chemical pesticides are developed by biocontrol companies, and implemented progressively after testing through the pilot farms.

Digitalization of farms facilitates the transfer of knowledge and innovations to farmers. As of 2022, the Italian government invests for fast broadband connection coverage in rural areas, accelerating the development of digital and knowledge skills in Tuscan rural areas. A new technical school is created to train future professionals at the pace with the newest digital technologies in agriculture. These professionals spread digitalization among farms. Adoption of new tools is promoted by public funds (de-taxation, incentives) and private loans provided by banks. Monitoring tools such as sensors, drones, collect many information in the fields, that are compiled in big databases, and enable the development of forecast models. These are then turned into DSS tools advising farmers about the best preventive methods to apply on fields. Cooperatives buy and lend new machineries and digital tools to farmers who try them and adopt successful solutions. In 2030, 50% of arable land practice precision agriculture. This allows the most efficient use of pesticides. It also gives farmers more capacity to manage their fields and mobilize technologies, thanks to mapping of the soil, precision mechanical weeding, application of targeted biocontrol solutions, … By 2037, robots act on each plant, and are managed by farmers who remain the decision-makers on their most efficient and safe use.

Farms continue to grow in size and to specialize. They gather into a smaller number of big cooperatives or network of farms, in order to aggregate their product offer, and trade them on national and

international markets. The endorsement of high pesticide-free production standards set by food processing companies gives a competitive advantage to Tuscany durum wheat producers on the market. This is acknowledged by a voluntary certification scheme « high quality Tuscan pesticide-free durum wheat ». In 2040, 80% of Tuscan farms produce pesticide free wheat. By 2035, the durum wheat value chain is integrated from farmers/producers, to retailers. This vertical integration (coordination) of the durum wheat supply chains has advantages for farmers (share of risks, access to distant markets, stable revenues) and for processors (guarantees of products delivery and respect of production standards). The digital tools in place enable the set up of efficient logistic platforms. In 2040, blockchains integrate data from the crop to the fork in a secured, unmodifiable and transparent way. Durum wheat farming attracts new generation of farmers who are interested by the high life standards in Tuscany rural areas, as a result of strong public policies and investments into rural development. These new farmers are on point with new digital technologies in agriculture, and well integrated in the durum wheat value chain. They act as "innovation brokers" who lead the way for Tuscany national and international market growth and reputation of high quality, pesticide-free durum wheat products.*

Figure 6: Target diagram summarising the key transition steps in the transition pathway of Tuscany towards chemical pesticide-free durum wheat production by 2050

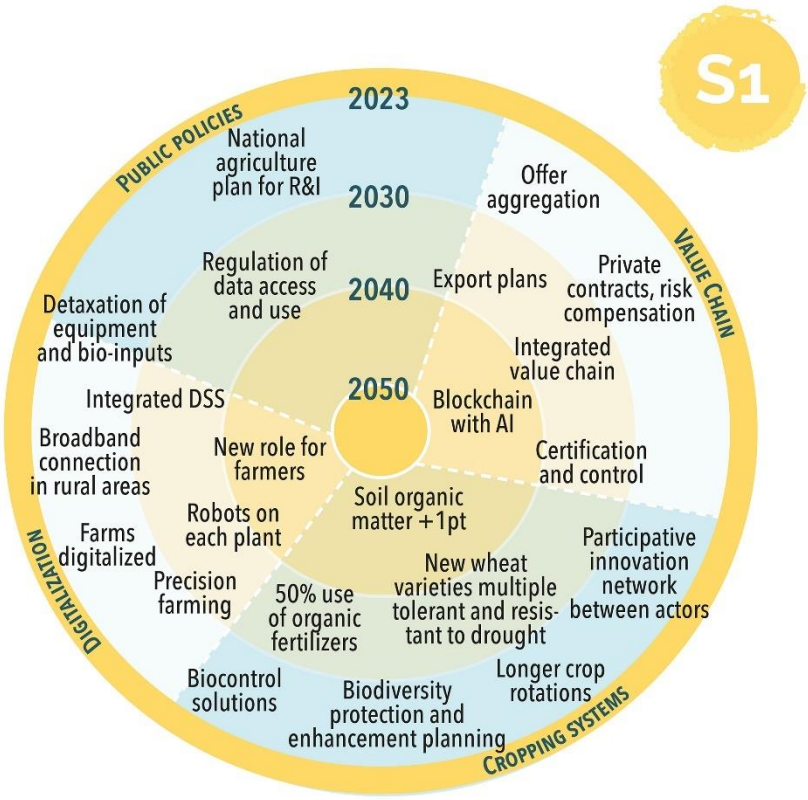
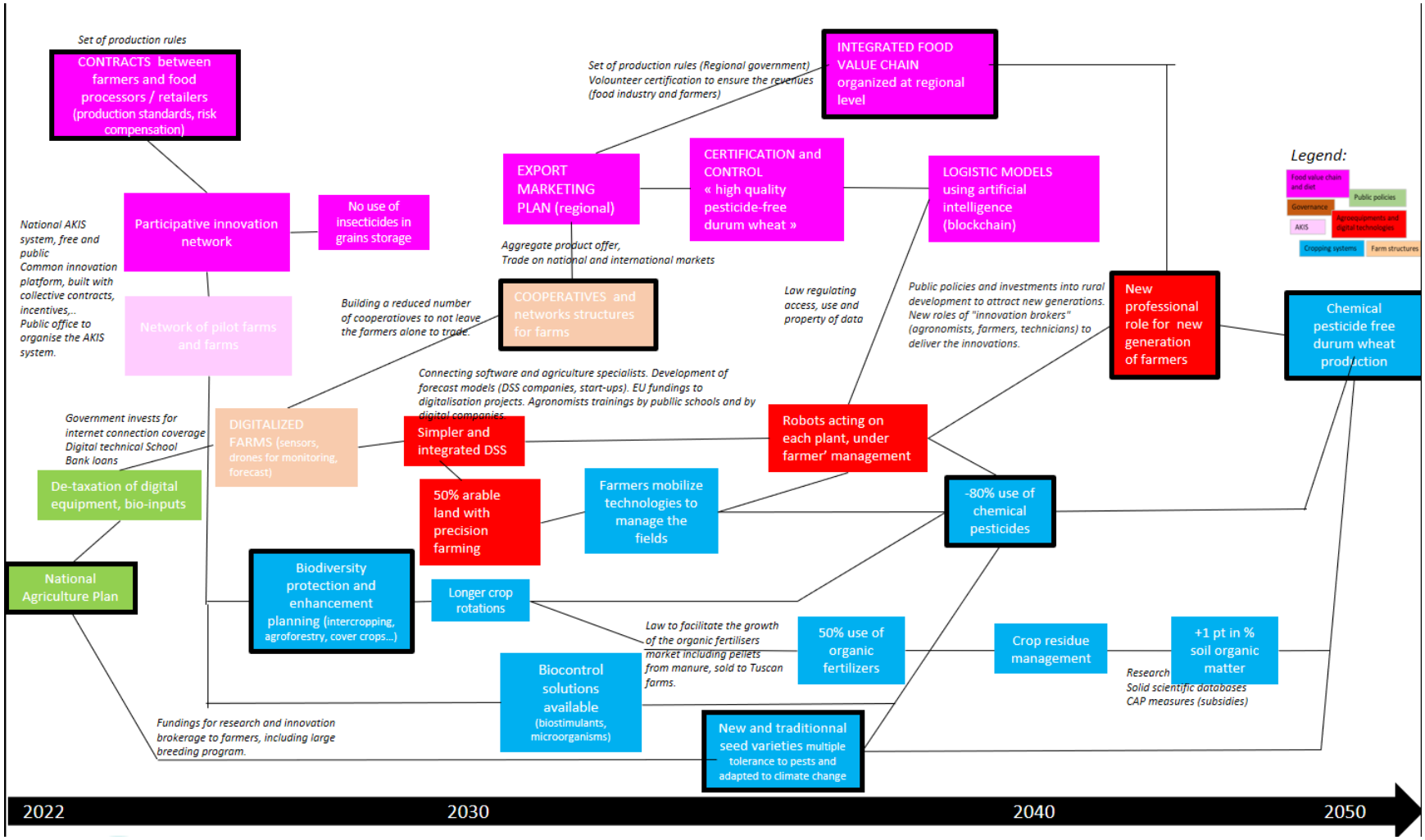


Figure 7: Simplified transition pathway for durum wheat production without chemical pesticides in Tuscany



VI.6- Overall feedback from the participants

At the end of the workshop we had an open discussion about the day with the participants, to gather their feedback and discuss potential next steps. The main points highlighted by the participants are summarized below.

They found the methodology interesting and imaginative, that could be used and duplicated for other topics, and be presented to the Tuscany region representatives. Foresight has already been used by the region Tuscany to build their biodiversity strategy.

They regretted that no representative of the authorities of the Tuscany region attended the workshop, although there were invited. In terms of public policies, the future CAP reform (2023-2027) will not help with the 2050 Tuscany scenario (vision). Foresight can only be implemented as of 2028 with the next CAP reform.

In all the transition, training is extremely important.

It would have been helpful to involve experts in the transformation of durum wheat (milling, flour, pasta) to complete the work on the transition pathways.

They also discussed How to use this work, by publishing a local report of the case study, by meeting again in 6 months? 1 year?, and working on a scientific publication.

VI.7- Feedback from the workshop facilitators

What worked well:

- The preparation ahead of the workshop and especially the day before, so that we are all familiar and comfortable with the different activities ;
- The participants : their expertise, very complementary; almost everyone took multiple times the floor (thanks also to the separation in two smaller groups) and gave his contribution from his point of view/expertise, which were very differentiated;
- The backcasting methodology and step by step approach ;
- The workshop setting : nice and large room, informal atmosphere but still on the topic, with a professional approach
- The material for the workshop;
- The facilitation: very active, numerous contributions to the discussions, high level of energy

What could be improved:

- The time keeping or extend the meeting to one additional hour
- The plenary sessions : give more time for each group to report on their ideas
- Sending the scenario ahead of the workshop, to let the ones who had the chance to do it to send questions and remarks instead of rising questions directly on the day
- The one-day workshop was a tough job, and many activities had to be explained. We could have enjoyed more short breaks, a shorter lunch break and to go straight to the point and finish more on time.

References

Adeux, G., Munier-Jolain, N., Meunier, D., Farcy, P., Carlesi, S., *et al.* (2019). Diversified grain-based cropping systems provide long-term weed control while limiting herbicide use and yield losses. Agronomy for Sustainable Development, 39 (4), 1-13. https://doi.org/10.1007/s13593-019-0587-x

Amici, S., Carlo Rossi, Primi. (2012). Increase in crop damage caused by wild boar (Sus scrofa L.): the "refuge effect". Agronomy for Sustainable Development, 32 (3), 683-692. https://doi.org/10.1007/s13593- 011-0057-6

Antichi, D., Carlesi, S., Mazzoncini, M., Bàrberi, P. (2022). Targeted timing of hairy vetch cover crop termination with roller crimper can eliminate glyphosate requirements in no-till sunflower. Agronomy for Sustainable Development, 42. https://doi.org/10.1007/s13593-022-00815-2

Arcuri, S. (2022) MAP Position Paper (Tuscany, Italy) - Alternative rural futures (foresight) DOI: 10.5281/zenodo.5920889.

Bianchi, A. (1995). Durum wheat crop in Italy. In : Di Fonzo N. (ed.), Kaan F. (ed.), Nachit M. (ed.). Durum wheat quality in the Mediterranean region . Zaragoza : CIHEAM, p. 103-108 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 22)

Bresciani, A., Pagani, M.A., Marti, A. (2022). Pasta-Making Process: A Narrative Review on the Relation between Process Variables and Pasta Quality. *Foods*, *11*, 256. https://doi.org/10.3390/foods11030256.

Carillo F. (2016). Vertical integration in Italian pasta supply chain: A farm level analysis. Rivista di Economia Agraria, Anno LXXI, n. 1: 47-66.

CREA (2020). Research Centre for Agricultural Policies and Bioeconomy. Italian agriculture in figures, 2020.

De Koning, S., de Haas, W., de Roo, N., Kraan, M., Dijkshoorn-Dekker, M. (2021). Tools for Transitions; An inventory of approaches, methods and tools for stakeholder engagement in developing transition pathways to sustainable food systems. Wageningen, Wageningen Marine Research, Wageningen Marine Research report C001/21.

De Vita, P., Matteu, L., Mastrangelo, A. M., Di Fonzo, N., & Cattivelli, L. (2007). Effects of breeding activity on durum wheat traits breed in Italy during the 20th century. Italian Journal of Agronomy, 2(s4), 451–462. https://doi.org/10.4081/ija.2007.4s.451

Dreborg, K.H. (1993). Essence of backcasting. Futures, Vol. 28 ; N°9, 813-28.

Elzen, B., Haas, W. de, Wigboldus, S., Bos, B. Dijkshoorn – Dekker, M. (2019). Transition Pathways Contours of an Analytical Framework. Wageningen Research, Report WPR-839. https://doi.org/10.18174/525092.

European Commission (2020). Commission recommendations for Italy's CAP strategic plan *Accompanying the document* COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Recommendations to the Member States as regards their strategic plan for the Common Agricultural Policy.

Hill S., MacRae R.J. (1995). Conceptual Framework for the Transition from Conventional to Sustainable Agriculture. Journal of Sustainable Agriculture vol 7 (1).

Hines, A., Schutte, J., Romero, M. (2019). Transition Scenarios via Backcasting. Journal of Futures Studies, 24(1): 1–14.

Kok, K., van Vliet, M., Bärlund, I., Sendzimir, J., Dubel, A. (2011). Pan-European backcasting exercise, enriched with regional perspective, and including a list of short-term policy options. SCENES Deliverable 2.10. Wageningen University, Wageningen. Available online at www.environment.fi/syke/scenes.

ISTAT (Italian National Institute of Statistics) database: http://dati.istat.it/Index.aspx.

Lazzaro, M., Bàrberi, P., Dell'acqua, M., Pè Mario, E., Limonta, M., *et al.* (2019). Unraveling diversity in wheat competitive ability traits can improve integrated weed management. Agronomy for Sustainable Development, 39, 6. https://doi.org/10.1007/s13593-018-0551-1

Leoni, F., Lazzaro, M., Ruggeri, M., Carlesi, S., Meriggi, P., Moonen, A.C. (2022). Relay intercropping can efficiently support weed management in cereal-based cropping systems when appropriate legume species are chosen. Agron. Sustain. Dev., 42, 75. https://doi.org/10.1007/s13593-022-00787-3

Nassi o Di Nasso, N., Bosco, S., Di Bene, C., Coli, A., Mazzoncini, M., Bonari, E. (2011). Energy efficiency in longterm Mediterranean cropping systems with different management intensities. Energy 36, 1924e1930.

Pecchioni G., Bosco S., Volpi I., Mantino A., Dragoni F., Giannini V., Tozzini C., Mele M. and Ragaglini G. (2020). Carbon Budget of an Agroforestry System after Being Converted from a Poplar Short Rotation Coppice. Agronomy, 10, 1251. https://doi.org/10.3390/agronomy10091251

Robinson J. (1982). Energy backcasting A proposed method of policy analysis. Energy policy; 337-344.

Scarabel, L., Panozzo, S., Loddo, D., Mathiassen, S.K., Kristensen, M., Kudsk, P., Gitsopoulos, T., Travlos, I., Tani, E., Chachalis, D. and Sattin, M. (2020). Diversified Resistance Mechanisms in Multi-Resistant Lolium spp. in Three European Countries. Front. Plant Sci., 11, 608845. https://doi.org/10.3389/fpls.2020.608845

Sherpa (2020). LONG-TERM VISION FOR RURAL AREAS: CONTRIBUTION FROM 20 SCIENCESOCIETY-POLICY PLATFORMS. MAP discussion paper.

Van de Kerkhof, M., Wieczorek, A. (2005). Learning and stakeholder participation in transition processes towards sustainability: Methodological considerations. Technological Forecasting and Social Change, vol. 72, no. 6 SPEC. ISS., pp. 733-747.

Xynias, I.N., Mylonas, I., Korpetis, E.G., Ninou, E., Tsaball,a A., Avdikos, I.D. and Mavromatis, A.G. (2020). Durum Wheat Breeding in the Mediterranean Region: Current Status and Future Prospects. Agronomy, 10, 432. https://doi.org/10.3390/agronomy10030432

APPENDICES

APPENDIX 1 – Pictures from the workshop

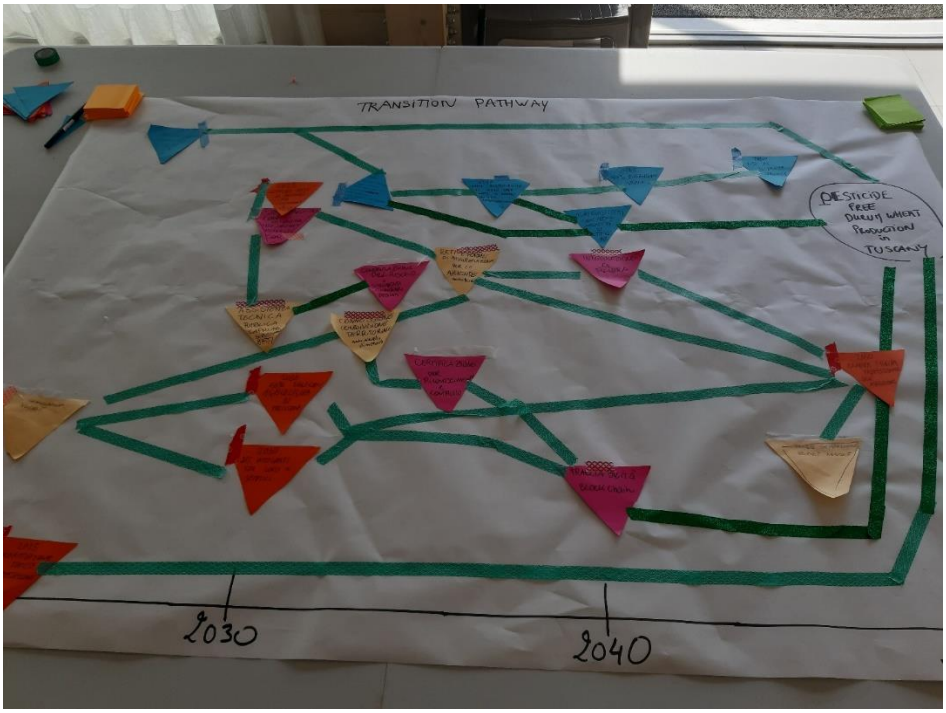
1.1- Backcasting template from group 1 – cropping systems and agricultural equipments (obstacles and opportunities could not be identified in this group because of lack of time)

1.2- Backcasting template from group 2 – food value chain and farm structures

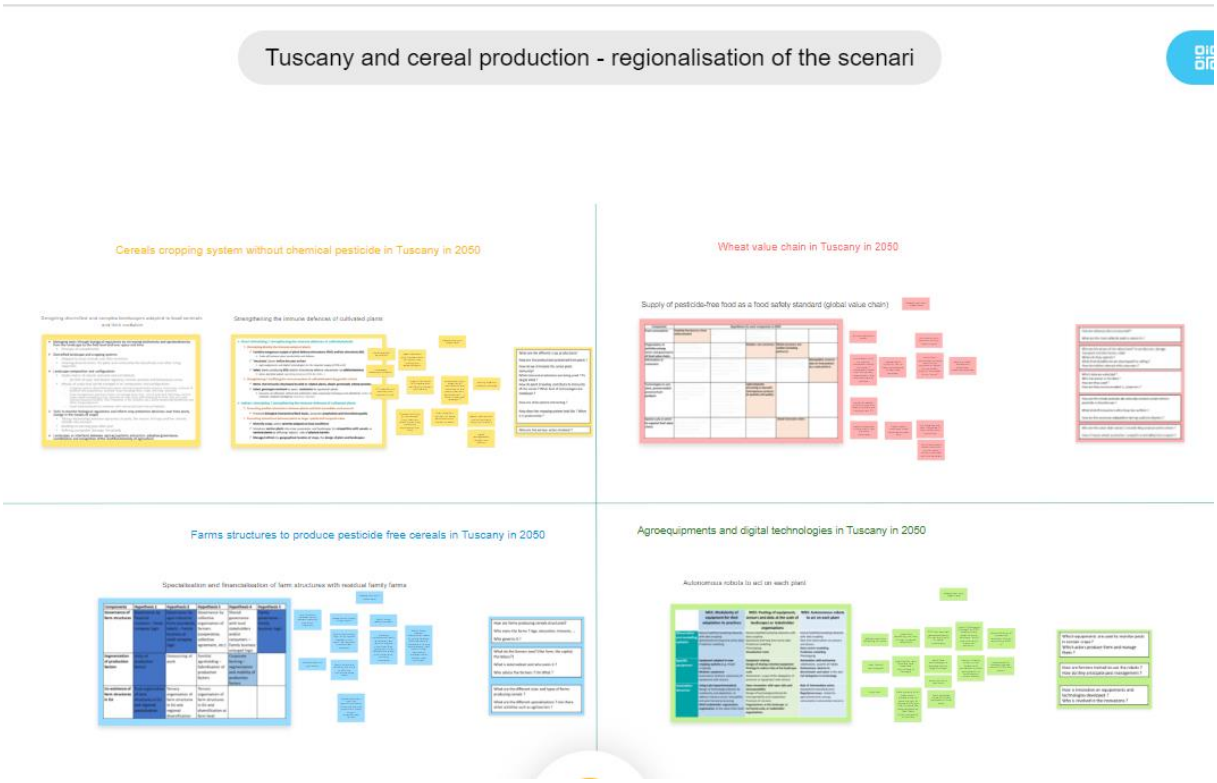
1.3- Backcasting template including list of actions from group 1

1.4- Backcasting template including list of actions from group 2

1.5- Transition pathway produced at the end of the workshop

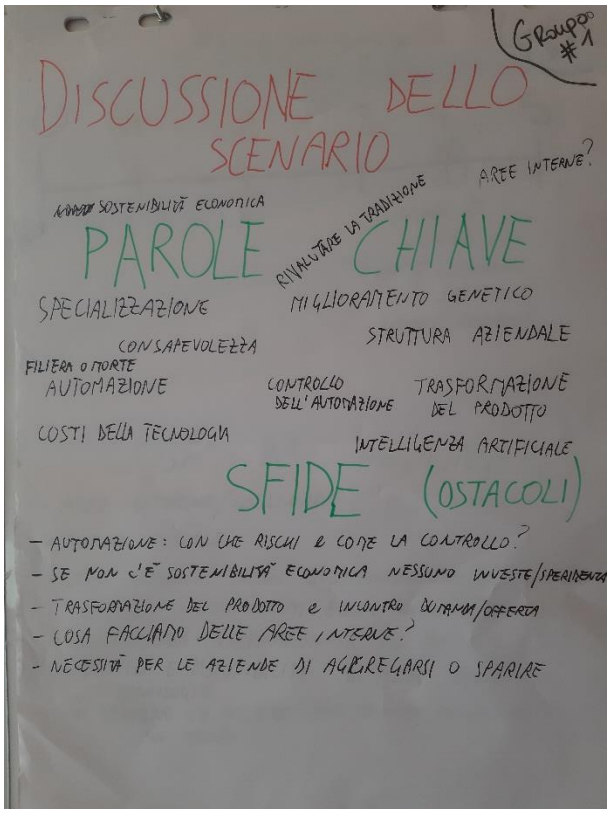


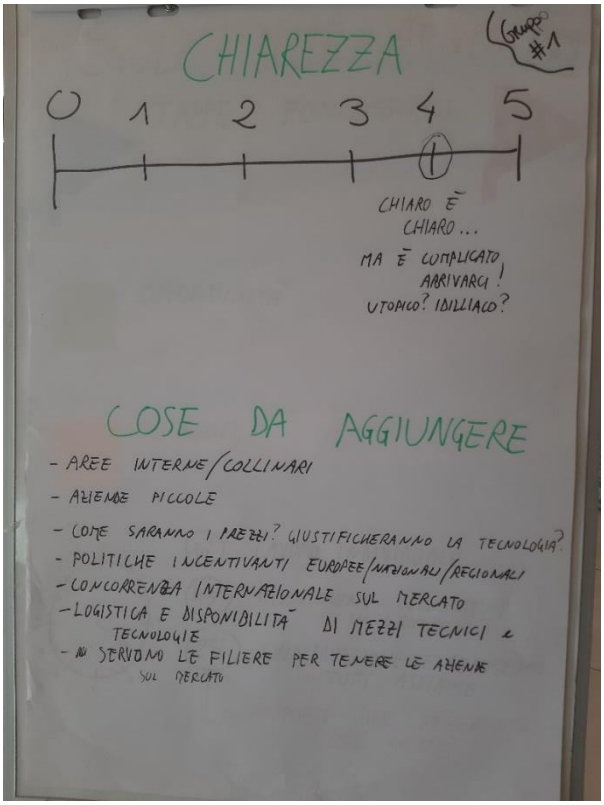
APPENDIX 2 – Overview of the klaxon page generated during the "regionalization meeting"



APPENDIX 3 – Detailed discussion about the scenario

Group 1 discussion over the scenario





KEYWORDS

Specialization

Self-awereness

Supply chain or "death" (of the farms)

Automation

Breeding

Farm structure

Re-evaluating tradition

Economic sustainability

Internal areas?

Automation control

Product processing

Artificial Intelligence

Technology costs

CHALLENGES

Automation: which are the risks and how to control it?

Without economic sustainability, no in-farm investments or experiments

Raw product processing and meeting offer/demand

What do we do with internal areas? (policies and ideas for the hilly/mountain areas of the region)

An urge (necessity) by the farms to aggregate (gather) or to disappear

CLARITY OF SCENARIO : 4 out of 5

(it is a clear scenario but it is difficult to reach, too idealistic)

SUGGESTED ADDITIONS

Internal areas or hilly areas

Small farms

How the commodities/products prices will be? Will they justify/permit the use of technologies)

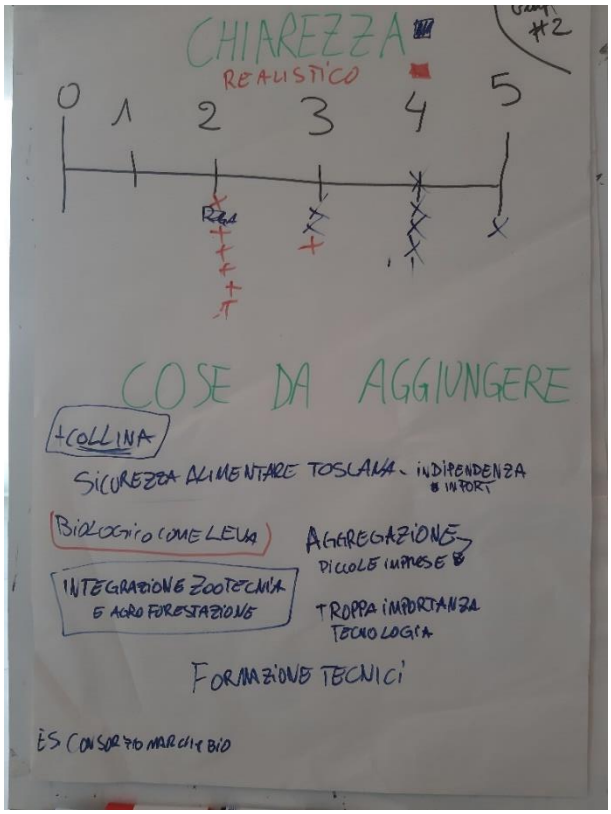
European/national/regional policies to incentivize the transition

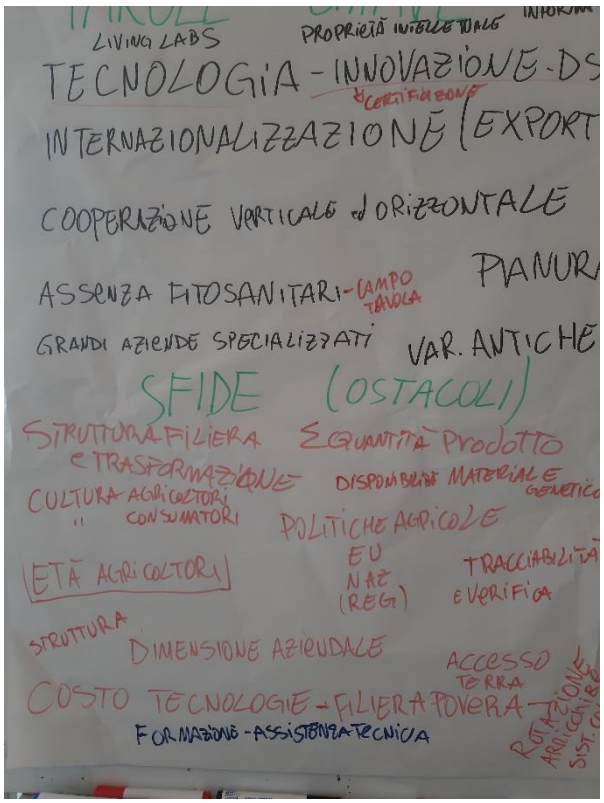
International competition on the market

Logistic and availability of technologies and input

Necessity to build food supply chain to keep the farms on the market

Group 2 discussion over the scenario





KEYWORDS

Technology and innovation

DSS

Internationalization for export

Vertical and horizontal cooperation

Pesticide free products form farm to fork

Lowland (plains)

Large structured farms

Old varieties

CHALLENGES

Structure of the food value chain

Product availability (how much?)

Availability of genetic material (suitable varieties)

Farmers' knowledge

Consumers' knowledge

Farmers' age

Structure and dimension of the farms

Technologies' cost

Wheat is a "poor" value chain (in terms of added value)

European/national/regional policies

Traceability and verification/control

Access to land property (or rent) to farm

Training/technical assistance to farmers

CLARITY OF SCENARIO : 3 out of 5

SUGGESTED ADDITIONS

Internal areas (hilly areas)

Organic labelling as a leverage

Organic labels consortium

Integration with animal husbandry and agroforestry

Farms' aggregation

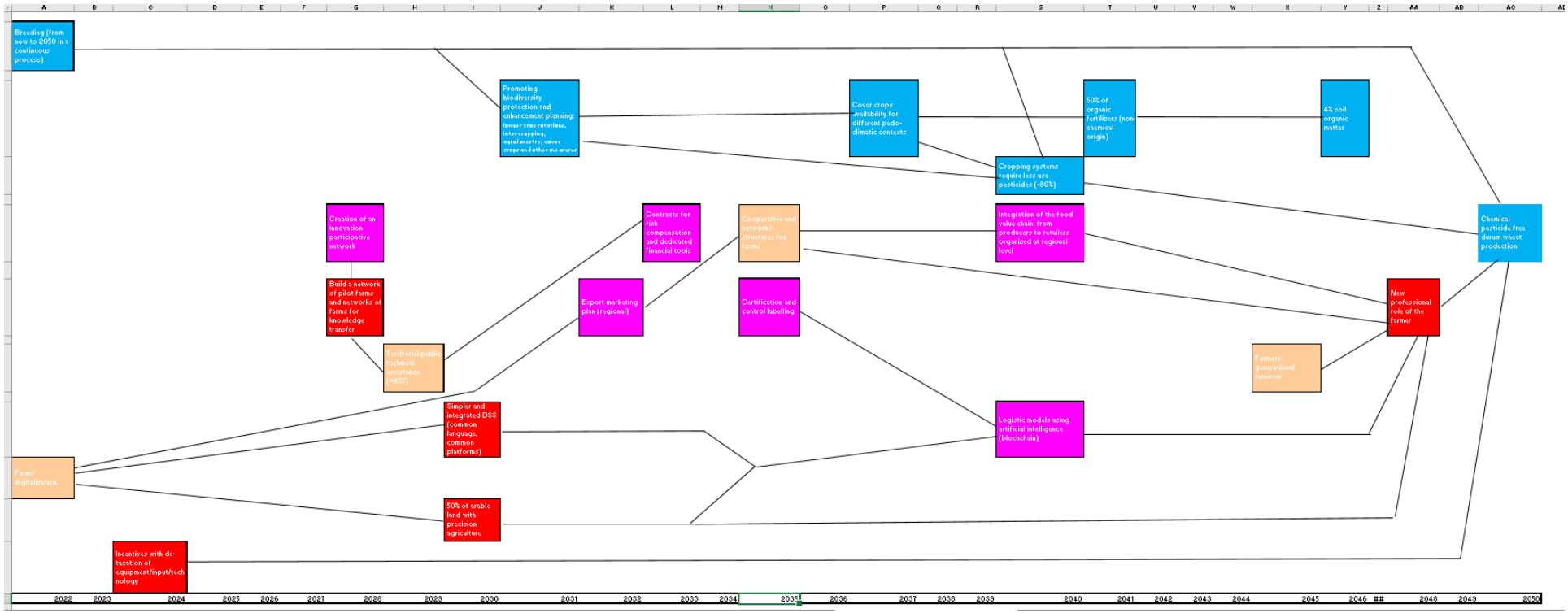
Regional food security (reducing import dependency)

Too much importance to technology

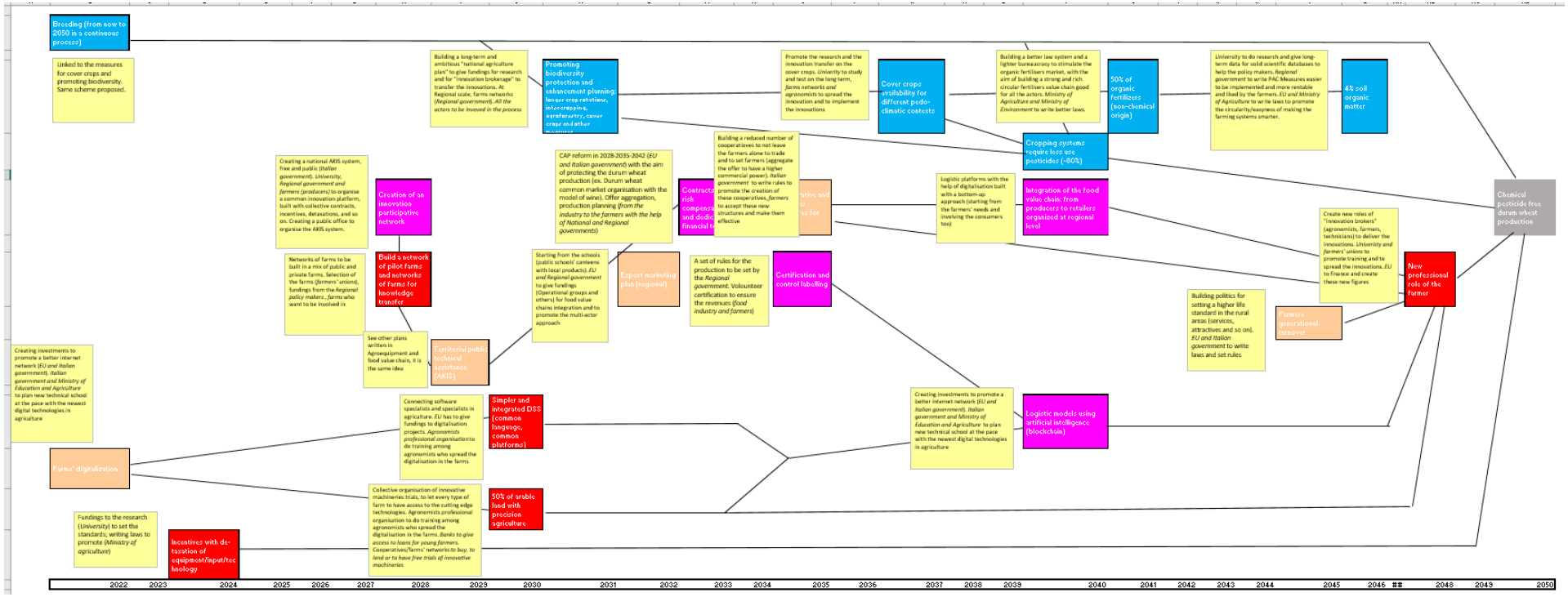
Training the technicians

APPENDIX 4 - Transition pathways

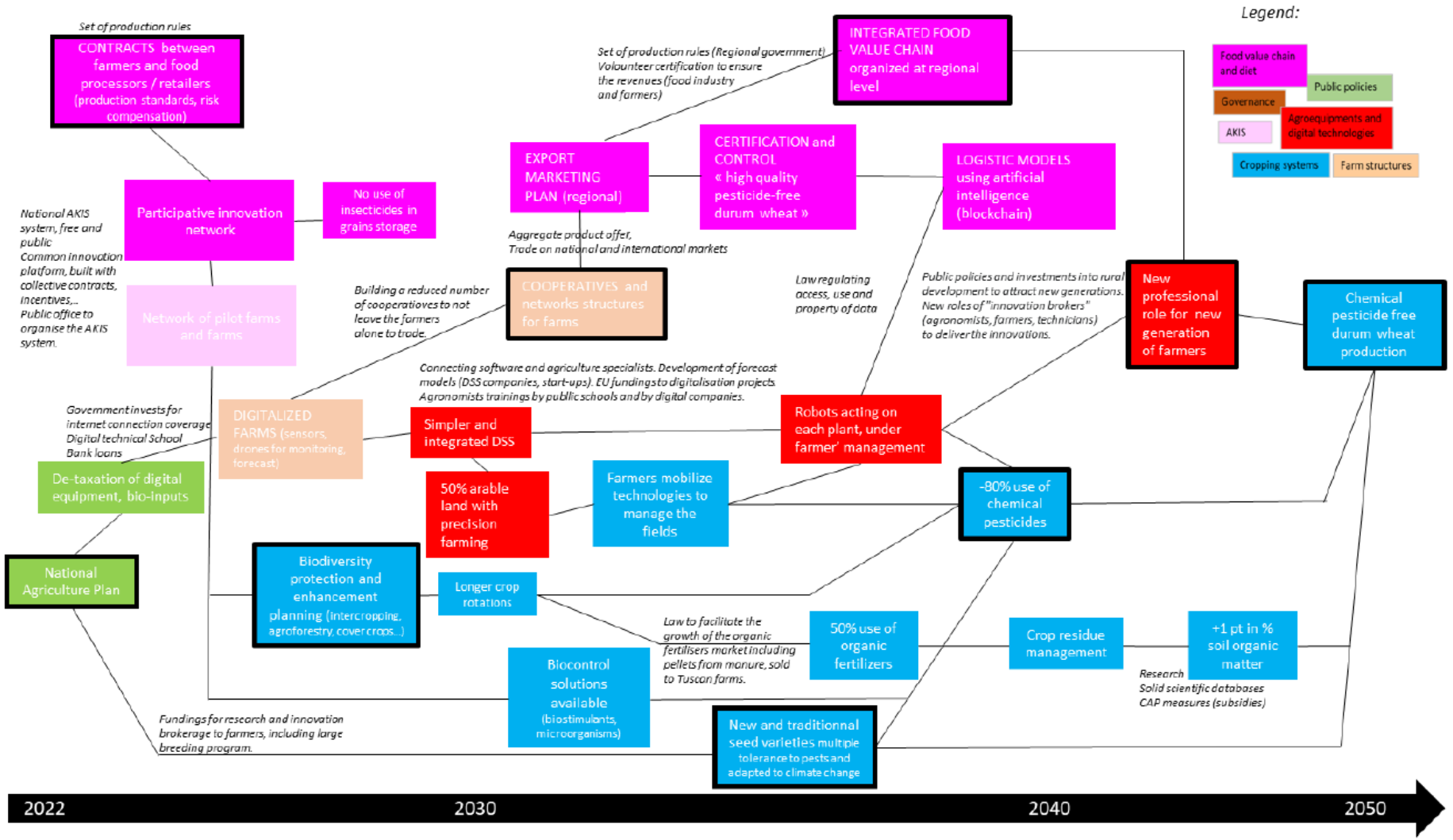
Transition pathway with milestones produced during the workshop



Transition pathway produced during the workshop, with milestones and actions



Revised version of the transition pathway with milestones and actions



Head Office Paris Antony

Directorate for Collective Scientific Assessment,
Foresight and Advanced Studies

147, rue de l'Université - 75338, Paris cedex 07
Tel.: +33(0) 1 42 75 90 00

Join us on:

Inrae.fr

National Research Institute for Agriculture, Food and the Environment