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AGRICULTURE & INNOVATION



EIP-AGRI Workshop

Cropping for the future: networking for crop rotation and crop diversification

FINAL REPORT

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1. Summary

On 4-5 June 2019, the European Commission's Directorate-General for Agriculture and Rural Development and the EIP-AGRI Service Point organised a one-and-a-half-day workshop in Almere, the Netherlands. This workshop was dedicated to networking and sharing existing experiences with innovative projects on crop rotation and crop diversification (CR&CD). The workshop highlighted the benefits and impact of these farming practices on ecosystem services, including soil and water-related issues, both in the short and long term. It also highlighted the challenges that related projects are dealing with, as well as possible solutions inspired by experiences and good practices.

The participants acknowledged a series of bottlenecks which may hinder the implementation of innovation in CR&CD. These include defensive attitudes resulting from cultural habits and behaviours at farm level; a relatively low technological knowledge, especially among small farmers; economic costs of changing crop rotation planning; specific soil, climate and agronomic conditions, which may constrain the wide adoption of CR&CD schemes; region-specific markets, equipment, technology, governance, land ownership, infrastructures, result-based reward systems for farmers; a lack of recognition from the market and the public policies for the ecosystem services provided by CR&CD.

To boost the uptake of best practices in CR&CD in practice, a series of initiatives were recommended, specifically: a better collaboration between the different stakeholders – farmers, advisers, researchers; an improved knowledge dissemination, particularly by identifying farmers who are front runners (pilot farms) to promote the uptake of good practices in the field, as well as individual coaching (training) for farmers (for example under pillar II of the Common Agricultural Policy (CAP)). The role of reliable, skilled and independent advisers is important, and public bodies are encouraged to invest in specific training. Technology and mechanisation should follow ecological needs and not vice versa. New, versatile CR&CD schemes require new and diverse types of machinery.

Innovation in CR&CD has an economic cost that can impede its adoption. This innovation should therefore guarantee an economic impact through the increase of agricultural sales and/or the reduction of costs. It should also give a monetary value to improvements of other ecosystem services. This includes for instance improving the aesthetic value of the landscape through well-arranged agroforestry, or by implementing landscape elements to prevent wildfires.

A marketing plan that considers the whole production and commercialisation chain is also needed. Traceability of foods and the involvement and education of consumers should be part of this plan.

Experts finally highlighted some research needs, such as:

- ▶ understanding the interactions between plant microbiota, rhizosphere and soil, and positive/negative impacts of allelopathic compounds;
- ▶ further discovering the relationships between soil management and different types of symbiosis;
- ▶ deepening the knowledge of above- and below-ground interactions between crops (intercropping and mixed crops) and systems (animals, grazing, crops, trees);
- ▶ gaining practical knowledge on carbon sequestration into the soil (humus) and its recycling;
- ▶ defining methods to measure the ecosystemic results obtained through the adoption of CR&CD innovations properly and in a practical way;
- ▶ obtaining more data about the performance and management (e.g. sowing density) of adapted crop species per region;
- ▶ understanding the relationships between biodiversity and soil functions, and between soil functions and their monetary value.

The workshop concluded that innovation in CR&CD is an important component for the development of agroecological farming and a tool to increase the quality of EU agriculture. It can also highly contribute to a smart EU agriculture, as foreseen by the post-2020 Common Agricultural Policy. It can also make farming more attractive for young people, improve the quality of life of farmers and rural communities, and support the development of rural businesses, thus contributing to fighting rural depopulation.



2. Introduction

Crop rotation is a very old agronomic practice, stemming from the empirical observation of the productive improvement that a cereal crop shows when it is alternated to a pulse. Similarly, the practice of crop diversification has been introduced to make profit out of the observed synergy between staple crops and legumes, when they are cultivated side by side in the same field. Many different schemes of crop rotation and crop diversification (CR&CD) have been introduced in the past centuries, to make the crops better adapted to local pedoclimatic, social, and market conditions. This was done by increasing the number and the complexity of the crops in the rotation cycle, including fallow. During the last decades the diffusion of these practices has been considerably reduced, in favour of an overspecialisation and oversimplification of cropping systems, which in the long run, however, produced several negative environmental and even economic drawbacks.

More recently, CR&CD have regained popularity, following the development of a new agricultural paradigm, shifting the focus from the immediate, single-farm benefits of yield and economic cost of production, to long-term, collective and comprehensive returns where yield is only one of the targets, complemented by several other services provided by the agricultural activity. This shift in the agricultural paradigm implies that crops are no longer mere vegetables to be fed with water and fertilisers, and protected by pesticides, but ecosystems to be sustained through a careful and precise agrotechnique, considering all possible environmental consequences of the single intervention. According to this new paradigm, the practical implementation of CR&CD should consider all the interactions with ecosystem services. The study of ecological processes that are applied to agricultural production systems has recently been summarised with the term "agroecology".

The vast scientific and operational interest in the implementation of agroecology, specifically through advances in CR&CD, was the reason for organising a one-and-a-half-day workshop dedicated to networking and sharing existing experiences with innovative projects dealing with these two farming practices. The workshop was organised by the European Commission's Directorate-General for Agriculture and Rural Development and the EIP-AGRI Service Point in Almere, the Netherlands, on 4-5 June 2019.

This workshop explored the benefits and impacts of CR&CD on ecosystem services, and looked at the challenges that related projects are dealing with, as well as possible solutions inspired by experiences and good practices.



3. Aim and approach of the workshop

Overall aims of the workshop

The overall aim of the workshop was to promote networking among Operational Groups (OGs), research projects and other innovative projects dealing with CR&CD. OGs are a pivotal element of the European Innovation Partnership (EIP) for agricultural productivity and sustainability. In the agricultural sector, the implementation of innovative projects in the context of the EIP should be undertaken by OGs, which bring together farmers, forest managers, rural communities, researchers, NGOs, advisers, businesses and other actors concerned by innovation in the agricultural sector. These partners come together to work on concrete, practical solutions to a problem or innovative opportunity. Operational Group projects are funded by Rural Development Programmes under the CAP.

The workshop was designed to let participants exchange experiences and learn about each other's projects, showing what works well, what does not work and why, to find common issues, explore possibilities and opportunities for future collaboration and knowledge exchange. [Find out about EIP-AGRI Operational Groups – basic principles](http://www.eip-agri.eu) at www.eip-agri.eu.

The event was also aimed at creating awareness and promoting the adoption of CR&CD as farming practices with multiple environmental benefits, such as soil and water-related issues, both in the short and long term.

Specific objectives of the workshop

The specific objectives were:

1. to assist OGs and other innovative projects dealing with these two farming practices by:
 - ▶ exchanging good practices
 - ▶ identifying common challenges
 - ▶ identifying knowledge gaps
 - ▶ exploring potential solutions to shared challenges
 - ▶ connecting participating projects
 - ▶ promoting further cooperation between partners from different OGs, research projects and other type of innovative projects
2. to highlight the benefits of CR&CD, and to link them to broader issues such as climate change, Sustainable Development Goals, and objectives in the future CAP.

Workshop programme

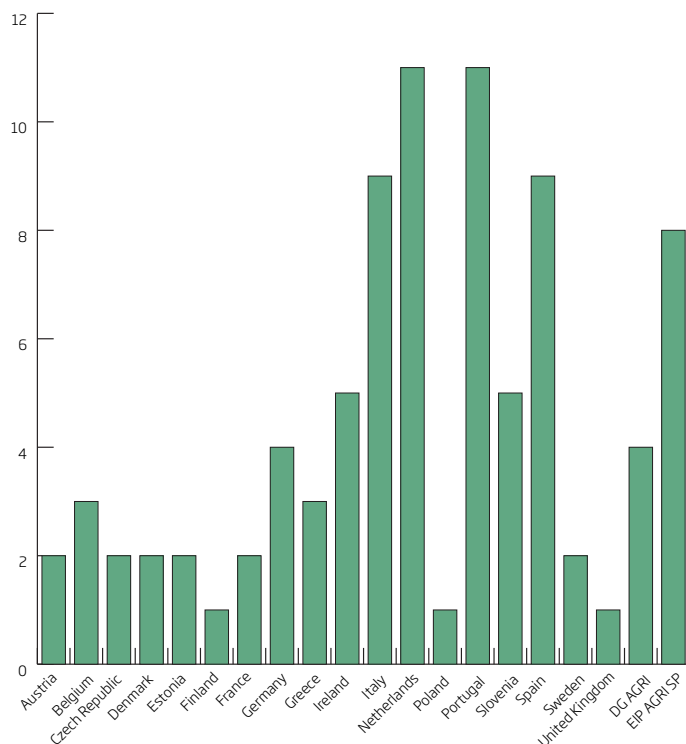
The workshop programme included a few presentations but was mostly interactive. The interactive and plenary sessions included:

- ▶ A poster session to exchange experiences and learn about each other's projects. This session was organised in 6 thematic corners on:
 - i) tree crops and agroforestry,
 - ii) arable lands,
 - iii) grassland and meadows,
 - iv) farm strategies,
 - v) ecological infrastructures and
 - vi) ecosystem services provided by crop rotation and crop diversification;
- ▶ A 'world café' session to get an overview of challenges and opportunities that innovative CR&CD projects are tackling;
- ▶ A 'carrousel' aimed at identifying common challenges in projects and potential ways to overcome them. This was followed by a short reporting in plenary to get a perspective on the broad scope of different impacts that come from these practices, and to collect research needs;
- ▶ An open space session to explore and present ideas and intentions for future collaborations and knowledge exchange;
- ▶ Field visits showing practical examples on private and public farms, and
- ▶ A final plenary session reporting the main conclusions, and exploring potential further collaborations and highlights from the workshop.



[Download the final programme of the workshop at www.eip-agri.eu](http://www.eip-agri.eu)

4. Participation



75 participants from 18 countries attended the workshop, including farmers, advisers, researchers and representatives from agricultural organisations, industry or manufacturing and NGOs (Figure 1). Participants from a wide range of countries were present at the workshop, with a notably large representation from the Netherlands and from southern European countries – namely Portugal, Spain and Italy.

Fig. 1 Number of participants by country, DG AGRI and Service Point

Concerning the composition of participants, researchers were the most represented community, followed by farmers, advisers, and experts from agricultural organisations, industry or manufacturing (Figure 2).

[Download the complete list of workshop participants](http://www.eip-agri.eu) at www.eip-agri.eu

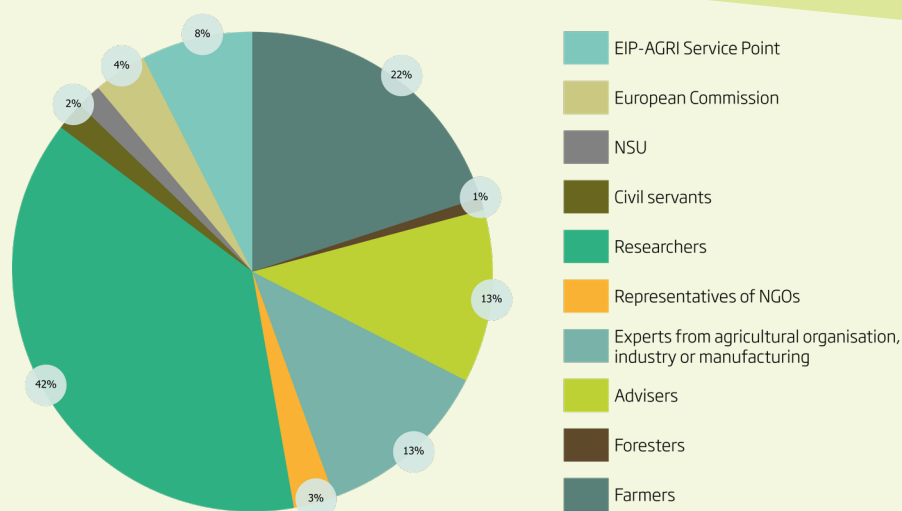


Fig. 2 Participants by type of actor (most significant)

Almost all workshop participants were engaged in innovative CR&CD projects. These projects, together with the projects that were presented during the field visits, accounted for 84 innovative CR&CD projects in total.

According to the type of projects, 38 OGs, 13 Horizon 2020 Multi-Actor research projects (H2020 MA), 6 H2020 Thematic Networks (H2020 TNs), 2 LIFE projects, 4 INTERREG projects, 6 projects funded via several ERA-NETs, and other projects funded by national/regional programmes or other funds were represented at the workshop (Figure 3).

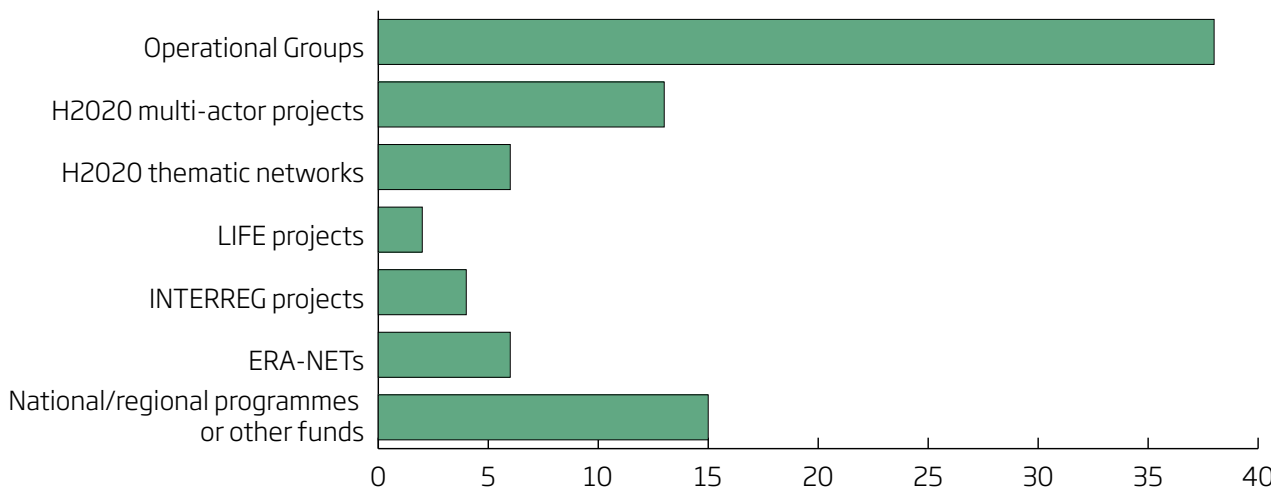


Fig. 3 Different types of projects represented at the workshop, grouped by funding source

The projects represented at the workshop were very diverse in terms of scope, scale and partnerships. Prior to the event, the organising team gathered information from participants on the innovative CR&CD projects they were involved in, and on the topics they would like to discuss during the workshop. A booklet was prepared, summarising the main features of the 55 projects that were most closely related to the topic of the workshop. This booklet was made available to all participants via the EIP-AGRI event app and was later published on the EIP-AGRI website.



Download the workshop booklet at www.eip-agri.eu

5. Setting the scene and getting to know each other

The workshop participants were welcomed by Martijn Weijtens, Director of the Department of Plant Production and Food Quality of the Ministry of Agriculture, Nature and Food Quality, the Netherlands, and by Anikó Seregélyi from the European Commission, DG Agriculture and Rural Development. In his introductory speech, Martijn Weijtens highlighted the importance of circular economy in agriculture. He expressed the wish that also CR&CD could help promote the role that agriculture plays in closing the circles of food production. He also recalled the efforts that Dutch agriculture has been making for years to promote strip cultivation and permaculture. The current challenges are related to the introduction of crop diversity on large-scale farms, the widespread use of IT, and ways to support mechanisation of different crops on small farms.

After welcoming the workshop participants, Anikó Seregélyi introduced the concept of the EIP-AGRI network, explained the objectives of the workshop, and made a connection between the workshop and other EIP-AGRI networking activities preceding the event.

Edoardo Costantini, coordinating expert of the workshop, introduced the subject of the workshop by clarifying the concept of CR&CD, and by giving a historical overview on these two practices. In this presentation, four presentations were embedded, presented by representatives of projects that are connected to the workshop topics. These presentations introduced different perspectives and examples of the different facets that CR&CD have in their practical application.



Bhim Bahadur Ghaley of the University of Copenhagen, Denmark, showed – through his experience with the ‘SustainFarm’ project – how agroforestry can have a scale dimension. It can enhance the complexity of biological cycles, but also allow waste to be valorised for innovative and unconventional uses, by recycling and reusing the waste between different enterprises.



Paolo Mantovi of the CRPA Foundation, Italy, introduced the Operational Group 'Agroecological Cover', which addresses the problem of decreasing soil organic matter and an increasing occurrence of weeds. The aim of the Operational Group is to use CR&CD to enhance ecosystem services provided by agricultural activities, aside from crop yield. One of the most important ecosystem services is definitely maximising carbon capture by cultivating multiple crops in the same field, such as trees, shrubs, grasses and vegetables. The Operational Group is developing innovative conservation tillage systems for farms in the Po river valley, based on the use of cover crops.

Using cover crops should allow farmers to take advantage of agroecological functions, to get a wide range of agronomic and environmental benefits. The effects on soil quality (organic matter, structural stability, earthworms and microarthropods, nitrogen dynamics, etc.), economic sustainability and carbon footprint are also evaluated. The Operational Group has proven that the new cropping system can be viable, although some technical difficulties remain regarding the termination of the cover crops and the operation of sod seeding. The agronomical trial will be continued within the H2020 project Circular Agronomics. In this project, the conservation tillage system will be compared with conventional (ploughing).



The next example discussed how CR&CD can be introduced in tree crop systems.

Roberto García Ruiz of the Center for Advanced Studies in Olive Groves and Olive Oils, University of Jaen, Spain presented the EU project 'SUSTAINOLIVE: Novel approaches to promote the SUSTAINability of OLIVE cultivation in the Mediterranean'.

Taking into account a set of pedoclimatic, landscape, socio-economic and technological conditions, SUSTAINOLIVE is implementing different strategies of crop diversification to diversify production and to reinforce other ecosystems services. The current simplified model of olive cultivation only promotes "production services". However, implementing other crops (or cover crops) and rotations between olive tree canopies can increase diversity and complexity, and let other ecological services (nutrient retention, soil fertility, agroecosystems production, diversity of habitats, C sequestration, aesthetics.....) gain importance without losing productivity. The project expects that crop diversification will also increase the resistance and resilience of agro-ecosystems.



Judith Treis from Operational Group 'Organic Vegetables', based in Hesse, Germany, showed how their Operational Group managed to develop a regional value chain and create jobs for people with disabilities, by introducing vegetables in arable crop rotation. This OG is part of an EU general strategy that promotes economic, environmental, and social sustainability of agriculture. The project can serve as an example of CR&CD projects that do not only focus on ecosystem services, but also on social services.

6. Learning about participating projects

To promote networking among participants, a discussion on selected participating projects was organised in six clusters:

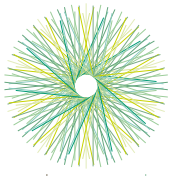
- i) tree crops and agroforestry,
- ii) arable lands,
- iii) grassland and meadows,
- iv) farm strategies,
- v) ecological infrastructures and
- vi) ecosystem services provided by CR&CD.

30 projects from different EU regions were presented in this session, including 16 OGs and Clusters, 8 H2020 research projects, 3 ERA-NET Core organic or Facce projects, 2 LIFE projects, and one Interreg North-West Europe project.



[Download a summary of the projects](#) with objectives, activities, partners and contacts at www.eip-agri.eu





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7. Sharing experiences: common challenges and possible opportunities in the innovation process

During a 'World Café' session, the workshop participants discussed the challenges and opportunities that the projects represented at the workshop are tackling. In doing this, they looked for common ground. The groups discussed 3 questions:

- a. 'Crop rotation/crop diversification: what have we understood?'
- b. 'Crop rotation/crop diversification: why are you using these practices in your project, what is the purpose, and what do you want to achieve?' and
- c. 'What challenges are you tackling / what opportunities are you exploring in your project(s)?'

At the end of the session, each group had to select the most important challenge or opportunity that they would like to take to the following day. All inputs were later clustered. This served as input for day 2 of the workshop.

Crop rotation and crop diversification: what have we understood

1. Compared to monocultures, CR&CD produce more stable yields in the long run, both in conventional and in organic farming. In general, crop systems based on CR&CD are found to be productive and economically viable, and they may be used for sustainable food and non-food production.
2. CR&CD can help to increase nutrient input and soil fertility, by introducing legumes and crops with rooting systems that explore different soil layers. This can also reduce nutrient depletion and leaching. Soil physical structure and chemical properties were always improved under CR&CD.
3. CR&CD can help make the control of weeds, and pests and diseases easier. This is also the case with a reduced application or without the use of pesticides, due to an increased crop resistance to pests. This was not only beneficial for the environment, but it also made working conditions for farmers safer.
4. Experts reported that CR&CD delivered a wide range of improved ecosystem services, compared with monoculture. This included reduced runoff and soil erosion, improved water conservation, more efficient use of water, enhanced soil carbon sequestration, reduced nitrogen in water (using intermediate crops that can



be sold), and increased above- and below-ground biodiversity.

5. The two practices also delivered other services. They for instance helped provide a diverse range of food products for balanced nutrition, helped preserve cultural heritage, traditions and landscape aesthetics, and improved the microclimate following the introduction of agroforestry.

Crop rotation and crop diversification in their practical application

1. Crop rotation does not have to follow a fixed sequence, but crops can rotate differently according to specific needs, such as market requests or climate changes.
2. In general, the main reason for adopting CR&CD has been the search for the best economic result of the enterprise. This could be done through sharing the risk of farming between crops (for instance introducing vegetables in the arable crop rotation), a better farm organisation (complementarity of workload) and more flexibility to cope with market and climate instability. Lower energy inputs and costs for machinery, fertilisers and pesticides were also important economic incentives.
3. One of the most widespread motivations for adopting CR&CD was that weeds were found to be increasingly hard to control. Different kinds of cover crops were tested to face this problem.
4. Another important and common reason to introduce CR&CD was to cope with an observed decrease in soil organic matter over time under intensive cultivation, as well as to reduce soil erosion and improve water infiltration.
5. Agroforestry systems, in particular, turn out to be well suited for recycling and reusing waste between different enterprises (e.g. animal waste for manuring pasture and grassland) and for creating ecological corridors.
6. Reducing pesticides, together with the diversified crop flowering, was reported to be beneficial for higher pollination rates.

Challenges tackled

1. After the introduction of CR&CD, many farmers observed a decrease in yield in the short term.
2. Managing complexity is not an easy task: farmers need to consider an infinite number of combinations of planting patterns of 2 or more crops, relative densities, and dates of planting.
3. Enhancing ecosystem services through a broad adoption of ecological infrastructures and scaling diversification requires new instruments and tools to be tested. This would allow an easier and more user-friendly upscaling of the effects of CR&CD, and a better prediction of their impact on yield and ecosystem services.
4. A transition to CR&CD implies the acquisition of specific machinery that is suited for more detailed spatial and time scales, and it calls for the introduction of precision farming. Both could be expensive and could require advanced training for farmers.
5. The importance of CR&CD in agriculture is still highly underestimated. It proves challenging to create awareness among stakeholders, including other farmers and advisers, as well as policy makers and the general public.



Opportunities explored

1. Projects explored the possibility to use CR&CD to respond to challenges posed by climate change. New crops were introduced in rotations and in the agricultural landscape to adapt the crop systems to climate change.
2. CR&CD were introduced in marginal lands with specific limitations, for instance to adapt to soil salinity, or to promote a circular economy by introducing waste recycling in the rotation.
3. Adopting ICT and Decision Support Systems to help choose and integrate CR&CD schemes at different scales contributed to the development of a more technological, advanced way of farming.
4. CR&CD help to diversify and create new market opportunities, differentiated according to regional demands. Current and future market opportunities should be considered.
5. Some projects tried to quantify the economical relevance of the ecosystem services provided by CR&CD through a detailed cost/benefit analysis and a reliable and effective monitoring of the exosystemic benefits.

In sharing their diverse experiences, the participants concluded that CR&CD practices, both in their traditional and innovative aspects, should be recommended for most agricultural, silvicultural and pastoral ecosystems. However, more needs to be understood about the societal benefits that CR&CD can bring, and how they can be improved and valorised. This remains the main challenge for farmers when investing in innovation in CR&CD.

8. Field visits – learning from practical examples

On the afternoon of the first day of the event, a group of participants visited the Test Facility Agroecology and Technology (Wageningen University Research - WUR) in Lelystad. Another group visited a dairy farm in Lopikerkapel, where the participants heard about projects related to CR&CD. The purpose of the visits was to let the participants see concrete benefits of CR&CD in their specific pedoclimatic and agricultural environment. The visits also offered them a firsthand look into several ongoing OGs, as well as other types of innovative projects and initiatives that are dealing with CR&CD.

Field visit to Lelystad – focus on crop rotation and crop diversification

The visit to Lelystad started with a presentation of two OGs and of the Test Facility Agroecology and Technology of Wageningen University Research (WUR), with related projects.

This presentation highlighted that diversifying Dutch industrial agriculture is a major concern for WUR. This is currently a very specialised form of agriculture, characterised by a very limited number of crops grown: 55% is grass (99% perennial ryegrass). Other crops include maize, potato, cereals and sugar beet, as well as flowers, fruits and legumes which also have an economic relevance. Farmers produce for world markets at world prices, which remain the same year after year. However, production costs are rising while yields remain the same. Up till now, the answer has been to scale up and intensify, but this strategy has some bottlenecks:

- ▶ Increased soil degradation due to increased mechanisation;
- ▶ Loss of biodiversity;
- ▶ Increased sensitivity to climate change, also in relation to the harvest time;
- ▶ Extra fuel consumption due to high mechanisation.

The field trip at the Test Facility Agroecology and Technology of WUR showed some concrete examples of crop diversification (cultivation in strips), and of crop rotation tests and technology (autonomous vehicles/robots). The experimental farm that was visited has 80 ha of demonstration fields. These are used for multidisciplinary research into regenerative plant production systems, focused on CR&CD in arable farming and open field horticulture. [Download the presentation](http://www.eip-agri.eu) at www.eip-agri.eu.

The WUR research programme aims to change the current paradigm in agriculture, in which technological advances, such as new machinery and equipment, tend to determine the adaptation of agricultural practices. The programme would like to see ecological needs and agronomy lead technology. Plenty of evidence shows that CR&CD can be a solution. However, to realise this, we need more advanced technology (drones, robots, sensors...). This is why WUR is looking to combine agroecology and technology, to integrate very diverse agro-ecosystems, including trees and birdlife, that would be supported by ICT and by small and low-impact machines and sensors.

A demonstration on the test field showed the participants an example of strip cropping with different strip widths. The aim of this technique is to slow down and lower the dispersal of pests, by spreading beneficial natural enemies that are hosted in one of the strip components. The strip components can have different dimensions, depending on different mechanisation models. Using rows with a width of 6 metres (which is the width that is covered by current mechanisation with normal tractors) already makes it more difficult for pests to develop. When two crops with different harvesting times are grown together in strips, predators can escape to the neighbouring strip when one of the crops is harvested. In the strips that have a width of 1.5 m, the benefits were as increased, but the mechanisation was more difficult with the current machinery. Another

example, which was very much appreciated by the visiting experts, was the combined adoption of CR&CD and Conservation Agriculture. This showed an increase in the population of soil dwellers and a consequent improvement of soil physical properties, among other benefits.

Several other projects were presented, to show the efforts that are being made in the Netherlands to put CR&CD in practice, in particular:

- ▶ **Operational Group 'SoMyCo'** – focusing on crop rotation in arable farming - [Download the presentation](#)
- ▶ **Operational Group 'Lasting Fields in Practice'** – focusing on crop diversification and multicropping in arable farming - [Download the presentation](#)
- ▶ **Collective Agricultural Nature Management in Flevoland** – with a focus on crop diversification in the management of field borders and on the use of biodiversity for crop health in arable farming
- ▶ **Agricultural research** – with a focus on multicropping, robotisation and smart farming in arable farming
- ▶ Several H2020 projects in which the Test Facility is involved were also addressed: ReMIX, DiverIMPACTS, DIVERSify, TRUE and LEGVALUE

The participants were very impressed by the organisation of the Wageningen University Research test location, where the operational synergies between the academics of Wageningen University and the researchers of the experimental station are put into practice. The participants were also impressed by the ability of the WUR to prioritise and address the research activities according to farmers' needs. This means that the proposed innovations, before being tested in the field, are always formulated in such a way that they can immediately become a practical solution that can be adopted by farmers.

Another important issue that was underlined during the discussion in Lelystad was that the implementation of new CR&CD schemes requires flexibility. There is no need to replicate a unique layout in space and time, but determining suitable local CR&CD ecological benefits may change according to market opportunities, farm needs, and challenges caused by climate change. Workshop participants and hosting researchers shared the practical observation that the longer the rotation layout is, the better the ecosystem services and the resilience of the agro-ecosystem will be, but also the time needed for a transition to the new equilibrium, which can be problematic to sustain.

Finally, the participants and the hosting experts both stressed the need to set up a better collaboration with plant breeders, to produce new varieties that are especially suited for mixed crop cultivation. The current varieties are more adapted to monoculture. In fact, the traditional varieties are not able to fully express the synergies of crop diversification, both operationally and physiologically.



Field visit to Lopikerkapel – focus on diversification in grassland

This field visit to Lopikerkapel took place at the dairy farm of Matté Eikelenboom. The visit focused on diversification in grassland. Dairy farmer Matté is testing new grassland management options to reduce the use of antibiotics in his dairy cows and to improve soil conditions (namely its structure and biodiversity). The farm is also involved in the knowledge dissemination and demonstraton project 'Carbon cycle'.

During the field visit, the farmer and his wife gave a clear presentation of their practical experience and vision on grassland management. They showed different management options, grassland compositions and differences in soil (Figure 5).

The group of participants who went to Lopikerkapel were very impressed by the farmer's willingness to innovate, the farm's history and the farmer's capacity to plan new targets. Participants were able to see the results of the grassland management system in the field. This allowed them to appreciate the fresh and voluminous crop that the herbaceous pasture produced, even though it looked quite dry. Actually, in terms of dry matter content, the yield was the same after the conversion to the new grazing scheme.

As for the improvement of soil quality and ecosystem services, participants could see how the farmer's innovative grassland management had reduced soil compaction. This was due to the reduced pressure of grazing, and the treatment of the manure, through which the fermented fraction can be spread directly on the land instead of by injecting it into the soil.

During the visit, the participants were introduced to different projects that deal with innovation in CR&CD, in pasture and grasslands, in particular:

- ▶ **Operational Group 'Powerful Herbs in Grassland for Better Animal Health'** – focusing on crop diversification in grassland, animal health / reduction of antibiotics - [Download the presentation](#)
- ▶ **Operational Group 'Smart Grass Production'** – focusing on diversification in grassland, soil fertility and carbon in grassland - [Download the presentation](#)
- ▶ **Demonstration project 'Carbon cycle'** – focusing on soil fertility, carbon/nutrient efficiency in grassland.- [Download the presentation](#)

In addition, the participants had the opportunity to attend a demonstration of a machine for circular fertilisation. The machine producer wanted to develop a machine that would reduce fertiliser losses, because the average loss is currently estimated as high as 40%.

The starting point was the 'four Rs strategy':

- ▶ Right fertiliser (from side streams)
- ▶ Right amount (measuring contents in the soil)
- ▶ Right moment (using sensors)
- ▶ Right place (would be root zone 2-5 cm if technically possible, using GPS)



The machine producer explained that many side streams are produced by agriculture, the food industry, landscape maintenance and newly developed biorefineries, and that this can be used instead of clean granules. To cut costs and even generate income, it is important to optimise the quality of these side streams. The machine that was presented is light, and can be used on fragile soils in February, in cereals and grass. It has a spoke wheel injector to avoid losses. The pumping systems can be used in many crops, also for robots. It can be used in sections or even a single wheel. It is made farmer-proof, so that farmers can adapt the machine to their own needs.

[Download detailed information on the OGs and presentations](http://www.eip-agri.eu) given during the field available at www.eip-agri.eu.

A farmer's story: "How I implemented diversification in my grassland"



The problem

Matté Eikelenboom measured the compaction of his soils, and it turned out to be very high. This was due to the use of heavy machinery in ryegrass monospecific grassland, which was used to feed the cows in closed stables.

A time to change

- ▶ Matté wanted the cows to graze outside during the day and let the cows graze in a different plot every day. He built a new barn and introduced a milking robot.
- ▶ There are 20 hectares for grazing around the stable, mostly consisting of ryegrass. Every day the cows enter a new piece of meadow in a cycle of 21-30 days. The choice of the field is based on how the grass looks, or by measuring the length of the grass.
- ▶ During the night the cows are fed with corn, grass and sugar beet pulp. At milking time in the morning, and at 1pm, there is concentrate distribution.
- ▶ The day schedule is: morning pasture in the field, robot milking, in another field in the evening, in the stable at night. During summer the cows go to the milking robot on average 2.3 times/day, in winter times 2.7 times/day.
- ▶ The straw is necessary to thicken the manure. The manure is well fermented before it is spread over the land.
- ▶ Matté started to use eggshells, sea salt and lava rock in one field. In addition, he is making bokashi with effective micro-organisms in manure, and is sowing herbs and clovers.

A success story

- ▶ Matté said that there was no loss of milk by bringing the cows outside. Some milk was lost because of the introduction of the milking robot. The cows had to learn how the robot works.
- ▶ Gradually, the amount of single-species grasslands on the farm was diminished in favour of herbaceous fields.
- ▶ Matté concluded that the use of clover instead of fertiliser is fine. "If you are using many species in the grassland, you don't need to use a large amount of synthetic N fertiliser." Grass "works" better, even with drought or over-humid soil. It also attracts a lot of insects.

But still a challenge

- ▶ In the direct surroundings, Matté doesn't know many farmers who think or act the same. They are still in the old system of growing only ryegrass, but some farmers in the North of the Netherlands are interested. According to Matté, this way of working demands a choice – whether to work with fertiliser or with clover.

Ideas for more investigation

- ▶ Matté is thinking about new ways to regulate the pressure of grazing on soil, possibly by introducing grazing in strips.

Read the [press article](#)
or watch the [video](#)



9. Exploring further key challenges and sharing experiences to identify potential solutions

Key challenges and opportunities that were identified on Day 1 were further explored in a 'Carrousel' session on Day 2. In this session, the participants were invited to share knowledge and experience, discuss potential solutions for these challenges, and identify research needs.

The groups first selected the (single) most important challenge or opportunity that had been discussed during the World café (in Day 1). They then clustered these challenges or opportunities into 6 topics, which were the starting point of the Carrousel session on Day 2.

These topics were:

1. Implementation – instruments and tools;
2. Creating awareness – among stakeholders
3. Market opportunities – markets in the future;
4. Economical aspects – payments for ecosystem services;
5. Dissemination – sharing knowledge among farmers;
6. Deepening basic knowledge

The questions posed during the group work were: "What is this challenge really about?", "What is region-specific and what is common to all?", "What solution(s) are you exploring / testing in your project or what solutions are you aware of?" and "What additional knowledge / research is missing?". This process was followed by a short harvesting in plenary.

Challenges

A series of bottlenecks were identified as obstacles for implementing innovation in CR&CD:

- ▶ CR&CD can be more expensive, especially during the transition from monoculture.
- ▶ Property regimes and governance, e.g. rented land, can be an issue that does not favour investments in innovative actions.
- ▶ Large-scale farmers will consider economic benefits when looking at changing their crop rotation planning. These farmers are very specialised, and they know the markets. For them, changing their crop rotation planning can be challenging.
- ▶ Giving subsidies to promote CR&CD can help as a starting point, but farmers cannot rely on them on a long-term basis.
- ▶ There are pros and cons for deciding whether incentives should be given either on the basis of the actual benefit obtained, or on the kind of practice that is adopted.
- ▶ There is no sound methodology to transform ecosystem services into monetary value.
- ▶ There is a widespread reluctance to adopt innovation systems, caused by cultural habits and behaviours at farm level.
- ▶ The level of technological knowledge is rather low, especially among small farmers.
- ▶ The communication and cooperation between researchers, advisers and farmers is still insufficient.
- ▶ The involvement of non-agricultural actors in the process, such as the agro-industry, plant breeders, machinery producers and retailers, is still inadequate.
- ▶ In Europe there are specific soil, climate and agronomic conditions which may constrain a wide adoption of CR&CD schemes. Species depend on pedoclimatic conditions.
- ▶ European agriculture is made up of many regional realities, with distinct markets, equipment, technology, governance, land ownership, infrastructures, and results-based reward system to farmers.

- ▶ There is still only a poor recognition from the market and from public policies for the ecosystem services that CR&CD can provide.
- ▶ Food is anonymous; it should be better differentiated for origin as well as for the sustainability of its production, including animal welfare.
- ▶ Dissemination of knowledge and innovation on CR&CD, both to farmers and to customers, is still in its infancy.
- ▶ The average level of technical preparation and level of awareness of European farmers is still far from the level that is considered necessary for a prompt adoption of innovation in CR&CD.

Solutions

To boost the development of best practices in CR&CD in practice, a series of initiatives were recommended:

Implementation – instruments and tools

- ▶ Creating a better collaboration between the different stakeholders: farmers, advisers and researchers. This implies strong commitments from researchers, to establish trust with farmers by involving them from the beginning in research projects. This is crucial to make innovations practical and ready to be adopted by farmers, also those who are not directly involved in the project.
- ▶ Supporting the creation of local-district farmers' associations, to popularise innovation from pilot farms to all farmers.
- ▶ Setting up OGs, starting from groups of farmers who are facing similar problems, involving researchers, and including trainers and advisers.
- ▶ Technology, mechanisation in particular, should follow ecological needs and not vice versa. New, versatile CR&CD schemes require new "ad hoc" machineries. Cooperative sharing of machinery can help in the purchase of new machinery.
- ▶ Including farmers in citizen science and providing guidelines and tools (e.g. simple sensors for soil testing) to collect and save data for research.
- ▶ Improving internet facilities, to better connect farmers to buyers, and increase direct sales.
- ▶ Developing simple models and tools for testing scenarios at farm level.
- ▶ Installing real-time soil and plant testing, integrating the use of proximal and remote sensors, including satellite imagery, feeding decision support systems for agricultural practices.



Creating awareness

- ▶ Farmers should be aware of the crucial role they play in producing healthy food for the population.
- ▶ There is an increased social awareness on the relevance of agroecology. This paves the way for a growth in CR&CD knowledge and popularity.
- ▶ Monitoring land use changes where CR&CD has been adopted, by means of remote sensing data analysis. The results can be popularised in the media.
- ▶ Strengthening food certification, ecological labelling, increasing consumers' knowledge of the whole process of food production
- ▶ In schools: distributing good and sustainable meals to children, teaching sustainability to students in the field. Possible initiatives: facetime with a farmer, open farm Sundays,...

Market opportunities

- ▶ Setting up marketing plans that consider the whole production and commercialisation chain, to convince consumers to pay for healthy and ethical food. Increasing the traceability of foods, and involving and educating consumers should be part of these plans.
- ▶ Involving retailers in campaigns that support the ecosystem benefits produced by CR&CD
- ▶ Involving local markets as demonstration sites
- ▶ Farmers could form a cartel in the food market.
- ▶ Europe could protect the market for specific crops, e.g. protein crops.

Economical aspects

- ▶ Innovation in CR&CD has an economic cost that can impede its adoption. This innovation should therefore guarantee an economic impact through the increase of agricultural sales and/or the reduction of costs. It should also give a monetary value to improvements of ecosystem services. This includes for instance improving the aesthetic value of the landscape through well-arranged agroforestry, or by implementing landscape elements to prevent wildfires.
- ▶ The economic relevance of the ecosystem services provided by CR&CD should become standard. This could be achieved through a better and more detailed cost/benefit analysis and a more reliable and effective monitoring of the benefits and positive environmental impacts. This could help obtain an official acknowledgement of these benefits, which could justify possible subsidies and market valorisation.
- ▶ A potential strategy could be to attribute a value for ecosystem services provided to any singular practice, or to quantify the economic value of the whole crop rotation/cropping system.



- ▶ A monetary reward for the aesthetic value of specific agricultural landscapes can give farmers a share of the local taxation for tourism, in renowned agricultural lands.
- ▶ Agricultural policies are needed to finance the acquisition of machinery that is required to introduce CR&CD, but also to have low-interest loans and tax credits to compensate for the increased costs and risks.

Dissemination

- ▶ Farmers should be approached in different ways depending on different economic dimensions of their farms. The most effective dissemination method is still assumed to be the farmer-to-farmer transmission of knowledge.
- ▶ Identifying farmers who are front runners (pilot farms) has proven to be a solution to promote good practices in the field, under real conditions. Another solution is individual coaching (training) for farmers under public programmes (for example under pillar II of the CAP).
- ▶ Setting up agricultural showcases, demonstration fields to compare the current situation with new solutions. Farming schools could be involved in this activity.
- ▶ Writing good stories to publish on media, print in journals, broadcast on television and in digital media.
- ▶ Training for reliable, skilled and independent advisers.
- ▶ Establishing advisory services in all European countries.
- ▶ Dissemination activities carried out in projects should promote the international exchange between farmers and advisers.

Deepening basic knowledge, research needs

Many research activities should be reinforced to better understand the mechanisms that lie at the basis of the positive effects which a proper adoption of CR&CD can have on crops and on the environment. These activities can also help tailor the practical application of CR&CD to different pedoclimatic and agricultural contexts. A selection of research topics that should be prioritised includes:

- ▶ Knowledge on physical, chemical, and biological mechanisms that are responsible for preserving/enhancing soil fertility through CR&CD, and basic mechanisms regulating roots interactions between plants
- ▶ Interactions between plant microbiota, rhizosphere and soil, and positive/negative impacts of allelopathic compounds
- ▶ Relationships between crop diversity and overall biodiversity
- ▶ Establishing background values for biodiversity
- ▶ Discovering the relationship between soil management and different types of symbiosis
- ▶ Deepening the knowledge on above- and below-ground interactions between crops (intercropping and mixed crops) and systems (animals, grazing, crops, trees)
- ▶ Gaining practical knowledge on carbon sequestration into the soil and its recycling, including storing carbon at different depths
- ▶ Defining methods to measure the ecosystemic results obtained with CR&CD properly and in a practical way. This includes tools and methodologies to make ecosystem services quantitative, based on sound science, and good modelling tools to predict long-term effects of cropping systems.
- ▶ An economic evaluation of the costs and benefits of the implementation of CR&CD on real farms, to discover relationships between biodiversity and soil functions and between soil functions and their monetary value.
- ▶ Long-term experiments to monitor the effects on ecosystem services, including wilderness species.
- ▶ More experimental data about the performance and management of adapted crop species (e.g. sowing density) by pedoclimatic region
- ▶ Production of new plant varieties for mixed cropping
- ▶ Relationships between CR&CD and food quality and health

10. Strengthening the potential for collaboration

One of the objectives of the workshop was to promote further cooperation between partners from participating OGs and other innovative projects. Keeping this in mind, the final part of the workshop focused on creating opportunities for future collaboration and knowledge exchange through an 'open space' session and a 'networking market place'.

As a result, a wide range of types of activities was explored, from very light and informal to more complex, both between individuals or entities, and considering various types of projects. An impressive list of offers and demands for networking activities was gathered from the participants. [Download a detailed list](#) at www.eip-agri.eu



11. Wrapping up

The final plenary session pointed out the main conclusions and highlights that emerged from the workshop. It was concluded that CR&CD are an important component of agroecological farming and a tool to increase the quality of EU agriculture. It is an important contribution towards a smart EU agriculture.

The input of the experts reflected the reality of CR&CD as well as of the whole agricultural sector in the EU. For instance, some obstacles to promote innovation in CR&CD are linked to the many specific social, agronomic, and context-based conditions. This includes areas with natural handicaps (less favoured areas, areas with physical constraints) where the agricultural activity has severe limitations and where farmers are acknowledged by the EU legislation for their role in safeguarding the agricultural territory.

During the workshop, some keywords repeatedly arose from the contributions of the participants in the different sessions. They are summarised in the following items:

Education and training

- ▶ More investment in education is recommended, especially on the ecosystem services that agriculture can provide. This issue should be introduced at all levels, starting from elementary schools, in particular. The adoption of educational programmes on biology and on agronomy in primary and secondary schools is strongly advisable.
- ▶ Farmers need training: the role of peer-to-peer knowledge exchange, and the presence of showcase farmers is vital, but also the role of good, reliable, and independent advisory services was highlighted, especially regarding the use of new technologies.
- ▶ Local district farmers' associations could be set up (work in similar conditions, face the same problems, etc.) to stimulate information sharing.

Economy

- ▶ "You cannot act green when the figures are in red". A quantitative monetary valorisation of ecosystem services should be provided by regulating authorities, for example under pillar II of the CAP. Nevertheless, sound methodologies to valorise ecosystem services have to be set up.
- ▶ Market: new strategies must be brought into the market, promoting the quality of the agricultural product and relating it to the sustainability of its production, for instance with ecological labels.
- ▶ The creation of farmer unions in local districts is important (e.g. biodistrict), also to link the local production to a territory and increase the reputation, image and value of products.

Linkages

- ▶ It is crucial to go beyond the agricultural sector. Linkages must be set up with industry (mechanisation), breeders (new varieties, new combinations of varieties in the same field) and ICT companies, to tailor what is needed for innovation in CR&CD.
- ▶ The large-scale organised distribution should be involved in strategies of promoting the ecosystem services produced by agriculture. Big supermarket chains impose food prices onto the farmers and decide which items are promoted. Collaborations could be found in campaigns that promote awareness on food sustainability.

Trust and awareness

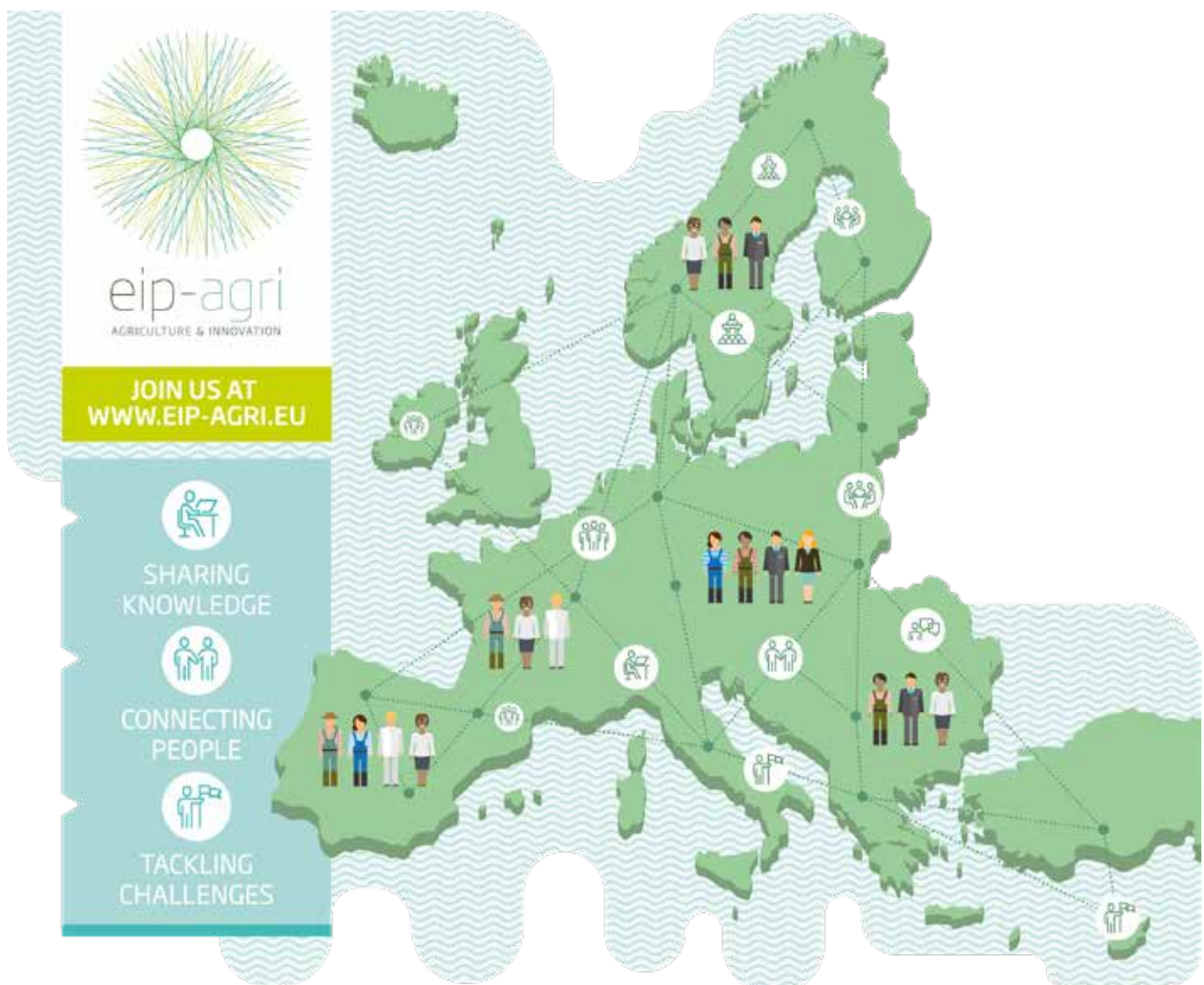
- ▶ EU consumers put more trust in EU farmers and their products than in food coming from other continents. This trust must be maintained, since it forms the basis for communicating a new concept of food health, which would include the environmental and social sustainability of the production process.
- ▶ Dissemination at all levels is needed. An EU campaign on the positive role of farmers in biodiversity issues, reaching all citizens, could be promoted (shared widely).
- ▶ Food traceability can also be instrumental, since it calls for involving consumers, producers, and public authorities.

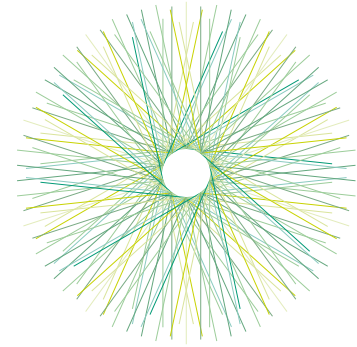
Knowledge

- ▶ Knowledge needs further improvements, starting from data on new combination of crops, mixing, alternation, etc. to better understand the relationship between soil biology, plant biology and soil and plant management, all related to the specificity of the territory.
- ▶ More examples are needed to show how CR&CD can be applied at different scales in the same territory: from the field to the farm and the watershed, to improve ecosystem services like carbon sequestration, biological control of pests and diseases, water flow and runoff regulation, contributing substantially to the increase of water use efficiency and reduction of soil water erosion, and to the improvement of the attractiveness of the landscape.
- ▶ Further experiences are needed on the combination of CR&CD with other emerging agro-techniques, like Conservation Agriculture, Precision Farming, organic farming, etc.
- ▶ More understanding is needed on how these systems can be used in a circular economy approach: innovation in CR&CD can allow a better recycling of agricultural and urban wastes.

Further reading

For more information, access all presentations and workshop documents [at the event webpage](#) on the EIP-AGRI website.





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The European Innovation Partnership 'Agricultural Productivity and Sustainability' (EIP-AGRI) is one of five EIPs launched by the European Commission in a bid to promote rapid modernisation by stepping up innovation efforts.

The **EIP-AGRI** aims to catalyse the innovation process in the **agricultural and forestry sectors** by bringing **research and practice closer together** – in research and innovation projects as well as through the EIP-AGRI network.

EIPs aim to streamline, simplify and better coordinate existing instruments and initiatives and complement them with actions where necessary. Two specific funding sources are particularly important for the EIP-AGRI:

- the EU Research and Innovation framework, Horizon 2020,
- the EU Rural Development Policy.



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