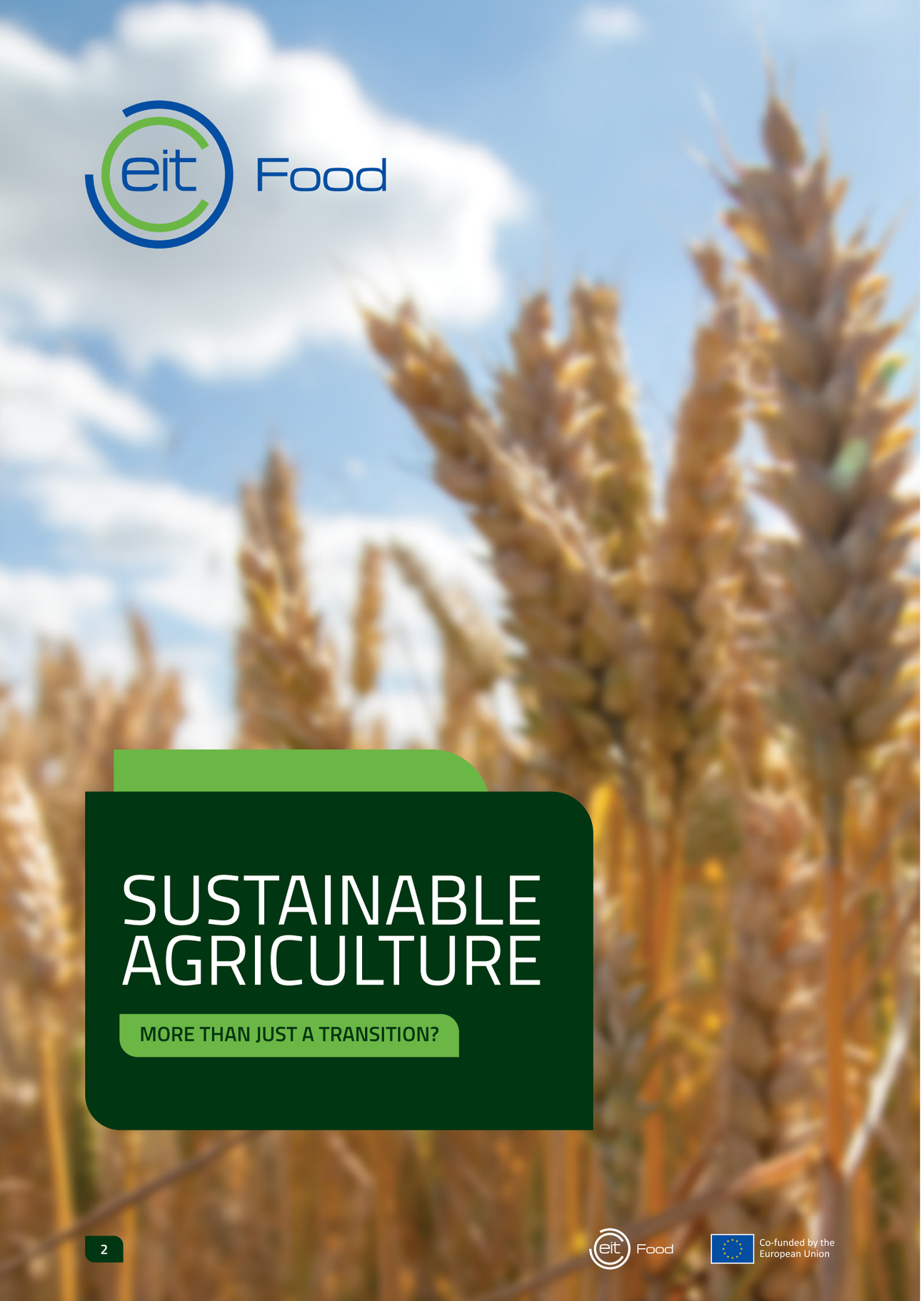
eit Food

Co-funded by the European Union

SUSTAINABLE AGRICULTURE

MORE THAN JUST A TRANSITION?



SUSTAINABLE AGRICULTURE

MORE THAN JUST A TRANSITION?

eit Food
Co-funded by the European Union

SUMMARY

The year 2021 has been characterised by 3 events that were of high relevance for Europe's agricultural sector:

The COP 26 UN Climate Change Conference, the UN Food Systems Summit and the adoption of the new common agricultural policy: 2023-27 (New CAP). Their common denominator: The impact of human activity on climate change and biodiversity loss with agriculture playing a significant role. There is an urgent need to implement mitigation and adaptation actions to achieve net zero emissions by 2050 and to limit global warming to 1.5 degrees Celsius, while restoring biodiversity and sustaining global food security.

The agricultural sector is both contributing to – and suffering from – global warming. A series of mitigating and adaptation solutions have been developed that are based on e.g., advanced digital tools or regenerative practices. In this paper we review some of the most promising solutions that not only support a transition to more sustainable agriculture but also help European farmers to meet the sustainability targets set out by the EU Green Deal and new CAP. We advocate a systemic approach that includes all stakeholders in the European food value chain, where co-creation with farmers is key to the successful adoption of climate-neutral, resilient and economically-viable farming practices.

eit Food
Co-funded by the European Union

INTRODUCTION

On September 24, just weeks before the COP 26 UN Climate Change Conference, the international climate movement Fridays for Future mobilised hundreds of thousands of people in 99 countries to join a coordinated global climate strike in protest against the lack of action on the climate crisis (global climate strike).

Human activities have fundamentally increased the concentration of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in Earth's atmosphere. This has contributed to global warming (NASA: The Causes of Climate Change), prompting the movement to continue its demands for more actions for "a safe pathway under 1.5 degrees Celsius". In fact, human-induced climate change is already causing many weather and climate extremes in every region across the globe. These include heatwaves, heavy precipitation, droughts and tropical cyclones which threaten livelihoods, ecosystems and food security (ipcc: Climate Change 2021 - The Physical Science Basis).

Limiting global warming to well below 2 degrees Celsius, preferably to 1.5 degrees Celsius, compared to pre-industrial levels has been the target of the Paris Climate Agreement, introduced during the 2015 COP 21 UN Climate Change Conference. For the first time, legally-binding targets were set out for 196 nations with the aim of mitigating climate change by reducing greenhouse gas emissions by 45% over the next decade and reaching net zero emissions by 2050. The 2021 COP 26 UN Climate Change Conference once again highlighted the urgency of protecting, conserving and restoring nature and ecosystems for climate change adaptation and mitigation. It also implemented measures for accelerating actions for achieving the Paris Climate Agreement goals. More specifically, in the COP 26 Glasgow Climate Pact, the participating countries confirmed their commitment to maintaining global warming at 1.5 degrees Celsius. Their actions here include reducing greenhouse gas emissions (mitigation), helping those already impacted by climate change (adaptation), enabling countries to deliver on their climate goals (finance), and working together to deliver even greater action (collaboration). To this end, **agriculture, land-use and food** should play a more prominent role in achieving net zero emission by 2050. Governments recognized that **soil and nutrient management practices and the optimal use of nutrients** lie at the core of climate-resilient, sustainable food production systems. Moreover, **livestock management systems** should improve in terms of sustainable production and animal health, contributing to reducing greenhouse gas emissions while enhancing carbon sinks on pasture and grazing lands (COP26 and Significant Progress on Issues Related to Agriculture).

eit Food
Co-funded by the European Union

It is well established that the agricultural sector **has an impact on both climate change and biodiversity loss**. At 10%, agriculture plays a key role in the production and emission of greenhouse gases (epa.gov: Sources of Greenhouse Gas Emissions). Emissions stem mainly from livestock farming and manure management, CH_4-release from ruminants' enteric fermentation and the use of nitrogen-containing fertilisers resulting in the production and release of N_2O (eea.europa: Greenhouse gas emissions from agriculture). The latter, in combination with manure storage and slurry spreading, is the main source of nitrates in surface and ground waters. Together with non-sustainable irrigation practices – seasonally, the sector consumes more than 50% of the water used in Europe (EEA Agriculture) – conventional agricultural practices exert major pressure on renewable water resources as well as Europe's ecosystems. Moreover, agricultural activities contribute to the loss of biodiversity and soil organism populations as the growing trend toward monocultures combined with intensive farmland cultivation reduce the availability of habitats for manifold plants and animals (German Environment Agency: Threats to biodiversity).

The use of pesticides in agriculture has a negative impact on pollinators and pollination by insects is crucial for 75% of global crop types with one third being pollinated by bees alone (FAO). A loss of pollinators is therefore directly linked with crop loss and **global food security**. Lastly, many **antimicrobials used in food-producing animals or plant production** are identical or closely related to antimicrobials used in humans. In its guidelines on using medically important antimicrobials in food-producing animals, the World Health Oganization strongly recommends an overall reduction in the use of all classes of such drugs to prevent the spread of antibiotic resistance.

Tackling these challenges is a task too big for each of us individually. "Everyone, everywhere must take action and work together to transform the way the world produces, consumes, and thinks about food." This was the guiding principle of the first-ever international UN Food Systems Summit held during the UN General Assembly in New York on September 23, 2021. During this "people's summit," participants from all around the world met to co-create solutions and actionable commitments with the aim of reducing biodiversity loss, pollution, water use, soil degradation and greenhouse gas emissions. This would be achieved by globally optimizing environmental resource use in food production, processing and distribution. To increase the **efficacy of climate change mitigation actions** the needs of farmers should be at the heart of each initiative. Examples include the NDC's toolkit for farmers and the Pathway to Dairy Net Zero that are based on **systemic, multi-actor initiatives that integrate environmental, educational, and behavioural components**. Regen10 will work with and financially support over 500 million farmers to apply regenerative production methods and to sustainably transform agricultural systems: By 2030 over 50% of the world's food shall be produced in a way that drives positive outcomes for people, for nature, and for climate. To achieve this, farming communities shall operate under a new farm economic model. This is based on convergence and alignment with the aim of **catalysing an economically sound, collaborative leap towards regenerative food systems in which farmers play a leading role**.

eit Food
Co-funded by the European Union

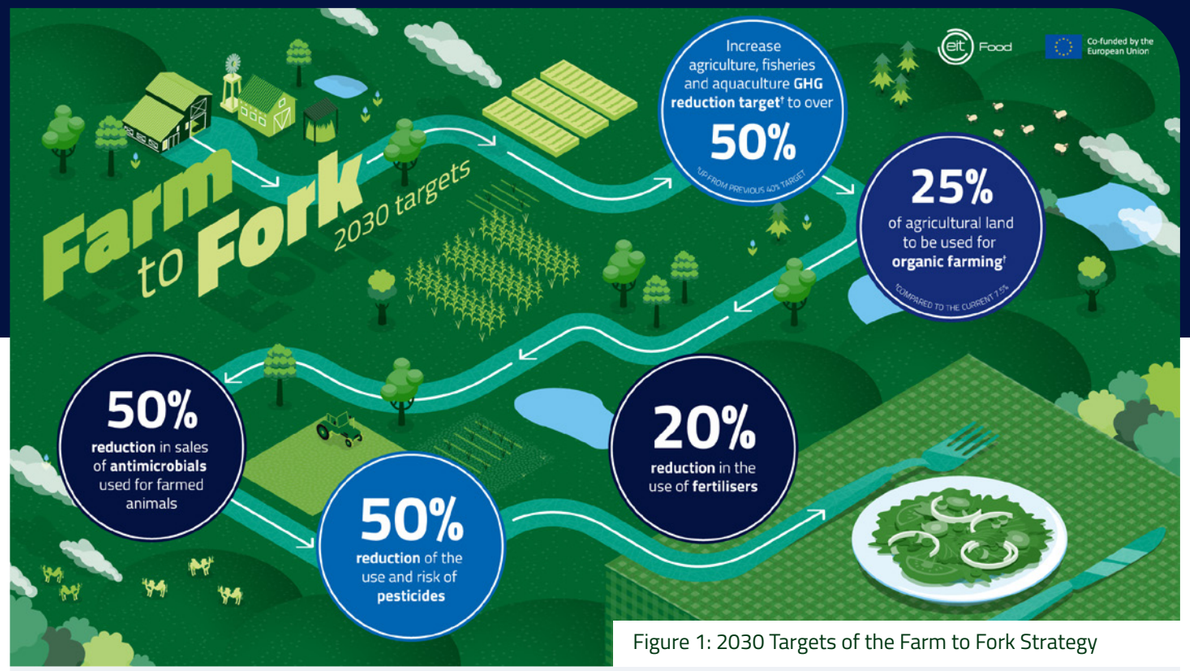


Figure 1: 2030 Targets of the Farm to Fork Strategy

Through the EU Green Deal the European Union (EU) has committed itself to reducing climate change and environmental degradation and transforming the EU into a modern, resource-efficient and competitive economy postulating (i) no net emissions of greenhouse gases by 2050, (ii) economic growth decoupled from resource use, and (iii) no person and no place being left behind. The Farm to Fork Strategy (Figure 1) and Biodiversity Strategy are key pieces of the EU Green Deal. They summarize measures to ensure more sustainable food systems, the protection of Europe's ecosystems and to "halt pollution of soil, water, and air, as well as biodiversity loss." By 2030, these measures shall reduce the use and risk of chemicals as well as more hazardous pesticides by 50%, nutrient losses by at least 50% and fertiliser use by at least 20%. The sale of antimicrobials for farmed animals will also be reduced by 50%. A further target is to reach 25% of total agricultural land under organic farming. The new common agricultural policy: 2023-27 (CAP) will be instrumental in achieving these targets. Key objectives are to improve social ("a fairer cap"), environmental ("a greener cap"), and economic sustainability ("improving competitiveness") in agriculture and rural areas and facilitate the transition towards sustainable agriculture and forestry.

EIT Food is the world's largest and most dynamic agri-food innovation community. We are on a mission to build an inclusive and innovative community where all stakeholders in the food value chain are actively involved in the **transition of the food sector towards more sustainability.** We support the development and implementation of sustainable solutions that contribute to the reduction of GHG emissions. We also promote the regeneration of biodiversity and ecosystem services through a significant reduction of the environmental impact of agricultural activities, while sustaining agricultural productivity and profitability. Our solutions help farmers cope with climate change and build-up agricultural resilience through **more sustainable use of resources (energy, water and land), net-zero carbon strategies, reducing food loss, land degradation and biodiversity loss**.

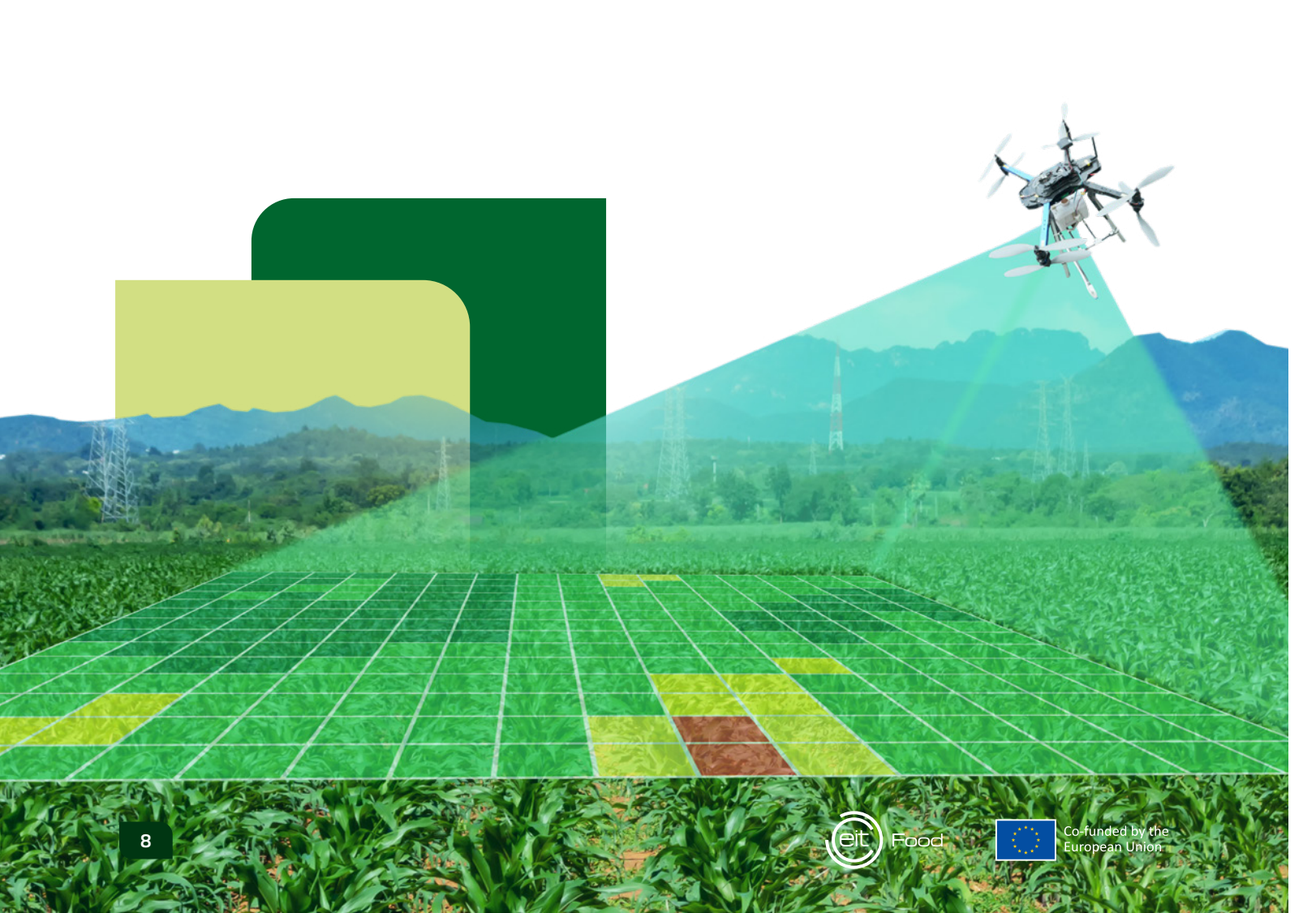
In this paper, we showcase some of the most impactful agri-tech solutions for climate-neutral, resilient and economically viable farming. Since farmers are the guardians of our environment, we postulate that any solution must be based on a multi-stakeholder approach with the needs of the farmer at the heart of each activity. Co-creation is key to establishing knowledge capacity, not only with and for farmers, but along the whole food value chain for the successful adoption and uptake of innovative and impactful sustainable practices. These practices are based on:

- Smart farming technologies for sustainable and maximized resource use;
- Acknowledging the importance of healthy soils in sustainable farming;
- Fostering trust and adoption of agricultural innovations.

SMART FARMING TECHNOLOGIES FOR SUSTAINABLE AND MAXIMIZED RESOURCE USE

Agriculture is experiencing its Fourth Revolution. It has been sparked by the availability and adaptability of information and communication technology in agriculture, in particular the use of artificial intelligence (AI) in combination with smart decision and planning tools as well as robots.

Technologies are being used for growing and picking crops, weeding, milking livestock and distributing agrochemicals via drones. Farmers can track weather changes, precipitation, pest infestations and more to ensure precise water, fertiliser and pesticide application based on accurate data derived from, e.g., satellite imagery for farmland monitoring. Next to reducing the workload of farmers from the dairy to the horticultural sector, digitising agriculture is one of the most promising ways towards sustainable, viable food production and protection of the environment (Opinion: Smart farming is key to developing sustainable agriculture).



Farm inputs can be reduced by means of digitally-controlled **site-specific weed management** where the treatment is only applied on the weed patches. The EIT Food project DACWEED is testing this for herbicide applications in cereals like wheat and row crops like maize. Sensor data derived from cameras provides input to a neural network trained to separate viewed plant material into crop plants and weeds and to autonomously initiate specific spraying implementation. The integration of such a perception system for the detection and control of action devices will allow a more selective and effective herbicide treatment and, overall, reduce herbicide input leading to safer, more sustainable agricultural products for the consumer and environment.

Connecting smart sensor data by means of Near Infrared Spectroscopy (NIRS) coupled with GPS location allows **real-time measurement of crop constituents** such as protein, carbohydrate or oil levels already at harvesting. This allows better segregation of different quality levels to improve planning and efficiency in the next processing steps and reduces food loss of **grains such as wheat, barley and oilseed.** In addition, since protein levels are highly linked to the nitrogen uptake from the soil, yield maps can be produced to support a more sustainable balanced nitrogen fertilization in the following years (EIT Food project "Constituent sensing of small grains").

"The big advantage of smart farming is to get a better understanding of what is actually happening on the field. Sensors, drones or satellites – in combination with predictive modelling – allow us to reduce the use of fertilisers and pesticides and increase nutrient efficiency through tailor-made handling of soils and crops. To gain consumer trust, we also use the data to demonstrate to consumers how famers contribute to sustainability and environmental protection." **Erik Jennewein** operates a farm, hotel and restaurant in the Southwest of Germany. He is participating in the project "constituent sensing of small grains" to test new smart farming technologies with the aim of establishing environmentally friendly farming practices by limiting the use of fertiliser and phytosanitary inputs.

In **precision livestock farming**, smart technologies can help with promoting and certifying positive animal welfare practices, supporting the rearing of healthier animals and managing herds more efficiently. Automation is widely applied in the form of fractional feed distributions (High-Tech stabling: robots in animal husbandry). Biosensors and wearable technologies like thermal and vision sensors measure changes in body temperature and walking gait to detect medical problems in their early stages and provide the individual animal with special care (Recent advances in wearable sensors for animal health management). In herds, cameras or robots are used to track the animals' health and check they have enough pasture to graze on.

The EIT Food project Pig Tracker uses real-time monitoring of pigs to track them from birth to abattoir. The technology combines state-of-the-art video cameras with an AI-driven tool to predict pig weight and behaviour. This generates traceable, transparent information about where pork comes from and the conditions in which the pigs are reared. It offers multiple benefits: (i) promoting and certifying positive animal welfare practices, (ii) supporting the rearing of healthier animals and (iii) helping farmers to manage their herds more efficiently. Most importantly, it will promote transparency in the food chain, improving trust and supporting decision-making by consumers who are interested in where their food comes from and conscious of the conditions it is reared in.

"It is vital that the solutions we provide are co-created with end users and other stakeholders to ensure we help solve real-world problems. Through the EIT Food Pig Tracker project, we engage with farmers and other actors along the value chain to understand their needs and tailor our solutions accordingly. This approach provides farmers with the productivity and welfare gains they demand."

Luke Dalton, Commercial Alliances, Zoetis

Livestock farms routinely produce and monitor data relating to environmental conditions, animal behaviour and production parameters. This requires advanced data analytic systems that integrate different data sets and act as a decision-making tool for the farmer. In the dairy sector, milk quality reports at dairies and labs are often logged for long-term analysis. To develop a data-driven decision support tool which brings separate data together is the objective of the EIT Food project "Big data and advanced analytics for sustainable management of the dairy cattle sector". Parameters such as heat stress, fertility and milk quality in dairy cows are monitored to build algorithms that are integrated in an online platform. The platform is designed for stakeholders in the dairy farming sector to improve their decision-making processes with the overall aim of enhancing sustainable production, animal welfare and productivity.

"Farmers' profit margins are small and minor changes in cost structure have a significant impact on profit. Farmers consider innovation an investment in terms of time and money. To convince farmers to invest in and adopt new, sustainable technologies, profit and contribution to sustainability requirements must be clear. New (smart) technologies are often only profitable for large farms."

Łukasz Czech is a farmer and consultant. Together with his family he produces pigs on 250 hectares. Engaged in sustainable solutions within the framework of the Rural Development Programme, EIP-Agri and Operational Groups, he is also the creator of the biggest internet group for Polish farmers on the Facebook page "Rozmowy o Rolnictwie".

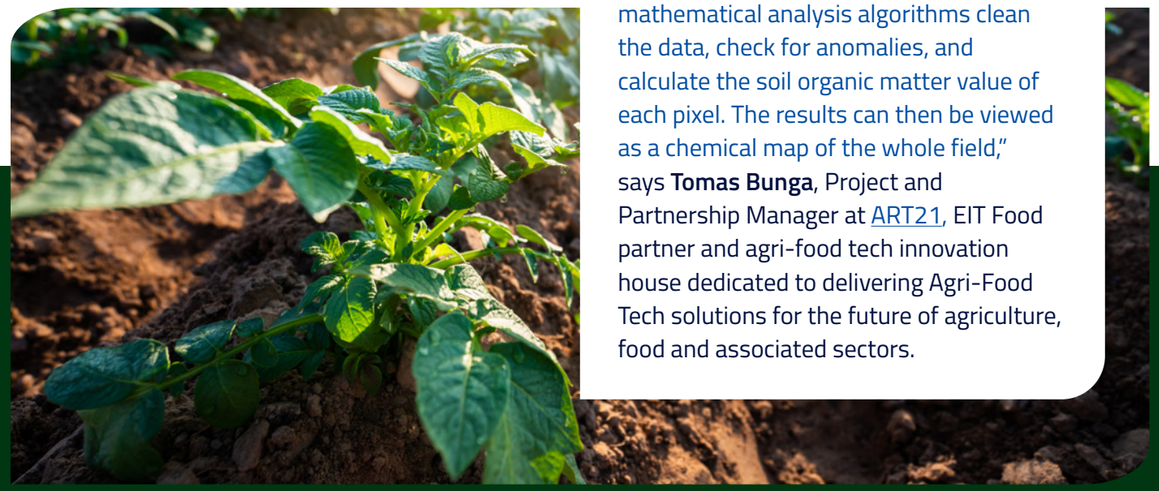
ACKNOWLEDGING THE IMPORTANCE OF HEALTHY SOILS IN SUSTAINABLE FARMING

A healthy soil is the most precious resource farmers have. Understanding the needs of soil not only helps generate higher yields but also plays a vital role in mitigating the greenhouse effect (The Increase of Soil Organic Matter Reduces Global Warming, Myth or Reality?).

It does this directly by capturing and storing carbon (Soil C Sequestration as a Biological Negative Emission Strategy) and indirectly by providing nutrients for various carbon cycling ecosystems (Soil organic carbon is not just for soil scientists: measurement recommendations for diverse practitioners). Soil quality is dependent on the amount of soil organic matter (The Ability of Conservation Agriculture to Conserve Soil Organic Carbon and the Subsequent Impact on Soil Physical, Chemical, and Biological Properties and Yield) and soil organic matter is recognised as an important indicator of soil structure and quality, as well as ecological balance and stability of the biosphere. It has additional environmental and economic benefits by reducing the quantity of fertilisers required.

The ability to assess and track changes in soil organic matter is of immense value for agricultural stakeholders. MOSOM (EIT Food project "Mapping of Soil Organic Matter") is a novel technology for remote assessment of organic matter within soil. Using a range of Earth Observation techniques with a unique AI-based analysis architecture helps to assess organic matter within soil remotely and generate field maps for more efficient soil stewardship by the farmer.

"The technology behind MOSOM is based on the analysis of the multispectral reflectance spectroscopy data, which is collected via satellites. Sophisticated mathematical analysis algorithms clean the data, check for anomalies, and calculate the soil organic matter value of each pixel. The results can then be viewed as a chemical map of the whole field," says **Tomas Bunga**, Project and Partnership Manager at ART21, EIT Food partner and agri-food tech innovation house dedicated to delivering Agri-Food Tech solutions for the future of agriculture, food and associated sectors.



The European Commission estimates that **60-70% of soils in Europe are unhealthy**. To combat this, the new EU soil strategy for 2030 has established an overarching policy framework for soil remediation to assess the degradation of Europe's soils. One promising approach is offered by microbiomes, communities of microbial organisms found in, on and around us that can be critical to the well-being of humans, animals and plants. In plants, they play a central role in providing nutrients, improving stress resistance, degrading toxins and eradicating pathogens. In addition, they influence plant metabolism, the methane cycle and carbon formation (Calling for a systems approach in microbiome research and innovation). Consequently, the use of microbiomes (e.g., as biofertilisers, biological control agents and pre- or probiotic supplements) to increase biodiversity and reverse desertification and land degradation has become increasingly important in innovation and research (EU soil strategy for 2030; Food 2030).

Although the **benefits of microbiomes** are obvious, hurdles remain in the formulation, application, selection and prediction of microbiomes (Microbiome Applications from Lab to Field: Facing Complexity). There is a lack of a coherent regulatory framework and shared awareness and technical skills for formulating R&I strategies. International partnerships and collaboration between private and public entities at regional and European levels are critical to enable progress in microbiome research.

The EIT Food project BIOSUVEG merges the efforts of biostimulant producers, farmers and academics in a co-creation effort to bring a novel plant-based biostimulant for tomato growers to market. The biostimulant is derived from beneficial plant extracts, which naturally boost plant resilience to conditions such as drought and nutrient stress.

Professor **Andrea Schubert**, Università degli Studi di Torino, Department of Agricultural, Forest and Food Sciences, is leading this EIT Food activity. He says: "Many biostimulants are already on the market, but demand is expanding and few products specifically address improvement of yield under stressful conditions. The biostimulant will contribute to enhanced vegetable crop yields by increasing their resilience to environmental changes. It will benefit EU farmers by offering them new business opportunities as well as an increase in competitiveness and profitability, allowing them to obtain more and better-quality products while reducing water and fertiliser use and consequently reducing costs."

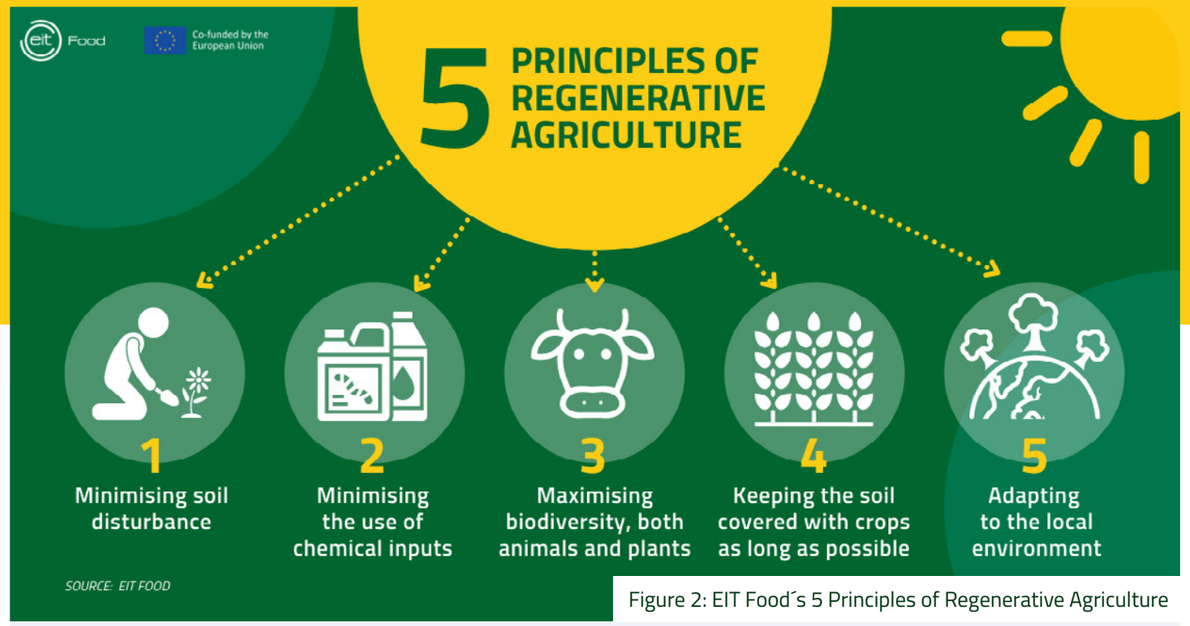


Figure 2: EIT Food´s 5 Principles of Regenerative Agriculture

Regenerative agriculture (Figure 2) is a system of farming principles and practices that enriches soils, increases biodiversity, improves watersheds and enhances ecosystem services. In terms of protecting the environment, farmers are also improving their bottom line thanks to higher yields, lower input costs and increased resilience to extreme weather events and climate change. The most important aspect of regenerative agriculture is soil health, because soil is ultimately the most valuable asset on the farm. Some of the key techniques being used in regenerative agriculture to increase soil health are no tillage, cover crops, rotation cropping, reduced use of chemical inputs and the integration of plants and animals.

Regenerative agriculture works according to a whole ecosystem approach, meaning aiming to work with nature instead of against it. When taking farm management decisions the whole farming ecosystem is considered. All of the involved stakeholders are also taken into consideration and mutually beneficial relationships are established between them. The farm is a dynamic environment and continuous improvement and growth is pursued to utilise the full potential of the farm, community and individuals.

As part of its mission to make food systems healthier and more sustainable, EIT Food created the Regenerative Agriculture Revolution. One of its main aims is to help farmers learn about and transition to more sustainable methods of agriculture.

To help bring about the Regenerative Agriculture Revolution, efforts target the following areas:

1. **Farmer training and support:**
   EIT Food offers innovative farmers comprehensive training programs that help them learn about and then apply the principles of regenerative agriculture on their farms. The most promising projects were chosen to participate in a three-year advisory program in which experts in regenerative agriculture advise the farmers on how to transition from conventional or organic to regenerative farming. By the end of 2021 a total of 45 farmers had been enrolled across Spain, Italy, Portugal and Poland.
2. **Monitoring ecosystem improvements:**
   Over 20 environmental and economic parameters are measured on the farms as part of the advisory program to better understand the impact of regenerative farming practices on soil health, biodiversity and farmer income. The evolution of these parameters is monitored thanks to an application called "Soilmentor" that farmers and agronomists use to input soil management data from every farm in the programme.
3. **Consumer engagement:**
   For farmers to adopt regenerative agriculture it is essential that the European public understands and appreciates what they are doing and how it benefits the environment and our health. Through compelling research and powerful storytelling (videos, a blog and articles on successful regenerative farmers), the connection between soil health and human health is explained.

These services are offered to agri-food businesses that are seeking ways to regenerate their supply chain. Participation in the **Regenerative Agricultural Revolution programme** is expected to have enormous potential as corporations come under increasing pressure from consumers and shareholders to reduce their carbon footprints.

I am having an incredible experience. I had been reading about regenerative agriculture for years but lacked the drive to make the leap. Thanks to the advice of EIT Food I have started the transformation, which is now unstoppable because I am seeing results. I know I'm on the right track. I have joined the livestock of the future. Best of all, I have an expert by my side who helps me solve all the problems that arise. I am not alone.

José María Molina – Livestock breeder and grain farmer (Cordoba)

My experience in EIT Food's Regenerative Agriculture programme has been very satisfactory, as it has allowed me to discover that another model of agriculture is possible and that farmers and ranchers have a real alternative in our hands to recover the biodiversity of our planet. I think this programme should be repeated and much more publicized. It has also served our family to meet very valuable people. Regenerative agriculture has marked a milestone for us and has opened a path of change, hope and new dreams. The year has passed by very quickly and I didn't realize that the programme is drawing to a close.
I hope that EIT Food continues with its programme and that you achieve many successes. The truth is that it is much needed. I hope to continue receiving information about your courses and progress and, if possible, I will join one.

Miguel Angel Gomez - Olive and grain farmer (Cordoba)

For me the programme has been very positive. From 1 to 10, 12 . Why? Well, I already had the idea of doing things in a more natural way and to foster the work of microorganisms, both in the field and in the wine. Having Ruben Borges as an advisor and later meeting Orkatz (another advisor on the team of agronomists) and Iris (the agronomist who performs soil monitoring on the farms) has given me a more technical and structured perspective of what I was doing well on the farm. I really appreciate the practices, knowledge and experience that they have acquired and shared with me. They are enriching and improving my work and connection to the environment.
This season we are going to continue implementing actions that Ruben has proposed, such as the addition of organic matter and humic acids (adjusted according to soil analysis carried out by EIT Food). Both Ruben and Iris agree the plot has great potential if I continue with the practices I am implementing. For example, during Iris' visit, we saw a tremendous development of rhizomes in the roots of spontaneous grasses. It was great to see and comment on it.
But I recommend the program not just from a technical point of view, but also from a personal point of view – the organization is fantastic. I hope I can continue to be involved. I will attend more events that you organize.
I talk about our collaboration with EIT Food to everyone who comes to the winery to visit us and learn about our project and wines.

Victor Negro – Winemaker (Burgos)

CARBON FARMING

Carbon farming should be understood as a subset of a much larger regenerative agriculture topic, which recognizes the farmer as a steward of the ecosystem in which her/his farm is embedded.

Each farmer is a steward of cycles of nature, including the carbon cycle. From this perspective, each farmer of the world is a carbon farmer. In terms of the carbon cycle, the greenhouse gas emissions cycle is addressed, which is composed not only of carbon (with its different forms, such as CO_2), but also CH_4 and N_2O as well as other greenhouse gases (IPCC, 2006).

Therefore, an objective of each carbon farmer is to understand the carbon cycle present in her/his ecosystem and steward it in the best possible way. Here, farmer's actions can be grouped into three areas:

1. Avoiding emissions,
2. Reducing emissions,
3. Developing carbon sinks.

An example of farming practice in the first group is eliminating ploughing, so that the carbon stored in the soil is not released back into the atmosphere. An example of farming practice in the second group is optimizing fertilisation depending on the soil map, so that only the right amount of fertiliser is applied at any point of the field, rather than using flat rate application. Finally, an example of practice in the third group is rewetting parts of the farm, so that peatlands (one of the world's largest skins of carbon) can be maintained and restored.

The perspective on carbon farming presented above is a very broad one, reflecting the systemic nature of ecosystems. Today, in public discourse, the term "carbon farming" is used to refer to the carbon payments in the carbon credit formula.

"In the agricultural carbon credit payment mechanism, the farmer receives payment from the purchaser of carbon credits for each ton of CO2e she/he has additionally reduced and/or sequestered on the farm (Figure 3). Here, the key term to note is "additional", which means that to qualify for the carbon payment the payment must be the reason for making changes on the farm, which lead to the reduction/sequestration of greenhouse gasses.

Finally, while there is considerable interest from the private sector in terms of purchasing agricultural carbon credits, as well as from the farmers' side in meeting this demand, it is critical to note that the regulatory environment for this market is either nascent, or non-existent. Therefore, both farmers and purchasers of agricultural carbon credits are advised to take particular care, while regulators must connect the CAP with its climate change ambitions. A promising way might be to restructure the CAP away from action-based payments to results-based payments centred on soil carbon maintenance and enhancement.

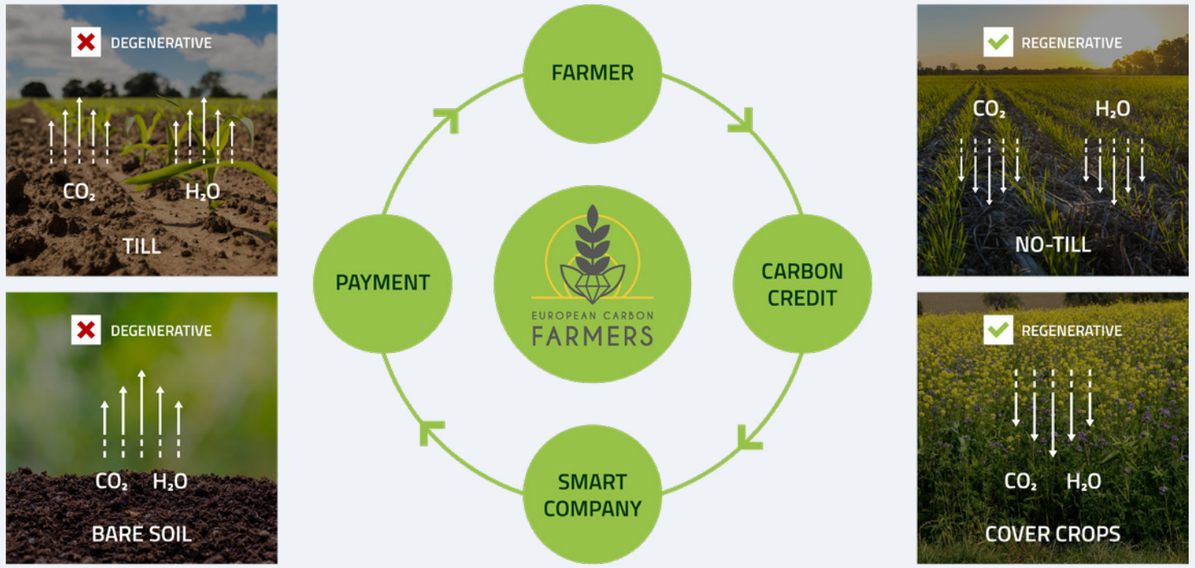


Figure 3: Agricultural Carbon Credit (European Carbon Farmers, 2021)

The EIT Food project C-Neutral Farming uses a combination of farmer focus groups and workshops to co-create a digital tool that is cost-effective, scientifically driven and both interpretable and practical at farm level. Its purpose is to enable a reduction in net greenhouse gas emissions within livestock production systems. Co-creation facilitates two-way knowledge exchange to mitigate greenhouse gas emissions and maximise carbon sequestration by developing a sustainability mindset among farmers. In addition, the tool will also foster peer-to-peer learning about the economic benefits of carbon accounting and whole-farm sustainability.

"While Europe is committed to reducing its greenhouse gas emissions to reach a net-zero target by 2050, the pathway to net-zero emissions will require deep emission cuts across all agricultural sectors including livestock farming. The precise consequences for this sector have yet to be determined. However the pathway to net-zero emissions will have implications for productivity, environmental impact and land use. C-Neutral Farming, an EIT Food project, aims to co-create an innovative digital solution with farmers and industry to help mitigate the environmental footprint of livestock production systems."

Prof **Nigel Scollan** Director of Institute of Global Food Security

"The way that we are grazing our animals is actually enhancing our soils and our environment. We take care of the balance of butterflies and bees and insects on the farm and because of that we got a lot more birdlife and the farm is really flourishing. We allow soils and plants to recover, increase organic matter and improve biology in the soil all the time. This is helping to capture carbon in the form of CO_2 from the atmosphere where it comes from. We are part of the solution to climate change."

James Evans is Organic Beef Farmer in Shropshire. He believes that sustainable farming is possible by working in harmony with nature (A day in the life of a farmer).

FOSTERING TRUST AND ADOPTION OF AGRICULTURAL INNOVATIONS

Agriculture is at the heart of our food system; as our population grows, so too does our dependence on it to feed and nourish us. But how much do consumers trust farmers?

Of all players within the food system, **farmers were recorded as the most trusted by the public**, with two thirds (67%) of European consumers reporting that they trust them as part of the EIT Food Trust Report 2020. When asked about the competency, care and openness of farmers, overall trust for farmers has increased since the first survey in 2018, and two thirds of European consumers (69%) said farmers do a good job in their role in the food system. Over half (56%) also said farmers act in the public interest, with the highest score in the UK at 72%. These findings were also supported in the EIT Food Citizen Participation Forum results.

This overall increase in trust for farmers may have been influenced by the fact that more European consumers are buying locally as a result of COVID-19 and have, in many cases, depended on them to source their essential food during isolation periods. There were also high levels of trust specifically in small farms. Many consumers reported an idealised image of these farmers, calling them 'custodians of the land', 'the backbone of the food industry', 'hardworking' and 'passionate'. However, there was less trust in larger 'industrial' farms, with concerns voiced around intensive farming methods, animal welfare, genetically modified organisms and the use of chemicals, pesticides and hormones – and a lack of information about these things.

The study found **that consumers want farmers to be more approachable and offer more opportunities to visit their farms**. This would enable consumers to see first-hand what farmers are doing to transition to more sustainable practices. Consumers also felt that large farms in particular need to be more transparent and honest and show what they are doing to minimise the negative impact their processes and practices could have on animals and the environment.

Improving transparency also means consumers can play a more active role in accelerating the transition to sustainable agriculture. With clearer information about the sustainability of their food, consumers can make more informed decisions about what they buy and prioritise brands that focus on sustainable agriculture, for example.

One example how farmers can reach out to consumers is the concept of market gardening which is about reviving traditional agricultural production methods. A market garden is a small plot of land where fruits, vegetables and flowers are grown and sold directly to the consumer (Inspirational ideas: Market gardening). Market gardens are mostly run as "organic farms" using agroecological methods and typically range up to 1 hectare in size. They may consist of large greenhouses or a combination of plants grown both indoors and outdoors. This allows them to be managed by manual labour and simple equipment only. Benefits are healthy, fresh and organic products the consumer can source locally and directly from the farm.

"Market gardening is a multifunction, systemic solution that helps mitigate climate change and restore biodiversity, while building resilience and supporting the regional rural economy, especially by providing meaningful jobs for young people. My vision of market gardening is to establish a market garden in each larger village by 2035 to provide fresh vegetables for the local community". **Alfred Grand** lives close to Vienna/ Austria where he runs a 90-hectare organic, regenerative, arable field farm that he also uses for research and demonstration purposes (GRAND FARM) to highlight the benefits of healthy soils, agroforestry, and market gardening to growers and consumers.

Aside from tending to the crops and animals, farming is becoming increasingly technology driven. As such, modern farmers need to be equipped with the knowledge and skills to use agricultural technologies that help their businesses flourish. Often, new technologies are developed by scientists without including the actual users in their design. Consequently, farmer adoption of these technologies is often limited and therefore the benefits are not realised. Central to the design of agricultural technologies are **understanding the user's needs and expectations of the technology**, its usability and robustness, the possibility of integrating it with existing systems and databases, technical support and the clear benefits of its use (Involving Stakeholders in Agricultural Decision Support Systems: Improving User-Centred Design).

At the University of Reading, researchers are combining data from various sources to create crop management zones for precision agriculture solutions. Historical, current and innovative spatial data sources (e.g., higher resolution image capture by drone/satellite, soil electrical conductivity/compaction scans) are integrated, and algorithms used to generate predictive maps of potential yield and grain quality. This is currently being tested for protein levels and seed moisture in wheat (EIT Food project "LINKDAPA"). This will allow the spatial application of inputs such as fertilisers and harvesting higher grain quality. Most importantly, all developments are undertaken in co-creation with farmers and their advisors to better understand farmers' needs to build confidence in these maps and also their willingness to pay for (more) data with the aim of facilitating the adoption of the technology under development.

eit Food
Co-funded by the European Union

"The LINKDAPA project brings together large and complex data sets to generate smart innovative predictions for crop yield and quality in a spatially explicit way. However, these predictions have little value if farmers don't use them. We are working with farmers as part of LINKDAPA to co-create the role of data in managing their farm and investigate how the data can be collected and used to improve their management practices and profit margins. Understanding the type of information farmers want to see and how it is delivered to them is critical for long-term user engagement. The benefits of our approach will give farmers the knowledge they need to optimise the use of fertilisers on farms and identify the most productive areas of fields for crop yield and quality. This will improve farm profits and reduce the environmental impact of their operations." **John Hammond** is Professor at the School of Agriculture, Policy and Development at the University of Reading. His main research interests focus on the elemental nutrition of plants, combining research into plant physiology, elemental nutrition and genetics.

EIT Food actively drives technology uptake in the primary sector by linking innovative agri-tech start-ups with professional farmers and their farmlands, where inventors can test and validate their solutions under real-life conditions (EIT Food Test Farms). After validation, start-ups present their products to potential clients and investors by organizing demo days at a farmer's site or promoting their innovation on social media. The direct connection between the farmer and start-up allows the clear benefits of innovative technologies, such as saving time and money while simultaneously increasing yield, to be demonstrated.

Technologies tested in 2020 included smart solutions to help farmers become more sustainable. For example, by increasing yield with the help of electrostatic technology to assist pollination of susceptible crops, the application of biofertilisers and biostimulants that regenerate the soil, reducing the use of herbicides through automatic weeding, or saving water thanks to smart irrigation system.

eit Food
Co-funded by the European Union

Farmers trust their peers and are more open to listening and learning from other farmers who have already adopted agri-tech on their farm. The EIT Food project Focus on Farmers is dedicated to recruiting and training farmers to become champions and technology ambassadors for other farmers. Alongside world-leading industry and academic institutes, they develop engagement activities where they will be responsible for encouraging the wider farming community.

Focus on Farmers works across a range of agricultural industries (beef, arable, dairy) and countries (UK, Germany, Italy, Poland and Spain) and has been running since 2018. Groups support works and encourage networking in the form of farm tours, demonstrations and agricultural shows. These have proved to be successful formats for **engaging farmers and encouraging them to try new technologies on their farms**. To date over 6,000 farmers have participated in the project.

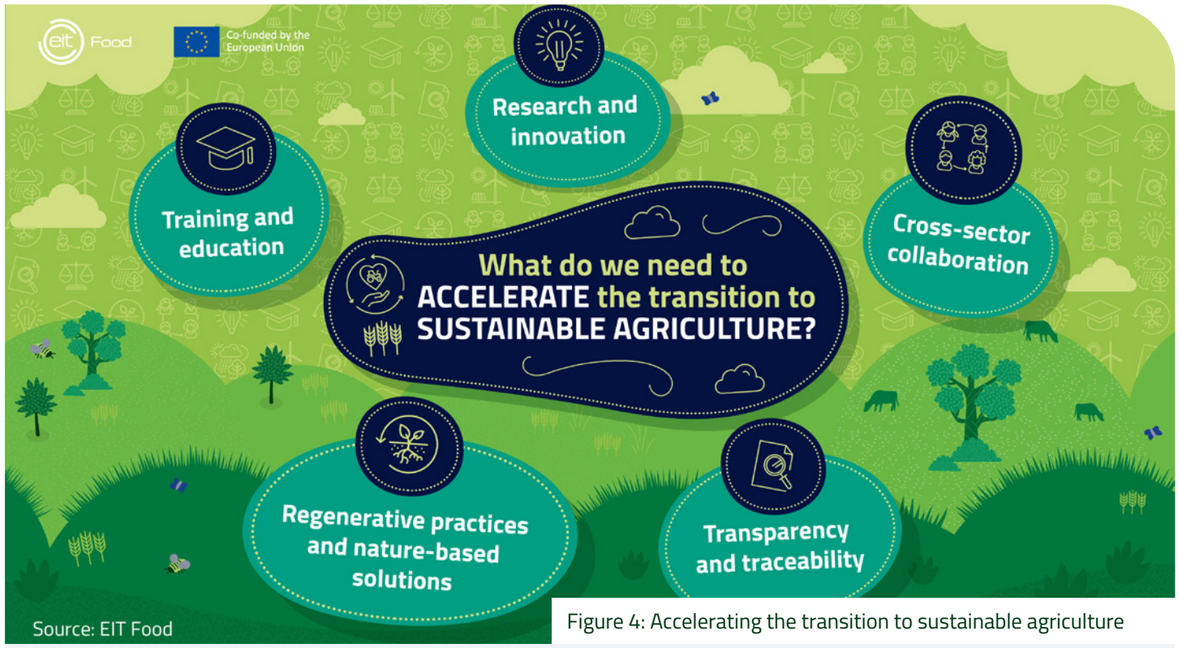
Online tutorials or Massive Open Online Courses (MOOCs) designed by EIT Food (EIT Food Future Learn) are also successful ways of engaging with farmers who appreciate the flexible viewing schedules and the ability to select topics relevant to them. These formats allow the sharing of evidence-based information with a large group who can learn the benefits and challenges of adopting new technologies through case study examples of real applications.

EIT Food MOOCs are also of great benefit to students, professionals and consumers, enabling them to become more familiar with the journey plants take from crops in the field to their plate. They learn about the challenges faced by farmers and the trade-offs required when considering organic, environmentally sustainable and socially acceptable production methods. They can also reflect on how innovative technologies help farmers provide a secure and sustainable food supply for a growing population (Explore How Farmers Produce Food Sustainably, Improving Food Production with Agricultural Technology and Plant Biotechnology, Farm to Fork: Sustainable Food Production in a Changing Environment, Innovation in Arable Farming: Technologies for Sustainable Farming Systems).

Sharing information based on real-life scenarios and supported by science gives confidence to consumers, restores their trust in the food value chain and enables them to act on their own motivations to choose sustainable and healthy food products.

CONCLUSIONS AND OUTLOOK

European farmers face a variety of challenges that they must address to ensure the efficiency, profitability and sustainability of their businesses. Farmers are under pressure to use less fertilisers and pesticides and to produce natural, safe and healthy products that protect biodiversity.



Source: EIT Food

Figure 4: Accelerating the transition to sustainable agriculture

Combining modern techniques with traditional methods of farming might be a promising way forward. Innovations based on big data and AI can help farmers measure the quality of their crops in real-time to improve yield and profitability, whilst advanced machinery and robotics can help farmers improve the efficiency and speed of harvesting. Alternative practices such as regenerative agriculture and carbon farming offer significant opportunities to improve the effectiveness of farm businesses through optimised yields, reduced environmental impact and increased profitability.

To foster adoption of sustainable solutions, peer-to-peer learning – through farmer champions in combination with linking farmers with start-ups and testing innovative technologies together on-site –proves to be a successful strategy. The transition to more sustainable farming also needs the "buy-in" from the consumer to continue growing trust, stimulate buying locally and prioritize sustainable products. Farmers already use modern technology and infrastructure to connect with consumers, invite consumers and local schools to their farms or collaborate and connect with local communities and chefs (Figure 4).

We at EIT Food believe that to protect the environment and our nutrition, the development and adoption of sustainable agricultural management practices needs to accelerate in a systemic way – from farm to fork. People-centric and systemic innovation, where no one is left behind, will be the key enabler in building net-zero, nature-positive food systems while at the same time guaranteeing food security and fair incomes to farmers.

While the transition towards sustainable agriculture offers immense potential for delivering on the commitments under the Paris Agreement and the EU Green Deal, it is clearly **more than just a transition and too big a challenge for each of us individually**. It requires inclusive and systemic innovation that involves all stakeholders in the food value chain. Farmers must collaborate with innovators, agri-tech providers and agri-food businesses and establish a transparent dialogue with consumers.

EIT Food has therefore joined the European Carbon+ Farming Coalition, a farmer-centric initiative to accelerate progress towards the European Green Deal carbon neutrality goals. By pooling resources, avoiding duplication of efforts, sharing and establishing best practices in such collaborative partnerships, greater impact can be achieved more effectively. Moreover, to help consumers make a sustainable food choice and encourage more sustainable food production across Europe, EIT Food is supporting the "Eco-Score" initiative. This places a front-of-pack environmental score, issued by the non-profit organisation Foundation Earth, on food products. Eco-Score shows the merits of bringing science-based information to consumers with the help of a pan-European partnership between business, education and research organisations.

eit Food
Co-funded by the European Union

ABOUT EIT FOOD

EIT Food is the world's largest and most dynamic agri-food innovation community. We accelerate innovation to build a future-fit agri-food system that produces healthy and sustainable food for all.

Supported by the EU, we invest in projects, organisations and individuals that share our goals for a healthy and sustainable food system. We unlock innovation potential in businesses and universities and create and scale agri-food startups to bring new technologies and products to market. We equip entrepreneurs and professionals with the skills needed to transform the food system and put consumers at the heart of our work, helping build trust by reconnecting them to the origins of their food.

We are one of eight innovation communities established by the European Institute for Innovation & Technology (EIT), an independent EU body set up in 2008 to drive innovation and entrepreneurship across Europe.

You can follow EIT Food via:
www.eitfood.eu

or via social media:
Twitter,
Facebook,
LinkedIn,
YouTube,
Instagram.

eit Food
Co-funded by the European Union

ABOUT THE AUTHORS

Dr. Kerstin Burseg is Innovation Programme Manager at EIT Food Central. With a degree in food chemistry and a Ph.D. in flavour sciences, Kerstin initially started her professional career in research and development before moving to the B2B and B2C sector. At EIT Food she is responsible for the strategy and project portfolio of the focus area "Sustainable Agriculture" (EIT Food Focus Areas).
Dr. Georg Schirrmacher is Managing Director of EIT Food Central. He graduated with a degree in agricultural sciences and holds a doctorate in natural sciences at the intersection of food and health. Georg started his career at the Technical University of Munich before moving to industry. He joined EIT Food in 2018. Together with his team he works hard to improve the current ag-food system.
Enquiries and contact: clccentral@eitfood.eu

CONTRIBUTING AUTHORS

Marie Ammann,
Innovation Manager EIT Food Central

Vivien Bodereau,
Education Programme Manager, EIT Food

Mateusz Ciasnocha,
Farmer & CEO, European Carbon Farmers

Matt Eastland,
Head of Brand and Content, EIT Food

Philip Fernandez,
Agriculture Project Manager, EIT Food

Sofia Kuhn,
Head of Public Engagement, EIT Food

eit Food
Co-funded by the European Union

www.eitfood.eu