

# A resilient food system for Flanders

ILVO RESEARCH VISION 2030



**Flanders**

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# Colophon

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We work toward food systems that are healthy in all respects, from production to processing to consumption, firmly embedded in a healthy environment and characterized by fair socio-economic relationships. This is the horizon toward which ILVO sets its sails

”

- Joris Relaes

# Introduction

A future-proof and resilient food system has two important aspects. First, various components need to work together in both a purposeful and resilient way. What does this mean for the future of the agricultural, fisheries and food sectors?

The Oxford dictionary defines system as: 'a set of things working together as parts of a mechanism or an inter-connecting network; a complex whole.' From this I remember the words 'working together' - synonymous with efficiency - and 'a complex whole'. Without parts working together efficiently to realize a common goal, there can be no system. This is certainly true of food systems. In essence, this is a human creation: shaped, influenced, regulated, controlled by and for people, with the goal of providing food security and income to people.

It should come as no surprise, therefore, that the challenges facing our food system are predominantly man-made. Fortunately, we now see the importance and usefulness of working with nature and ecosystems, starting (oh so appropriately) from a systems approach. This is the starting point in almost every research project that ILVO signs up for.



The second important term in the title of this document is resilience. I translate that as 'able to resist'.

In times of economic crisis and a pandemic, everyone understands how important it is to build systems that are not only efficient but also resilient. At the beginning of the COVID-19 pandemic, ILVO made a statement: we work toward food systems that are healthy in all respects, from production to processing to consumption, firmly embedded in a healthy environment and characterized by fair socio-economic relationships. This is the horizon toward which ILVO sets its sails.

More than ever, we do that by working together on a clear mission: building knowledge for the agriculture, fishery and food sectors, so that they can produce sufficient, healthy and varied food in a socially responsible manner and within the planetary boundaries for the 10 billion mouths that will need to be fed by the end of this century.

In this document you will read how we do that, which choices we make and why. Of course, this text is a snapshot in time. Just like science, our research projects are constantly changing. Nevertheless, we set out a number of landmarks here to ensure that we stay on course towards 2030.

Always ready to engage in debate,

Joris Relaes  
Administrator-General of ILVO



# 1

## What drives us?

How do we ensure that people have access to balanced and affordable meals that are produced in an ecologically, economically, animal-friendly and socially responsible manner? The solutions of the past are now under pressure because of their impact on the climate, the environment, animal welfare and our health. With independent scientific research ILVO aims to offer sustainable solutions for a changing world.

# Research for a changing world

**Our society is in full transition. Emerging global challenges put pressure on the planet, on our health and on the food supply. In the coming years, our research will focus even more on these shifts.**

## The climate crisis is accelerating

The climate crisis is the greatest challenge of our time. According to the sixth report of the UN Intergovernmental Panel on Climate Change (IPCC), 2021, the climate is heating up faster than we thought it would. The warmest years on earth since 1900 have all been

recorded in the last seven years. The average annual temperature in 2020 was already 1.2°C higher than in the pre-industrial era.

The urgency of the need to stop global warming is enormous. Its impact on our food production can already be measured. Not only in other parts of the world, but also in Europe and here in Flanders, harvests are suffering from more extreme weather conditions. With the earth heading for a population of around ten billion people by the end of this century, ensuring food security is imperative. Climate change is putting pressure on that ambition.

## Reduction of greenhouse gas emissions

The agricultural sector emits greenhouse gases: mainly methane ( $\text{CH}_4$ ) but also nitrous oxide ( $\text{N}_2\text{O}$ ) and carbon dioxide ( $\text{CO}_2$ ). The fisheries sector, food processing and supply industries also have environmental impacts. To meet the European and Flemish climate objectives, we must reduce emissions throughout the entire agri-food chain, without causing problem shifts.

## Carbon sequestration

At the same time, agriculture helps to mitigate the climate problem. Soil life converts crop residues and organic manure into soil organic matter and thus stores the  $\text{CO}_2$  that plants absorb from the air in agricultural soils for longer periods of time. At least part of the global greenhouse gas emissions from agriculture are offset in this way. And because there is still room to store more carbon in soils, climate gains can still be made in this way.





### Dealing with extremes

More extreme weather conditions and the emergence of new diseases and pests lead to more volatility in the yields of our main food crops. This can lead to food safety risks, even though our temperate climate and fertile agricultural soils make us one of the world's most important food producing regions. To secure this strategically important food supply, the development and rollout of adaptation measures are especially urgent. Non-edible greenery can also play an important role here, together with the climate-smart design of open (agricultural) space.

### Natural resources are under pressure

Agriculture is both a user and a producer of natural resources. To ensure that future generations can still enjoy the ecosystem services they provide, we need to use our resources more carefully. Thinking in terms of loops is essential.

### Soil

Soils are full of life and provide many ecosystem services, such as carbon storage and buffering of water and nutrients. The importance of soils as a basis for food production is being increasingly recognized in all parts of the agro-food sector. Today, however, many soils are not in optimal condition. Both physically (soil structure), chemically (nutrients) and biologically (soil life), we have some catching up to do.







### Fresh water

Surprising changes in the availability of fresh water for agriculture is a relatively new phenomenon in Flanders. Worldwide demand for water will continue to increase, however, at the same time that the water supply is under structural pressure due to more frequent and longer dry spells. Because agriculture is highly dependent on water, this phenomenon also puts pressure on food production.

### Biodiversity

Agriculture benefits from rich biodiversity: for the pollination of crops, the natural protection of plants against diseases and pests, and crucial soil processes, among others. But biodiversity is under pressure. Because of its strong interaction with nature, agriculture contributes to this. However, this strong interdependence offers opportunities. By choosing certain crops and techniques, agriculture can actually stimulate biodiversity in our environment.





### Marine resources

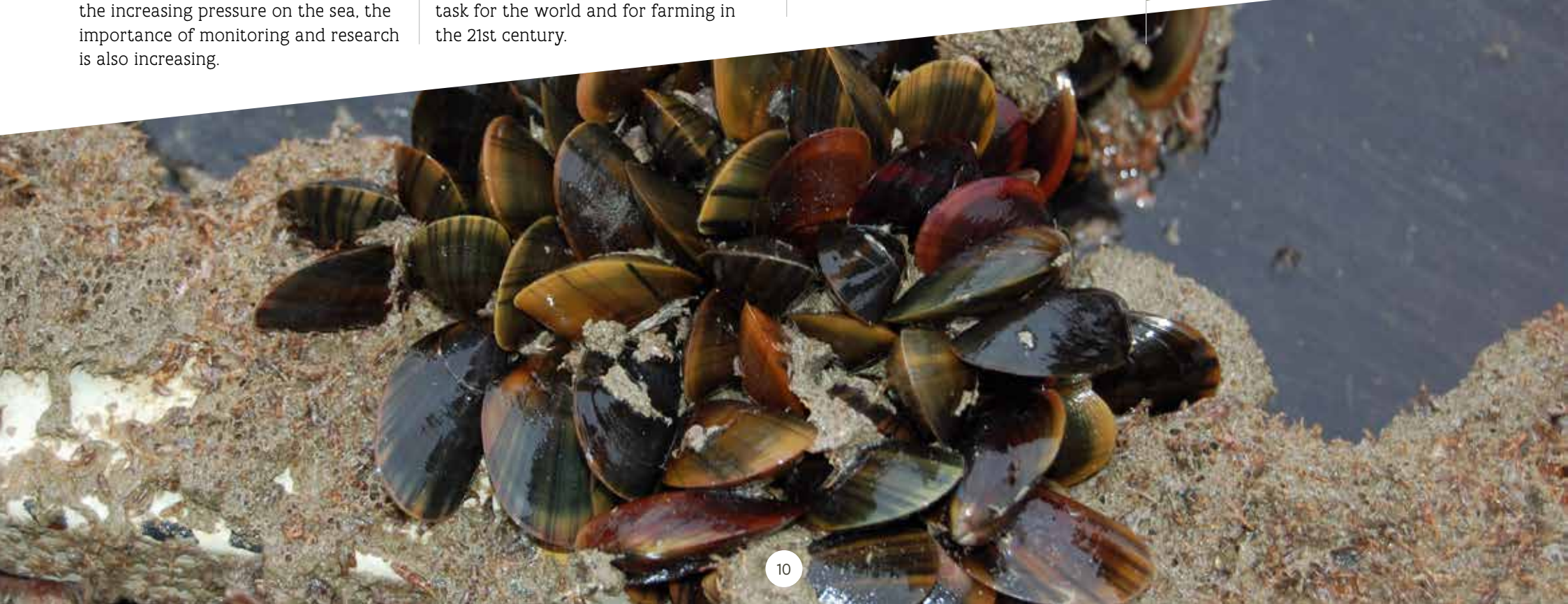
The oceans and seas cover over 70 percent of our earth's surface and contain a wealth of organisms and critical ecosystems. The 'blue economy', which makes use of that potential, is gaining in importance. International maritime transport is increasing. In addition, energy production, marine aquaculture and marine recreation are becoming more important. To make this possible, there are also more port and dredging activities. Along with the increasing pressure on the sea, the importance of monitoring and research is also increasing.

### Raw materials

Fossil-based materials, ores and minerals have played an important role in industrialization since the 19th century. In agriculture, they have contributed to the green revolution of the 20th century. In the form of chemical fertilizers, crop protection and cultivation substrates, they have generated global wealth and (food) abundance. Today, the use of these same raw materials is under pressure. The search for alternatives is a major task for the world and for farming in the 21st century.

### Renewable raw materials

The primary sectors are not only users of raw materials, they also produce them. Plant and animal products have potential for applications in the bioeconomy, in which fossil raw materials are systematically being replaced by renewable ones.







## We expect more and more from the sector that feeds us

Our society is changing, and with those changes come new demands on the agri-food sector: less chemical inputs, less bothersome or harmful emissions, farms with a less industrial approach, shorter chains and more welfare for animals and farmers. We are also making new demands on our food itself. In addition to being safe, affordable, sustainable, tasty and healthy, food must also be convenient, have a long shelf life and look good on the shelf. On the other side there is the regulatory, economic and historical framework within which the various links in the agri-food chain operate. These demands create a difficult balancing act for an industry, businesses, families and people under pressure.

## Urbanization is gaining ground

More than half of the world's population lives in urbanized areas; by 2050 that share is likely to increase to two-thirds. Europe and also Flanders are urbanizing at an unprecedented rate. This means that more and more urban claims are being made on valuable open space - while the functions of 'water buffering' and 'cooling' are becoming more important as the climate heats up. This poses special challenges for the agricultural sector as an original 'rural inhabitant'.

## Globalization creates opportunities but also challenges

Globalization in a free market expands the potential market for agri-food companies and provides opportunities for economies of scale, efficiency gains and specialization. The other side of the coin is how farms, located at the beginning of the chain, have little bargaining power and are exposed to fluctuations in the global market caused by events happening around the world.

## Need for new earning models

Profitability in the agri-food sector is under pressure. The dependence on what happens on the world market, the unequal distribution of value in the chain, high costs (raw materials, land and labor) and a lack of a quick response to unforeseen circumstances are at the root of this. There is an acute need to find other earning models that consciously build in resilience and spread risk.

## More and more people are either under- or over-nourished

By the end of this century, the world will have an estimated 10 billion people to feed. The demand for food will double. At the same time, prosperity is also expected to increase. Providing all people with nutritionally balanced and sustainably produced food is a challenge.

## Unbalanced diets

Malnutrition is a growing problem, including here in Europe. It contributes directly and indirectly to the increase in nutrition-related disorders such as obesity, diabetes and cardiovascular diseases. Better mapping out the relationship between nutrition and health is an important task. Developing meals that meet the nutritional needs of different target groups is also becoming increasingly important.

## Food debate

Western diets and eating habits are changing and awareness is growing about the role of balanced nutrition in our mental and physical health. Worldwide, there is a scientific consensus that we should eat more vegetables, fruits, whole grains, legumes, nuts and fish than we do today, while reducing our consumption of dairy, meat, eggs and starch. Even so, there is much debate and confusion in society about what constitutes a balanced diet, both for people and the planet.

## Food waste

There is little room for debate about the need to limit losses of food and valuable biomass. Every year, about one-third of the world's food is lost. In Flanders, this translates into about 2 million tons of biomass, both edible (food) and non-edible (by-products). Losses occur at every link in the chain. Investing in prevention but also in the high-quality valorization of unavoidable losses, including the bio-based economy, is a priority.





## A new policy context

A sustainable and resilient food system is high on the Flemish, European and international policy agenda. Now that the climate crisis is becoming increasingly palpable, the need for a sustainable agriculture and agri-food sector is also growing. The transition has already started in many areas. Well-founded scientific research is needed to promote and accelerate the process.





## The European Green Deal

Europe is aiming to be the first climate-neutral continent by 2050. The European Green Deal aims to transform the EU into a modern, resource-efficient and competitive economy. The ambitions are:

- net zero emissions of greenhouse gases by 2050
- economic growth without depleting raw materials
- no human being or region left to its own devices

The Green Deal covers all sectors of the economy, including transport, energy, infrastructure, ICT and agriculture. The European Climate Act, in force since 2020, enshrines the ambitions in binding rules and regulations. In 2021, the European Commission proposed a corresponding package of measures: 'Fit for 55'. This will profoundly transform the European economy and society.

## The Farm-to-Fork Strategy

The Farm-to-Fork strategy, part of the European Green Deal, is the strategy through which the European Commission aims to achieve a climate-friendly, sustainable and healthy food system.

This strategy has four major targets:

- 50 percent less use of chemical pesticides
- 50 percent reduction in nutrient losses and 20 percent less fertilizer use
- 25 percent of agricultural land farmed organically
- 50 percent less sales of antibiotics for farm animals and aquaculture

Europe is launching no fewer than 27 actions to achieve these goals. Included are actions on food security, food availability and food safety, food waste, packaging, processing and marketing of sustainable food.



## The Flemish protein strategy

Proteins are an important part of human and animal nutrition. We get them from meat, fish, eggs and dairy, but also from cereals, legumes, nuts, vegetables and potatoes. Our current protein production and consumption focuses mainly on animal proteins. With the protein strategy, Flanders aims to have a more sustainable, diverse and future-oriented protein supply by 2030:

- **Sustainable animal feed.** Soybean meal is (partly) replaced by locally-grown, protein-rich animal feed, such as field beans, peas, local soy and clover-rich grasslands. By-products from the food and

biofuel industries are also used to the maximum extent possible.

- **Sustainable livestock production.** The livestock sector has a place in circular agriculture, but its impact on climate, environment, water, animal welfare and biodiversity must be reduced. By targeting the European market with a differentiated offering (product, production process and/or sales channel), livestock farmers can better respond to this. They must also receive a fair price or financial benefit for their contribution.

- **More vegetable-based proteins.** Flemish agriculture produces not only protein crops for animal consumption but also protein crops for human consumption. New chains must offer sales security for crops such as soy or quinoa.
- **More protein from new sources.** New sources of protein, such as insects, algae, microbial proteins and proteins extracted from biomass (e.g., food by-products), have a place in the agri-food chain and the biobased economy. Flanders aims to become a hotspot of expertise in this field.

- **More product diversity.** Consumers must have access to a wide range of tasty, safe and nutritionally high-quality protein products.
- **Sustainable protein consumption.** A shift to more vegetable and alternative protein sources is necessary for a healthier and more sustainable diet.

Left to right: quinoa, pig, field peas, chickpea, microalgae (*Spirulina*)





Soja

## The UN Sustainable Development Goals

The United Nations Sustainable Development Goals (SDGs) are a major international sustainability framework for the next decade. The aim is to eliminate global warming, hunger and inequality, among others, by 2030. Several SDGs are linked to agriculture and the agri-food industry. At all levels of government, our country is committing to reach the SDGs. Many companies and organizations - such as ILVO - take the SDGs as a guiding principle for their sustainability process.

### 5 Ps as a guideline

The well-known '5 Ps' help shape the SDGs: People, Planet, Prosperity, Peace and Partnership. The 5 Ps make it clear that the SDGs cannot be separated from each other. Progress within one P must not mean a decline in another P. Prosperity, for example, may not be attained without attention to the planet and to the welfare of people.



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# 2

## Our DNA

Flanders Research Institute for Agriculture, Fisheries and Food (ILVO) is an independent scientific research institute of the Flemish government. Our main task is to help make agriculture, fisheries and the agri-food sector more sustainable in Flanders and the rest of the world. We fulfil this task in our own way.

Photo p. 17, 18, 19: ILVO's agri-food research landscape



## Values-driven corporate culture

Five essential values characterize ILVO as an organization:

- **Working together**
- **Being an example**
- **Proactivity**
- Impeccable **professionalism**
- Contagious **positivity**

We expect from all our employees that they support this corporate culture and that they help disseminate our values as ILVO ambassadors. Thanks to an intensive values project, today we can say that the five ILVO values are embedded in all layers of our organization.

### Trust

In 2020, we added the overarching value of **trust** to our five known values. Giving and receiving trust motivates us and connects us with each other and our organization.

## Tangible research nearby: ILVO's agri-food research landscape

Relevant research is not done from an ivory tower, but is done as much as possible in collaboration with the partners involved. That is why we decided to go one step further in 2020:

- We are taking the concept of **transparency** to the next level by making our 240 hectares of experimental fields accessible not only to our research partners, but to all stakeholders from the agri-food sector and everyone in our immediate surroundings. That is why we are working on a

network of 'slow trails' to make the landscape more accessible, with informative walking or cycling routes to tell passers-by about our research.

- We valorize our scientific knowledge, our unique infrastructure, our network and our practical experience in **high-quality agricultural and food research**. We realize this together with our stakeholders within high-powered living labs.
- We translate '**setting an example**' into practice by strengthening the link between our research and our own agricultural practices. Where possible, we apply data technology and precision techniques as well as



agroecological principles and the best practices from our research. In this way, we experience the same challenges as farmers in practice. We have appointed an ILVO farm manager, who takes our experiences and feeds them back into our research and vice versa. The goal is to make our research even more relevant, and thus to further promote the implementation of the practices we prioritize as a research institute.

- We work with partners to achieve social goals in our trial fields. For example, we are transforming a piece of intensive grassland into flower-rich, ecologically interesting

extensive grass and grassy meadows planted with trees and bushes, while monitoring the impact of this on our farm operations. In this way, we are not only setting an example in terms of agriculture or research, but also in terms of water buffering, desealing, landscape integration and climate adaptation.

These efforts take place in an open, typically Flemish landscape that houses the majority of our trial fields. That is why we call this comprehensive future trajectory 'ILVO's agri-food research landscape'.

## Systems thinking

A few years ago, ILVO was a pioneer in the field of systems thinking, certainly in Flanders. In the meanwhile, many other knowledge and research institutions have embraced this holistic approach. We continue to uphold systems thinking as a principle and embed it as a methodology in our organization. We also help external stakeholders to set up systems thinking exercises for their sector.

## A bigger picture

Complex issues such as emissions in animal production are unraveled through a systems thinking exercise and placed in their multifactorial framework. To explore this issue, we invite not only experts in measuring emissions to the table but we consciously choose for dialogue with several disciplines. Veterinarians, feed specialists, agronomists, climate experts, economists, policy experts, sociologists, and others are all consulted. Our people are trained in systems thinking so they quickly get the hang of it.





Researchers texturize protein through extrusion in Food Pilot.

## Living labs: hotspots for co-creative research

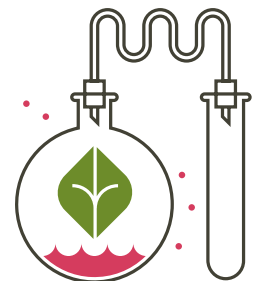
In our living labs, we conduct innovative research shoulder to shoulder with the end users: mostly farmers, feed and food companies, policy makers and entrepreneurs from the marine sectors. In addition to developing our own technologies, we also test, adapt or demonstrate existing technologies. Technology suppliers, other knowledge centers and relevant policy and chain actors are closely involved.

## Accelerating innovation

This approach guarantees a faster and above all more relevant innovation process. By focusing on the end users, our living labs succeed in better tailoring innovations to their specific needs. This increases the acceptance and implementation rate of new technologies. ILVO has several thematic living labs. By also involving the government where possible, we accelerate the legal acceptance. The living labs all work according to the same principles, but each has its own interpretation.

## Open science

Sharing knowledge is one of our most important goals: through the media, workshops, seminars, publications, and so on. With our commitment to open science and open data, we go one step further: we not only share our knowledge and research results, but also the data sets and databases on which they are based - both within and outside ILVO. This provides more opportunities for high quality research, as the entire process of scientific evidence becomes more transparent.





## Scientific integrity

In 2015, we established our Scientific Integrity Committee. That committee ensures that all our research is done correctly, openly and with integrity. If errors are reported, the committee acts as an internal investigative body.

We also maintain close ties with the Flemish Commission for Scientific Integrity.

Prevention is our most important tool: we train our researchers extensively on correct and honest scientific research. We

also provide extensive advice on what can and cannot be done and encourage researchers to talk with each other about this.



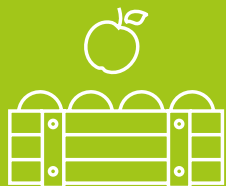
# 3

## Our 10 lines of scientific research

ILVO supports the entire agri-food sector and wider society with relevant and applied knowledge. On the following pages we highlight ten important scientific research lines.





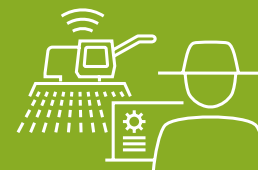


1. Food and health

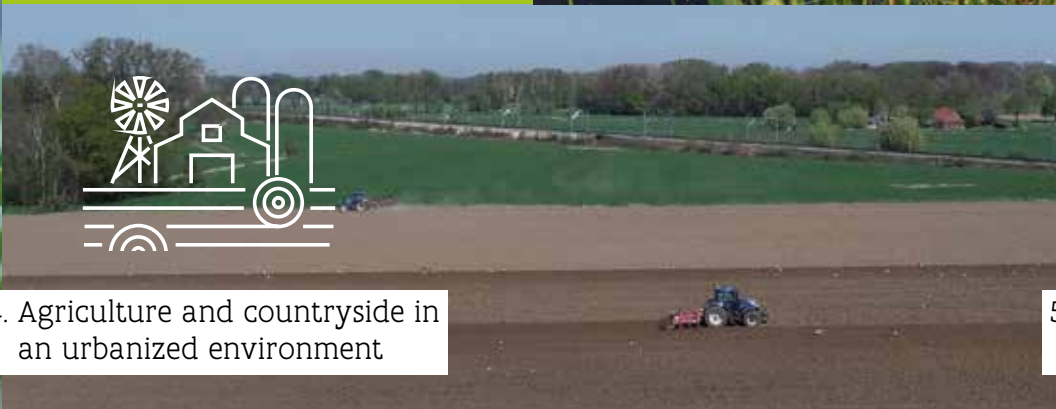


2. Role of animal production in society

3. Profitable and resilient food systems



4. Agriculture and countryside in an urbanized environment



5. Bioeconomy and closing loops



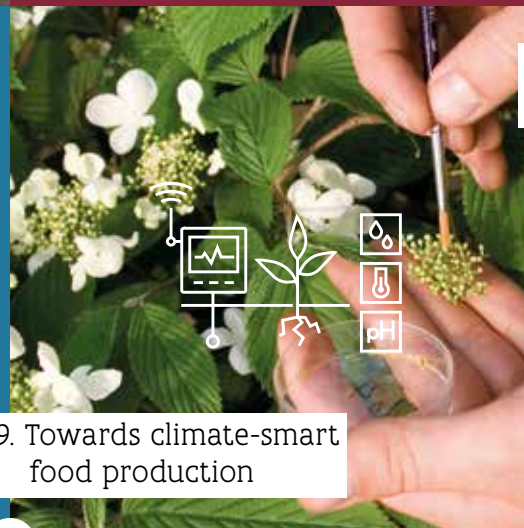
6. Precision agriculture and data technology



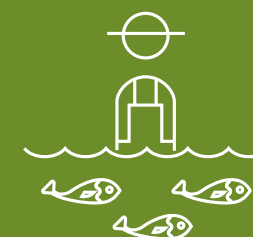
7. Healthy soil and crops



8. Protein diversification



9. Towards climate-smart food production



10. Marine production and the marine environment



## Food and health

**We want to use research to help fight malnutrition. We do this from an integrated view of the entire food chain and in close cooperation with a broad group of partners. Research that enables a more diverse range of safe and sustainably produced food is an important focus.**

**With the healthcare sector, we work on feasible, nutritionally balanced meals for different target groups. For the primary sectors, we are developing raw materials with even more interesting components. We are using our knowledge of the link between nutrition and health in animals to better understand how we can use nutrition to increase our resistance to infection and disease of civilization. For people with food allergies, we are sharpening our knowledge of how allergens work and how processing influences them.**

### Systems approach against malnutrition

The term 'malnutrition' covers not only malnutrition but also overeating and unbalanced diets. Because the causes are complex, malnutrition calls for a system approach in which all actors involved work together. In such a system approach, ILVO brings in knowledge about new (mild) processing techniques, new raw materials, a characterization of components and (new) ingredients, nutraceuticals (products and ingredients

with a proven medicinal effect), the composition of end products, food in function of individual needs and safeguarding of food safety. In this way we enable our partners to bring a more diverse range of raw materials and food products to the market and to develop nutritionally balanced diets tailored to different target groups.





## Collaboration with the healthcare sector

ILVO continues to work on NuHCaS, the research center for Nutrition, Health and Care. The NuHCaS platform brings together actors from the agri-food sector and the care sector and combines research into the impact of nutrition on health. We believe that more cooperation between knowledge institutions, food producers and the medical world will promote the exchange of knowledge and enable clinical tests to be carried out with or without specific target groups in mind.

## Link between nutrition and (intestinal) health

We know that animal nutrition has a major impact on the quality of our animal production. ILVO's food physiologists calculate very precisely what an animal must eat to grow optimally. Intestinal health is central to this, because it also prevents other health problems. In the recently established Gut Health Platform, ILVO, together with external partners, investigates using a *multiomics* approach the extent to which the knowledge about gut health in animals can be translated to humans. The focus is on strengthening human resilience to infectious diseases, metabolic diseases such as obesity and neurological diseases such as Parkinson's.



## Raw materials with more useful properties

For healthy food, we first need raw materials with a wide range of nutritional properties. In recent years, primary producers have taken important steps to improve the quality of their raw materials. Special attention has been paid to niche crops such as quinoa, and alternative sources of protein such as soy, insects and algae. ILVO supports that process with research into cultivation and breeding techniques, suitable varieties and (in some cases) breeding. But ILVO also searches for bioactive components 'inside' the raw materials. Together with international partners, we unravel the biosynthesis routes so that we can make targeted adjustments to cultivation, selection and breeding techniques. In this way we can offer primary producers the opportunity to grow raw

materials containing even higher levels of the desired components.

## New production processes

ILVO looks for new recipes and production processes and investigates what happens to certain components or ingredients during processing. In doing so, we monitor all the quality aspects: health, safety, composition, properties, taste, aroma and the social acceptability of the production process. In this way we want to create possibilities for a wider range of safe and sustainably produced food products.

## The fight against allergens

The use of new ingredients and recipes also brings new challenges. For example, numerous plant-based protein sources such as nuts and soy are known food allergens. Moreover, processing of proteins can affect how well allergens can be detected – and perhaps even the extent to which a food product provokes allergenic reactions. ILVO's allergen lab is making great progress in the detection of known allergens and is investigating whether protein processing can influence allergenicity. This knowledge should help food producers to develop a wider range of safe foods for people with food allergies.



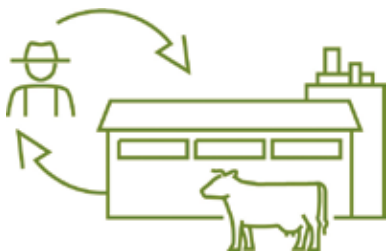


## Role of animal products in a balanced diet?

**Western standards of production and consumption of animal-derived food products are under fire.**

Good arguments for making do with less animal protein include sustainability as well as health. Excessive consumption of animal-derived products is linked to increased risk of cardiovascular disease, diabetes and certain types of cancer. At the same time, products such as meat, fish, milk, eggs are good sources of protein, vitamins A and B12, iron and zinc. To combat malnutrition worldwide but also here at home, these macro- and micronutrients deserve more attention. They are present in

several food sources, but not in the same quantities, and are not equally absorbed by our bodies. Nevertheless, they are essential for **optimal growth** and development and for our **general health**. Els Van Pamel (ILVO): 'We see that a responsible portion of animal products for certain target groups, such as the elderly, can prevent health problems such as loss of muscle tissue. It is therefore of great importance that we further increase our knowledge of nutrients and their bioavailability in various raw materials, as well as the impact of processing on them and their potential health (enhancing) effects.'



## ROLE OF ANIMAL PRODUCTION IN SOCIETY

**We are committed to using our research to promote a livestock industry that both farmers and citizens can feel good about. We aim for an animal-friendly production that combines a low environmental impact with a fair return and a healthy product with a delicious taste. In this way, we help to maintain international and local competitiveness.**

**Our scientific research also provides opportunities to fit local livestock farming into a circular food production system in a sustainable way. As societal concerns about (large-scale) livestock production increase, the resilience and resilience of the sector become critical for the future.**

### Broad fundamental knowledge needed

Livestock production produces many valuable end products, such as dairy, meat and eggs. Nevertheless, its impact on the environment cannot be denied. At the local level, this is mainly related to excessive nitrogen and the eutrophication and acidification of the soil and groundwater. Globally, livestock farming has negative consequences for the climate and biodiversity. The intensive use of antibiotics can also lead to problems.



ILVO approaches all of these aspects from an overarching system approach. We rely on a thorough knowledge of all sub-aspects, such as physiological and production processes, housing systems and technological expertise. We strive to understand the







fundamental links between feed and management as well as animal health, animal performance, product qualities and environmental effects. We invest in intelligent data use, sensors and microbiome and metagenomics research, among others. Our living labs guarantee that our knowledge is built up in collaboration with various stakeholders, and that innovations and improved management are quickly rolled out in the sector.

### Tailor-made livestock farming

End users and food processing companies have very different expectations of livestock farming. Some attach more importance to animal welfare or a low ecological impact, others to correct prices, an authentic product or a higher quality of life for the farmers. ILVO translates these priorities into the knowledge and communication that livestock farmers need to pursue a particular goal or profile. By



adjusting management in different areas - such as feeding, housing or genetics - we optimize animal welfare, taste, nutritional value, the *feed/food* ratio, water consumption and various emissions.

### Space for livestock

The livestock industry is increasingly encountering space-related barriers, such as limited access to land, neighborhood protests, environmental permits and current regulations. The strong fragmentation of the landscape and of farms leads to discussions. In addition, livestock farming is a much-discussed topic that generates a range of opinions.

ILVO supports farmers, policy makers and social actors by mapping out all kinds of space-related aspects. For example, we synthesize the space actually available for various types of livestock housing and designs. We also conduct research into modular construction techniques and the integration of animal housing into the landscape. Farm-specific permit parameters around odor and environmental impact are assessed for their scientific weight and (un)certainty. When based on correct data, simulations and dialogues go more smoothly.

### Residual flows and loops

In the context of circular agriculture, ILVO is investigating whether biomass and residual flows can be used more efficiently as animal feed. That should result in less protein being imported from overseas. We can close these loops by making maximum use of roughage from permanent pastures. Our expertise in the field of feed evaluation and animal performance contributes to the societal choices we make about biomass, residual streams and by-products, and of additives in animal feed. Our objective knowledge allows us to rationalize choices and reduce competition between food, feed, fuel and fiber.



## Attention to animal welfare

Society is becoming more sensitive to the welfare of animals in production systems. ILVO's expertise helps the agricultural sector to deal with this. Among other things, we optimize the scientific basis of the concept of 'animal welfare' and develop new welfare indicators. We also perfect protocols to determine animal welfare on a farm and throughout the food chain. Thus we support the use of specifications, labels and quality marks.

ILVO proactively looks for points of improvement with regard to animal welfare and for feasible solutions to welfare problems. We always start from a system approach, so that we can identify the underlying causes of certain problems.

## Objective information and social dialogue

ILVO stimulates the dialogue within agriculture and the agri-food sector. At each link in the chain it is important to understand how environmental impact, animal welfare and profitable production are measured and what efforts this requires. We underpin the social and political debate with scientific insights. In dialogue with the sector we work proactively on livestock farming systems that take public opinion and future legislation into account.

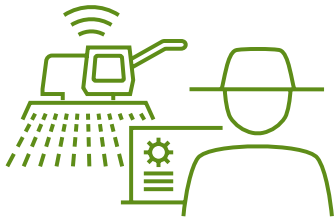
### IN THE SPOTLIGHT

## "Tailored emissions measurements per farm"

**More and more challenges have surfaced in recent years regarding emissions from livestock farming. ILVO conducts research into greenhouse gases, odor, ammonia and particulate matter, among others. One of our main targets for the coming years is the effective measurement of emissions from livestock buildings.**

Eva Brusselman, expert on barn emissions at ILVO: "It is currently very expensive to measure all types of animal housing systems for all animal categories separately. A license application is therefore assessed based on average emission figures: a pig in a certain type of housing has a certain fixed emission factor and therefore emits a certain estimated amount of odor and ammonia, independent of the farm where it is located. But in practice there can just be big differences between farms.

"With the new sensor techniques we are developing, the actual emissions of a farm can be continuously monitored. In this way, a farmer knows exactly how much greenhouse gases, ammonia and other substances are being emitted at any given moment. This makes the effect of management more visible; the farmer can then take targeted action based on certain parameters."



## Profitable and resilient food systems

**ILVO aims to contribute to improved profitability throughout the agri-food chain, without trading in on environmental, climate, animal welfare or social objectives. After all, food systems can only continue to exist in the long term if each link is viable and therefore profitable. But today that profitability is under pressure.**

**The changes we propose range from relatively minor adjustments within food systems to drastic changes in entire systems. These suggestions are situated at the level of production, processing, distribution and consumption. We focus on system innovations in a circular context, diversification and demand-driven production. The creation of new markets and marketing channels and a greater focus on added value are crucial to achieving a profitable and resilient food system.**

### Efficiency in a circular context

Efficient production has always been important for agriculture and the agri-food sector. However, in a circular economy, where raw materials, products and by-products are (re)used for as long as possible, efficiency is no longer a matter of separate links, but of the entire circular system. The use of by-products or waste flows may be less efficient in primary

production, for example, but can lead to greater efficiency throughout the chain.

ILVO unravels the tensions that arise at the economic level during such transformation processes. We show how the transformation to efficient circular systems can be made smoother, what partnerships and agreements are needed to achieve this, and what this means for the profitability of various links in the



Quinoa

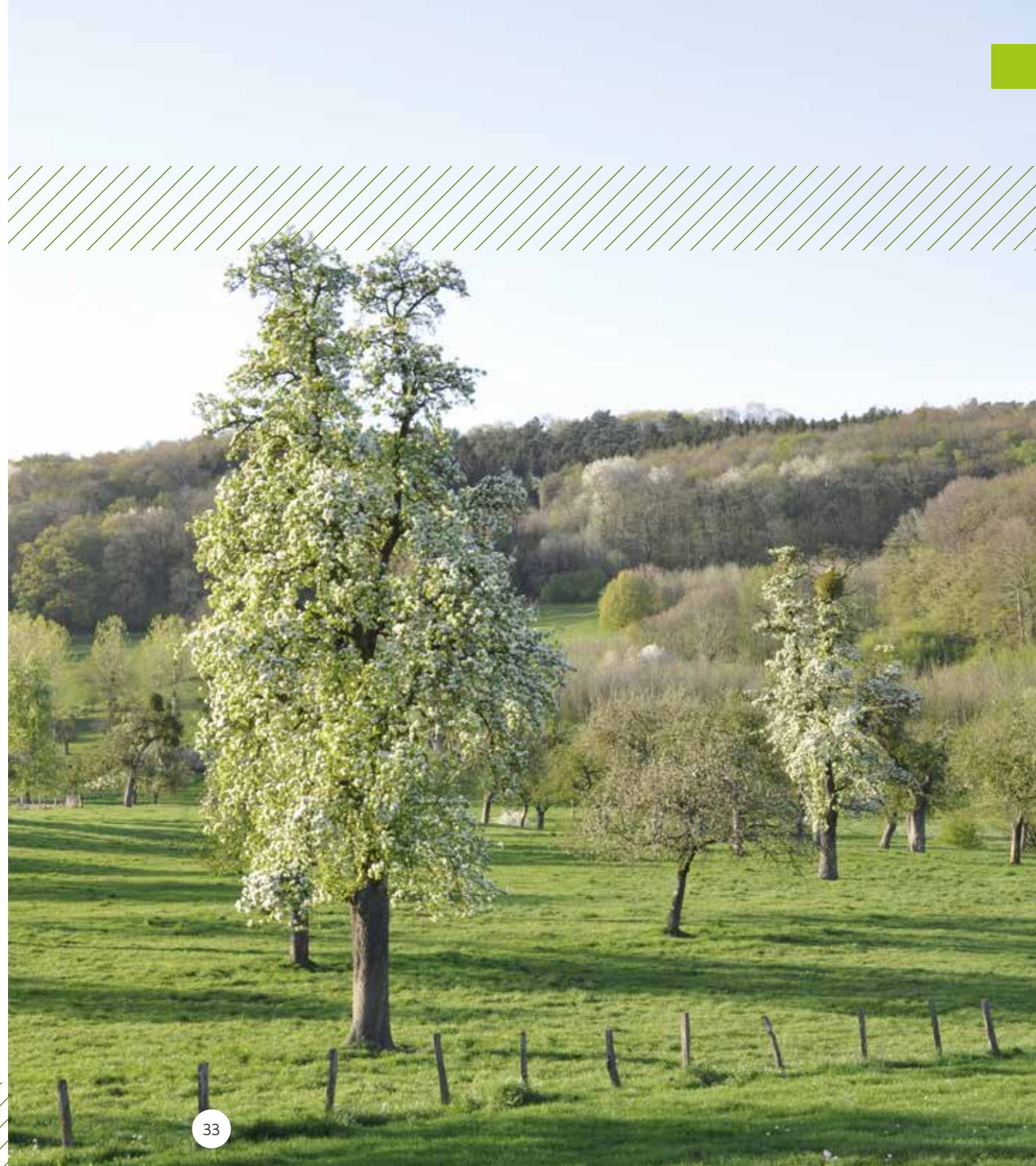


system. In doing so, we look at circularity at different levels, from products and materials over raw materials and energy to residual flows. We develop and evaluate technologies that can be useful in the circular economy and new data flows that can contribute to greater efficiency throughout the chain.

## Diversification

A greater diversity of products, processes or markets increases efficiency and can also deliver greater profitability and resilience. On farms, for example, this involves engaging in multiple agricultural activities to create more sales outlets. Combinations with non-agricultural activities, such as farm tourism or landscape management, are also possible. In this way, farmers spread the risks and farms become a little more agile in case of unforeseen circumstances.

ILVO provides applicable knowledge about diversification at different levels. We focus, among other things, on new cultivars, new crops (such as soy and quinoa), new cultivation systems (such as agroforestry), new products and processes, new marketing systems and citizen-farmer models (such as CSA or short-chain sales) and completely new interpretations of the food system (such as agroecology).



## Responding to demand

By responding to societal expectations and new market demands, farms and companies can increase their competitiveness in a future-oriented way. New demands and expectations may relate, for example, to freshness, taste, health, animal welfare, environmentally and climate-friendly production or an innovative way of processing or selling. By responding to these, farms/companies can distinguish themselves from existing practices on the market and thus create added value.

Those who want to go a step further can create an entirely new market. This can be done, for example, by coming up with a groundbreaking solution to an existing problem or by discovering a new demand and immediately offering an answer to it. Such an approach increases competitiveness based on quality and has less to do with cost control. Within this context, ILVO is expanding its capacity to analyze market demands.

## Maximal valorization

The value of a process, product or service can only be exploited well if companies reach the right customers in the right way. It is important to tell the right story, be transparent and authentic, choose a clear target audience, select suitable sales channels and build a good relationship with customers. ILVO investigates how farms can create added value, for example by focusing on local sales markets, niche markets or short-chain initiatives, or by providing ecosystem

services such as carbon storage. We are also looking at how data collection and use can further support the narrative around authenticity, transparency and traceability.

## New business models

As an independent partner, ILVO is looking for better business models for all links in the food system. We are looking at how we can improve the earning models for existing products, services, technologies and production processes. In addition, we analyze possible earning models for new developments. The earlier a potential business model comes into view, the sooner the development can be adjusted on the basis of that information.

Because a system innovation is developed in different stages, specialized research is needed to map out the economic picture. ILVO examines, among other things, how companies can gear their technologies, business



models, chain configurations and system innovations to market demand. We also investigate whether existing technologies can be used in a different environment or for a different application.

## Collaboration

ILVO strives for correct food systems, in which all links in the production chain earn a full income and there is a healthy distribution of added value throughout the chain. In order to make that possible, the various actors must collaborate as much as possible: chain partners, governments, consumers, research institutions, educational partners, interest groups, etc. ILVO makes its expertise available as a facilitator and generates insights, methods and trajectories that guide the partners together towards other tracks.





## IN THE SPOTLIGHT

### The Flemish wine sector: growing professionalism

**Viticulture in Flanders is flourishing. In the last ten years wine production has increased sixfold. To help the sector in its maturation process, wine growers and researchers are teaming up.**

Marc De Loose, Scientific Director at the ILVO Technology and Food Science Unit: "The research world is working hard for the wine sector. Research projects include sustainable vineyard management, less invasive analytical techniques to control quality, control of plant diseases and

pests, controlled steering in vinification, and grape varieties better adapted to local conditions.

"Winemaking is a long and complex process that requires a wide range of expertise. ILVO is therefore trying to set up partnerships between different research centers. In the coming years, we want to further connect winemakers and researchers, in order to improve **knowledge sharing** and accelerate the implementation of valuable **innovations** into winemaking practice."





## Farming and rural areas within an urbanized society

ILVO wants to work towards a livable countryside, with room for agriculture, nature and forest in both the literal and figurative senses of the word. Just as in other European regions, our countryside is experiencing fast and strong urbanization. The pace is hardly slowing down, despite the measures that have been taken. The phenomenon has an enormous impact on the countryside

and its users. What emerges is a peri-urban area, with both rural and urban characteristics. The wealth of functions present in such a peri-urban area offers opportunities but also leads to conflicts. Urban desires such as rest and relaxation, recreation, tourism, private space and exclusive living put pressure on the more traditional functions of agriculture, nature and forest.

A thorough social discussion about the use of our open space is sorely needed. We aim to feed that discussion by mapping gradual, subtle changes in land use, as well as their impact on ecosystem services such as food production, biodiversity, water buffering and cooling. ILVO also seeks solutions for multiple land use and explores innovative concepts and alliances between different rural actors.



## Mapping sneaky changes

The urbanization of the countryside not only causes open space to disappear under pavement, but also changes the use of the remaining, unpaved open space. Because these changes are subtle, gradual and spread out across Flanders, they attract less attention than large, planned shifts, such as an announced port expansion. ILVO has therefore been mapping and objectifying these land use changes for years. In this way, we provide figures and insights into the evolution of the agricultural area and its users, the interweaving of agriculture and nature, but also into other forms of land use, such as converting land into horse pastures or private gardens, and the use of farmsteads for

non-agricultural purposes.

ILVO continues to monitor these (sometimes invisible) rural trends and place them on society's agenda. Specific attention is paid to the increasing centralization of agricultural land by a few large players, as well as to the role and position of public land, the spatial consequences of the declining number of farmers, and the changes in our agricultural and food system. We complement these quantitative and cartographic insights with insights into causes and possible solutions.

## Added value of shared use of space

Because the open space in Flanders is limited and the social expectations are high, an economical manifold use of space is necessary. ILVO is proactively looking for innovative solutions to this challenge. Among other things, we focus on policy strategies for the preservation and management of open space. In collaboration with the partners in our living labs, we experiment with various forms of multiple uses of space, such as *agroforestry*.





© Jonathan Clerckx

We are also facilitating dialogue between different actors, such as agriculture and nature, and setting up new partnerships. In addition, we are examining whether success formulas from abroad, such as agricultural parks, are also feasible in Flanders. The profitability of the proposed earning models is a point of attention in all research areas, both for the farmers and for the other parties involved.

### Seeking alliances

Numerous actors come together in the countryside and in the agricultural sector. ILVO wants to map and understand their different interests and expectations. By means of multi-actor processes at home and abroad, we stimulate knowledge exchange. Time and again, this turns out to be an important component of successful cooperation and society. Learning processes between actors are therefore also an interesting object



of study. Among other things, we investigate how co-creation leads to innovation and how farmers can be motivated to try out innovative techniques with effective tools. Finally, we also actively involve citizens and other actors in our research and explore the possibilities of citizen science as a new, possible form of data collection.

### Well-being and livability

In our urbanized and globalized world, stress among farmers is a growing problem. ILVO investigates what causes this stress, how farmers deal with stress in general, and what effect this has on their well-being. In the search for solutions, we rely on an integrated approach in which different actors and strategies play a role. Besides the well-being of farmers, the general livability of rural areas also deserves attention. Among other things, we explore whether and how

digitalization can be part of the solution.











## Bioeconomy and closed loops

**We want to boost the bioeconomy, so we offer our broad expertise, network and infrastructure for the cause. In the bioeconomy, fossil-based raw materials are replaced by renewable ones, such as residual flows and by-products from agriculture, horticulture, fisheries, aquaculture and the food industry. Maximum value creation in all links of the chain and sustainability is paramount here.**

**We also focus on closing loops in the bioeconomy and throughout the agri-food chain. We remove obstacles at the technological, economic and social levels: we conduct research into the stabilization and processing of wet biomass flows, we characterize interesting molecules, we research and evaluate new business models, we look for partners, and we guide them towards effective system innovation.**

### Great diversity and great potential

Raw materials for the bioeconomy can come from various sources: from land-based systems, such as agriculture and horticulture, to non-land-based systems, such as the cultivation of insects or algae. Residual streams from various production systems can also be used as renewable raw materials. Because biomolecules are complex and offer many possibilities, they can replace fossil raw materials in many places. This is possible, for example, in the food and feed industry, in circular horticulture, in the chemical and pharmaceutical industries and in the building materials sector.

ILVO makes its expertise and infrastructure available to this growing sector:

- With the **Meet@all** platform, we have expertise and equipment to identify and quantify molecules of interest in raw materials.
- The **Food Pilot** (a joint venture of ILVO and Flanders'FOOD) has an infrastructure as well as experience with process and product development for both food and non-food applications.
- Our **Living Labs for Plant, Marine and Livestock** have an extensive network of trial fields, trial cultures and a full composting infrastructure.
- We have expertise in **systems thinking, economic modeling, techno-economic (TEA) and life cycle assessments (LCA)** to assess the impact, feasibility, sustainability and cost-effectiveness of concrete system innovations.



Cultivation of microalgae (*Chlorella*) on residual CO<sub>2</sub> from pocket digester





## Logistics and preservation

The collection, stabilization and conditioning of different types of bio-based raw materials must be done efficiently, in function of the processing and the final application. ILVO is investigating various ways to do so. Specifically for horticultural residues, an additional difficulty is that they are only released on a small scale in a geographically fragmented way, often only during a few weeks per year. Weather conditions also impact quality and quantity and can create unexpected surpluses on the market. The same applies to macroeconomic or geopolitical shocks. Therefore, we are investigating the technical and economic feasibility of biorefining small-scale horticultural residues. The focus is on the production of stable ingredients, semi-finished or finished products for the food sector.

## Cascade

Biomass is preferably valorized according to the well-known 'cascade principle': first for human food and then for animal feed. This principle should be seen as a guide, not as a dogma. ILVO considers it important to look case by case for the most suitable valorization. For the primary sectors, it is challenging to produce bio-based raw materials with respect for natural resources and without competing with potentially more sustainable applications. Therefore, we conduct research on biomass streams that lead to crop diversification and more biodiversity in the field and the greenhouse. We also strive for risk diversification and high added value in the chain.



Residual flows for growing media

## Closing loops

ILVO is committed to a circular economy that closes loops to the maximum extent possible. That is why we are expanding our expertise in farm composting and the development of sustainable growing substrates. The use of residual flows in compost or as a soil improver in the field offers several advantages: it allows carbon and nutrients to be returned to the soil, it stimulates microbial life and improves the general soil quality. In crop substrates, this also limits the use of unsustainable raw materials, such as peat. Given



Farm compost, monitoring the composting process.

the high degree of specialization in primary sectors, multiple farms often have to work together to close their loops. We also want to highlight this aspect of a circular economy in our research and in our own practice.

## Building new chains

The expansion of the bioeconomy and circular projects is accompanied by numerous system innovations. These have consequences for the relationships between

actors within a sector. ILVO has expertise in system thinking and can therefore make a good estimate of how the relationships in a sector will shift. Thanks to a broad network of chain actors, we bring the necessary parties into contact with each other and guide their discussions. This enables them to discuss concrete ideas, build mutual trust and develop new value chains. We also have the experience and expertise to work out business cases and estimate their profitability.



Production of wood chips from organic material.



## Matchmaker in bioeconomy

Many companies are interested in the bioeconomy, but do not know where to start. ILVO has gotten behind the **B2BE Facilitator**: a matchmaker that couples entrepreneurs around concrete innovations in the bioeconomy.

We focus on two target groups:

- **SMEs and industrial entrepreneurs** who want to make their products or processes more sustainable by replacing fossil raw materials with raw materials from local biomass;
- **producers of biomass and green residual flows** who are looking for sales channels outside the classic agri-food chain. Think entrepreneurs from agriculture, horticulture, fisheries, aquaculture, food etc.

### Economic feasibility

To give green innovations every opportunity to develop, we give maximum assistance to interested parties. We map out any technological challenges, create trust between the partners and make a first assessment of the economic feasibility of a joint trajectory. In this way we hope to accelerate the development of the bioeconomy in Flanders.

The B2BE Facilitator at ILVO was commissioned by the Government of Flanders as part of the Flemish Bioeconomy Policy Plan.



## Precision agriculture and data technology

ILVO combines promising new technologies with the so-called tacit knowledge held by researchers and stakeholders. The aim here is not to maximize productivity, but to optimize it: in other words, to produce as much food and feed as possible with the least possible impact on the environment,

by minimizing the use of (artificial) fertilizers, crop protection products, water and veterinary medicines.

This approach will only be truly successful if various data sources are integrated and if the innovations are implemented in practice. That is why we are putting maximum effort into the further roll-out of the data-sharing platform DjustConnect and we involve farmers, fishermen

and food producers as early as possible in the development, evaluation and demonstration of innovations. In this way, precision agriculture and data technology can effectively contribute to the systemic change that the European Green Deal and the Farm-to-Fork strategy are shooting for.





## Better tools

In arable farming, everything starts with the soil. Technology can map the spatial variables in the soil. Together with traditional soil analyses, this new data provides insight into the causes of local yield differences. With the Soil Passport, ILVO goes a step further by integrating even more data, such as crop history, crop monitoring, weather conditions and the spread of diseases and pests. This makes it possible to quickly and effectively estimate the yield of a crop during its growth and to identify problems that may arise.

In addition, we are working on site-specific applications such as precision fertilization, precision irrigation and targeted treatment and monitoring of diseases, pests and weeds. Precision management

of soil fertility, crop protection, nutrients and water comes one step closer. To promote the implementation of these precision techniques in practice, we test and demonstrate them on-farm. These new technologies also offer opportunities for the selection and breeding of crops. With new sensors both below and above ground, we accelerate the screening process for desirable characteristics such as drought tolerance in new candidate varieties.

In the animal sector, livestock farmers also have access to an increasing number of sensors and more data. Both the animals and their environment are systematically monitored. By linking that data to data on production and health, digital systems send out increasingly accurate warnings, which can promote the welfare and well-being of both animal and farmer.

## Transparency and tailored policy

Affordable sensors make it possible for farmers and cattle breeders to monitor, adjust and prove their climate, environmental and animal welfare efforts on their own. This also offers opportunities in terms of policy: where today policy is necessarily written on the basis of averages, such a degree of monitoring and transparency allows us to evolve towards an individually tailored, results-oriented policy.

## Big data, machine learning and AI

We are all collecting more and more data. Much of it remains untapped, however, because the various data sources are insufficiently linked to each other. The users also do not have enough insight into the large amount of data they collect. ILVO is working hard on the development of an AI4Agrifood platform, which makes use of artificial intelligence (AI) and machine learning. That platform should make it possible to better understand and control complex interactions in biological systems and generate useful advice for farmers.

By creating a more intelligent integration of data streams, we can offer new farmer-managers a dashboard that will help them make better choices based on objective data. The Soil Passport that ILVO is helping to develop is a first concrete example of this.



This prototype of a multi-purpose agrorobot can weed, hoe, spread fertilizer and take soil samples.

## Collaborating with the farmers

“Everyone is doing precision agriculture, except the farmers.” This commonly-heard statement does not exactly make ILVO happy. That’s why we choose a co-creative approach within our Living Lab Agrifood Technology. Farmers and companies are involved in the development of new applications from the very beginning. Sometimes new sensors are even developed or tested on-farm, with the farmer.

Within ILVO’s agri-food research landscape – our own farm with experimental animal housing – we are using data technology and precision agriculture techniques. The techniques we develop there, and the resulting insights, flow back into research and are translated into wider farming practice. We take care to use an appropriate business model and monitor the user-friendliness, involvement and development of digital skills in the end user. We actively disseminate our results, including through physical demonstrations. This makes for successful implementation of technology and system changes at the same time.

## Sharing data

For year, ILVO has been doing pioneering work in the field of data sharing technology. With the development of the data sharing platform DjustConnect, we have guided the agri-food sector into the world of the API economy. DjustConnect is based on an innovative reference architecture and is committed to data sharing with respect for privacy, security, interoperability and equal access for all. Trust and data

sovereignty are ensured; the farmer, as the owner of the data, stays at the helm. With DjustConnect, we go beyond a demonstration: we develop concrete, usable applications and thus create effective added value for farmers.

## Towards a single data market

To take data sharing to the next level, more research is needed into the possibilities of data access, data governance and data usage. The strategic importance of a European data space can hardly be underestimated. The aim is to create a level playing field in legal, operational, technical and functional terms. The first steps are currently being taken in projects such as GAIA-X, a German-French project that aims to unite the cloud and edge services of European providers in a federal data structure. ILVO follows the developments closely and collaborates where possible.

The data and information flow must also go beyond the farmer: it must connect the entire chain. The European Data Strategy strives for one European data market in which data can be shared without any hindrances. For example, this will allow agri-food sector to communicate with consumers about its efforts regarding healthy and sustainable production. It also allows for data-driven (results-oriented) regulation, whereby policymakers can take into account the specific situation of each agricultural approach and adjust their policies accordingly. In this way, precision agriculture and data technology become powerful tools to achieve the systemic change of the European Farm-to-Fork strategy.





## “AI platform lowers the barrier to using AI”

**Artificial intelligence (AI) has already proven its usefulness. It enables collection of a vast amount of data and - most importantly - makes it possible to generate better insights from that data. Yet for many people, AI remains something abstract. ILVO's new AI4Agrifood platform should change that.**

Ruben Van De Vijver, AI expert at ILVO: “With the AI4Agrifood platform we are primarily focusing on researchers. The agri-food sector has many different partners, each with their own expertise. With the platform, we try to lower the threshold for using AI so it becomes more accessible. In addition, the platform offers researchers the chance to come together and share their models and research results.

“Most studies and research today are done in isolation. We can get more out of that research by bringing everything together, where one researcher can use the tools developed by another. This will help scientific research run much more efficiently.

In time, this platform should also allow new knowledge and expertise to be quickly translated into concrete advice for farmers, machine builders and other chain partners.”

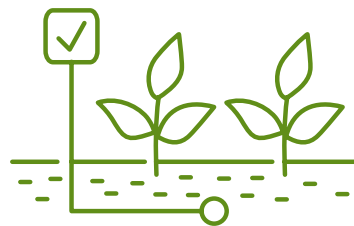
### Fast and agile

An important cornerstone of the new platform is **Rapid AI Prototyping**. That technique allows models and algorithms to be tested and adjusted quickly. Ruben Van De Vijver: “Researchers still often start a new study in the usual way: they identify a problem, collect data and write a model that can provide a solution. That model is then tested in practice: is it correct, does it work as expected? If it doesn't, then you have a problem.”

Rapid AI Prototyping allows a model to be written immediately based on a very small data set. If it does not work (well), it is first adjusted. The data collection is done in a very targeted way, in function of the model. In this way researchers avoid collecting large quantities of unusable data.”



mixed crop of maize and pole bean



## Healthy soil and crops

We deliberately put the soil at the heart of our research on crop production. After all, sustainable agriculture and horticulture strives for high-quality production with as few inputs as possible and recognizes the importance of the soil as the most strategically important production resource. In all our research we start from a systems view of soil and crops. As a result, we know that methods

to improve the quality and ecosystem functions of agricultural soils go hand in hand with efforts to keep crops healthy and cropping systems robust. We strive to minimize risks of nutrient losses, greenhouse gas emissions, and soil compaction, and maximize our efforts to close loops and store carbon.

On the basis of our experimentally substantiated improvement processes, we formulate clear advice to farmers, growers and policy makers. We play our part as an expert in numerous soil partnerships in Flanders, Europe and even worldwide.







## Data-driven tools and techniques

ILVO wants to improve the soil with data-driven soil management. To this end we use innovative techniques such as soil scans, sensors, remote sensing, tractor and machine data and the smart integration of data sources. We are also actively working on opening up data for soil applications such as the Flemish Soil Passport. ILVO is pulling out all the stops in the areas of water storage, infiltration and variable irrigation. A better understanding of the role of microbial soil life in the interaction between soil and plants, through the use of new data-driven techniques, is also an important ambition.

## Carbon farming

By storing carbon in agricultural soils, we can remove CO<sub>2</sub> from the atmosphere. ILVO inventories the carbon storage potential in Flanders, improves carbon simulation models and investigates the possible effects of measures to promote carbon storage. We are also looking at various possibilities for setting up

an accurate and cost-efficient system for monitoring, reporting and verification. This should form the basis for a fair compensation system for those who make efforts to increase the carbon content under their fields.

## Valorizing soil functions

Healthy soil is not only essential for good crop production. It also provides ecosystem services, such as carbon storage, biodiversity, water buffering, and nutrient retention and release. Farmers have techniques at their disposal to promote these soil functions, but their added value is not always reflected within their business model. There are still many technical and monitoring issues to be resolved, but ultimately society, the climate and agriculture itself will reap the benefits of these soil improvement efforts. ILVO proactively follows up on the developments and discussions regarding potential earning models in order to make a fair remuneration of these efforts negotiable

## Crop protection: a major challenge

ILVO actively supports the European ambition to take a more bio-based approach to plant health. Simultaneously, the climate crisis and the growing international plant trade are increasing the number of pathogens and pests. This combination of factors makes crop protection an ever-greater challenge. Continued control of the growing number of plant pathogens and other threats will require an acceleration in terms of methodology. We are studying on the potential of mixed crops and the interaction between host plants and pathogens, pests and soil life.

## Focus on prevention

We continue to focus on rapid, sensitive and accurate detection and diagnostic techniques. The new high throughput sequencing technology demonstrates how we can integrate innovative technologies into both



research and diagnostics. However, prevention is being emphasized more than ever, with ILVO exploring the possibilities of permanent monitoring. Such monitoring involves not only researchers, producers and policy makers, but also motivated social and citizen groups, such as students or citizen scientists. We link official monitoring data to data from public observation platforms and powerful prediction models. This allows us to conduct rapid and targeted risk analyses.

### Multidisciplinary focus on weeds

The interaction between crops and so-called 'weeds' is an area of knowledge that has yet to be explored. Weeds form a nutritional symbiosis with the crops. The challenge is to better understand the coherence of that complex ecosystem so that we can identify elements that keep the whole in balance while providing an advantage to the cultivated crops. Building up expertise in herbology can potentially contribute to efficient weed maintenance with fewer chemical herbicides.

### Robot weeder

In the field of technical, non-chemical weed control, ILVO mainly aims to use its capacities in the field of digital engineering and AI. In the long run, we want to help develop robots that recognize unwanted plants using artificial intelligence and pull them out using the most appropriate movement. Our knowledge of the market (price, technical performance, etc.) and our open collaborations with private and research partners bring the development process within reach.

### Away from polarization

Europe prioritizes more than just a bio-based approach for the control of plant diseases and weeds: socio-economic aspects must also be interwoven with fundamental research. We are thinking here, among other things, of the acceptance of certain techniques by the general public. Any search for biological control agents should, from the start, take into account possible resistance on the part of consumers.



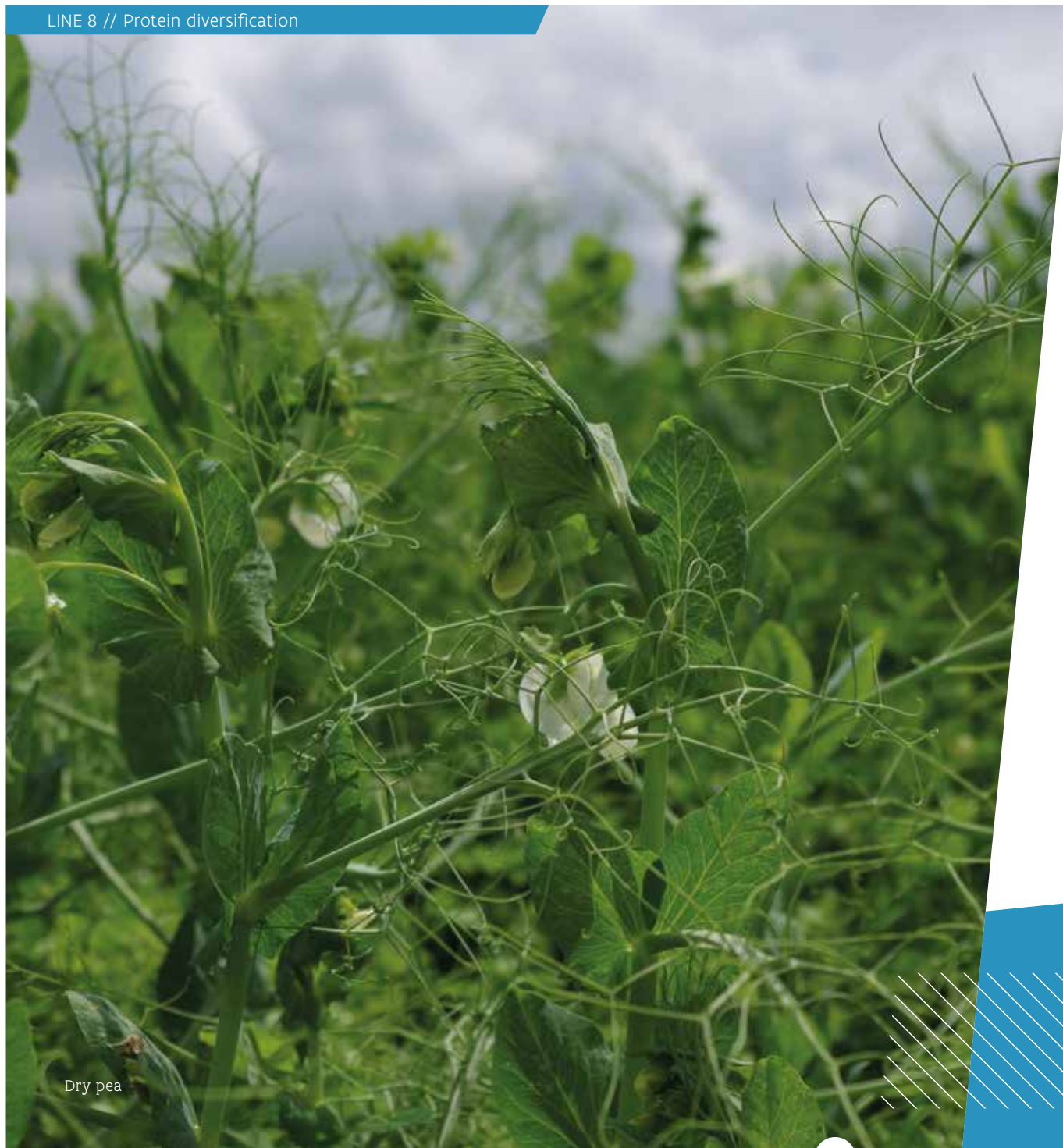
## ILVO launches first agro-ecological trial platform

In 2020, ILVO launched the first large-scale agroecological trial platform in Flanders. At the organic farm at Hansbeke Castle, the principles of agroecology are being tested and put into practice.

The Experimental Platform for Agroecology in Hansbeke is a collaboration between ILVO, organic farmer Felix de Bousies and agricultural consultant and researcher Alain Peeters. Koen Willekens, bio- and soil expert (ILVO): “We conduct research into agroecological techniques and optimize them on the basis of practical observations. We monitor the effect of various techniques on **soil fertility** and **crop yield**, without losing sight of the business model. By sharing our knowledge, we hope to accelerate the implementation of useful applications.”

The pilot platform conducts research on farm composting, soil monitoring, reduced tillage, mixed cropping, closed-loop farming and agroforestry, among other topics.





Dry pea



## Protein diversification

ILVO supports protein diversification on the condition that it contributes to a balanced, tasty, healthy and safe diet for a growing world population - within a sustainable and economically profitable framework. The term 'protein diversification' refers to an adapted diet in which animal proteins are alternated with vegetable and other protein sources. This is not only useful from a nutritional point of view, it also offers prospects on an economic, ecological and social level. Protein sources for animal feed also deserve attention. We invest in expertise and infrastructure to help all actors in the agri-food chain on their way in this growing market.



## Protein diversification starts in the field

Today, Flanders and Europe are heavily dependent on the import of vegetable proteins, especially soy from overseas. However, local production of legumes, such as soybean, chickpea, dry pea and bean can offer interesting opportunities for Flemish farmers. This allows them to broaden their crop rotation, which contributes to greater crop diversity, better risk spreading, and interruption of the growth cycles of pests and diseases. Legumes also require little fertilization because they live in symbiosis with soil bacteria that take nitrogen from the air. By-products generated by increased production and processing of legumes also create new opportunities. However, certain issues are impeding the broad rollout of legume cultivation in Flanders. That is why ILVO conducts research into suitable cultivation techniques, adapted varieties, and the development of local chains. We also have a lot of expertise on stabilizing, processing and valorizing residual flows and will thoroughly investigate their potential for legumes.

## What about animal protein?

A shift in our diet towards more diverse and plant-based proteins obviously has implications for animal production. Animal products can have a place within a varied and balanced diet. But which place is that? To answer that, a nuanced social debate is needed where experts with different backgrounds can have their say. In the trend towards fewer animal proteins, ILVO takes the role of observer and facilitator. We assist all actors

involved with scientific knowledge and offer them access to our research infrastructure.

## More local protein in animal feed

ILVO studies ways to improve the protein quality in Flemish forage crops, such as grasses, clovers and alfalfa, as well as how to diversify the protein sources in the ration. By incorporating more legumes and





Cultivation of microalgae (*Chlorella*)

residual flows from the food and biofuel industry in animal feed, the protein quality of the feed improves and we can better valorize locally produced proteins. The effects of this on welfare, (feeding) behavior, growth and even the emissions of the animals must be closely monitored and adjusted based on science.

### New protein sources

In addition to the traditional animal and vegetable protein sources, we are discovering the potential of 'new' protein-rich raw materials and products, such as insects, seaweeds and micro-organisms. ILVO investigates whether and how these raw materials and their residual flows can be optimally utilized in the agri-food chain: as an alternative source of protein with an interesting fatty acid composition, for methane reduction, as a flavor enhancer, as a colorant, or other things? The potential is clear but more research is needed. We look at the potential with an open mind, taking into account taste preferences, cultural aspects, food safety and allergens.

### Not simply interchangeable

Proteins from plant products and from insects, seaweed and other (micro-)organisms can be just as much a part of a balanced diet as animal proteins. An important note here is that each protein has different nutritional and functional properties. You cannot simply replace a traditional animal component with another component in order to obtain an end product that is just as tasty, qualitative and nutritional. The growing range of protein-rich raw materials therefore poses new challenges for the primary sectors, the food industry and research.





## IN THE SPOTLIGHT

# 'Protein processing line' for a wider range of proteins

**The Food Pilot of ILVO and Flanders'FOOD is investing in special protein processing equipment for research in the context of protein diversification.**

This new equipment line includes a high moisture extruder that processes protein powder, isolated from alternative proteins such as soy and sunflower seeds, into protein with a fiber-like structure. This is interesting for the development of a new generation of products for vegetarians and flexitarians. A new **drying and threshing line** is being installed at ILVO, so the new protein crops being tested in the field can be seamlessly delivered for testing in the Food Pilot.

### Several research tracks

The new protein research line makes it possible to perform much needed research for the food industry. After all, alternative protein sources still raise many questions in the sector. For example, what is the impact of processing on the quality and nutritional value of the proteins? Research is also needed on the solubility, gelling and water-binding capacity, foaming capacity and other properties of the new protein fractions before they can be successfully applied in flavorful, quality products.



## Towards climate-smart agriculture

**The ILVO Center of Expertise for Agriculture and Climate is committed to a food chain that is environmentally friendly, climate-robust and profitable. Special attention is paid to closing loops, limiting losses throughout the chain, efficient use of natural resources, carbon storage, sustainable consumption patterns and limiting the impact of animal production.**

**With our knowledge we try to reduce the impact of agriculture on the climate (mitigation) and we try to adapt agriculture to the consequences of the climate crisis (adaptation). In doing so, we always keep the broader sustainability of the agri-food chain in mind.**

### Holistic approach

The Center of Expertise for Agriculture and Climate was created in late 2016 to support and advise agricultural policy and the broader agricultural sector. We bring together diverse climate research, identify gaps and initiate new research. Because we closely follow international agricultural and climate research, we can place the Flemish situation in a European and global perspective.

An important asset of ILVO is the holistic way in which we approach issues related to agriculture and climate. To this end, we use our multidisciplinary knowledge and our expertise in systems thinking. Via life cycle analysis (LCA), we also calculate the total environmental impact of an agricultural product, from raw material to end product. In this way we map out possible problem shifts and avoid a situation where a lower emission in Flanders or in one link of the production chain creates an increase in another link or in another part of the world.

### Climate scan for more insight

The evolution towards climate-friendly and climate-robust farming is a challenge for every farmer. To meet this challenge, farmers first of all need insight into the main causes of greenhouse gas and other emissions on their farms. In addition, they need to know what impact climate change will have on their farm. ILVO is working with partners to develop an LCA-based climate scan that will provide them with these insights. Subsequently, we want to map out a path of







relevant climate measures with the farmer, tailored to the individual farm. We ensure that these measures are practical and economically feasible and we map out any side effects for the farm or the environment. In this way we take all aspects of sustainability into account. In time, together with our partners, we want to roll out the climate scan for all sectors in the agri-food industry.

### Animal emissions

Cattle and other ruminants are the largest source of emissions in the agricultural sector, because their digestion releases methane. A great deal of ILVO's climate research is therefore aimed at reducing methane emissions from cattle, primarily through ration adjustments. Through the Flemish Covenant on Enteric Emissions, in which ILVO plays a leading role, we are taking steps to implement methane-reducing measures from the research in practice. We also devote

attention to the reduction of other emissions, again through a systems approach.

### Energy consumption

In greenhouse horticulture, energy consumption is the most important climate-related issue. To help reduce that consumption, we improve existing systems, such as lighting systems, and develop new technologies, such as a vapor heat pump. This type of pump converts plant vapor into heat. When used in combination with energy-saving screens, it can significantly reduce energy demand. We are also looking at how growers can apply successful low-carbon innovations by co-creating with relevant stakeholders. In addition, we pay attention to increasing sustainability further down the chain, because the processing of primary products also requires a lot of energy. By expanding a sensor network within the Food Pilot, our semi-industrial





food processing plant, we aim to map out the energy consumption during the various processing phases and techniques. This is a pioneering role.

### Reducing water consumption

Agriculture is vulnerable to the effects of global warming, such as heat, drought, heavy rains that cause erosion, as well as the emergence of new diseases and pests. In a relatively new water research program, ILVO has a two-pronged focus: strategies to reduce water demand from agriculture as well as ways to increase the water supply. For example, the demand for water can be reduced by more efficient irrigation, but also by opting for drought-tolerant crops and even for climate-resistant systems, such as saline agriculture or agroforestry. To increase the water supply, we want to literally give water more space again: infiltration, buffering and reuse are all important for this.

### Smart carbon management

Agricultural soils contain soil organic matter and can therefore capture and store CO<sub>2</sub> for a long time. ILVO has extensive knowledge about ways to increase the carbon content in the soil, for example through adapted crop rotations and cultivation systems or the use of organic fertilizers and soil improvers. Some of these techniques also allow farmers to save on mineral fertilizer. In our research, we also pay attention to so-called trade-off effects of carbon-increasing measures, such as nitrous oxide emissions from the soil and nitrate leaching, and to co-benefits, such as water storage and biodiversity.



Farmers that make an effort for the climate also need to see those efforts getting validated. That is why we are helping to develop an adequate carbon monitoring and compensation system. In addition to increasing the carbon storage under agricultural soils, we also want to better protect existing 'carbon hotspots', such as peat-rich areas and old grasslands.

### Closing loops as a way of thinking

Closing loops is becoming increasingly important in agriculture. This means, among other things, that biomass must be optimally valorized. This can be done, for example, by linking plant and animal production chains in a smart way, so that by-products from the agricultural and food industries can be used as animal feed. In that context ILVO also wants to increase appreciation for the role of grasslands and ruminants. In places where only grass can grow, ruminants play a crucial role in circular agriculture. They eat grass, which is not digestible for humans, and convert it into high-quality protein and manure. This manure maintains the fertility of other fields so that field crops and vegetables can grow there. In this way, livestock farming also makes a small contribution to a climate-smart agricultural and food sector.

### IN THE SPOTLIGHT

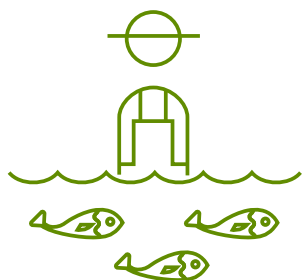
## Water in agriculture

**Belgium ranks high among the world's list of regions with water stress. This is a consequence of the green-house effect, combined with our high population density and percentage of sealed surfaces. Like nature, agriculture is very vulnerable if there is not enough water. How do we deal with this?**

Sarah Garré, water specialist at ILVO: "We are strongly committed to **water buffering, infiltration and reuse**. Specifically, we encourage farms to use less but smarter drainage, to choose climate-friendly crops and cultivation systems, and to make farm water consumption as efficient as possible. Whenever this is an option, we also try to increase the water storage capacity of the soil."

### Becoming more resilient

ILVO is continuing to expand water-related research and is setting up strategic research to meet the water challenges of the future. Garré: "To make Flemish agriculture more resilient to drought and flooding, we need to increase and spread the supply of water over time while simultaneously reducing the demand for water. This means, for example, that we minimize the paving of open space, and preferably even desal it here and there. This allows rainwater to infiltrate quietly into the soil. In general, agriculture, like other users, must give water some space again, both on the farm and in the wider landscape."



## Marine production and marine environment

**We are committed to the sustainable exploitation of natural resources from the sea and to innovative monitoring of the consequences of that exploitation on the marine ecosystem. Due to increasing investments in 'blue growth' and 'blue biotechnology', the use of our seas is on the rise. This growth has consequences for the natural resources and the use of (marine) space, which ILVO will monitor in an efficient way, using innovative techniques that we are helping to develop.**

**We continue to equip the Flemish fleet with sensors that will provide valuable data for both fisheries and research, we offer fishermen the necessary tools to make their sustainability plans a success, and we are collaborating on the construction of one large ecosystem forecasting model that will enable the sustainable exploitation of our marine resources. We are broadening our view to a systems view with a focus on valorization and collaboration with companies and policy.**

### Wide range of research

The sea is a complex biotope with a wide range of uses. Within scientific research, this requires a variety of expertise and several lines of research. ILVO strives to understand the functioning of the marine ecosystem and to map the cumulative impact of human activities as framed within in an ecosystem approach. We also study the rich variety of existing and untapped products and molecules that the sea provides, along with ecosystem services, the importance of which we still too often underestimate.

An important part of our work is devoted to making human activities at sea sustainable, linked to multiple uses of space and working with nature. All of this flows into scientifically substantiated advice for users of the sea. In the coming years, ILVO wants to extend the frontiers of various (marine) domains, from



data-driven fishery to further development of our Marine Living Lab.

### Data-driven fishery

In order to accelerate the digitalization of our marine fisheries, ILVO is working with a number of shipping companies on precision fisheries. We supplement the data-producing instruments on fishing vessels with new sensors and bring them together in real time in the cloud. With the resulting broad mix of data, we can design tools that allow ship owners and fishermen to fish more efficiently and sustainably. The new datasets are also valuable for scientific research.





## Innovative data collection

ILVO is working on innovative ways to monitor the marine ecosystem. In addition to the traditional morphological identification of marine organisms, we focus on metabarcoding and eDNA (environmental DNA). That means we use genetic traces in the seawater and the seabed to monitor the biodiversity of different ecosystem groups and to map the state of fish stocks and their functional connectivity.

Image processing is becoming a crucial tool to analyze fish catches and survey catches automatically and at a large scale. Through self-sampling, the fisherman is increasingly involved. For mariculture (aquaculture at sea), we are investigating how to use drones and



Plastic waste from the sea.

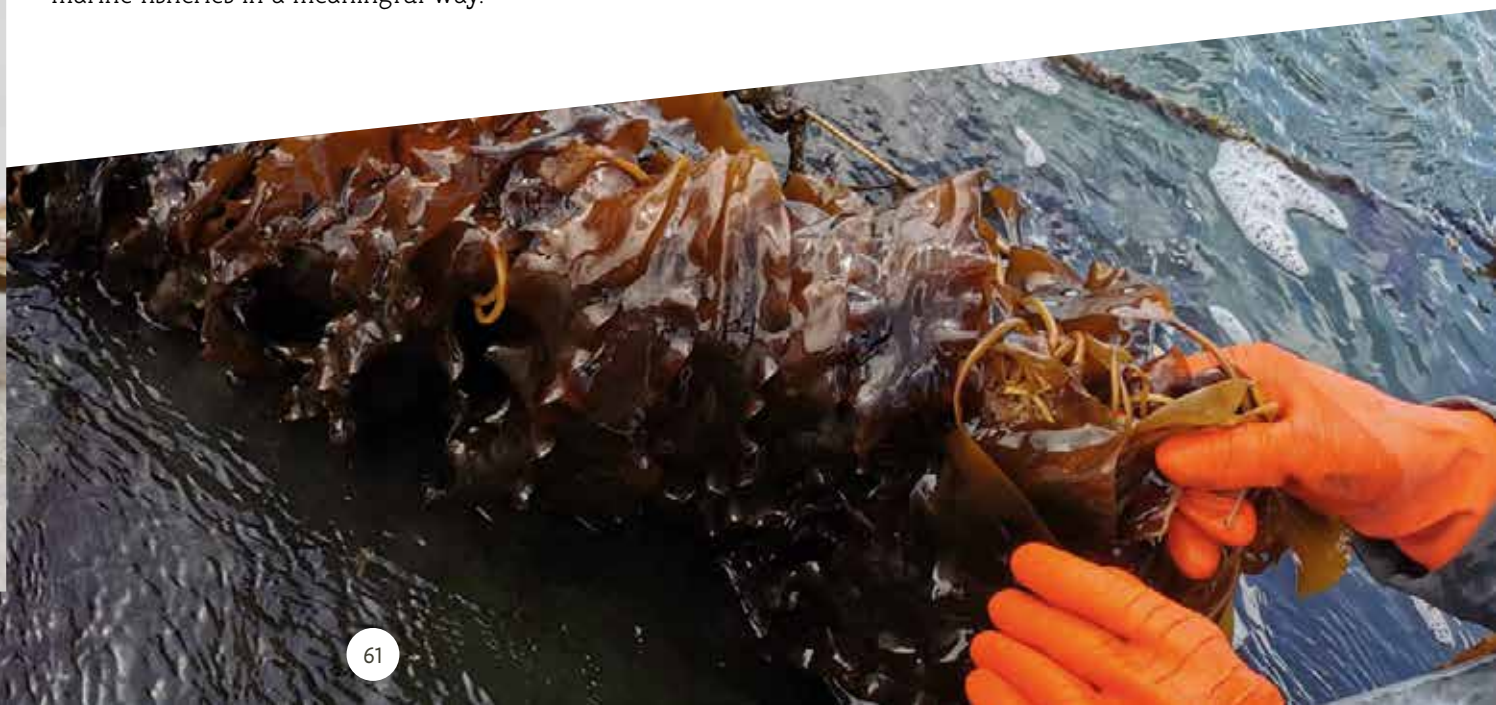
sensors for monitoring, among other things, growth in breeding facilities.

## Prediction models

Being able to predict how an ecosystem behaves has many advantages. For example, it allows us to evaluate the impact of climate measures or predict where fishermen will find large numbers of marketable fish versus where they will find more undersized fish or endangered species. In other words, it allows us to exploit our marine resources in a sustainable and efficient manner. ILVO is involved in the development of statistical models as part of one marine ecosystem model for our (North) Sea, which should make that possible. Furthermore, we continue to develop software to capture the growing flow of data in marine fisheries in a meaningful way.

## More sustainable fishing (*Visserij Verduurzaamt*)

As part of a project on 'More sustainable fishing' (project *Visserij Verduurzaamt*) ILVO has developed scientific indicators with which the sustainability of a fishing fleet, sub-fleet and even individual vessels can be reliably assessed. Then fishermen can work together with scientists to make their operations more sustainable. Fishermen who score higher than the minimum threshold secure their access to the market and contribute to a positive image of Flemish sea fishery.



IN THE SPOTLIGHT

## New campus for marine research

**In Ostend, ILVO and the Flemish Institute for the Sea (VLIZ) are moving into the new InnovOcean Campus. This will give marine research a boost.**

VLIZ and ILVO Marine have already been working together for some time and are now literally growing towards each other. In 2022, together with several national and international partners, they will move into the new **InnovOcean** Campus. The state-of-the-art research complex will contain several specialized laboratories in addition to offices and shared conference facilities.

## Symbiosis between people and nature

Management of marine projects based on a deep knowledge of biological processes creates a win-win situation for the project and the ecosystem. We use this principle of 'working with nature' in research on natural coastal protection, the restoration of shellfish beds, innovative aquaculture methods, multiple uses of the same space and the provision of new food products from the North Sea. For example, we are investigating the extent to which algae and shellfish offer potential for reducing the amount of nutrients in the sea and the concentration of greenhouse gases through CO<sub>2</sub> sequestration (the storage of carbon in the seabed).

For everything 'harvested' from the sea, we strive for the zero waste principle. In processing, we look beyond only human consumption. A combination of passive fishing and mariculture can increase biodiversity and make Flemish fisheries more sustainable. In the cultivation of micro-algae and seaweed, for example, we not only

pay attention to taste and quality: we also examine whether we can process them into animal feed, which may help reduce the methane emissions from cattle on land.

In addition to mining the multitude of marine (bio)molecules, 'blue biotechnology' also includes exploiting the still largely unrecognized marine gene pool. We have known for some time that marine microorganisms are very diverse, due to the extreme conditions found at sea. ILVO is investigating whether we can use certain microorganisms in synthetic biology or in the fermentation or biodegradation of persistent substances such as POPs or plastics.

## Co-creation in the Marine Living Lab

The Marine Living Lab represents a flexible, co-creative way of doing research, together with the various sectors active at sea. By bringing together the expertise of ILVO with that of the partners involved, companies, sectors and society can find faster solutions for their challenges. ILVO Marine can always rely on the expertise present in other ILVO research groups and vice versa. This allows us to take a systems approach, which fits in with our pursuit of a sustainable and profitable exploitation of marine resources in the growing blue economy.





# 4

## The horizon: “5G” for 5x Health

In the coming years, our research efforts fall under the heading of a fivefold approach to the health of the agri-food system. Healthy primary production, healthy food processing, healthy socio-economic relationships, healthy consumption patterns, and a healthy environment are key to this “5G” approach (or “5x Health” in English). The aim is to contribute to a healthy agri-food system in all its aspects. This is completely in line with the sustainability ambitions of Flanders, Europe and the world.

## 1. Healthy primary production (and catch)

Under 'healthy production' fall a number of innovative research lines that have already seen a lot of investments in recent years:

- protein diversification: more variety of protein sources (plant, animal, microbial)
- less crop protection products through better knowledge of plant pathogens and their interaction with plants and their environment
- climate-smart agriculture
- reduced use of antibiotics and more health and animal welfare in livestock farming
- the transition to a circular, bio-based economy
- attention for the valorization of secondary and residual flows

## 2. Healthy food processing

When we talk about 'healthy processing', food processing companies and farm processors immediately think of ILVO expertise in the area of food safety: pathogens, decay, disinfection, etc. But research is also needed into what processed food will be produced in the future. Our society can expect a great deal of innovation and knowledge development in the field of protein diversification. New technologies and open or shared data systems play a crucial role in this.

In addition, we want to conduct research into the allergenicity of food, health-promoting properties, nutritional values and anti-nutritional factors of various nutrients at all different phases of processing.

## 3. Healthy consumption

With 'healthy consumption' we are aiming for a holistic knowledge structure: we are striving for a total diet that is healthy for people and for the planet. For example, a new line of research is coming that focuses on the relationship between nutrition and intestinal flora. We are also concerned with malnutrition and the reduction of sugar, fat and salt in food. We are also looking at smaller problems, such as nutrition for specific target groups. Think for example of Parkinson's patients or people who stay in a residential care center.





## 4. Healthy socio-economic relationships

We conduct research into healthy socio-economic relationships in various ways. Striking highlights are studies on alternative business models, well-being and the short chain. By way of a 'living lab', we have set up structural cooperation with six short-chain farms. Scientific observations and experiments are carried out on these farms. We are also conducting extensive research into the well-being of farmers and their families.

## 5. Healthy environment

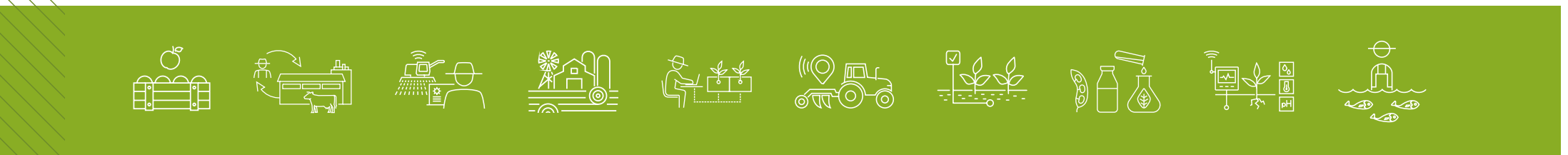
Healthy soil is a priority. It is good for agriculture, for the climate and for biodiversity. That is why we recently started a new living lab. A structural collaboration with an agroecological farm in Hansbeke makes it possible to study new cultivation approaches and evaluate their value and feasibility.

A last important knowledge domain, one where we have already built a great deal of expertise, is the reduction of emissions. This is a difficult matter to investigate, with many uncertainties and subjective aspects. By using methodological, technological and biostatistical approaches, we are making great strides forward.













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