ILVO Vision Statement: 2020 and beyond

Research for efficient and sustainable agricultural and food production
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**INTRODUCTION**

This is the future vision of Flanders Research Institute for Agriculture, Fisheries and Food (ILVO). This is not the first time that we have written down our strategical guidelines in a vision document. Our previous Vision – ILVO 2020 - was published in 2008, but the fast evolutions in society, agriculture and the food sector have made that document out of date. The coming challenges are huge. Think of the growing world population, the depletion of natural resources, climate change, the increasing globalization and polarization of our society, and high-speed technological evolutions. In this new and challenging context, it will be difficult to guarantee provision of enough healthy food and biomass while operating within the carrying capacity of the Earth.

**FOOD RESEARCH: ESSENTIAL**

New challenges and new issues require innovative and creative answers. The role of scientific research is therefore crucial. To maintain our food supplies and food production while preserving and dealing with the challenges of the future, there is a great need for innovation, sufficient know-how, applied expertise and thorough practical knowledge. This need exists both in primary production and in the secondary sectors that are responsible for processing agricultural products. In order to successfully realize the transition in our food system, an integrated knowledge approach is needed, one that looks at the entire production chain. Food is central to all our research activities. This focus on food has been made explicit in our name since 2017: now “ILVO” stands for: Flanders Research Institute for Agriculture, Fisheries and Food.

**OUR RESEARCH STRATEGY, A DYNAMIC VISION**

No longer are scientific studies and research projects set up and executed in an ivory tower. Our ‘antennas’ reliably detect the needs and questions from working farmers and fishermen, from different sectors, companies, the government and the society. Using applied research, our wish is for all those who want to progress in the agri-food chain: farmers and fishermen, suppliers and processors, citizens and policymakers, to provide solutions and answers for increased profitability, sustainability, and fairness in their practices and harmony with the environment and the society. ILVO has always stood with both feet firmly planted in agriculture and fisheries. Starting from a critical view of its social role, its relevance, and its future-oriented function, ILVO strives to further expand its function as a demand-driven knowledge center. It is also a conscious choice to establish our future vision in close cooperation with our partners and stakeholders. Our research

**READING GUIDE**

The key points of our research strategy are described in this document. We describe the trends, challenges and our new research context (Chapter 1) and explain how horizontal concepts (system approach and integrated knowledge) span our research. (Chapter 2). We formulate new ambitions and redefine our lines of research (Chapter 3). But we do not limit ourselves to a theoretical program. Because our true desire is to stimulate and support the transition in the food system with tangible innovations, we invest in technology platforms and create living labs. Those real-life laboratories are our way of testing the processes and products from the future, together with all the food chain stakeholders (Chapter 4).
strategy sets the guidelines for our work in the coming few years, but that strategic document remains dynamic, one that we will constantly improve based on the feedback and suggestions of our stakeholders. This will make our research and services stay targeted and efficient.

TEAMWORK: A POWER TOOL

As a scientific institute of the Government of Flanders, we share our expertise with the Department of Agriculture and Fisheries. And the other policy areas in Flanders – environment, nature, spatial distribution, rural development, science policy, animal welfare, etc. – benefit from our knowledge as well. Moreover, we offer our services and knowledge to the Federal and Flemish governmental bodies (food protection, public health, plant health, marine environment, economic fraud prevention, etc.) and the European Institutions (Common Agriculture Policy, Common Fisheries Policy, etc.)

We build and nurture close partnerships with the agriculture, fisheries and food sectors. Through a partnership with Flanders’ FOOD and Fevia, the Food Pilot is an example of a well-oiled machine for innovation and practical troubleshooting in the field of food processing. We invest in knowledge sharing and collaboration with fellow research institutions and research stations (united through the platform Agrolink Flanders for primary agricultural production), as well with other scientific institutions and organizations from Belgium and abroad.

We have adapted our internal organization to be able to affront the new challenges more powerfully. Teamwork forms the basis of our research programs. By joining the knowledge from the agro-food sector to the high-tech expertise, and through multidisciplinary working groups, we are able to unravel complex issues ‘from the stable to the table’ and ‘from the table to the stable’ and arrive at tailor-made solutions.
The challenges facing Flemish agriculture and the agri-food sector are complex and diverse. At the societal, ecological and economic levels, many big questions need to be answered, but there are also rich opportunities. Knowledge development and innovation, grafted onto the tangible challenges, trends and questions in the sector and in society, are absolutely necessary to achieve the transition of our food system. To handle that complexity and achieve solutions and optimally serve both society and the sector, we need strategic and scientifically supported innovation. ILVO has therefore developed a research vision based on two horizontal concepts – the systems approach and knowledge integration – and 8 thematic lines of research.
1. CHALLENGES AND TRENDS

Our society is making a far-ranging transition. Megatrends are being manifested worldwide with strong consequences that have an impact on our food supply, the agricultural and fisheries sectors and the agri-food sector. Just think about the growing world population, climate change, the accelerated technological developments, the depletion of our natural resources and so on. This changing context of complex challenges and trends is what sets the course for ILVO.

1.1 THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS AND FLANDERS “VISION 2050”

ILVO has a societal as well as scientific role. Therefore, ILVO aims to contribute as much as possible to the Sustainable Development Goals (SDGs) of the United Nations. These goals were adopted by world leaders at a United Nations Summit in September 2015. Ending poverty and inequality and struggling against climate change are therefore central. The SDGs substitute the Millennium Goals that expired at the end of 2015. The SDGs will be valid until 2030.

The expertise and knowledge present at ILVO contributes mainly to the following Sustainable Development Goals:

**Goal 2:** End hunger, achieve food security and improved nutrition and promote sustainable agriculture

**Goal 3:** Ensure healthy lives and promote well-being for all at all ages

**Goal 9:** Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

**Goal 12:** Ensure sustainable consumption and production patterns

**Goal 13:** Take urgent action to combat climate change and its impacts

**Goal 14:** Conserve and sustainably use the oceans, seas and marine resources for sustainable development

**Goal 15:** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

The execution of the Sustainable Development Goals (SDGs) requires a commitment - not only from all the governments, but also from civil society organizations, companies, citizens, and knowledge institutions. ILVO has also taken responsibility by adopting the Flemish Vision 2050 project, among other. With this project, the Flemish government wishes by 2050 to turn Flanders into a social, open, resilient and international region which creates prosperity and welfare in an innovative and sustainable way, one in which everybody counts.
1.2 THE CARRYING CAPACITY OF THE EARTH

POPULATION GROWTH HEIGHTENS FOOD CHALLENGES

An estimated 10 billion people will live in this planet by the end of this century, most of them in cities or urban areas. To provide enough healthy food for all these people is one of the biggest challenges of the coming decades. But the way we produce our food must also become a subject of debate in our society.

TOWARD SUSTAINABLE MANAGEMENT OF NATURAL RESOURCES

For the survival of the Earth and humankind, it is crucial that our food production is done with respect for the carrying capacity of the planet’s ecosystems. Without adapting our production methods, the continued growth of the world population threatens to deplete natural resources, leading to a real risk of scarcity of both raw materials and natural resources. We must manage our raw materials and resources in a way that severely limits or even eliminates loss and waste. Sustainable (food) production requires a radically new way of looking at the management of raw material and economics, as well as the agricultural economy and the agri-food sector.

BALANCE BETWEEN AGRICULTURE AND NATURE

The intensive use of resources, as well as the inexorable intensification and specialization of the agricultural sector, are causing increasing pressure on ecosystems. The quality of the marine and terrestrial ecosystems is deteriorating. At the same time, social awareness is growing about the fact that we cannot go on this way and that we must reduce our ecological footprint. Society demands a food supply that strives for sustainable production systems and a balance between agriculture and nature. Flanders is in a specific situation: as a densely populated and urbanized area, our region is striving toward a highly productive agricultural system, where the services provided by nature are used effectively and are well-protected.
1.3 **Resilient, Innovative and Responsible Agri-Food Chain**

**Technological Shocks**

Renewal is needed in the production process, together with innovative solutions for food processing and logistics. The demand for materials and products of organic origin is increasing, to enable the transition to a bio-based economy. Innovative agricultural practices, which can reverse the negative impact of agriculture on the living environment, still need to be improved and introduced more widely. The same applies to commercial fisheries and the marine ecosystem. This changed view of the production processes of the entire agricultural and agri-food chain has a big impact on the future development of the Flemish agricultural sector.

**The Qualities of Food**

Food production must also respond to specific trends in society and consumer needs; one clear example is changing dietary needs. The Belgian food companies, traders, restaurant chains, catering companies, and the government have made agreements to lead consumers to a healthier and more balanced food pattern in the Covenant for a Balanced Diet (2016). With these concrete commitments from the entire sector, Belgium is a European leader. The food companies are committed to continuing efforts to reduce fat, salt and sugar content in processed foods. To achieve this, specialized efforts are needed in product development. ILVO identifies with the United Nations trajectory to ban malnutrition by 2030 in the context of Sustainable Development Goal 2. Overfeeding and malnutrition are increasing problems in Flanders as well.

**Opportunities from the Circular Economy and the Bio-Economy**

The time when agriculture and fisheries were only suppliers of food and feed is over. Fiber, fuel, pharma, flowers and other functions are playing an increasingly important role. In other words, the threat of depletion of the natural resources and raw material also creates opportunities for the primary sector. A circular economy – one in which products, materials and resources remain in the supply chain so long as possible and where waste is limited to a minimum - is the key to a sustainable, low-carbon and resource-efficient economy. The transition to a circular economy is already happening in Flanders, and will only become stronger in the future. At the same time, the bio-economy is looking for renewable raw material as an alternative for fossil-based products and energy while also closing the organic cycles. Materials of organic origin have several advantages: they are renewable, biodegradable and compostable. Closing cycles can take different forms: reuse of re-use of waste streams within the company or the sector. But also the use of agricultural, food and fishing (waste) streams in other sectors offers new perspectives. When using organic resources, attention must be paid to the environmental effects of the life cycle and the sustainable input-output balance.

**Need for an Inter- and Transdisciplinary Approach**

Answers to all these issues require an inter- and transdisciplinary approach, one that not only examines the components, but also the complete system. The scientific research supporting the primary and secondary economic sectors must respond to this need.
1.4 Changing climate

The agricultural sector is one of the sectors that, due to its CO$_2$ emissions, participates in climate change, but at the same time can contribute to the solution through CO$_2$ storage. Both agriculture and fisheries experience the impact of climate change first hand. In both domains – climate mitigation and climate adaptation - there is a need for knowledge development.

Reduction of CO$_2$ emissions

To reach the European and Flemish climate goals and agreements, the emission of greenhouse gases coming from agriculture must be reduced. Agricultural production will always be based on natural processes, which are unavoidably linked with emissions. It is also important that the sector makes efforts to minimize its emissions through a more system-oriented approach. There is a continuing need for scientific research on economically efficient methods in order to make it possible for the agricultural sector to reduce its emissions. The agricultural sector can also contribute to the solution of the climate problem by storing CO$_2$ in the soil and in crops. There is also a huge need for research in that domain.

Changing climate calls for adaptation

The effects of climate change are already perceptible across the world, including in Belgium and Flanders. For example, the annual average temperature in Uccle is today almost 2.4 °C higher than in the pre-industrial period. At the same time, annual rainfall is increasing and the sea level is rising. The already noticeable impact of climate change on agriculture and fisheries is manifested mainly through changing soil humidity levels, the rising environmental temperature and the increase of CO$_2$ concentrations in the atmosphere. All of these factors influence crop yield. Climate change not only has affects the crops themselves, but also influences the presence of diseases, pests and pollinators. This can lead to changes in the behavior of the organisms present and new pests can also appear.

To secure our food supply in a changing climate, Flemish agriculture and horticulture must urgently adapt mitigation measures. Scientific research must provide the building stones for these measures.
1.5 **THE FARM’S SOCIO-ECONOMIC POSITION**

**SOCIO-ECONOMIC PRESSURES**

The agricultural sector is having a difficult time. This is reflected in the socio-economic position of farmers and their sector. Almost everywhere in the world the market position of farms is weakening, as they are wedged in the food chain between suppliers and processing companies. To reinforce the position of the sector, alternative business and policy models are needed, such as a stronger commitment to finding new ways to collaborate and create value in primary production.

**CHANGES IN RURAL AREAS**

The (sub)-rural areas in our region are subject to intense changes. The claims of many actors and users have to be reconciled: agriculture, nature, recreation and leisure, mobility, tourism, the catering sector and the local economy.... New challenges such as climate change require new functions from rural areas, such as energy production or environmental buffering against flooding.

This transition creates new opportunities and roles for the farmer: as a manager of the agro-ecosystem, actor in the recreational and tourism sector, producer of renewable energy, player in the healthcare sector, and more. Which role can family farms adopt in tomorrow's Flemish countryside? To foster the success of these transition trajectories, a thorough, qualitative, objective and scientific monitoring of social trends is a must.
2. **Fundamental Strategic Choices in ILVO’s Organization**

ILVO has laid three horizontal foundations under its eight thematic lines of research: systems thinking, the integration of many types of knowledge, and the ILVO values. Through systems thinking, ILVO aims for the required added value by incorporating the complexity of the entire issue instead of providing isolated solutions for unraveled parts of the problem. With the words “integrated (types of) knowledge”, we mean enriching our knowledge by linking community-based, historical knowledge about agriculture, food and fisheries in Flanders with ultra-modern, innovative, technological knowledge. In addition, ongoing work to internalize the five ILVO values among all ILVO personnel supports a collective work mentality that facilitates sustained high performance.

2.1 **The Systems Approach**

The agro-ecosystem is a complex system that includes a mind-boggling number of elements: the diverse biotic and abiotic factors and their complex interactions, the response of plants and animals to changed production factors, the influence of external parameters such as climate and the impact on policy, economy and society. Interventions or changes cannot be seen from the perspective of one isolated element; we must keep an eye out for the interaction between all components and aspects of the system. Only the combined knowledge of all these facets allows us to develop strategies that sharpen the resilience and natural defenses of the plant and animal production systems. The result: more sustainable food production, less residues, better revenue, and healthier plants and animals.

**Understanding Interactions**

Sustainable agriculture requires an exhaustive understanding of the interaction between the individual facets of the agricultural system. Individual practices or innovations that are favorable for one element of the ecosystem are often a disadvantage for other elements. For example, adding high doses of nutrients can promote the growth of crops, but negatively affects water quality. Insecticides protect the crops against pests, but they have a negative effect on natural predators. Innovation can also lead to competition regarding biomass: for example, investing in fermentation based on the guarantee of financial return via green power certificates can impede the higher-quality valorization of fruit and vegetable biomass.
NEW AGRICULTURAL FUNCTIONS

To understand the interactions between the different biotic and abiotic components and feedback loops within the agro-ecosystem, and to develop agricultural practices that optimize input, output and trade-offs, we must think from the complete system. The term ‘farming and food systems approach’ is used in this context. For agriculture - the supplier of food products and fodder crop -, a holistic vision offers huge added value. For example, when choosing a production system, nutritional value of feed, raw materials for balanced food, soil management, horticulture systems, preservation of bioactive components and recovery of waste flows are all aspects that have to be taken into account. But the systems approach also has an eye on new or changing functions of agriculture: as energy supplier, supplier of raw materials for the green economy, provider of ecosystem services, actors in short supply chains, etc.

TEAMWORK AND GOVERNANCE

ILVO wishes to develop knowledge that fosters the transition to innovative agricultural systems. These new, sustainable agricultural systems have a positive impact on the ecosystem and at the same time, they have the necessary resilience to stay economically profitable. But innovation of existing agro-ecosystems is a complex task: the relations and conflicts between stakeholders, with policymakers and the often uncertain socio-economic impact of both technological and system innovations all have to be taken into account. Teamwork, knowledge sharing, governance, and socio-economic aspects are also part of the systems approach.

SYSTEMS THINKING AS A SEPARATE RESEARCH TOPIC

To offer an answer to complex multidisciplinary issues, ILVO starts from a systems-oriented, interdisciplinary approach. As a knowledge center, we have technological and technical knowhow as well as socio-economic expertise. ILVO is profiling itself as a hub of creativity and innovation in both domains. For this purpose, we use application-oriented as well as socio-economic research based on a broad scientific and technological foundations.

The systems approach is not only a way of looking at existing or new research, but also an independently developed research topic at ILVO. By developing methodological knowledge and new systems-oriented tools, this work reinforces the more technically oriented lines of research.
## 2.2 Integration of Expertise and New Technology

In the world of Flemish agriculture and fisheries, an impressive amount of expertise is already present among the people working in those sectors. Call it unwritten wisdom, ‘tacit knowledge’ or experiential knowledge. Regardless of the term, this expertise is a treasure that forms the foundation of our agricultural, horticultural and fishing businesses. At the same time, international trends indicate that the agricultural sector will become drenched in new technology in the coming years. High-tech instruments and applications, such as robots, drones and sensors are excellent tools to make Flemish agriculture even more sustainable and profitable. However, the use of these instruments in practice will be hindered unless they are integrated with practical expertise. Therefore, traditional practical knowledge will need to be linked to the latest innovations and vice versa, and newly-developed technology will need testing at an early stage in agricultural practice.

### Re-valuing practical knowledge

After many years of observing agro-ecological concepts, many practical basic insights have become interwoven in diverse production systems in Flanders. Many of these insights and principles have been forgotten due to the increasing mechanization, monoculture and new possibilities for crop protection and fertilization. Sometimes some of these old techniques were used as a ‘black box’ because there were no technical means available to study them deeply and to understand the specific reactions of the systems and their parts. Other lessons from the past can be found regarding the socio-economic field and the position of farmers within the rural community. Think of the earlier construction of chain structures, the evolution of market mechanisms and price development. Historic relationships between farmer and consumer can teach us a great deal: how can we incorporate these positive elements into the current Flemish context?

ILVO can be proud of its extensive in-house practical knowledge regarding agriculture, livestock farming, and management, garnered through years of experience. Since the beginning of the last century, invaluable data has been collected on the 200 hectare test fields at ILVO. We want to make full use of existing experience and expertise when searching for solutions for the challenges of today and tomorrow. ILVO wants to look up, revalue, capture, and then link the experiential expertise, skill, and other often unspoken knowledge (both in the sector and within our own institute) to the high-tech possibilities of the 21st century.

### Experimental innovations translated into practice

International trends indicate that agriculture will be confronted in the coming years with a wave of data and technological innovations. Think of digital farming, Agriculture 4.0, and so on. As a practice-oriented research institute, ILVO wants to tailor the supply of technology to the sector’s demand for useful and profitable technological innovations, which provide answers to the farmer’s daily practices. Knowledge about agriculture and a broad, deep-rooted expertise play an essential role here.

Daily agricultural practice is, for ILVO, an appropriate frame of reference to test our innovations. Whether we are developing new technologies from scratch or starting from the preliminary stages of technical innovations, we take practical applicability and feasibility as a starting point to accelerate innovation, orient it better to daily practice and make it more effective.
2.3 THE FIVE ILVO VALUES

Five essential values are nestling within our human resources: 1) teamwork, 2) striving to be an example; 3) a proactive attitude; 4) serious professionalism and 5) contagious positivity. These values are the automatic touchstone for management decisions. Through a personnel action plan, the importance of these five ILVO values are repeatedly presented in different ways to all groups and levels. The values also play a role in recruitment and evaluation criteria.

TEAMWORK

ILVO is an open, approachable and accessible organization. We consider it both obvious and an honor to be interlocutor, colleague, source of information and service provider for policymakers, relevant sectors, universities, social actors, and the environment for local organizations and citizens. In 2017, ILVO’s management team used this value as the foundation for more and better internal collaborations and targeted partnerships with other knowledge centers (universities, structural consultations with Flemish scientific institutions, Agrolink Flanders, and more).

EXEMPLARY FUNCTION

There is a Flemish saying: “words wake people up but examples reach them”. A knowledge institution wishing to stimulate sustainable and profitable agricultural, fisheries and food products must show exemplary performance in its own experimental way of working and applied research. This means that ILVO’s experimental farm, experimental fields and greenhouses, the Food Pilot, and labs must strive for perfection. But that is not all: when ILVO talks about sustainability, the ILVO personnel themselves give the example, for example through an ILVO-wide sustainability day (workshops) and an internal sustainability working group. When we consider investing in our infrastructure and machinery, sustainability criteria are taken seriously. Academic integrity is also taken seriously. We implement the European and Belgian definition of academic integrity by drawing up an active training plan for all levels, with internal ethical “dilemma exercises”, monitoring, a complaint procedure and a system of sanctions.
PRO-ACTIVE

The relative slowness with which scientific knowledge is created contradicts the hectic nature of some social evolutions. ILVO does not want to respond to the latest sensational news. However, we are a flexible and agile organization that, within a reasonable time frame, can address questions and concerns of the policymakers, the sectors that can find themselves in acute crisis situations, and of the citizens who, due to sudden events, are looking for reliable background information. ILVO’s researchers have been trained to quickly consult specialized scientific literature. Recent examples include responses to the climate issue as related to agriculture, and the concern for the health of residents living close to large animal farms. Proactivity means that we sense developing opportunities. And that we consciously keep our finger on the pulse of both local and global challenges. This vision statement is a proactive exercise to keep ILVO’s research on track to 2030 and beyond.

PROFESSIONAL

ILVO strives to reach far deeper than just a façade of professionalism. The professional attitude at and even outside of work is a standard, a way of being. Thoroughness, quality, timeliness, service orientation, friendliness, open and transparent communication, spontaneous responsibility, commitment, etc... These are some aspects of how ILVO understands professionalism. We reinforce these values by offering all ILVO employees training opportunities, good leadership tools and through a stimulating work environment with the most modern scientific equipment.

POSITIVE

Optimism is a moral duty. If you look at the situation of primary production and the many challenges confronting our sector, pessimism is lurking just around the corner. That is why ILVO strongly advocates for a positive attitude: research and innovation will lead to sustainable improvements in production that will benefit the people, the animals and our environment. ILVO employees are therefore more likely to show themselves as ‘yes’-sayers rather than ‘yes-but’ thinkers. ILVO wants to be open to listening, helping and being reliable. By making this value concrete, ILVO has already generated high scores on customer satisfaction and employee satisfaction surveys.
To provide necessary and appropriate knowledge to the agriculture and food sector as much as possible, we have redesigned our lines of research. Eight new lines of research will enable us to confront the future challenges of the agriculture and food system efficiently and decisively.
3. **OUR LINES OF RESEARCH**

3.1 **HEALTHY CROPS, ANIMALS AND SOIL FOR HEALTHY FOOD**

The agri-food system of the future must be both ecologically and socio-economically resilient and it must supply healthy food crops and food products. The most sustainable production is achieved by striving for optimal plant, animal and soil health. That’s what ILVO strives for.

**HEALTHY CROPS**

*Diseases and pests*

The health of plants is mostly determined by the presence or absence of harmful organisms, but also through the sensitivity and defense capabilities of the plants.

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**ILVO’s research on diseases and pests on plants has three main points:**

1) **To continually assess possible new threats of pests and pathogens to ensure timely and adequate intervention.** ILVO’s research has a strong international orientation. That is necessary, among others, to research the increased risk of introduction, spread and impact by new harmful organisms. The highly intensified international trade as well as the changing climate reinforce this phenomenon.

2) **The development of management strategies for important diseases and pests in our crops in the context of Integrated Pest Management (IPM).** Flemish agri- and horticultural production must focus on cultivation systems that lead to ‘high value crops’ with low residues of plant protection products. Crop security and value creation are central here.

3) **Soil conditioning.** The awareness is growing that a healthy soil life – all fungi, bacteria and living organisms, perhaps even more than the physical and mineral composition of the soil - influences the defensibility and resilience of the plants to suppress diseases and pests. We focus on soil research because soil, in contrast to the climate, must be well-managed in function of plant health.
**Mixed crop farming and crop rotation**

Mixed crop cultivation – growing multiple crops on the same parcel at the same time – can offer many advantages. The mixed crop technique helps to control diseases and pests, helps adapt to changing and extreme weather conditions, provides higher buffering capacity, increases diversity, and improves the soil. Agroforestry is an example of a mixed-crop system, but also complex crop mixtures based on green manures, grass-clover, and herbaceous grasslands deserve our attention. Here we discuss both systems thinking and the integration of old-and-new knowledge. Development of mixed crop cultivations and expanded crop rotations is an important task for the future. Both offer opportunities to create economic added value and they will be needed to deal with the consequences of climate change. Therefore, ILVO focuses its breeding and variety testing on creating better resilience for new climate conditions. In addition, the appropriate cultivation techniques for those crops must be studied. The combination of these two knowledge areas will form the basis for a successful introduction in practice.

**Healthy animals**

The intensity of our animal production systems makes high demands on the animals. By improving both management and production systems, diseases and metabolic disorders can be minimized and animal welfare can be given the attention it deserves. Another goal is to minimize the use of antibiotics, which ILVO studies by performing health research from an integrated point of view. Animal health and welfare are directly linked with the food safety of meat-based products. We map all the factors from throughout the supply chain that influence animal health, e.g., feed, housing, management, genetics, transport, slaughtering, etc. in order to optimize them in a later stage of research.

**Chronic stress**

By accumulating knowledge about acute and chronic stress in animals and the validated determination of stress through analysis of feathers, hair or scales, ILVO has created an extraordinary scientific niche. Chronic stress can have harmful consequences for observable parameters such as growth, reproduction, immunological defenses and the animal’s general body condition. ILVO is studying fundamental questions while also establishing practical applications in aquaculture, for example. By monitoring long term stress, producers can improve the welfare and the performance of their animals.

**Heritage breeds**

Can the genetics of historic or ‘heritage breeds’ incorporate more robustness, higher longevity and other desired sustainable parameters into existing genetics? This could be a way to improve the health of the animals within specific production systems. Mainly by setting up new alternative production systems to develop niche markets, heritage breeds can incorporate interesting characteristics. ILVO is committed to this genetic research.
Gut microbiome

We are also working on deepening our understanding of the relation between the microbiome (that is, all the micro-organisms in the body of an animal), metabolism, and the health of the host. In this way, we want to gain a better understanding of the factors that influence the development of the microbiome during early life, as well as the stability of the microbiome during adult life. This knowledge is essential when striving for optimal health and efficient production of animal products.

Healthy soil as interface between plants and animals

The soil quality in and around the farm is mainly determined by the farmer’s management practices: the use of manures, soil conditioners and crop protection products, mechanization, adapted crops and crop rotations. ILVO aims to help the farmer to manage chemical, physical, and organic soil quality. The goal: to reduce weed and disease pressure in the crops and to achieve good, high-quality yields based on customized provision of oxygen and water, a good utilization of nutrients such as nitrogen and phosphorus, and a good processing and root penetration of the field soil.

Fertility and soil microbiome

The soil has an important influence on the growth and health of plants. By “soil” we mean the actual soil as in arable farming as well as the substrates and mats used in horticulture. The soil determines the health of the plants on two different fronts. Harmful organisms can survive in the soil and damage the root system; while the soil also conducts the properties of plants and influences the resilience against diseases and pests, both under and above the ground. The composition of the soil and the direct environment of the roots - the rhizosphere - play an important role in both cases.

ILVO is committed to researching soil conditions and microbiology that suppress the influence of diseases and pests. The microbiome in the soil forms an important starting point in our systems research.

Manure processing and treatment

ILVO will also carry out targeted research on the treatment and processing of manure and organic waste products before they are applied in the soil. This treatment is necessary to increase the resilience and functionality of the soil, but also to limit the risk of introducing human pathogens and antibiotic residues via the fertilizer. This contamination has a huge direct effect on the soil microbiome, but also on the microbiome of the aboveground biomass. Contamination via manure can also lead to contamination of the wider environment, for example, by leaching to surface and ground water.
3.2 Socially acceptable animal production

Despite the significant societal contribution of Flemish cattle farming and fisheries, the sector is sometimes subject to societal criticism. ILVO is committed to use dialogue and research to enable discussions around the possible position and future modalities of cattle farming and fisheries in Flanders and to study them.

Objective information in social debates

Resilience is decisive for the future of the animal production sector. Consumers may be critical about animal husbandry, fisheries and aquaculture, but their opinion is often based more on gut feeling and perception than on knowledge. At ILVO we consider it our task to provide objective information, preferably in a proactive way, to feed the social debate and the political decisions in a scientifically responsible way. Therefore, it is essential to make the link explicit between environment and impact, animal welfare and profitable production in Flanders.

Research steers practice

The environmental impact of animal husbandry has become undoubtedly larger due to intensification. This can be translated into local problems such as the ammonia problem, nitrification and eutrophication of the ground water - but also in problems with global consequences, such as climate change, deforestation and the problem of antibiotic resistance. Through a systems approach based on technological expertise and a thorough understanding of all aspects, ILVO’s research helps the sector to choose the correct direction to follow in these societal issues.

But also solid fundamental knowledge and expertise are important to support systems thinking. Therefore, insights into the physiological processes, the production processes, outfitting of animal housing, and the management systems are all essential.

Use of biomass and plant waste streams

Our research in the animal sector also focuses on more efficient use of biomass and the use of plant waste streams in animal feed. We therefore take into account the general competition for carbon and nitrogen sources – Feed, Food, Fuel, Fiber – and circularity. To answer the growing criticism about importing from overseas, we work on possibilities for alternative protein sources. Feed evaluation and performance research play an essential role in making sustainable choices about the incorporation of alternative feed materials, waste and side streams and additives in animal feed, with minimal competition with directly edible human foods. We always start from a holistic vision on nutrient flows, animal health and sustainable animal production. Also genetics, animal welfare, stress, emissions, taste, identity, profitability, and water consumption are focus points in this line of research.
ANIMAL WELFARE

The sensitivity of society around the welfare of animals in production systems is growing.

**Expertise in animal welfare and behavior is a basic pillar of this line of research, in which we strive for:**

1) Better scientific support for the concept ‘animal welfare’ by developing and integrating new welfare indicators, for example regarding chronic stress;

2) Developing protocols that make on-farm determination (and by extension, throughout the entire supply chain) of animal welfare possible, to support specifications (e.g., at the request of the retail sector).

On a practical level, ILVO can help with the search for solutions to problems in animal husbandry, where certain aspects are under societal pressure. Think of foot pad lesions in broilers, castrations and tail docking in slaughter pigs, maternity cages in sows, separation between calf and mother animal, and so on.

3.3 EFFICIENT PRODUCTION SYSTEMS AND VALUE CREATION

QUALITY CONTROL

In addition to local marketing, the export of agricultural and food products is an important economic factor for the Flemish agricultural and agri-food sector. Quality and authenticity are important to maintain existing sales channels and create new ones, but also to enable control of compliance with the regulations in the areas of food safety and quality. ILVO works hard to develop methods for quality control of agricultural products. ILVO’s position as a governmental research institute, independent from commercial pressure, is crucial for the credibility of our monitoring programs.
SUPPLY CHAINS IN TRANSITION

Despite the excellent quality of their products, farmers do not always succeed in getting a sufficiently high price for it. Many factors such as scale, labor costs, logistics, and more all determine the pricing. The price of agricultural products fluctuates because our farmers are producing for a global market. Action labs, participative research, learning research networks, agricultural economic business analysis, etc: ILVO develops methods and trajectories that guide agriculture, fisheries and food businesses onto other tracks. These can lead to broadening, deepening, product innovation or specialization, or to changed organizational forms of the production system.

NICHE MARKETS, SHORT SUPPLY CHAINS, CSA, BIO, URBAN AND CONVENTIONAL AGRICULTURE

The profitability of the production systems is under pressure, partly due to globalization and international trade agreements. Cost-efficiency becomes ever more important for mass production. At the same time, there is space at the local level for less intensive niche production systems with a shorter link to the consumer. These systems are also helping to improve the image of the sector.

ILVO certainly sees a future for specific products developed for smaller markets with larger margins. This larger margin can be the result of better characterization at nutritional level, the presence of bioactive components, an innovative way of processing or the specific local character of a product.

The cattle farmers who chose for an alternative approach by setting up a niche production system are responding to the demands of society, such as short supply chains, outdoor grazing, free-range chickens, non-castration or organic cattle farming. Organic cattle farming and plant production are forming a separate niche with specific questions. At the same time, these new subsectors deliver knowledge that helps the conventional sector to become more sustainable. An exchange of knowledge and expertise between the conventional and organic sector can help to establish a more sustainable and acceptable cattle system through collaborative research. Knowledge development and expert support are indispensable here because such changes can obviously have a big impact on farm operations. By developing a systems vision of niche production systems, we help the sector to focus more on niches that guarantee sufficient market demand and profitability. Scientific research and technical knowledge can help to make these niches successful.

In addition, it is equally important that we continue to offer support in further optimizing the primary production for our own food processing industry. ILVO will continue to be a valuable technological partner for all these players.
CREATION OF VALUE VIA PLANT BREEDING

The extensive expertise in plant breeding built by ILVO over several decennia offers a whole range of possibilities for creation of added value in different sectors. ILVO advocates for new, marketable cultivars of agricultural and horticultural crops (green manures, industrial crops, feed, food and ornamental crops) with a clear added value: higher yield, better quality (nutritional and feeding value, visual-aesthetic value), increased tolerance to biotic and abiotic stress factors, more efficient use of water and nutrients, or a modified composition of compounds. We work on participative development of new breeds, which can be applied either on a large scale or in niche markets.

HIGHER PROFITABILITY IN THE FOOD INDUSTRY

In the sectors that process primary products, there are also important steps to take towards more profitable systems or products with added value. Examples include milder processing technologies, monitoring of the impact of processing on food quality, and taste testing. ILVO strives continuously to capture the needs of both primary producers and the processing industry in Flanders, and to underpin them with scientific expertise, in order to increase the economical added value of both sectors. We provide specific recommendations to innovative companies that want to specialize in the short supply chain as well as to food companies. Together with them we design new food products and processes and help them to commercialize innovations under construction in these sectors via our scientific support.

3.4 Bio-economy

Europe and the rest of the world are working hard on the bio-economy. That means developing renewable raw materials and the corresponding adapted processes as an alternative to the products and the energy from fossil-based raw materials.

Anyone who says "renewable raw materials" inevitably ends up at "farming". For the Flemish agro-industry, the potential of the bio-economy is real. The range of possible end products is many times greater than what is traditionally associated with applications of agricultural products. In addition to food and feed, it can also include plastics, bio-energy, chemicals, medicines, or building materials.

ILVO finds that two characteristics of the green economy are essential:

1) Wherever possible, the cascade principle is taken into account, in which biomass is first used for the highest possible valorization value and then waste streams are used as input for the following applications.

2) The bio-economy is also organized in a circular way, so that there is no waste. The final waste stream from a bio-refining process can be processed into soil improvers.
It is already obvious that technological innovations are an important key in the transition to the circular and bio-economies. ILVO advocates for a multi- and transdisciplinary approach and a systems perspective, in which all parts and actors are involved in a certain chain supply. To reach adequate production numbers, the industry must be able to count on stable levels of available renewable products and a stable level of quality. ILVO chooses to focus on both medium-sized and the large local biomass streams. In Flanders, medium sized flows are definitely relevant, given the large concentration of small and medium-sized farms and food and feed companies.

ILVO defines the following research questions for the future bio-economy-related research:

1) How do we produce biomass as sustainably as possible in function of the bio-economy, without depleting the soil?

2) Which biomass do we produce?

3) How do we process this biomass as efficiently as possible in a larger range of bio-based products?

4) What can bio-economy mean for Flanders and, more specifically, for the agricultural industry?

5) How do the Flemish bio-economy innovation pioneers innovate, and what can the future players in this chain learn from their experience?

6) And how do we generally reduce the use of fossil resources?
3.5 Healthy Food

Optimize Production Processes

High quality food depends in large part on the production process. ILVO research helps to optimize existing production processes with attention to the different aspects of quality: taste, health and safety, societal acceptance of the production process, and the composition and characteristics of the end product.

Covenant for Balanced Diet

In the Belgian Covenant for Balanced Diet (see above), the Belgian food companies have committed to increase their efforts to reduce fat, salt and sugar in foods. In addition, the Covenant pays attention to the nutritional composition of food products, consciousness-raising and research, and product development to expand the available range and supply of food products. With its research and expertise, ILVO aims to support the food companies and the government in meeting the goals of the Covenant.

Ban Malnutrition by 2030

ILVO is on the same track as the sustainability trajectory of the UN, i.e., to ban malnutrition (under- and overfeeding and unbalanced diets) worldwide by 2030. We are constantly looking for opportunities to integrate new raw materials, new processing techniques, and new insights in the area of nutritional needs into this trajectory. At the same time, we want to continue to guarantee the food safety of food products that may present new risks due to a recipe change (e.g., less salt).

Because of the complexity of malnutrition and the fight against it, we always start this type of research by involving all stakeholders: the agricultural and food companies, distribution, food service, consumers and health workers. In this way, all of the relevant available information can be used when performing this research. This approach also creates a foundation of support for fast transfer of research results to practice.

In this line of research, we aim to:

1) Develop a system to make an inventory of the intrinsic properties of the primary products. We start with a targeted characterization of desired functionalities (nutritional value, dietary fiber) and bioactivity. We then make optimal use of these characteristics in the production process.

The functionality will be determined, among others, through model systems and high-tech measurement techniques. As stated above, it is generally accepted that there is a link between the composition of the intestinal microbiome and health, both in animals and in humans. Therefore, it is highly relevant to map the impact of the composition of food and feed on the composition of the intestinal microbiome and on intestinal health in general. Based on these insights, the next step is to guide product composition and processing.

2) Develop models that make possible to develop and reformulate food products in a targeted and efficient way, in function of specific goals.

We want to make these prediction models applicable for a larger range of food products. This approach is also used for the development of food for special target groups that require specific food characteristics.
3.6 Rural development in urbanized Flanders

More and more, Flanders is being labeled as an “urbanized area”. This term refers to the (sub) urban areas that fulfill many functions, where urban and rural areas are not strictly separated but rather interlinked. Policy documents often refer to the “Flemish Metropolis”: a region that, thanks to its urban allure, can compete with prestigious world cities such as London or Paris. The ubiquitous access to open space is put forward as one of Flanders’ important assets.

The countryside as a resource

Open space is crucial not only for our food production, but also for climate change: to temper the heat-island effect and to buffer against flooding. It maintains biodiversity and creates a landscape for city-dwellers seeking rest and recreation. The countryside has not only natural resources, but also human resources. The presence of human and intellectual capital offers many opportunities for the development of open space. We can therefore consider open space or the countryside as an important resource, with an intrinsic power to stimulate transitions and innovations.

Support for consultation processes in rural areas

Despite their benefits, rural areas are increasingly under pressure. The world we live in is constantly changing. Globalization, climate change, urbanization and population growth are some of the challenges we are confronted with. Various sectors and actors, such as agriculture, nature, tourism, residents, entrepreneurs, landowners, building sector, governments, etc. are all involved in the evolutions of rural areas. These actors are usually organized and can show their interests in various ways, both in the public space and in policy bodies. The dynamics between these actors leads to changing processes in the countryside. We want to map the diversity of interests and expectations of these actors and understand the processes of how interests are prioritized. ILVO has built considerable expertise. Based on that, we wish to guide these discussion processes with various actors from the agricultural and food sector.
RESERVING OPEN SPACE

ILVO occupies a unique place in the research for rural development in Flanders. We have considerable expertise regarding the spatial changes in rural areas and open space. ILVO will continue its research unabated to quantify and map these changes. In that way, our research helps to find ways to establish policies that address the pressure on open space. This may involve not only innovative strategies and instruments for maintaining and managing open space, but also innovative forms or multiple uses of open space.

It is important to ask ourselves which agricultural systems best fit with the advantages and potential of a specific area, which role the farmer can adopt and how best to support farmers. The interdependence of urban and rural areas, dialogue between the different actors, and monitoring of the quality of life in rural areas are important strategic challenges.

SOCIAL CHANGES

The influence of new actors - non-farmers - creates social changes in rural areas. These new actors look at the rural areas in a different way and they have different expectations. Moreover, other people get responsibility for making decisions about land use, which creates new power relations. These new actors and their activities transform the landscape. Fertile grounds and healthy soils are now occupied by a range of activities. Village centers expand, roads are constructed and surfaces are hardened. Urban functions are also finding their way into the rural areas: housing, industry, infrastructure, port expansion, small-scale economical activities, and so on.

The extent of the impact of such changes can also be determined by the resilience of the rural areas: the capacity of an agricultural area to adapt to changing conditions so the living standard is still maintained. This concerns both the inherent economical, ecological, and socio-cultural aspects of a specific rural area.

Several research tracks are used at ILVO to look for ways to fully use the rural areas as a resource and how to use their location within an urbanized area as an opportunity. Research into so-called ‘green’ and ‘blue’ services also fits into this framework.
3.7 Exploitation of Marine Production

Marine production is gaining importance in the context of the blue economy, partly through the developments around ‘blue growth’ and ‘blue biotech’. Within ILVO, fisheries and the sustainable exploitation of the marine environment remain an important line of research. The pressure on natural resources and space at sea is increasing; therefore, strict monitoring of European, federal and Flemish regulations is increasing in importance. ILVO is expanding the sector-oriented research into a systems vision of fisheries and marine production. Within this vision, valorization, international contributions, and collaborations with companies and policy play a major role.

Healthy Fish Stocks

Healthy fish stocks are the basis for socio-economically viable fisheries. ILVO works on high-quality data collection of all aspects related to the Belgian fisheries and the continual improvement of methods of analysis and modeling. Our strength is that we bring together data from a large variety of data sources and make them available in a standardized high-performance database.

Fisheries and Technical Innovation

Innovation in the fisheries sector is essential. The new Common Fisheries Policy (CFP) and the corresponding landing obligation (discard ban), the demand for sustainably caught fish, the need for more efficient fishing techniques, the high operating costs and the fear of limited access to fishing grounds are important driving forces. ILVO advocates for the use of dialogue and targeted and innovative scientific research to make the sector more sustainable and to advise Flemish and European policymakers. Adjusting to the landing obligation and addressing the environmental impact of fishing are major challenges for the sector. Specifically, ILVO’s fisheries technical research focuses on reducing the impact of the current beam trawl, continuing to develop pulse fishing and passive fishing, and on research on survival of discards. New ideas regarding better spatial planning of fisheries to reduce discards and reduce seabed disturbance are being developed. The use of the fishing fleet as a new data source that can give real-time recommendations for an optimal spatial distribution of fishing activities, will receive more attention in the coming years.

Toward Sustainable Aquaculture

Fish, crustaceans, shellfish, seaweed and more: the sea’s natural resources are no longer able to meet the global demand for seafood. The main focus of aquaculture production is currently in Southeast Asia: countries with strong economic growth and a growing internal market as well. Within Europe, there is a fear that the influx of cheap farmed fish from these countries will decrease. That is why Europe is striving to increase its own aquaculture production.
ILVO is conducting research into the development of sustainable aquaculture, on land and at sea. Sustainability is central here: reducing the impact on the environment, reducing the dependence on fishmeal and fish oil by developing feeds based on alternative sources of protein and fatty acids, increasing produce diversification, developing new production processes and systems, and resolving acute problems at the company level.

**PRODUCT MONITORING**

Fisheries products must meet requirements for food safety and quality. ILVO develops biological, sensorial, physical, chemical and chromatographic methods to monitor freshness and quality. Food integrity and authenticity are also increasingly important in ILVO fisheries research. One new aspect is the focus on new so-called “emerging contaminants” in the marine ecosystem for that have no existing standards yet. Examples include the accumulation of new antifouling and toxic metals, micro- and nano-plastics in foodstuffs and new biotoxins that are emerging as a result of climate change. Endocrine disruptors, algae toxins and pharmaceuticals are also possible areas of research.

**BLUE BIOTECH**

Blue biotechnology is one of the five sectors of the EU ‘Blue Growth’ initiative to further exploit the potential of the European oceans, seas and coasts. ILVO supports the further development of blue biotechnology. The sea represents a protein and gene pool that is barely known and is exploited even less. Marine organisms such as bacteria and fungi can be useful in biotechnological processes, such as the conversion and degradation of various substances. The immense gene and protein pool itself can also form an important new marine resource with an important valorization potential. Enzymes, biomaterials, intermediate compounds for medicines, etc. can be developed into products for food, human health or for industrial applications.

Blue technology also contributes to the concepts of the circular economy (zero-waste) and bio-economy. Micro and macro algae represent an important component of marine biomass, with a wide variety of valorization products (from pharmaceuticals to feed). The CO$_2$ storage capacity of algae is also an asset and a possible way to combat climate change.

Many factors have an impact on this quality, which calls for an integrated approach. ILVO focuses on:

1) the study of biological, toxicological and chemical effects of human activities on ecosystem components and their habitat;

2) the study of different types of pollution on the marine ecosystem.

In addition to the conventional measuring and analysis methods, we also focus on new techniques such as sediment profile imaging, DNA metabarcoding and metagenomics.

**QUALITY OF THE MARINE ENVIRONMENT**

In the pursuit of sustainable exploitation of natural marine resources there is a need to evaluate the quality of the marine environment in a scientific way.
3.8 Climate

Climate change is one of the top challenges for policy, business and research. The agricultural sector is subject to climate change and at the same time contributes to it.

Climate Resolution (2016)

There is a near-global consensus that all sectors must urgently enact measures to meet oncoming effects of climate change through mitigation, adaptation and spatial planning. In terms of agriculture, Flemish policy meshes seamlessly with that thinking and also expresses an explicit desire. The Flemish Climate Resolution (2016), which was broadly approved by the entire Flemish parliament and signed by all parties, reads:

"...that Flanders plays a leading role in the field of climate-efficient agricultural and horticultural production; (...) that the know-how of the Flemish agricultural and horticulture sector regarding the global climate problem is further developed to obtain climate-efficient agricultural and horticultural products, with lower greenhouse gas emissions per unit of product in comparison to other countries, (...) that the methane emissions of livestock must decrease through research and knowledge transfer, by optimizing feed ration and / or efficiency; and by building low-emission animal housing systems, (...) that a focus is put on precision agriculture, a technique tailored to the crop and the animal, an agro-ecological principle, on biotechnological processes, and on other techniques that reduce the use of resources (energy, plant protection products, antibiotics, fertilizer, and so forth). "

The ILVO Center of Expertise for Climate and Agriculture, established at the end of 2016 under the impetus of the Flemish Minister for Agriculture, has a dual goal:

1) To further strengthen the multidisciplinarity of climate research by grouping the various expertise and knowledge areas in the field of climate within ILVO, to further develop the expertise and to closely monitor the international evolutions in the field of climate and agricultural research.

2) To link current and new research projects and results within and outside ILVO to the climate impact and challenges.

Center of Expertise for Climate and Agriculture

ILVO already has a great deal of knowledge in this field. Both the effects of agriculture on the climate (quantifying greenhouse gas emissions from agriculture) and the effects of climate change on agriculture (development of new diseases and pests) are already present in numerous research projects.
**Mitigation**

The agricultural research strongly focuses on the reduction of carbon dioxide, methane and ammonia. Emissions from livestock farming of greenhouse gases like ammonia as well as odor and particulate matter, are caused by biological processes that cannot easily be reduced in a mechanical way. The line of research on the rumen microbiome fits in with the climate mitigation theme, for example. The aim of this research topic is to influence the gastrointestinal flora of ruminants and to emit less methane. In animal husbandry, ILVO therefore aims for effective interventions at animal and herd level, as well as measures in the field of farm management. Fisheries research includes studies on energy-efficient engines, low-nutrient mariculture, and valorizations of marine biomass to mitigate the emission of greenhouse gases and more. In research on plants, mitigation is linked, among others, to alternatives to peat (a fossil resource) and compost. Compost can promote carbon storage in the soil and reduce the need for fertilizers that burden the environment and climate.

**Adaptation and LULUCF (Land Use, Land Use Change and Forestry)**

We know that CO₂ can be captured and stored in the soil. ILVO wishes to add to this knowledge. Where, using which cultivation and fertilization regimes, using which climate-adapted crops, and which incentives can help to store more carbon in Flemish soils?

Climate change is putting pressure on Flanders, partly due to the increase in flooding, prolonged droughts and the increasing demand for cooling. ILVO therefore focuses on strategies to make the open spaces more climate-proof. Agricultural soils will have to contribute to this by storing surplus water and, by supporting the living organisms in the soil, making plants more resistant to (new) plant diseases.

Climate adaptation is a challenge, not only for the food sector but by extension for the entire (bio) economy. ILVO is already keeping a sharp eye on the emerging risks in food safety. Sustainable use of biomass, including waste streams, with specific attention to minimizing the climate impact of plant and animal production and processing these raw materials into food, feed or other bio-based products (materials, energy, etc.) are also climate-related ambitions.
4. **Scientific ambitions and instruments**

Our horizontal concepts - system thinking and knowledge integration - and our thematic lines of research point to the direction that ILVO research is evolving in the coming years. In the complex context of changing ecosystems and new challenges, we use our technical skills, tools and methodologies to make them lead to the optimal realization of the ILVO vision. In living labs - meeting places where specialized developments and services come to light - we facilitate the dialogue between research and society. Our technology platforms and the central role given to experimental design unlock the most specialized tools for all our researchers. And ILVO continues to deliberately invest in the interdisciplinary and transdisciplinary nature of its research.

4.1 **Living labs**

ILVO has all the assets to act as a testing ground for multidisciplinary, practice-oriented, targeted innovations in the agricultural and food sector. Our research center bundles various research hubs where interaction takes place between fundamental and applied research, industry, extension research centers, farmers, policy and farmer educational services. The exact nature of that interaction depends on the infrastructure and the research being done. In the pig sector, the Pig Information Center is already responding nicely to this.

ILVO has various research and service activities that are perfect examples of the above definition. ILVO wishes to give these centers of dialogue and co-creation more visibility and identity. On top of that, we put a number of new living labs in the spotlight:

**Food Pilot**

The Food Pilot’s expanded infrastructure and thorough understanding of every aspect of food processing make ILVO the ideal meeting place for businesses on both sides of the production chain. Interaction between companies active in primary production and companies from the processing industry is crucial for our food supply. The Food Pilot, operated together with Flanders’ FOOD, is an example of a living lab. The pilot processing plant is an analysis and service center with expertise and infrastructure, such as a semi-industrial pilot hall where challenges and needs of the processing industry are linked to questions from primary production. Now, more than ever, ILVO wants to be the bridge builder between production and processing and to act as a hub for capturing research needs and providing tools that accelerate innovation. ILVO will therefore take an active role in the Flemish agro-food industry cluster.
CATTLE FARMING

There are also many opportunities in the animal sector to make farms more competitive. ILVO has the ambition to continue to grow as the central point of contact for research for the animal sector. ILVO’s animal housing infrastructure, together with our extensive expertise, form the perfect foundation to further build our role as a living lab for sustainable animal production. We do this by gathering all the players from production, processing, and research in an open, constructive, and innovative environment. ILVO’s recently renewed dairy barn and Pig Campus are striking examples of this.

EXPERIMENTAL FARMING

ILVO’s experimental farm is the ideal infrastructure to convert into a living lab. The location of the test farm in the surrounding semi-rural area can also be used as a landscape observatory or living lab.

Through practical follow-up and practical implementation of technological developments at the experimental farm, ILVO can make a significant contribution to innovation in the Flemish agro-food sector. Concrete innovations, initiatives around sustainability, energy and water consumption or adjustments of cultivation techniques are used optimally at our own experimental farm. We are transforming the farm into a meeting place for farmers, policy actors, sector organizations, researchers and extension personnel. With the knowledge acquired here, we can then take the step towards research on the farm itself after the proof of concept has been delivered at our own test farm.

The development of the experimental farm as a landscape observatory is an illustration of our systems approach. Most of the ILVO infrastructure lies in a peri-urban and multifunctional landscape in the territory of the East Flemish villages of Gontrode, Lemberge and Landskouter. This landscape is a good reference as a research zone for primary production, but also has other important functions: biodiversity (e.g. the Natura 2000 zone 'Aelmoeseneiebos'), housing, recreation and supply of regulatory ecosystem services. Both ecological and social interactions can be studied in this environment and used as proof of concept for other studies that take place in a multifunctional landscape.

PRECISION AGRICULTURE

Precision agriculture or smart digital farming is an important key to make the traditional agricultural system more sustainable. Precision agriculture offers a wide range of possibilities that involve not only a variety of scientific disciplines, but also a diversity of sectors. ILVO is developing precision agriculture as a living lab. We do this by constantly focusing on the expansion of the necessary field and animal housing infrastructure, as well as the necessary computational strength and engineering skills.
Precision agriculture is located at the intersection of technological evolutions (drones, robotics, sensors) and evolutions in business management (innovative monitoring techniques, business automation, labor reduction). The rapid development of ICT and sensor-based technologies and software ensures that a growing amount of data can be collected. The data revolution will develop rapidly in the agro-food sector in the coming years. In consultation with all actors involved, we carry out research into suitable business models and into capturing the value of data and sensor technology. ILVO wants to further expand its services in this area and to further strengthen its interaction with the agricultural and food sector. In this way we wish to play an active role in unlocking the economic potential of that data revolution for Flanders and help to heighten the competitiveness of Flemish farms.

PLANT BREEDING

From a decennia-long tradition of breeding research, ILVO has evolved into a meeting place for the breeders and the young plants and seed sectors. Own breeding programs are carried out in close cooperation and interaction with production cooperatives and seed companies. We invest in the development of specific technologies such as protoplast mergers and in CRISPR/CAS9.

We supervise the implementation of the developed know-how in specific breeding programs at breeding companies. We are committed to build a learning network with companies and knowledge centers to speed up the flow of knowledge in the field of breeding technology and to permanently increase the knowledge level of the Flemish companies. We have the necessary labs and greenhouse infrastructure to carry out research in compliance with bio-safety requirements.

DIAGNOSTIC CENTRE FOR PLANTS

Many companies and governments ask for advice from ILVO’s Diagnostic Centre for Plants. With a wide range of activities, it is also a hub for knowledge and development of new technologies. That is why the Diagnostic Centre for Plants is recognized in Belgium and the European Union as National Reference Laboratory for Plant Health, the expertise center that scientifically support governments and other laboratories. There are also various collaborations in diagnostic research and development of bio-tests, at the request of institutions for fundamental research and foreign research centers. ILVO’s Diagnostic Centre for Plants also participates in training courses for students and employees at universities and professional schools.
Compost Site

ILVO has a licensed compost site (VLAREM) with a quality assurance system (VLACO certified OBA-compost (organic-biological waste)). This site is used to process the green waste from the experimental fields and greenhouses as well as the green waste from ILVO’s gardens. The ‘wind-row’ installation allows maximal control of the compost composition and process. The mature compost is applied to ILVO parcels to improve the soil quality by providing stable organic matter, nutrients and beneficial soil organisms. The compost site is also used within the framework of ILVO’s scientific mission.

Research is being conducted into:

1) The optimization of the composting process by using additives;

2) The possibility of using alternative organic waste flows;

3) The preparation of compost products that can replace peat products in cultivation substrates. Compost is also prepared for the multi-year experiments regarding soil management on ILVO’s fields and beyond.

4.2 Experimental design

The general social trend towards further digitization and the increasing importance of solid data is also visible in ILVO research. Public funds spent on scientific research must be used as efficiently as possible. We also wish to apply extensive use of models and statistical tools to conduct our research in a more efficient way. ‘Experimental design’ is a collective term for statistical tools that can be used to carry out experiments more efficiently without compromising the quality or relevance of the results. ILVO will make optimal use of these available tools and further develop expertise in their application.
4.3 **OUR TECHNOLOGY PLATFORMS**

ILVO has invested heavily in recent years in the development of specific and advanced equipment and infrastructure. These investments have created new opportunities for future-oriented research and services. The sustainable exploitation and further expansion of our technology platforms is crucial to realizing our research strategy.

**GENOMICS**

What?
*A high-tech platform on genomics (Next Generation Sequencing), quantitative genetics (association mapping) and population genetics.*

The focus here is the implementation of innovative experimental and bioinformatics methods for processing and interpretation of (meta) genomics data. These include (quantitative) data for taxonomical or functional composition of complex communities (e.g. microorganisms, etc.) and the (quantitative) analysis of the genomic diversity within specific species via genomic annotation and ‘Allele Frequency Fingerprinting’ (cultivar identification, adaptive loci, and so on).

**MEET@ALL**

What?
*Een state-of-the-art expertisecentrum rond chromatografie en massaspectrometrie.*

A state-of-the-art expertise center on chromatography and mass spectrometry. This expertise center is equipped with modern, high-performance devices. It is aimed at developing scientific know-how around mass spectrometry based on analysis of specific components in plants, animals and food.

**iSENSE**

What?
*A technology platform to explore the wider field of sensor technology.*

By using sensor technology through specific innovations in agriculture, fisheries and food, ILVO aims to increase sustainability, efficiency, animal welfare, quality and safety. With this technology platform, we wish to be an example for the sector and become the reference for research around sensors in the agricultural and food sector. ILVO focuses on ‘smart farming’, precision agriculture, drone technology and digital farming. We always use technological innovations with practical and economic added value. Through the combination of research infrastructure, an experimental farm, a constantly-updated materials and solid knowledge, ILVO is uniquely positioned to lead the way.
NBT

What?
The platform for New Breeding Techniques (NBT) was recently founded on the observation that a number of innovative breeding techniques have recently been developed, including cis-genesis, TALEN, ZFN, CRISPR/Cas9, and others. These new techniques are intended to redirect the genetic information of an organism in a targeted and stable way.

For ILVO it is strategically important to closely monitor the evolution in this domain for both technology and regulations. Moreover, specific new technologies, such as CRISPR/CAS9, will be implemented at ILVO. In so doing, we are building upon the long tradition of high-quality breeding research. This expertise makes it possible for us to make the latest breeding technologies available to the Flemish sector and to support policy in the area of NBT and relevant regulatory developments.

MODELING

What?
A broad cluster of expertise on modeling

ILVO will continue to focus on expanding models in the coming years. Which concrete influence, and how large this one is, is predicted on the basis of scientifically based computer models. Due to the fact that these models are mainly of a generic nature, they do not take into account the specificity of certain crops such as the lower yields of grasslands during the summer and the lower production of summer crops as a result of drought periods. Over the past few years, we have built up a large amount of know-how in this area, which we want to bundle in an expert cluster around modeling. The importance that we attach to modeling directly follows the systems approach pursued by ILVO.

ILVO has two unique assets related to modeling:

1) We have the expertise to design and program models as well as expertise in measurement and objective, scientifically correct validation of the models under practical conditions.

2) When making diverse, complex models, we can rely on both historical and newly-generated data series from a wide variety of research disciplines.
4.4 Continuation of inter- and transdisciplinary research

The inter- and transdisciplinary research at ILVO, started with the ILVO 2020 vision statement in 2008, has become one of our greatest assets. Our aim is to increase our efforts to apply scientific knowledge and expertise within a specific research field or to use it in other research fields. By applying knowledge beyond the limits of research domains or ecological niches, we can organize the research cycle even more efficiently.

Genomic research is an illustration of this. International science has made enormous steps in this area in previous years. In the meanwhile, it is generally accepted that a healthy microbiome determines good health. The aspect of intestinal human and animal health is not yet fully understood. However, there is a global consensus that other parameters, in addition to the intestinal microbiota, are also important for describing this, such as the intestinal barrier, the mucosal immunity, and intestinal metabolites. Further research into the intestinal microbiome requires the combination of different areas of expertise within ILVO and beyond.