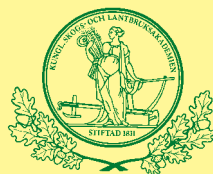


A biobased economy for sustainable development

A strategy document on the role of the green sector and the life sciences in Sweden's development towards a sustainable society. Prepared as an input to the 2012 Research and Innovation Bill with reference to the green sector, under the direction of the Royal Swedish Academy of Agriculture and Forestry (KSLA) and with the support of:



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A BIOBASED ECONOMY FOR SUSTAINABLE DEVELOPMENT

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A BIOBASED ECONOMY FOR SUSTAINABLE DEVELOPMENT

Progress towards a society based to a large degree on renewable biological resources – a ‘biobased economy’ – is of great importance in contributing to the supply of raw materials and mitigating climate change. The main challenge to the green sector is to produce as efficiently as possible, working within the constraints of ecosystems, the goods and services society which demands, and to receive by-products and waste in such a way that future human welfare and ecosystem sustainability are not put in jeopardy.

R&D needs for the green sector

With this input to the Research and Innovation Bill, the Royal Swedish Academy of Agriculture and Forestry (KSLA) wishes to:

- Identify needs for strategic knowledge that can form a basis for new, competitive innovations in the areas of:
 - Climate change – adaptation and mitigation.
 - A biobased economy.
 - Food – supply and security.
 - Human and animal health.
- Point to the need for both fundamental and applied research in the green sector as a basis for developing competitive goods and services.
- Highlight the importance of combining knowledge from different disciplines.
- Emphasise that the development of competitive products and services calls for an effective innovation system, and stress the importance of collaboration between research and business.
- Draw attention to the need for closer interaction between universities, other higher education institutions, institutes and the wider society.



GLOBAL CHALLENGES AND THE GREEN SECTOR'S POTENTIAL

Global issues relating to a sustainable supply of food and raw materials are assuming growing importance, as are issues of energy and water supply, climate and the environment, and human and animal health and welfare.

In proposals for the EU's eighth framework programme for research and innovation – Horizon 2020 – six challenges have been identified for the transition to a sustainable society. All of them are also highly relevant from a Swedish point of view. The green sector is well placed to play a part in meeting virtually all these challenges:

- Health, demographic change and well-being.
- Food security, sustainable agriculture, marine and maritime research and the bioeconomy.
- Clean, secure and efficient energy.
- Smart, green and integrated transport.
- Resource efficiency, climate action and raw materials.
- Inclusive, innovative and secure societies.

The Swedish Government has likewise identified six global challenges as key to achieving the goal of equitable and sustainable global development, and as areas in which Sweden can make an effective contribution. Several of these challenges are relevant to the green sector, including climate change, environmental impact, communicable diseases and other threats to human and animal health.

Ecosystems are fundamental

All societal development and production ultimately build on the goods, services and life-sustaining functions which ecosystems produce. Land and water resources and the green sector thus form the natural foundation for the sustainable development of a biobased society. The green sector includes research, business and innovation activity in all the primary sectors of agriculture, forestry and fisheries.



A key starting point here is that all future production systems need to be ecologically, socially and economically sustainable in the longer term. Creating conditions for sustainable development coupled with high productivity, without overexploiting the ecosystems on which we depend, is a major challenge.

A new and broader understanding of how the potential of biobased production systems could in future be harnessed to supply raw materials for energy, food and industrial products is fundamental if the green sector is to play its part in meeting the global challenges to society, while also contributing to Sweden's prosperity and providing ways of fulfilling our global environmental commitments.

Green sector industries today

The green sector, in the sense used here, includes forestry, agriculture, horticulture, fisheries, aquaculture and urban green space, together with industrial and service activities based on primary production. The sector is of great significance to the national economy, accounting for some 10 per cent of GDP. Together with the intermediate goods industry, green sector industries form the basis for roughly a third of Sweden's industrial output. They employ around 400,000 people, many of them in sparsely populated rural areas.

In 2010, the forest sector exported goods worth a total of SEK 128 billion (€15 billion), or 11 per cent of all visible exports. Between 2009 and 2010, the export value of agricultural products and food rose by SEK 4.3 billion to just under SEK 54 billion (€6.5 billion), an increase of 9 per cent (Swedish Board of Agriculture). At the same time, trends in output for the domestic market give cause for concern, particularly as regards livestock production.

The green sector in international perspective

As business becomes increasingly international, it is of the utmost importance for Sweden to have an innovative and efficient green sector, especially with so much of the country's prosperity based on industries within that sector. Technology development is crucial to competitiveness and profitability.

A new world economic order is emerging. What does it mean for large-scale industry in the green sector? How should the sector position itself? Are there new opportunities for small businesses? A large share of business in the green sector is based on small enterprises.



An important area of research, therefore, is the conditions on which they operate, in terms of economics, technology development and position in the innovation process. Systems need to be put in place to help small businesses develop or benefit from innovations.

Successful development is dependent on Sweden being at the forefront of knowledge internationally, and on it being attractive to invest in innovation and research here. Sweden's strong position is now increasingly being challenged by high-growth, low-cost countries and economies. Greater access to high-quality raw materials at competitive prices and the development of innovative products are crucial to a continuing contribution by the green sector to Sweden's prosperity.

Green sector industries operate on open markets, in the face of stiff competition. Continuing globalisation is increasing that competition and the pressure for change. The productivity of these industries' value chains is therefore fundamental to competitiveness and profitability, necessitating constant development and innovation. Thanks to long-term strategic investments in R&D by both government and business, the green sector has managed to combine sustainability with productivity and satisfactory profitability. To maintain this, vigorous, utility-driven and targeted research, development and innovation are needed, with central government and business working together. For the sector to remain competitive, world-leading technological, economic and biological/ecological capability must be maintained and put to use in R&D, and new knowledge and technical methods must be implemented in practice.

The green sector's services to society

Ecosystem functions are fundamental to all human life. Natural ecosystems provide society with several types of ecosystem services: (1) provisioning, in the form of crops, animals, wood and fibre, (2) supporting and regulating services, such as climate regulation and purification of water, and (3) cultural services, which can for example bring us quality of life and health (Figure 1). Research and development with these ecosystem services as their starting point produce knowledge that can translate into innovation and enterprise, in agriculture, forestry and fisheries and in the rest of society. The green sector thus delivers a wide range of services to society.

In the sphere of provisioning ecosystem services, the potential for growth is good. This presupposes of course that, through R&D, we are able to develop new products and services and stimulate the demand needed to build markets and profitability.



In the area of supporting and regulating services, we need research and development in order to understand, maintain and improve the functioning of ecosystems. Knowledge concerning nature's capacity to regulate and support provisioning ecosystems can be used in society as a basis for adapting to and mitigating climate change and other environmental effects.

Knowledge relating to cultural ecosystem services can be used to develop economic activities in the sphere of recreation and rehabilitation. Here there is good potential for growth, with benefits for human health and quality of life.

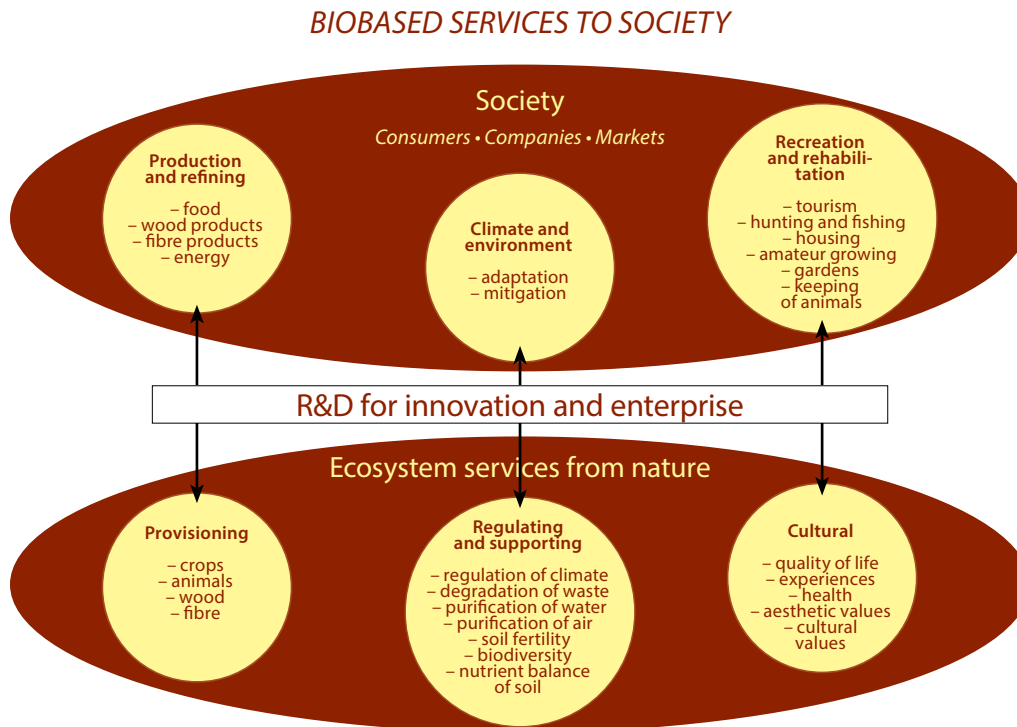


Figure 1. The green sector provides society with a wide range of services, whose competitiveness in society is dependent on innovation arising from effective and productive R&D.



Research needs across disciplinary boundaries

The Academy has identified a number of strategic research needs of importance in promoting long-term sustainable development. These research needs relate to innovation in support of sustainable growth, increased productivity and greater efficiency in all three of the spheres in Figure 1: production and refining, climate and environment, and recreation and rehabilitation.

To translate advances in production-oriented research into advances in society, research should also be designed to illuminate and reflect on the role of production in a broader social context. Another task is to integrate unpriced ecosystem services and biodiversity into business models and society's decision-making processes, which requires a research approach combining humanities and social sciences with the natural sciences.

The various stakeholders in the green sector anticipate major potential benefits in years to come from both research relating to the forest and food industries and research that asks questions about society.

CLIMATE CHANGE – ADAPTATION AND MITIGATION

The Swedish Commission on Climate and Vulnerability concludes in its final report (SOU 2007:60) that Sweden will be strongly affected by climate change. The green sector has to adapt to this change, but with its carbon-neutral products it also has great potential to mitigate it.

Adaptation

For Sweden, climate change could have both positive and negative effects. The temperature regime in the Lake Mälaren basin towards the end of the century is expected to resemble that of northern France today, though with more precipitation. In many parts of the country, the risk of flooding, landslides and erosion could increase. At the same time, conditions are expected to improve for forest growth and the cultivation of new and old crops on arable land.

In our planning, we need to take account of climate change and the risk of extreme weather events. This is particularly true in forestry, with its long production cycles. Forest growth is expected to increase very significantly, with climate change having an estimated effect of 10



per cent. Conditions for agriculture, which has short production cycles, are likewise expected to improve from a yield point of view. On the other hand, damage of various kinds to harvests and to forests will become more common, as will windthrow of forests and water damage to field crops, with consequences for the whole of society. The risk of invasion of harmful organisms will increase, although their enemies will also become more abundant. Far-sighted adaptive measures are needed to exploit the advantages and limit the damage, and to avoid undesirable forms of adaptation – such as greater use of pesticides and the introduction of tree species detrimental to biodiversity.

In a warmer, wetter climate, humus levels in lakes could rise, a phenomenon that has in fact been observed over the last decade. This could have a number of consequences, not least for the production of drinking water. Humic substances can result in bacterial growth, and some compounds of this kind have hormone-like effects. To tackle these problems, effective treatment processes are needed.

Plant and animal breeding are unrivalled ways of developing new, innovative traits in cultivated plants and livestock, affecting both the properties of end products and, for instance, the organisms' tolerance of environmental stress. Resistance to pests will need to be strengthened, for example, and with pests' natural enemies also becoming more abundant, new opportunities will arise for biological control and for breeding. Both resistance to insect pests and attraction of their enemies are genetically regulated. It is important to invest in plant and animal breeding in Sweden, as the special conditions that exist here mean that we cannot rely on the work being done in other parts of the world.

Mitigation

Sweden's forests, acting as a carbon sink, contribute substantially to reducing the country's net emissions of carbon dioxide. Wood products also serve as sinks. Products with a long lifetime have the greatest carbon storage effect. Using timber as a building material instead of concrete is highly advantageous from a climate point of view. Ultimately, such products can in addition be used as a biofuel, replacing fossil fuels.

Production of bioenergy is of major significance to the environmental objective Reduced Climate Impact. However, where greater use is made of such forms of energy, conflicts with other goals for the environment cannot be entirely avoided. At the same time, bioenergy can help to meet several environmental objectives besides the climate goal.



Agriculture and forestry can replace fossil raw materials with renewable biomass. In addition to this, the two sectors offer other ways of reducing levels of greenhouse gases in the atmosphere. Carbon is tied up in growing crops and in the soil, at least in the short term. Every opportunity to sequester carbon from the atmosphere can be of value, even if it is only for a limited time. On the other hand, ruminant livestock in agriculture release significant amounts of the potent greenhouse gas methane, while the sector's use of nitrogen adds to emissions of nitrous oxide, which has an even stronger greenhouse effect. Urgent action is needed to reduce methane and nitrous oxide emissions.

The global transition to an economy without fossil carbon will take time, but Sweden is better placed in this respect than many other countries. It is important that we refine bioenergy in Sweden, as this will greatly increase the economic return.

Research issues

We know that climate change will affect the green sector, but many questions remain unanswered. Both research and new, innovative services and products are needed to effectively respond to and mitigate changes in climate and weather conditions.

Adaptation

Adaptation of the green sector calls for a deeper understanding of the long-term effects of climate and weather change.

- What will happen to *biodiversity* in production systems and the surrounding environment? *Long-running field experiments* and *ongoing environmental monitoring* are important and unique tools for studies of this question.
- How will the production biology and pathogens of plants and animals be affected? *Plant diseases of crops* are a growing problem. Problems of fusarium toxins in cereals are increasing, and more research is needed to find countermeasures.
- What will be the effects on *urban-rural recycling* – how can optimum use be made of recycled nutrients and how can health risks be minimised?
- How will *water regulation and conservation* in forests and on arable land be affected? How can we adapt regulation of water levels so as to minimise the adverse effects of nitrous oxide emissions, for example?
- Effective breeding to *adapt crops and livestock* to climate change.



- Developing new ways of *controlling pests with a minimum of undesirable impacts on the environment*.
- Developing new technologies for *drinking water production*, to address quality issues arising from increased humus levels in raw water from surface sources.

Mitigation

Examples of innovative solutions needed to mitigate the greenhouse effect:

- Development and optimisation of cultivation, production, refining and logistics to ensure *sustainable production of biofuels*. It is important to use biomass resources efficiently, for example by means of integrated biorefineries (biocombines), where biomass is used to produce several different commodities, such as second-generation transport biofuels.
- *Fixation and recycling of carbon dioxide* in production systems. Research into how best and most efficiently to sequester carbon in agricultural and forestry ecosystems, and how to maintain these stores over a long period, while making optimum use of production potential.
- *Development of wood products* as an efficient way of storing carbon.
- *Reduction of methane and nitrous oxide emissions* from soil and livestock.
- Characterisation of the soil environment, crops, feed and livestock, to optimise inputs and *make efficient use of land and animals*, taking into account site-specific production conditions.
- Development of green systems to *improve urban climates*.

A BIOBASED ECONOMY

A biobased economy uses biomass and bioprocesses for the purposes of production that can provide energy, new, high-value products, healthy foods, employment and growth.

A biobased economy is a resource-efficient one, inspired by nature's methods of production. Biomimetics – imitating nature's solutions – is a very interesting field of research with potential for innovation in the green sector. For example, using bacteria, researchers have managed to spin cellulose threads into a fine-meshed network that can replace damaged tissues in humans, such as a meniscus or a blood vessel. One company has modified biofibres to make cellulose-based materials water-repellent, stronger and lighter. Another is using ma-



croalgae to purify water, resulting in major energy savings. The process also yields biomass that can be anaerobically digested into biogas.

The scope to produce bioenergy is limited by the areas of land available, and at the same time production of bioenergy and bioproducts competes with food production and can affect biodiversity. A major advantage with biomass products is that they can be recycled and always, ultimately, converted into energy by burning. This is referred to as cascading use of the material.

It is important to use biomass efficiently to replace a large proportion of fossil-based and energy-intensive raw materials, processed materials and products. One way of achieving this is in biorefineries (biocombines), where biomass is used to produce materials, heat, electricity, transport biofuels and other chemicals. Research is needed to shed light on optimum use of this resource from a system point of view. Large-scale biomass production could face a paradigm shift as bulk handling makes way for production of higher-priced and well-defined raw materials from fields and forests for biorefineries and biotechnology processes.

Long-term strategies are needed to further develop the biobased economy, strategies that are based on the potential of biomass and which maximise its benefits to 'all' interests in society.

New products from biomass

Several types of materials based on renewable raw materials could be developed on an increasingly large scale: packaging materials, building materials, biobased plastics and composites for a variety of purposes, carbon fibres, textiles, chemicals and so on.

These products offer high added value and build on both fundamental research and a functioning innovation process. To obtain this high added value from biological raw materials, we need an understanding of biochemical processes in cultivated plants and new knowledge regarding process design at green refineries. There is also a need for effective plant breeding, utilising all the possibilities which new breeding techniques offer. Production and use of new products should be preceded by relevant risk assessments.



Research issues

- *System approaches* to efficient and sustainable use of bioresources (plants, animals and microorganisms).
- *Biotechnology and biomimetics*, drawing inspiration from solutions in biology to develop new materials, technical solutions and fermentation processes.
- *Biorefining*, with the aim of achieving competitive fractionation of bioresources into different components, offering high added value and significant benefits in various areas of society.
- *Packaging*, with the aim of creating lighter, stronger, smarter and more interactive solutions that provide protection during transport, prevent contamination and reduce spillage.
- *Plant and livestock breeding*, with the aim of increasing productivity and customising 'end-use' quality.
- *Handling goal conflicts*. With growing competitiveness leading to increased production, efficiency and specialisation in a biobased economy, conflicts could arise, for example, between the environmental objectives Reduced Climate Impact and A Rich Diversity of Plant and Animal Life. Other areas of conflict could include how best to use land resources, animal welfare versus productivity, and land use planning.
- *Value creation*. How can businesses create and offer values that consumers are prepared to pay for?
- *Land use planning*. How can society be planned so as to make greater use of the ecosystem services nature provides?

FOOD – SUPPLY AND SECURITY

The growing global population needs to be supplied with nutritionally sound and hygienically safe food. To achieve this, the whole of the value chain from 'field to fork and back to the field' must be made more efficient. This is true globally, and it is true of Sweden. The negative trend in production in Sweden needs to be reversed, as does the decline in the EU's share of global markets. Both productivity and efficiency must be improved.

National collaboration across sectoral boundaries is called for, to achieve international competitiveness and exploit new export opportunities. Many companies in the food industry



are transnational players who recognise the potential and are ready to intensify their exports. But development of the domestic market is also important. People in Sweden are now consuming more and more imported food, although there is also a trend towards rising sales of locally produced and value-added foods. Examples of products with benefits for health are cereals with elevated levels of β -glucan and foods based on healthy lactic acid bacteria.

Food is produced throughout the country, by a multitude of small businesses. Even a large agricultural enterprise in terms of area is classed as a small business when it comes to turnover and number of employees. It is important to create good conditions for small enterprises, for example through technology development. Another key issue is management. How, for instance, are ever growing livestock herds and hence enterprises to be managed, without losing sight of important ethical values?

Research issues

- *Improved utilisation of resources* through reduced waste and increased efficiency, in areas such as food production, inputs and cycling of plant nutrients, packaging and transport.
- To achieve more *climate-efficient consumption* (for instance, by reducing food waste), R&D is needed on the interaction between the green sector and consumers, to identify possible improvements in distribution and new products for protection and storage.
- *More efficient land use* (increased yields) through the development and use of modern production technology.
- *Sustainable intensification of crop production*, i.e. how to ensure that crops make better use of nutrient inputs.
- *The capacity of soils to store and cycle nutrients* with minimum losses to the wider environment.
- *Ecological effects of crops with new characteristics*.
- Research to achieve *more efficient photosynthesis*.
- *Developing high-value, innovative foods* with clear added value, among other things to increase profitability and reduce diseases of affluence and deficiency diseases in Sweden and around the world.
- Knowledge relating to *product development guided by different market preferences* and socio-economic conditions.



- Studies of the *scope for entrepreneurship* in small sectors with potential, such as aquaculture.
- Value creation in *agriculture and small-scale food businesses*.
- Working with *urban growing as a strategy* to increase understanding of and openness to interaction between town and countryside to promote long-term sustainable food production.
- *Consumer attitudes* to new products and to food from large-scale livestock production.
- *Nutrients in water as a resource* – how can they be captured and used in food production?
- Developing *aquaculture* in terms of both breeding and sustainable production technologies.

HUMAN AND ANIMAL HEALTH

Human and animal health are affected by where and how we live. Of the earth's population of seven billion people, one billion are undernourished and another billion overnourished. Mental ill health is also a reality for many people. Infectious diseases and antibiotic resistance are growing problems.

Infectious diseases and antibiotic resistance

Problems in the area of infectious diseases are growing, with increasing threats of pandemics and antibiotic-resistant bacteria. The concept of *One Health* refers to the close links that exist between animal and human health, including the fact that many communicable diseases circulate between animals and people. Vectors in the environment, such as mosquitoes and ticks, are often involved in their spread. Understanding of the ecological system's role in maintaining and transmitting infectious agents requires research collaboration between different disciplines, such as human and veterinary medicine and ecology. Water is an important route for the spread of infection.

Circulation between animals and humans drives the development of infectious agents and antibiotic resistance. To maintain our current level of welfare, it is essential that we get to grips with the problems of antibiotic resistance. Otherwise, currently trivial infections could in future become life-threatening.



New infectious agents are being introduced into Sweden as a result of the increasingly warm climate, which is causing several vectors to migrate north. At the same time, people, animals and food are being moved with increasing intensity and over ever growing distances, which is also contributing to the spread of communicable diseases. Preventive measures to avoid infections of various kinds will result in lower consumption of antibiotics, healthier animals and people, and lower costs in livestock production.

Understanding of infections and antibiotic resistance from a One Health perspective provides a basis for a society where the spread of infections and resistance to antibiotics can be counteracted. Sweden's green sector has long played a part in reducing the antibiotic load by diminishing the need for antibiotics in livestock farming. Despite this, evidence has emerged in the last decade of several new types of resistance in Swedish animals, with implications for public health. New knowledge to prevent their spread within and between herds is therefore urgently required.

Animal welfare

Animal welfare is an important issue in food production and animal keeping. A recent Eurobarometer survey (2010) from the European Food Safety Authority (EFSA) shows that the biggest concern of Swedish consumers when it comes to food-related risks is the well-being of farm animals. In the case of both production animals and sport and companion animals, high standards have to be met in terms of providing for the animals' basic physical and psychological needs. This in turn creates a very significant need for research-based knowledge, a point underlined in a proposal for a new Animal Welfare Act in Sweden in November 2011, which states as a general principle that *'Regulations issued under this Act must be based on science and proven experience'*. The same proposal also emphasises that good standards of animal protection include good animal health.

Quite clearly, though, there are major gaps in existing knowledge, regarding both different species of animals and different systems of animal keeping. To meet the requirements of the legislator and society, significant investments need to be made in fundamental and applied research in this area.



Diseases of affluence

A good, healthy diet helps to reduce the risk of several of our commonest diseases, such as cardiovascular disorders, overweight and diabetes. The green sector has an important part to play in supplying consumers with foods that promote health and diminish the risk of disease, while at the same time catering to consumers' wishes.

Sweden's National Institute of Public Health estimates the direct costs of health care in the country arising from poor diet at SEK 4 billion (€0.5 billion) a year. Together with the indirect costs of loss of production, that makes a total annual cost of SEK 18 billion (just over €2 billion).

New, promising research approaches can potentially have significant impacts on public health. A case in point is the new understanding that is emerging of the relationship between our genes and what we eat – a field of knowledge that holds considerable potential for innovation and which will, among other things, lead to much more individualised dietary advice in the future. An ageing population presents specific health challenges that call for new knowledge.

Recreation and rehabilitation

The green sector can provide opportunities for recreation, sport, outdoor pursuits and rehabilitation, evolving areas for which research can improve the basic conditions.

Considerable potential exists to make greater use of gardens, nature and domesticated animals in the care and rehabilitation of those with physical or mental ill health, for example in the form of ecotherapy (green therapy) or riding therapy. Here there is a growing need for knowledge in a number of areas. The target group is large, comprising both young people with adjustment and learning difficulties and patients with brain damage requiring rehabilitation. Possibilities also exist in the treatment of substance misuse and in child day care. Both qualitative and quantitative methods are needed to calculate the significance of ecotherapy in economic terms.

The green sector can also play a part in recreation and the promotion of health by creating opportunities for hunting and fishing, and for tourism with an emphasis on aesthetic and cultural values. Rural tourism is a growing sector with great potential for the future. It can contribute actively both to improved quality of life and health for people and to positive development that is of economic significance for rural areas, agriculture and the hospitality



industry. There is a need for research and development projects on new opportunities and limitations in this area, including people's attitudes and perceptions.

Research issues

- *Transmission routes for antibiotic resistance.* Resistant microorganisms spread between humans and animals. Genes can also be transferred directly between microorganisms and passed on by new infectious agents. Resistant bacteria can spread via watercourses and food.
- To be able to halt the spread of infectious agents, we need to study *transmission mechanisms* for infections that circulate between humans and animals and spread via the environment.
- *Protection of animals/infectious disease control.* Research linking infectious disease control and animal protection. Animal protection aspects of antibiotic resistance. The risk of an increase in zoonoses in a changed climate.
- *Animal welfare.* Increasingly stringent ethical standards for the keeping of animals. High productivity versus welfare, longevity and health. Sustainable large-scale livestock husbandry. Animal welfare problems linked to different systems of animal keeping.
- *Animals used in aquaculture* (at present mainly fish). Welfare, feed, farming systems, transport, stunning and slaughter.
- Risks of infection from man-made *wetlands and water purification systems* and from *irrigation*.
- *Recreation and rehabilitation.* Development and validation of ecotherapy and the use of animals in care.
- *Business development* in rural tourism and recreation. Development of new concepts and knowledge concerning the business logic involved.
- *System approaches* to maximise the user benefits of land use for purposes such as recreation, hunting and fishing.
- The relationship between *food/feed* and *health/disease* in humans and animals. There is, for example, a need to understand the mechanisms behind metabolic syndrome ('diseases of affluence', overweight in both humans and animals).
- Ways of influencing the risk of disease through *choices of food and feed*.
- *An ageing population* presents specific health challenges that call for new knowledge.



CHALLENGES OF THE INNOVATION PROCESS

To strengthen competitiveness in the green sector and to meet the global societal challenges we face – climate change, energy issues, water and food shortages and pandemics – there is a need for new knowledge which can be translated into new solutions that are demanded by society and the market – that is to say, for effective innovation processes.

This calls for a well-developed innovation system in which knowledge, skills, learning, experience and other resources interact effectively. A properly functioning innovation system is fundamental to sustainable growth and embraces every part of society: universities and other higher education institutions, institutes, companies, financial markets, the public sector and other organisations.

An important precondition for an innovation is that the 'right' new knowledge and capabilities are available, whether it is a matter of a completely new product or an improvement to an existing service. The green sector is also a customer of other sectors, and can enter into partnerships and serve as a 'test bed'. One example of a collaboration of this kind is a project in which plant-based door panels have been developed together with Volvo and other partners.

Broad knowledge and expertise are needed to strengthen innovative capacity and to develop competitive solutions. Early discovery of potential applications means a head start in their development, greater efficiency, and usually enhanced competitiveness.

Collaboration is the key

If research is to play a larger role and be more influential in shaping the development of society, arrangements for collaboration need to be enhanced. Interaction between universities and other higher education institutions, the public sector and business is of vital importance if Swedish research is to contribute to greater competitiveness and innovation.

Investments should be designed to provide incentives for contacts and relations between researchers and external actors from both the public and the private sphere. Broad-based collaboration is also crucial to Sweden's and Europe's prospects of tackling the major social and ecological challenges we face, and to turning these, as far as possible, into opportunities for society and for development of the business sector.



For there to be a transition to a sustainable bioeconomy, consumers will need to accept and have confidence in new production methods and products. Transparency and knowledge transfer concerning the benefits and risks of a bioeconomy are therefore important.

Proposals to improve the innovation system

Here, the Academy of Agriculture and Forestry proposes a number of measures that could improve the innovation system. They are concerned, on the one hand, with bridging the gap between universities/other higher education institutions and the innovative application of research results in the development of new products and services, and on the other, with making higher education institutions more attractive and competitive.

Collaboration

- Coordination of research – both within and between higher education institutions.
- Research into communication and interaction between universities/other higher education institutions and the wider society, among other things to clarify the role of sectoral institutes as a 'bridge'.
- More effective communication to make research results useful to society and to make clear society's need of research.
- Closer coordination of innovation activities in different value chains, that is, between universities, institutes, companies and so on.
- Concerted cross-boundary efforts by stakeholders, innovators and knowledge producers to make Sweden more competitive and attractive.
- A strengthened system of institutes to identify and formulate the development projects which industry and society need.
- Closer integration between research, education and innovation, for example through increased support for secondment of staff from companies to universities/other higher education institutions or of postdoctoral researchers to companies.
- Resources for *translational* research to turn the results of fundamental research into practical applications.
- A strengthening of innovation support functions at universities and other higher education institutions (holding companies), to enable them to play an active role in the early stages of the innovation process.



- A review of the system of academic career appraisal, so that collaborative contributions are rewarded (development of innovative products and services, advice, and involvement in the wider society and in external professional organisations).
- Harmonisation of the intellectual property rights of academic staff with prevailing systems in the EU.

Capability

- Measures to ensure the availability of technological capability and a well-qualified workforce for green sector activities.
- Enhanced provision of knowledge and education in areas with an identified or expected capability deficit.

Small and medium-sized enterprises (SMEs)

- Targeted initiatives in support of SMEs, since their innovative capacity and competitiveness are crucial to future growth and revitalisation of the green sector. These could, for example, include innovation vouchers, planning grants for EU applications, or R&D programmes aimed at SMEs.

Funding

- Creation of incentives through knowledge and policy development to strengthen new business models.
- Venture funding models whereby central government and business share the risks involved in long-term investments. One approach could be a high-risk fund that is prepared to take significant risks early in the development phases of R&D projects with considerable benefits for society.
- Increased funding of later phases of the innovation process, making greater use of structural funds.
- Encouraging greater access to expansion capital from private sources.
- Support for demonstration plants, long-term field research and ongoing environmental monitoring and assessment.



CONCLUSIONS

In the Academy's assessment, it is important to strengthen the entire value chain of research, especially in areas that can provide green growth and welfare in response to climate change (both adaptation and mitigation) and other environmental challenges.

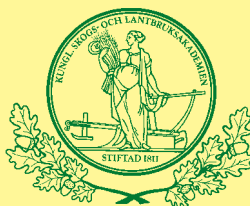
In its last Research Bill, the Government made investments in strategic areas of research. By now broadening this to investments in strategic areas of research and innovation, the Government can give priority to entire value chains corresponding to the global challenges we face.

With reference to the green sector, and as explained and exemplified above, the Academy wishes to propose such strategic investments in:

- Climate change – adaptation and mitigation.
- A biobased economy.
- Food – supply and security.
- Human and animal health.



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The Royal Swedish Academy of Agriculture and Forestry (KSLA) is a meeting place for the green sector. The Academy is a free and independent network organisation working with issues relating to agriculture, horticulture, food, forestry and forest products, fishing, hunting and aquaculture, the environment and natural resources, and with agricultural and forest history. We work with issues that concern all people and interest many!