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à débattre & décider

Diffusion and transfer of knowledge in agriculture

Christian Huyghe, Pascal Bergeret, Uno Svedin, editors

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The authors

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Christian Huyghe, Pascal Bergeret, Uno Svedin, editors

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Aims

This book focuses on innovation in the agri-food system and the new paradigm drawn by bioeconomic approaches and principles. It draws on contributions presented during the 29th EURAGRI annual conference held in Luxemburg (September 2015) as well as on other workshops organised as part of EURAGRI. EURAGRI is an informal gathering of EU research and higher education organisations and ministries interested in agri-food research. It works as a platform of exchange and discussion on topics of common interest pertaining to the organisation, orientation and outlook of agri-food research in Europe in connection with global changes. It holds annual conferences and organises workshops twice a year.

http://www.euragri.aau.dk/

The editors

Christian Huyghe is a plant geneticist and has been researcher at INRA in the Plant Genetics Division on grain legume and on forage legumes and grasses. He coordinated several European projects or work packages of projects. He implemented the Carrefour de l'Innovation Agronomic, dedicated to the dissemination of research results and innovations towards farmers, advisory services, agri-food companies. He is presently Scientific Director of Agriculture at INRA. He is involved in regulatory domains as in the French Committee for Variety Registration and the French pesticide regulation named. He chairs the Scientific Committee of Acta, coordinating the various French agricultural technical institutes.

Pascal Bergeret is Doctor in agricultural economics, Montpellier University (1986).
He worked in agricultural research and development programmes in Nepal, Cameroon, and Vietnam. He was Head, environment and sustainable development, for GRET, a French NGO involved in international development work, and was later appointed as Director, Innovation Department, in the French Ministry of Agriculture, Food and Forest. During that period he was mandated as French representative in SCAR.
He is presently Director of the Mediterranean Agronomic Institute, Montpellier, one of the four institutes of the International Centre for Higher Agronomic Studies (CIHEAM).

Uno Svedin, born 1943, PhD, is Senior Researcher at the Stockholm Resilience Center (SRC) at Stockholm University and former Professor at the same University. He is Doctor honoris causa at the Linköping University were he was adjunct Professor 1994-2004. He has been Director of Research at the Swedish Council for Planning and Coordination of Research (FRN) until 2000 and after that Director of International Affairs at the Swedish Research Council Formas until retirement 2010. He is member of the EURAGRI Board and was member of the initiating PREFARN Group in the EU preparing for the re-establishment of the EU-SCAR and member and later chair of its coordinating Working Group. He has been the chair of the EU Consultative Forum for Sustainability and the Environment.

Preface

Agriculture is at the basis of all human activities. European cities first emerged in the most productive areas. Today, most people no longer need to produce the food they consume; a very small number of farmers handle this task. We must develop the farming systems of the future while taking into account more sustainable land and resource uses. Research and innovation can help address these issues.

The main EU-level research funding instrument is the EU Framework Programme for Research and Innovation (Horizon 2020). The challenges facing the knowledge based bioeconomy have clearly been recognised and increased funding compared to the Seventh Framework Programme for Research and Technological Development (FP7) has been allocated to tackling this societal challenge. One precise objective is to better integrate the Common Agricultural Policy with European research policy. The Standing Committee on Agricultural Research (SCAR), with representatives from Member States' agricultural and research ministries, plays a vital role in this task. SCAR's fourth foresight report addresses the challenges agriculture of tomorrow will face and provides a long-term outlook on how to tackle complex challenges: expected climate change, biodiversity loss and emerging scarcities, mainly for land and water use.

In Luxembourg, the research priorities also follow more sector-oriented government plans such as healthcare technologies, eco-technologies and logistics. These are part of a multi-specialisation strategy that seeks to diversify Luxembourg's economy and reduce its dependence on the financial sector.

One major concern to achieve critical mass and necessary cooperation between the main actors at national level was the scattering of the institutions, laboratories and teams over several different sites. This has changed quite recently with the inauguration of the brand new Belval site, which brings together most public research activities in a single area. The former steel production site offers an interesting contrast, with the modern buildings of the so-called "knowledge triangle" – research, teaching and innovation – standing next to the vestiges of the old steel industry.

Marc Hansen,
Minister of Higher Education and Research of Luxembourg

Agriculture in the developed world has important economic, social and ecological dimensions. A wide range of national and regional policies have been developed to support these dimensions. Within the EU, it is widely recognised that supporting agriculture through a combination of market measures, supply side measures and direct payments contributes to both the economic and environmental sustainability of an industry that has a key position in the provision of public food and goods.

There is also recognition that European agriculture is forced to actively work in increasingly globalised markets. There is often a gap between the considerably high capital investment in agri-food research and knowledge accumulation and the adoption and uptake of this knowledge in innovation by European farmers to improve their competitiveness and the environmental sustainability of our food production chain.

Europe's agri-food industry has been radically reshaped by the combination of international policy changes and a wide range of growing public concerns such as food security, climate change, energy supply, environmental sustainability, animal health and welfare, ethically-sourced food and fair trade. As such, the development of resource efficiency and sustainable food production has become not just an ideal, but an imperative reality.

The ongoing reform of the Common Agricultural Policy (CAP2020) shifts economic support in European agriculture from a production-based systems approach to the provision of public goods. This requires improvements in technical production efficiency that takes into account the current economic situation on European farms, without ignoring the sustainable goals in food production. Increased global demand for food along with the interlinked roles of agricultural research and advisory support services should result in efficient stimulation for farmers. The adoption of new production methods and relevant technologies is the main tool to face not only the economic challenges in the agriculture industry but those facing the global population as well.

To address the complex challenges in developing resilient and sustainable food production systems, the EU has proposed creating a European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) and expanding the role of the Farm Advisory System (FAS).

All EU Member States have identifiable agricultural knowledge and innovation systems (AKIS), knowledge exchange (KE) systems, knowledge transfer (KT) systems or agricultural advisory services. However, the different approaches do vary widely between Member States and, in some cases, between regions within Member States.

These variations are related to the size, scope, capability, objectives, delivery models and funding models of the relevant systems and organisational structures. However, all models attempt to encompass the task of translating and diffusing new issues from research to the agricultural sector, i.e., the agroindustry and European farming businesses.

While there is no single solution to this extremely complicated issue, we should work together to move forward and optimise the processes at all levels. Recognised, efficient approaches exist that can be applied across the agricultural sector. All those working in this industry should consider such approaches and contribute their expertise in this area. Several generic lessons are universally true, including the need for:

— A clear purpose, client focus and client trust
— Innovation as a key component in knowledge transfer from research as well as recognition of the need to adapt the level of innovation to client capability the nature of their business
— Appreciation and respect of the key roles of social, economic and technological entrepreneurs

The diffusion of innovation and knowledge in agriculture is crucial to overcome obstacles preventing efficient implementation of innovative techniques and methods in the agricultural sector.

Fernand Etgen,
Minister of Agriculture, Viticulture and Consumer Protection of Luxembourg

Introduction

Innovation in the agri-food system and the bioeconomy

Pascal Bergeret, Christian Huyghe, Uno Svedin

The topic of the 29th EURAGRI annual conference – and of this book – was chosen as a rather natural response to increasing concerns in the sphere of agri-food research. Additionally, there is a need to tackle increasingly complex issues that develop from pressing societal challenges and the subsequent far-reaching transformations in how agriculture and food systems operate.

The key word is sustainability. Agri-food research is needed to come up with solutions that can simultaneously reduce the environmental footprint of agriculture and agri-food systems, cope with climate change, provide a fair income to farmers and other economic agents in the system, and ensure a reliable supply of safe and healthy food and other biomass-based products at a reasonable price. It must also answer citizens' concerns about fairness and ethics and foster social acceptance of innovations.

Foresight studies can help imagine the shape of our future in this regard. The fourth SCAR foresight exercise, the executive summary of which is included in this book[1], sets the scene of the emergence of a bioeconomy that is able to respond to societal challenges thanks to holistic and reflexive governance. The bioeconomy in a desirable future will be based on giving top priority to food production when trade-offs between different biomass uses are required, on the cascading approach to biomass exploitation and on a waste-free circular economy. How the bioeconomy operates will depend on the relative balance of biomass supply and demand. The desired bioeconomy will be intensive in knowledge, widely participative and inclusive. It will be centred on people, departing from the agri-food systems of today and of the past, primarily based on narrow economic paradigms and where technological innovation is often imposed by dominant actors. It is to be expected that social sciences and the humanities will take a crucial, if not leading, role in illuminating research and facilitating implementation.

The emergence of the bioeconomy has far reaching effects on the way our agri-food research system is organised and operates. This is precisely the theme of the 30th EURAGRI annual conference (Tartu, Estonia, September 2016).

Research alone is, of course, unable to design and implement solutions to such complex issues and to impose the emergence of a sustainable bioeconomy. Co-ordinated efforts by all stakeholders – starting with decision makers – are required, as there is an urgent need to align sector-focused policies. As will be discussed in the following pages, the EU has already started to co-ordinate its Common Agricultural Policy and research policy (as part of Horizon 2020) via the European Innovation Partnership for Agriculture (EIP-AGRI). Some Member States, such as Luxembourg, have begun to do the same.

In addition to sound policies and a smart research system, the emergence of the bioeconomy of our desired future will depend on involvement from all stakeholders. Here, the key word is innovation. The word innovation expresses the conviction – as noted in one of the chapters in this book – that our future belongs to us, that it is not imposed by determining factors, constraining as they may be. While innovation has now become a buzzword, it has been extensively used over only the past decade when we realised that societal challenges were the key drivers of agri-food systems and that as a result, simple, one-directional, linear solutions were becoming insufficient. Sustainability itself can be considered an innovation as it can only be obtained by the commitment of all to change our ways. Measuring sustainability is a good illustration of the innovation process in all its complexity. It requires differing views and interests from different fields to be reconciled (see the remarkable contribution by Vera Bitsch in the following pages).

A considerable part of this book is devoted to the innovation paradigm and deals with the new concept of the knowledge and innovation system (KIS). The KIS (or AKIS for our concerns – agricultural knowledge and innovation system) reflects the way stakeholders interact in the agri-food system and beyond to produce a range of innovations (technological, organisational, social, etc.) aimed at solving their problems and addressing their concerns. Such innovations often combine features that are endogenous and exogenous to the agri-food systems. To be suited to the bioeconomy of our desired future, the AKIS must tackle radical and systemic innovations. It will help to cope with large economic risks and put a new focus on human capital by fostering new approaches to education and capacity building. It will strengthen the professionalism of how interactions between actors of the so-called “triple helix” (government, industry, academy) are managed. It will promote the structuring of triple helix clusters at the local level to encourage innovation. Universities and other knowledge organisations will build incentive and reward systems to motivate researchers and academics to engage private operators and civil society, while public policies will boost public-private partnerships.

Readers may find the lines above idealistic and unrealistic. This may be so, but the examples and case studies presented in this book allow for cautious optimism. It is interesting that such encouraging case studies come from the horticultural sector, one of the sectors which is most exposed to wide fluctuations in consumer demand and which has undergone far-reaching technological and organisational changes in the past decade, requiring for rapid adaptation and restructuring. The demand for sound support to innovation has been high in the sector and has resulted in the establishment of a partnership with the Swedish University of Agricultural Sciences (SLU, Alnarp campus), a regional innovation platform with the abovementioned characteristics. This initiative was soon used as a reference in Sweden and beyond, such as in the German national strategy for the horticultural sector designed by the Leibniz Institute of Vegetable and Ornamental Crops (IGZ).

The book also describes difficulties encountered by certain AKIS set in cultural and historical contexts that are unfavourable to knowledge circulation and sharing due to a generalised lack of trust between stakeholders. This is the case of the Opole Voivodship in Southern Poland presented in Chapter 6, where information and knowledge are retained by actors for their own short-term benefit. This jeopardises innovative projects that could accomplish more than simply spending public money allocated to creating innovation clusters in that region.

The emergence of multidimensional AKIS and the gradual development of the bioeconomy organised around the cascading approach and the principles of the circular economy call for revisiting the value chain concept. The way to understand value chains must evolve to take into account the cascading approach, the zero waste principle, the linking in energy and matter flows and the central importance of human capital and trust. This book provides a cutting-edge value chain analysis that convincingly shows the need to renew conceptual approaches to food systems. The growing acknowledgement by value chain analysts of the growing role of social factors, the necessary – if difficult – connection of scales (from local to global) and temporalities (what are the cultural roots of social values?) call for new paradigms and concepts based on the principles of the bioeconomy and the circular economy.

This book is the first of a series of EURAGRI e-books. They offer a way to share the insights gleaned from the constructive interactions of the EURAGRI conferences and workshops with those who did not attend.

1We would like to express our appreciation to the European Commission for allowing the inclusion in this book of the executive summary of the fourth SCAR foresight exercise.

Chapter 1

Sustainable Agriculture, Forestry and Fisheries. A challenge for Europe

Erik Mathijs, Gianluca Brunori, Michael Carus, Michel Griffon, Luisa Last

The editors of this book would like to thank the European Commission for authorising them to reproduce the executive summary of the 4th SCAR Foresight report: *Sustainable Agriculture, Forestry and Fisheries in the Bioeconomy - A Challenge for Europe* presented on 8 October 2015 in Brussels[2].

Introduction

The 4th SCAR Foresight exercise aims to identify emerging research questions and to anticipate future innovation challenges that can support the implementation of the Bioeconomy Strategy for Europe. The concept of the bioeconomy brings together the agriculture, forestry, fisheries and aquaculture sectors (the primary sectors) on the one hand and the sectors producing processed food, chemicals, materials and energy on the other. The 4th Foresight exercise explores the interactions between the primary sectors and the broader bioeconomy. With an emphasis on the future, the exercise explores what might happen by developing the paradigm of the bioeconomy, within the fundamental constraint of sustainability.

The transition to a sustainable European bioeconomy: premises and conditions

In 2012, the European Commission launched the strategy for “Innovating for sustainable growth: A bioeconomy for Europe”. The bioeconomy concept is built on two premises. First, current biomass is being underexploited, as many waste streams are not used in an optimal way. More materials and energy can be extracted from current biomass streams. Second, the biomass potential can be upgraded by increasing current yields by closing yield gaps, increasing productive land, introducing new or improved species that may or may not be generated by various biotechnological advances, and introducing new and improved extraction and processing technologies. Technology development in the field of use and transformation of living matter has opened the way to a variety of scenarios. The occurrence of one or the other scenario will depend on how the potential presented by the technologies will be integrated into rules, organisational patterns, policies, infrastructures, patterns of behaviour. Looking at future scenarios through a bioeconomy lens implies broadening the scope of the possible interdependencies related to biological resources, and assessing risks, costs and benefits that may occur.

Within the coming decades the world is projected to face enormous and unprecedented challenges that are influenced by environmental, social, political, and economic changes taking place across geographical scales. Overall, a population of more than 9 billion people is projected by 2050, which, together with projected increases in income, will result in increasing demand for consumables such as food, feed, fuel and materials to be provided by depleted and finite resources in an environment facing increasing pressure alongside the effects of climate change. Business-as-usual scenarios show that in the near future competition over the use of land, water, biological resources will increase as a result of the effects of climate, population growth, technology, economic and policy trends. Worst-case scenarios, based on the acceleration of some of the existing drivers, entail increased insecurity, inequality, conflicts, and even collapse. In the best-case scenarios, solar, wind and other renewables will play a major role; waste will be fully recycled; policy decisions will be more coherent and submitted to sustainability and resilience checks; investments will be made responsibly and consumers will share responsibility for the outcomes of their action and change consumption patterns accordingly.

For the bioeconomy to deliver on its goals of food security, sustainable resource management, reducing dependency on non-renewable resources, tackling climate change and creating jobs and maintain competitiveness, a set of principles should be strived for:

— Food first - How can availability, access and utilization of nutritious and healthy food be improved for all in a global view. Relevant policies, such as those related to agriculture, food, environment, health, energy, trade, foreign investments should be checked through a food security test, and direct and indirect impact assessment should become common currency.

— Sustainable yields - Users should consider the renewable nature of biomass production and apply economic rules that govern their exploitation, such as the sustainable yield approach that prescribes that the amount harvested should not be larger than regrowth. This should be regarded from a holistic view, which takes all biomass into account, including that in the soil. An important indicator here is the amount of organic matter in the soil.

— Cascading approach - To avoid unsustainable use of biomass, the concept of cascading use prescribes that biomass is used sequentially as often as possible as material and finally for energy. Cascading use of biomass increases resource efficiency, the sustainable use and the generation of value added from biomass and is part of the circular economy. Creating higher resource efficiency also increases the general availability of raw material supply, because biomass can be used several times. While appealing in theory, the practical application of cascading rules meets with two problems: (1) how can a sequential use of biomass be implemented and (2) how can rules be implemented if they run against today’s existing market environment.

— Circularity - The cascading approach does not address the issue of waste reduction per se. Waste is generated where the costs of reuse and recycling are higher than the value created. The concept of a circular economy is based on three principles: (1) waste does not exist, as products are designed for a cycle of disassembly and reuse; (2) consumables should be returned to the biosphere without harm after a cascading sequence of uses, contributing to its restoration, while durables are designed to maximise their reuse or upgrade; and (3) renewable energy should be used to fuel the process.

— Diversity - Production systems should be diverse, using context-specific practices at different scales and producing a diversity of outputs. As diversity is key for resilience, innovations in the bioeconomy should be developed to foster diversity rather than limit it.

A transition to a sustainable bioeconomy is a process that cannot be governed only by markets and technology. It requires a constant monitoring of these principles and a strong strategic orientation based on a clear identification of societal challenges, a holistic view, reflexive governance and a sound base of empirical evidence. Given the interplay of different issues, interests and actors involved, attention should be paid to processes of integration of policies, which would imply giving attention to interaction patterns, tools and mechanisms. Member States should carefully evaluate, in a comprehensive way, the expected impact of support policies that change the intensity of material and trade flows and land use. Research should generate the knowledge base necessary to support coherent policies and to anticipate problems.

State of play in the bioeconomy

Food and feed together account for the majority of biomass demand. These products are generated by agriculture (including livestock), horticulture, fisheries and aquaculture. The main drivers of food and feed demand are human population growth and changes in diet. High growth in population in the next few decades will mainly occur in Asia and Africa, with any change in Europe potentially being a slight decrease. Changes in Europe’s diet are also predicted to be small, with the major driver of global dietary change deriving from Asia, due to the growth in economies such as China and India and also the size and predicted growth of their populations. The main demand impacts on Europe, therefore, will mainly be the consequence of global trade, unless consumers respond to the efforts of governments to tackle diet and health issues. A number of recent Foresight studies highlighted both current and future risks and also opportunities arising from recent scientific advances. At the same time, food commodity markets are increasingly integrated with energy markets, more volatile and subjected to geopolitical influences. The digital revolution may be an important game changer in supply chains and retail both of which are increasingly concentrated and globalised.

Currently, biomass for bio-based chemicals and materials is used for animal bedding, construction and furniture, pulp and paper, textiles and the chemical and plastics industry. The most interesting fields of innovation in the bio-based economy are the chemical-technical industry with the pulp and paper industry and the man-made fibre industry owning the largest facilities for biomass fractionation due to their history and long-standing expertise in biomass conversion. The oil-based chemical industry has matured into a central, sophisticated and advanced economic branch with significant economies of scale and low transport cost of the starting material. If chemicals and products are to be made out of sustainable resources, the whole chemical industry sector faces a transition with regard to starting materials, intermediates and processes. This requires a transition period with oil-refineries and biorefineries running in parallel. For a biorefinery, the economies of scale differ from that of an oil refinery and the transport costs for the starting biomass is much higher. Hence, economic efficiency needs to be reached by different means than in traditional fossil-based refineries. In order to cope with the mixed mode of operation of oil and biomass as starting materials novel concepts are required which still need a lot support from basic research efforts at all levels.

With regard to forestry, the future trend is to prepare the forestry sector for a multifunctional, better use: energy, fuels and chemicals, plastics, construction, furniture, landscape, recreational activities and other ecosystem services. Platform and specialty chemicals from biomass gain more importance relative to the established uses in the pulp and paper and materials sector. Forestry is directly affected by major changes in the chemical industries, where whole production lines are adjusted to cope with an increased share of the (partly) new starting materials from forestry. The pressure to operate high-value utilisation modes will increase. In addition, new tree species will be tested for their ability to cope with climate change and to secure resilience of the forest. More efficient nutrition management is needed in forest management, together with more diversified ways of generating the raw material and ecologically efficient approaches to wood harvesting are required.

The current energy system is still highly dependent on fossil fuels and nuclear energy. Reducing our dependence on fossil fuels requires a significant shift from using technologies based on transformation of fossil fuels towards using technologies based on renewable electricity, heat, and fuels in all end uses: industry, transport (electrical vehicles, synthetic fuels, biofuels), buildings (heat pumps, solar and other renewables), etc. As a result, bioenergy and biofuels will play a double role: first as a transition fuel as long as electrification is not yet fully implemented and second for those applications for which electrification will be difficult to implement. The range of feedstocks that can be used for bioenergy and biofuel production is large. Currently, the largest share of biomass is wood and agro-biomass (i.e., energy crops and residues), but also sewage sludge, animal wastes, organic liquid effluents, the organic fraction of municipal solid waste are used as feedstocks. However, these feedstocks need to be pre-treated and systems for processing biomass have to be designed to avoid fouling and corrosion. Pre-treatment technologies aimed at upgrading the energy density of feedstocks include drying, pelletisation and briquetting, torrefaction, pyrolysis and hydrothermal upgrading. Biomass combustion for heat production is based on stoves, incineration or gas combustion and is available at both small scale for individual house heating and at large scale. Biomass is converted into power, heat, and biofuels using steam turbines, thermal gasification, engines or biorefineries.

The current policy framework of the European bioeconomy consists of a multitude of regulations and strategies from several policy areas, including the Common Agricultural Policy, the EU Forest Strategy, the Common Fisheries Policy, the Blue Growth Agenda, the new EU framework for aquaculture, quality schemes for agricultural products and foodstuffs, food and feed safety regulations, the Renewable Energy Directive (RED), the 2030 policy framework for climate and energy, standards, certification and labelling for bio-based products and the Circular Economy Package. The cascading use principle could be a valuable tool to ensure the most efficient use of renewable resources and should play a significant part in the package, but its implementation meets with controversy. Further, it has become clear by now that the RED has had some adverse effects on bio-based chemicals and materials, which could offer more value-addition and be an innovative part of the bioeconomy. Finally, sustainability criteria is an area where policy decisions and scientific advancement are strongly connected to each other, as the object of research is highly uncertain and there are different - and conflicting - interests at stake. Addressing sustainability criteria in a proper way will need a specific focus of research on how to develop appropriate inter- and transdisciplinary approaches and methods.

Scenarios

In order to develop a research agenda to tackle future challenges and opportunities, the difficulty is that the future is unknown. What can be done is to identify the most important uncertainties influencing agriculture, forestry, fisheries & aquaculture (the primary sectors) and then to explore what will, can and should happen in the alternative futures defined by these uncertainties. Two major uncertainties were identified to form the scenario framework. The first one is the demand growth for biomass for materials and energy. This variable depends on population and economic growth, the relative markets of classical resources (e.g., fossil fuels), the evolution of bio-based and other competing technologies (influencing conversion efficiency and costs) and the evolution of non-biomass based technologies, like other renewables. The second is the supply growth of biomass. This variable depends on the development and implementation of new technologies and the rate of intensification in the primary sectors. We selected three scenarios:

• Scenario A assumes that the growth in demand for biomass for materials and energy is relatively low, for instance because solar, wind and other clean energy technologies take off more quickly than expected, making bio-based solutions less competitive. In this scenario, it does not matter so much whether the supply growth is low or high, so here we only assume a medium level of supply growth. We call this scenario BIO-MODESTY.

• Scenario B assumes that growth in demand for biomass for materials and energy is relatively high, while supply growth is also high. We therefore call this the BIO-BOOM scenario—a scenario in which a high demand for biomass coming from the non-food biobased economy is met by supply.

• Scenario C assumes that the same driving forces leading to high demand for biomass to be used by non-food applications apply. Low supply growth is assumed, for instance because of societal resistance towards new technologies. As a result, the amount of biomass available for bio-based materials & chemicals and bio-energy is lower than it is now (and even 0 for biofuels). However, when the food-first rule cannot be enforced, high demand will increase prices for biomass considerably, as biomass is a scarce commodity. We thus call this scenario BIO-SCARCITY.

It can be concluded that similar research topics appear in all scenarios, but their relative importance differs across the scenarios. For example, governance needs to make sure that a proper implementation of the bioeconomy strategy is inclusive with respect to small-scale and diverse systems, while in the BIO-SCARCITY scenario the focus of governance research is much more on mitigating the negative side effects of competition for biomass. Climate change research is much more pressing in the BIO-SCARCITY scenario. Employment issues appear in all scenarios.

Recommendations

In order for the bioeconomy to achieve its multiple goals of food security, environmental care, energy independence, climate change mitigation and adaptation and employment creation, it needs to be implemented according to the set of principles outlined earlier—food first, sustainable yields, cascading approach, circularity and diversity. Based on our analysis and three stakeholder workshops, the following research themes are proposed:

• New paradigms for primary production based on ecological intensification: Ecological intensification entails increasing primary production by making use of the regulating functions of nature. Its practices range from the substitution of industrial inputs by ecosystem services to the landscape-level design of agroecosystems. Research is needed to underpin ecological intensification to shift from the study of individual species in relation to their environment to the study of groups of organisms or polycultures in relation to each other and their environment. More insight is needed into the synergetic effects of combinations of ecosystem service processes, as current research mainly addresses how single service processes work in isolation.

• Emerging enabling technologies: the digital revolution: Sensor technology, remote sensing, etc. contributing to precision techniques in the primary sectors have great potential to improve resource efficiency. However, combined with other advances in technologies, the digital revolution fundamentally transforms the way science operates, as well as manufacturing, retail and even consumption. Research should further investigate how the digital revolution will affect primary production and their food and non-food supply chains, but also how these developments can help sectors address the diversity of production systems and their outputs with different qualities thus contributing to the realisation of a circular economy.

• Resilience for a sustainable bioeconomy: A resilient bioeconomy encompasses systems that are able to deal with different types of hazards. The bioeconomy and particularly the circular economy entail an increased coordination and integration of different sub-sectors. Combined with the increasing pressures from various driving forces, this may have significant effects on animal, plant and human health hazards as well as adaptation and risk reduction strategies tackling these hazards. Research should investigate the impact of the bioeconomy on resilience on the one hand, but should also develop new solutions and systems that are more resilient, from a biological and technological point of view as well as a social perspective.

• The new energy landscape: The transition to a new energy landscape involves abandoning fossil-fuel based technologies in favour of renewable energy technologies. This will have an enormous impact on primary production which currently is still heavily dependent on fossil fuels, particularly the production of inputs, such as fertilisers and pesticides. Research should investigate how this transition affects agriculture, forestry, aquaculture and marine resources, identify the needs of these sectors related to these changes and develop appropriate solutions.

• Business and policy models for the bioeconomy: A bioeconomy that is based on the concepts of circularity and cascading presents a particular challenge to making the economics work. Circularity implies new ways of designing and manufacturing products, new relationships between economic actors, new ways of recycling components and waste, etc. In other words, actors and activities will be reassembled in time and in space. In addition, different production models in terms of scope and size should not only be able to co-exist, but also capture the synergies between them. Public sector involvement is needed for these new business models to work, as public goods are generated in the circular economy but often not remunerated by the market. Research should support the development of these business models.

• Socio-cultural dimensions of the bioeconomy: A sustainable bioeconomy implies that knowledge about social impacts of technology and mechanisms of social change should progress as fast as technology itself. All stakeholders should be fully involved in the governance of the bioeconomy. Science may also radically change food production and consumption patterns, with the potential to reduce pressure on ecosystems, through changes in diet, the multifunctional use of land and aquatic resources, urban-rural nutrient cycles and the production of alternative proteins for animal feed and human consumption. However, this may break established routines and create resistance and anxieties, which need to be understood better.

• Governance and the political economy of the bioeconomy: The outcomes of the development of the bioeconomy through the implementation of a circular economy will depend on the rules put in place to regulate the system. The development of bio-based materials and bio-energy may create pressure on natural resources and on social inequalities in a scarcity-dominated world. Research should help develop a framework aimed at fostering the bioeconomy, including policies and sustainability and safety standards that are coherent, create a level playing field, avoid the overexploitation of natural resources and foster a diversity of practices. Research should also help in tackling the regional differences in national economic structures and the best use of national biomass resources.

• Foresight for the biosphere: Current foresight is mostly conducted using forecast-based modelling platforms, with comparative-static approaches and within a limited set of structural features. Research should also expand foresight capacity by integrating data and dynamic and flexible tools, in order to avoid lock-ins and monitor the sustainability and resilience of the bioeconomy and the biosphere as a whole.

Research and innovation are built upon a knowledge and innovation system (KIS) that develops and diffuses knowledge, inspires and identifies opportunities, mobilises resources, helps manage risks and forms markets, legitimises activities and develops positive externalities. EC initiatives support the transition towards a system in which knowledge is co-produced by all actors that engage with each other in processes of learning and even co-evolution that has the following characteristics:

• Challenge-oriented - Rather than only being driven by scientific curiosity, the KIS should also be challenged-oriented. The KIS should find a right balance between basic and applied research. Orientation is currently provided by the Europe 2020 strategy and more specifically the Grand Challenges for the bioeconomy.

• Transdisciplinary - The KIS should be transdisciplinary, that is, multiple theoretical perspectives and practical methodologies should be used to tackle challenges. Transdisciplinarity goes beyond interdisciplinarity as it transcends pre-existing disciplines.

• Socially distributed - Knowledge should be diverse and socially distributed in the KIS. Communication barriers have been largely lifted, such that knowledge is created in diverse forms, in diverse places and by diverse actors. However, several barriers still exist, such as intellectual property rights and unknown cost structures, hindering the inclusive and public-good character of knowledge. We recommend that open access and open innovation should guide knowledge production as much as possible. Particular attention should be devoted to social innovation and the inclusion of socially disadvantaged actors and regions.

• Reflexive - Rather than an 'objective' investigation of the natural and social world, research has become a process of dialogue among all actors. The KIS should devote sufficient attention to these reflexive processes, both within the boundaries of a research project and at the meta-level of organising and programming research. Current efforts of multi-actor participation and stakeholder engagement in projects and in programming are steps in the right direction.

• New rewarding and assessment systems - Quality control transcends the classical peer review as transdisciplinarity makes old taxonomies irrelevant. In addition, the integration of different actors also broadens the concept of quality into multiple definitions of qualities. As a result, assessment/rewarding systems relating to researchers, research projects and programmes, research institutes/bodies, other actors, education and even the organisation of regional/national/international KIS need to change. This makes the research and innovation process more uncertain from a traditional perspective on research.

Competencies and capacities - Researchers, other actors as well as other stakeholders in the KIS need to acquire a new set of skills and competencies. Institutions of higher education in particular can play a key role by integrating these skills and competencies into their curricula. The capacity to engage in KIS not only depends on the aforementioned competencies, but also on resources that need to be invested by actors and stakeholders.

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Chapter 2

Sustainability as innovation: challenges and perspectives in measurement and implementation

Vera Bitsch

Introduction

Framing sustainability as an innovation allows the analysis of the development of measurement systems for sustainability within an innovation framework. The discussion of sustainability's "wicked" characteristics enables conclusions to be drawn for other complex innovation processes.

Sustainability includes environmental, economic and social aspects, with the latter having received the least attention. Despite its 300-plus years of history, sustainability is a controversial concept. This chapter deals with the development of sustainability measurement as an innovation. The concept of wicked problems is used to structure content complexity and process complexity of the development of measurement systems. Based on documents published online and a case study where the author served as co-coordinator during the development process, examples of measurement are presented and discussed. Critical measurement issues and their impacts are highlighted. Process requirements are identified, including the involvement of multiple stakeholders with diverging perspectives and varying participation. Finally, the need for flexibility and continuous improvement is emphasised. Due to its characteristics, sustainability measurement is extraordinarily suited to serve as an example of complex innovations and the lessons learned can be beneficially applied to other cases.

Innovation: definition and framework

In its Oslo Manual, the Organisation for Economic Co-operation and Development (OECD) defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD/Eurostat, 2005, p. 46). This definition includes product, process, organisational and marketing innovations. The manual limits its scope to the manufacturing, primary industries and the services sector at the firm level. While relevant to innovation in the primary industries and related firms, public sector innovations, industry- and economy-wide changes (such as the emergence of a new market, development of a new source of raw materials or semi-manufactured goods) and industry reorganisation are not included. The above definition explicitly states that an innovation requires implementation, meaning it must be introduced into a market or put to actual use in a business.

Although the emphasis on implementation may lead to the perception that research and development (R&D), discoveries and inventions are activities before actual innovation, the Oslo Manual states otherwise. "Innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation." (OECD/Eurostat, 2005, p. 47).

How to foster innovation (and the necessary R&D) is subject to scientific analysis and broad discussion. For a long time, the distinction between basic and applied research served as a starting point or fall-back position in government and research institutions in the quest to develop a system for innovation in regions, states or broader economic contexts. Referring to Vannevar Bush, an American engineer who headed the National Defense Research Committee of the United States during part of the Second World War, government was held responsible for establishing goals for and funding basic research.

The strict separation of basic and applied research is attributed to Bush, e.g., by Donald Stokes (1998) who criticised this separation as leading to an incomplete perspective. Stokes' model famously personalised the quest for fundamental understanding with the scientist Niels Bohr as an example and the focus on considerations of use with the inventor Thomas Edison. Stokes added a third component with use-inspired basic research, relating it to the chemist and microbiologist Louis Pasteur.

The basic dichotomy between basic and applied research still holds considerable sway, despite having been shown to be insufficient and unrealistic by several innovation process analyses. For example, Vinsel *et al*. (2013) used the analysis of Nobel Prize winning research over a period of over 50 years to show the interrelated system of scientific research and technology. They found no definite hierarchy or linear trajectory been basic and applied research when analysing the innovation cycle in information and communication technologies.

Whereas Bush's original report (1945) focused solely on the role of academia and government in research and innovation, industry was identified as another important player in the innovation system. The identification of industry's role in the process eventually led to the triple helix model, the founding of the Triple Helix Association and, more recently, the Triple Helix journal. The roles of academia and government or the industry in innovation processes have been subject to many simplified policy recommendations and initiatives, which often neglect other aspects and stakeholders of the innovation system.

Lately, the triple helix model has been extended in a number of different directions, depending on data availability, empirical context and the political agenda. For example, Carayannis and Campbell (2010) expanded the model to the quadruple and quintuple helices. They first focused on (re-)introducing the role of civic society in the innovation system, then added the natural environment to form a quintuple helix. The quintuple helix is, however, often presented as a Venn diagram with the three institutions – government, industry, and academe – in the middle of the two circles of society and the environment, neglecting the time dimension (see Figure 2.1). Based on these models, Leydesdorff (2012) suggested that while the explanation of complex developments may need n-tuple helices or, based on earlier work by Simon, an alphabet of helices, data availability and pragmatic reasons recommend the use of the triple helix for most analyses. He emphasised the possibility for different kinds of chaotic behaviour beyond stabilisation already with the addition of the third helix. For Leydesdorff, market and governance form the first two helices, placing his viewpoint in socio-economic theory rather than the political sphere.

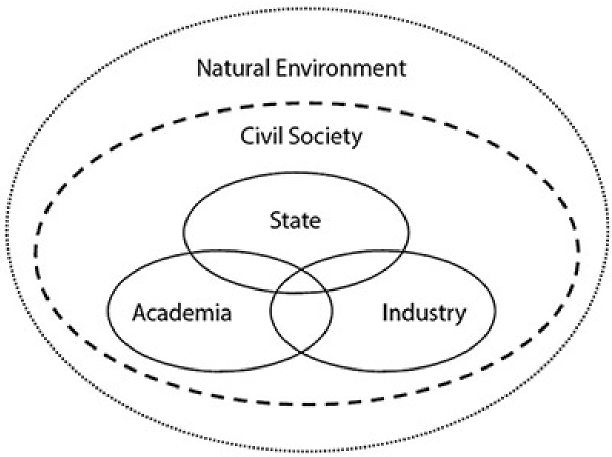

Figure 2.1. Quintuple helix model (based on Carayannis and Campbell 2010, p. 62).

Defining sustainability

The concept of sustainability is attributed to German forest scientist von Carlowitz (1713) while the German term Nachhaltigkeit was introduced by Hartig (1795) to convey the basic idea of economically harvesting wood while sustaining the forest for future use. Given the 300-plus-year history of the concept and the historical development of its understanding, it is not surprising that sustainability has entered the public discourse and is used in many different ways to mean a variety of things. Despite the fact that the concept of sustainability has developed into rather sophisticated measurement and certification schemes around the use of the term "sustainable" is commonly used to simply mean "being able to last or continue for a long time".

Reflecting the origin of the concept in forestry, early measurement systems focused on the use of natural resources, in the sense of taking something without using it up. This approach was then applied to the "use" of the environment, which also included the meaning of adding something into the environment (e.g., waste) without depleting the environment's capacity to absorb it. Early examples of these approaches are Carson (1962) raising awareness of the consequences of the use of agrochemicals on the environment and Meadows *et al*. (1972) modelling the limits of growth by exhausting natural resources and the environment's capacity to absorb waste and pollution. Their definitions of sustainability often neglected the earlier economic orientation, under the premise that enterprises – especially private enterprises – would naturally focus on economic benefits, and that economic principles and greed had led to these problems.

It was not until concern for the environment and the overuse of resources reached the public sphere and increasing numbers of environmental groups began organising with citizens around the globe that addressing these issues became part of a political agenda. In December 1983, the General Assembly of the United Nations (UN) asked the World Commission on Environment and Development (WCED), then chaired by Gro Harlem Brundtland, to propose long-term strategies to achieve sustainable development. The commission's final report has had a lasting influence on those working in the field of sustainability, and many cite its definition of sustainable development: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Report, 1987, p. 41). Due to the concern for poor countries and meeting the essential needs of people around the world, the Brundtland Report emphasises not only the environmental dimension of sustainability but the social dimension as well.

Despite the long-standing discussion of the social dimension of sustainability, it was not formally added to the political agenda until the Johannesburg Declaration on Sustainable Development (2002). The declaration includes social goals and reaffirms the indivisibility of human rights and the need for social development. It explicitly mentions women's empowerment and human resource development, among other social causes. Accordingly, the current understanding of sustainability is typically framed as the three pillars concept, which encompasses the social, environmental and economic dimensions of sustainability. Although many suggestions have been made to further expand the concept of sustainability to include more than three dimensions, this chapter will follow Leydesdorff's recommendation to not unnecessarily complicate the notion.

Challenges in developing a measurement system

As with other complex problems, Batie (2008) subsumes sustainability with the so-called wicked problems that sciences not only find challenging to solve, but for which complete solutions cannot be developed. Contrary to tame problems, wicked problems are overly complex and controversial to be fully addressed through normal science (Kuhn, 1996). The term wicked problem was introduced in the late 1960s to describe problems that cannot be fully defined and separated from their context, as well as from other problems on different levels. Each attempt at a solution changes the problem definition. Wicked problems also change over time. Causality is muddled and difficult or impossible to model. There are no final solutions to wicked problems; they only can be managed for better or for worse. Because every wicked problem is unique, management and solution approaches cannot be transferred from one problem to another but must be specifically adapted to the problem at hand (Churchman, 1967; Kreuter *et al*., 2004; Mitroff and Sagasti, 1973; Rittel and Webber, 1973; Weber and Khademian, 2008).

With respect to sustainability and the development of measurement systems for sustainability in particular, another aspect of wicked problems is critical: the involvement of multiple actors and stakeholder groups. Actors and stakeholders dealing with wicked problems hold differing and even contradictory perspectives, beliefs, values and goals. They do not agree on the facts or the definition of the problem. They also do not agree on trade-offs, possible actions, the evaluation of actions or a suitable process to approach the problem. Their participation varies and is ambiguous. Because wicked problems will not be solved, the termination of the process is controlled by stakeholders, political forces and resource availability (Batie, 2008; Kreuter *et al.*, 2004; Rittel and Webber, 1973; Stoppelenburg and Vermaak, 2009; Weber and Khademian, 2008). Whereas other fields, including civil engineering, management science, public administration and computer sciences, have embarked on incorporating the peculiar characteristics of wicked problems in research projects and applications, applied economics still focuses mostly on tame problems. However, the development of sustainability measurement systems requires considering the issue's complexity.

Deductive approach to measurement

The development of a measurement system typically includes at least three stages or is presented on three levels, despite the recursive process of system development. On the first level, the legitimisation of the system is based on general principles, often agreed upon in international treaties, standards or agreements, such as the United Nations Universal Declaration of Human Rights, the more recent UN Global Compact or the OECD Guidelines for Multinational Enterprises. One example of these shared principles with a social dimension is the "protection of human rights" (Example 1). On the second level, principles are broken down into a catalogue of criteria to frame concrete areas of action. For most principles, several criteria will be required. An example of a criterion for Example 1 is "no child labour" (Example 2). While actors and other stakeholders involved in the development process are more easily able to agree on general principles, settling on criteria shows diverging perceptions and interests. On the third level, criteria must be translated into measurable indicators. At this stage of the process, diverging values and conflicts between stakeholders involved become more visible and at times development efforts fail. An example of an indicator for Example 2 is "only employees 18 years of age and above" (Example 3). As this example shows, differing societal value systems, actors' perspectives and trade-offs between agreed upon goals lead to a greater potential for conflicts as the development process moves increasingly towards concrete measurement. For example, how is the suitable age for work to be determined? How is the right to work, even for minors, especially in countries with limited formal social security systems, to be factored in? How should the right to education, including professional education, figure in? Emotionalising terms, such as "exploitive child labour" do not provide answers to these questions. Answers may differ in different regions and societies and depend on their economic situation and development.

The final set of decisions regarding indicators will determine costs and applicability of a measurement system. Once general principles are broken down into criteria and have been solidified into measurable indicators, the actual measurement protocol must be determined. The measurement protocol describes the specific data collection approach. Data collection can include the full range of direct onsite primary data collection (e.g., interviewing employees), indirect onsite data collection (e.g., reviewing files), data reporting to a central institution and companies reporting compliance without specific data. Additionally, measurement specificity and precision are issues (see also Genier *et al*., 2008).

Requirements for indicators

While indicators are agreed upon during the development process of a sustainability measurement system, they do not necessarily meet requirements for indicators as suggested by the scientific community (see, for example, National Research Council, 2010). A prerequisite for successfully involving multiple stakeholders in the development process are the understandability, credibility and audibility of indicators. Indicators must be understandable by non-experts, even if measurement itself requires expert knowledge. The involvement of a well-rounded group of stakeholders in the process and access by the public for input is another prerequisite, as many decisions involve value judgements that require broad dialogue and cannot be left solely to experts (see also Busch, 2009).

Additionally, the measurement itself directs the focus of attention and therefore has value implications. Decision making and assessment takes into account what is measured. An important example, which is also a point of contention and potential outcome manipulation, is the definition of the system to be measured. As pointed out by Thompson (2007), “the definition of system borders involves a value judgement that frames the empirical assessment of sustainability” (p. 7).

Although many specific requirements for indicators are discussed in the literature (National Research Council, 2010), much of the current focus in research and development evolves around their feasibility. While the scientific community has an interest in comprehensive detailed measurement, practical requirements demand cost effective measurement. Many existing measurement systems meet specific needs within a narrow agronomic, economic and ecological context, but are not applicable beyond that context (Thompson, 2007). The feasibility requirement asks for applicability in a broader context, or at least the possibility for comparison across contexts.

Furthermore, it must be possible to measure and assess indicators in a timely manner, as well as show changes over a period of time. When priorities or situations change, indicators must also be adaptable and the measurement system be able to take into account other indicators. Moreover, the measurement system must be targeted and goal-oriented, taking trade-offs and complementarities into consideration.

Examples of measurement of sustainability in agricultural value chains

Despite the challenges outlined above, hundreds of sustainability assessment and measurement systems have been proposed and introduced worldwide. Few industries are as inundated by varied measurement schemes as agriculture. In agricultural value chains, a cornucopia of systems have been proposed, ranging from single crops and villages to global use. I propose a classification of the measurement systems by their origin and provide several examples of such systems below. As the different actors and stakeholders in the agricultural value chain are not able to exercise similar power regarding the adoption of a particular system, systems are categorised into three main groups: systems originating in retail, systems originating in the input industry, and systems originating in agricultural production. Whereas some retailers and some input providers hold enough market power to not simply suggest but rather coerce other actors into implementing their respective systems, others opt for a comprehensive approach covering different stakeholders along the chain from the beginning. Some of the most widespread and successful systems turned out to be multi-stakeholder initiatives. However, those originating in agricultural production have not yet reached that level of acceptance.

Both multi-stakeholder and standalone approaches have originated in retail. Individual companies, including SYSCO, Walmart and Unilever, developed codes of conduct for their suppliers many years ago. Another standalone approach was the development of proprietary sustainability labels by individual retailers. An example of this latter type is the Pro Planet label developed by the REWE group, a German retail chain. Whereas such labels are aimed at consumers, the most widespread multi-stakeholder initiatives work on a business-to-business basis and consumers or citizens may not even be aware of their ubiquity. Examples of such multi-stakeholder initiatives include the Ethical Trading Initiative (ETI) with over 120 corporate members with thousands of suppliers worldwide; the Business Social Compliance Initiative (BSCI) with over 1500 members; and GLOBALG.A.P. with a focus on certification of agricultural practices. Since its 2007 revision, GLOBALG.A.P. includes criteria for worker health and safety as well as animal welfare. Currently, GLOBALG.A.P. certification is carried out by over 140 independent accredited certification bodies in more than 100 countries. In practice, GLOBALG.A.P. certification acts as a gatekeeper to major retail chains around the world.

The input industry seems to favour standalone approaches. For example, BASF and Bayer seem to work mostly within company boundaries and have developed proprietary approaches, which limit stakeholder input and public scrutiny. A relatively early approach in that regard was BASF’s eco-efficiency analysis. The method aggregates economic costs and environmental costs of product alternatives based on comparable customer benefit levels. The assessment of the environmental costs is based on a so-called ecological fingerprint, which considers energy consumption, resource consumption, toxicity potential, risk potential, land use and emissions. In some cases, the eco-efficiency analysis is expanded to include social components. The expanded analysis is called socio-eco-efficiency analysis or SEEBALANCE. SEEBALANCE includes working conditions for employees, considerations of the international community (e.g., child labour), future generations and consumers, as well as considerations of the local and national community. An example of a measurement approach with a basis in agricultural interests is the Stewardship Index for Specialty Crops (SISC) in the United States. The SISC is a multi-stakeholder initiative including specialty crop growers, suppliers, buyers, environmental and public interest groups, agencies and experts working to develop a system for measuring sustainability throughout the supply chain. Currently, its focus is on the United States and on agricultural production, although there are plans to include the value chain from farm through processing and distribution to retail and food service.

The aim is to advance quantitative measurements in multiple areas of sustainability to enable chain participants to benchmark, compare and communicate their performance, rather than to provide standards to determine whether or not a practice is sustainable. The author has served as a co-coordinator during part of the development process for SISC, specifically regarding social and economic sustainability. Metrics already in pilot use are limited to the ecological dimension and include water use efficiency, energy use, nitrogen use, phosphorus use and soil organic matter.

Metrics under development currently target biodiversity and ecosystem, greenhouse gas, as well as irrigation efficiency. From early on in the project, ecological criteria were outlined in greater number and differentiation than criteria in other dimensions. Reasons appear to be that – albeit complicated – ecological criteria are less controversial and less subject to societal and personal values than other criteria. In addition, the ecological criteria are more likely to be accessible to quantitative measurement. Criteria in the social and economic dimensions, originally deemed just as important as the environmental dimension, are currently not being pursued further.

Critical issues in the development of measurement systems and conclusions

Due to the wickedness of sustainability, a number of critical issues ensue in the development of measurement systems both with respect to the system and the specific measurements, as well as with respect to the process in which the system is first developed and then implemented, sustained and further adapted. According to Genier *et al*. (2008), the sustainability impacts of measurement systems in use are often questionable and there is a lack of evidence that standards and codes are effective tools in increasing a particular user’s sustainability. This is due to the inherent inflexibility of standards and the neglect of complexity by many systems. Inflexibility and rigid bureaucracy limit the implementation of sustainability, as is the case with other innovations. During the adoption and diffusion process, further continuous improvement is required. For sustainability measurement, the need for improvement will continue for the foreseeable future. Accordingly, accompanying the implementation of measurement systems with rigorous scientific assessment can greatly benefit the further development of such systems. But the data collection needs for scientific assessment compete with feasibility and at times involve high costs that not all potential users are able to bear. Genier *et al*. (2008) have pointed to structural impacts of the widespread implementation of measurement systems that are too costly for small producers by food retailers on a business-to-business basis. In this way, sustainability measurement has become a gatekeeper to market access with unintended consequences for agricultural production.

For the initial development process and the continuing improvement of a system in use, stakeholder involvement is paramount. Several other authors (see Bokelmann – Chapter 4, Ekelund – Chapter 7, and Stenger *et al.* – Chapter 8) have discussed examples of different approaches to stakeholder involvement and the related challenges and opportunities.

Sustainability’s wickedness, especially due to the lack of a definitive solution, means that stakeholder participation during the process varies and some stakeholders use their participation strategically, e.g., threatening withdrawal when the process is not going in the direction they want to achieve. As such, procedural rules and agreed upon criteria for suitable indicators will support the development process. Although establishing rules and agreeing on criteria may constitute an additional challenge in the beginning, they are likely to contribute to sustaining the process and lead to the implementation of the resulting measurement system. Trust building and stabilising participation are both required for a successful development process and outcome on which future efforts can be built. As situations change, new knowledge becomes available and societal priorities change, achieving greater sustainability will not only require meeting current benchmarks, but relentless efforts of industry actors, stakeholders and the wider society working together towards a moving target.

The characteristic challenges of sustainability measurement are well suited to provide lessons for the development, adaption and diffusion of complex innovations in agriculture and beyond. In many ways, sustainability measurement can serve as an example for the challenges to expect and how to address them in other similarly complex cases. Of the common challenges, the degree and organisation of stakeholder involvement in the process might well be the most significant.

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Chapter 3

The contributions of the social sciences and humanities to the bioeconomy: implications for agriculture and food

Uno Svedin

Introduction

There are several reasons why contributions from the social sciences and humanities (SSH) to the bioeconomy and their implications for agriculture and food should be examined. They have long been included in how the bioeconomy – including in agriculture and food – is framed from both intellectual and policy standpoints. Ongoing discussions about governance, power relations and consumer behaviours all deal with this issue. However, further exploring traditional topics in the bioeconomy with regards to agriculture and food, such as efficiency and ecological and technical innovation, will require greater consideration of the human dimension in the broad range of concerns.

Many in EURAGRI circles feel that these aspects are not sufficiently showcased in the EU's current research and policy areas. There may even unexplored issues that could be brought into conventional discussions and insights that could be used to formulate a creative, intellectual framework to shape policy.

Framing the issues

One of the main concerns is whether the key topics for EU agro and food research are properly framed: better focus could be put on certain issues and the way central research targets are perceived could be improved. For example, research could address the following topics in greater detail:

— *The cultural roots* of a broad variety of agricultural practices, including how they are impacted by food preferences. The various agricultural practices in a specific location – which often have deep historical roots – can be framed within a cultural context. All products and services that are produced (e.g., food and other ecological services) are often a result of preferences in local markets for these products or services. Emerging ethical considerations and sustainability challenges must also be given greater attention. Finally, these cultural considerations are key when dealing with the EU regional and local contexts, where diversity is of considerable importance with regard to descriptions of practices and as well as policy constraints and possibilities. (Barthel *et al.*, 2013).

— *Institutions and the norms* they encompass. This is another major area of interest. Here, SSH contributions are significant, particularly because they have long been developed outside the agriculture and food industries. Findings from other fields may help shed light on practices and processes with agricultural and food applications. However, SSH contributions to the areas of agricultural and food are already visible through a wide array of interesting studies that provide fresh insight into these phenomena. However, challenges are constantly shifting (as reflected in the discussions about the Horizon 2020 programme) as is the role that SSH must play (Svedin, 2012, 2015).

— *Considerations on social capital.* Until recently, this topic has rarely been at the forefront of agricultural and food research interests. However, it is quickly gaining ground in such fields as economics, environmental psychology and anthropology. The same holds true for *the issue of trust,* interest in which is also quickly growing, with input not only from economics or psychology but from other domains such as history, anthropology and sociology as well.

— Due to the quickly expanding *international and global dimensions* of these topics, intellectual reflections from international studies, history, futures studies and broader activities dealing with policy development are quickly growing.

Additional considerations for European research and policy

There are other related considerations to include these issues in European research and policy. They include:

— *Rising interest in the changing social situation in Europe and related challenges* (e.g., the Horizon 2020 areas of interest and similar non-EU programmes). This includes an o*bservation of greater interest in SSH* dealing with such issues as voiced in many strategic research papers and in foresight and futures studies.

— *Interest in exploring the embedding of SSH research* in other research themes, which is essential to finding solutions to social problems and facilitating the implementation of results and new technologies.

— *Expanding attempts to address challenges through broad cross-cutting approaches*, including through related interdisciplinary and transdisciplinary applications. Because scientific research is largely organised by discipline, research policies are needed to showcase specific policies that foster interdisciplinary research and provide the relevant resources to accomplish it.

— *An increased overall importance of SSH as a tool* to explore interactions between science and society.

The agri-food bioeconomy

Shifting strategic thinking on agriculture and food with regards to framing current issues of developing a new bioeconomy will depend on how the agri-food sector is able to respond to societal challenges related to the following:

— *Multi-level concerns* (global, continental, national, sub-national/regional, local). Bioeconomy activities operate on different scales and all levels have different requirements in terms of governance: the EU has a specific way of handling activities, as do national and regional authorities. In the agri-food sector, this is especially important to keep in mind. For example, milk production in different countries brings up issues of production efficiency as well as how the various authorities assign value to such things as animal protection rights, antibiotic risk-taking, interest in local production in relation to consumption patterns, food preferences (e.g., various types of dairy products), etc. Cross-level concerns are also significant in a political, economic and managerial sense. Taking into account the multi-dimensional needs at the various levels is crucial.

— *A broad international panorama* of concerns and how it relates to more local challenges will require considerable efforts in research and empirical testing. While globalisation is not new, it is evolving. Contributions from SSH to considering these issues is of critical importance.

— *Innovation structures and directions of reform interests*. The different innovation strategies and mechanisms that have been developed in the EU and its member countries are significant to the bioeconomy and agri-food policy. These structure must be better understood and mobilised for different policy aims, such as SDG sustainability targets or climate change mitigation.

— *The impact of technological change on daily practices*. Innovation tends to reshape sociotechnical systems to empower individuals or raise barriers. Innovation assessment often looks at the “macro” impact on productivity and growth but is not able to detect the effects it has on the deep structures of daily life.

— *Changes in consumer behaviour*. Both the food industry and the agricultural sector are under strong pressure from several directions. There are many concerns across a wide spectrum – from global to local – which involve different time frames, from short-term forecasts to long-term strategic transitions. Examples include global food security at a time of international tensions, some of which may be due to climate change and the perceived long-term development of certain constraints, including socioeconomic and demographic considerations.

— *Value considerations*. Several of the above concerns are interrelated to value considerations. For example, as long as free markets alone are not able to guarantee people’s welfare, the search for shared values and their incorporation into economic agency becomes crucial to the performance of economic systems. Related ethical issues are thus associated with strategic choices that must be further investigated and understood.

Conclusion

We must explore the European agri-food model under rapid transition conditions and draw from the SSH knowledge base to face the future in a global context. The main areas of focus should be:

— Globalisation and how it connects to local drivers

— Time ranges: how we can draw on the many futures studies in this field and in related areas (e.g., EU/SCAR efforts as well as national and international initiatives) and how these issues connect to SSH research agendas and analyses of the past and future

— Changing pressures from environmental (including climate change) conditions

— The combined panorama of threats and opportunities and the resulting need to develop a change in perspective that addresses urgent new challenges over the next few decades.

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Chapter 4

Food value chains: a challenge for innovation

Wolfgang Bokelmann

Introduction

Today the largest part of agricultural production in developed and developing countries does not reach consumers directly from the production but is marketed via multilevel marketing systems. As a result, most farmers are increasingly integrated into value chains with forward (marketing) and backward (input supply) linkages (FAO, 2007). In industrialised countries, this division of labour is already more intensive and differentiated, while in many developing countries production and consumption partly still takes place together (subsistence) or spatially very close together.

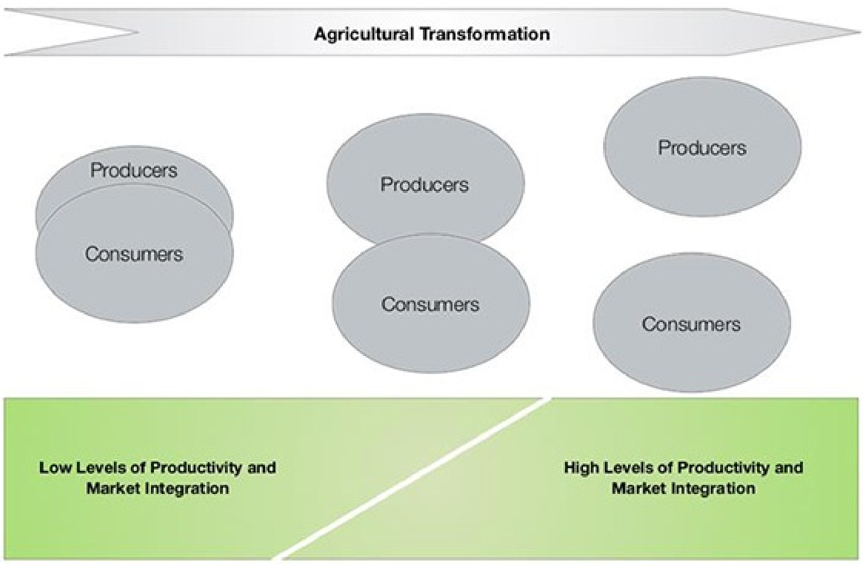

Figure 4.1. The food system transformation (FAO, 2007).

Figure 4.1 provides a more historical look at the development of the agricultural transformation process. Consumption and production have increasingly become separated both in time and in space in the course of the growing international division of labour as well as intensified urbanisation. Overcoming these spatial and temporal differences caused by the division of labour requires organised cooperation among all players in the value chain.

The value chain perspective

The emerging debate about whether our food system is sustainable and can meet future challenges leads to greater public interest directed at the different activities within the food system (Ingram *et al.*, 2013; McMichael, 2011; Godfray *et al.*, 2010). These activities take place in so-called value chains. Food value chains include everything from the production of agricultural raw materials and their inputs to transportation, processing for the retail trade and arrival on consumers' tables. Food chain management also has a significant economic importance. In the European Union, approximately 280,000 companies are involved, with a sales volume of around 840 billion euros in the food industry and about 4 million jobs.

Food Chain Management has gained increasing social significance, especially due to food scandals and consumer demands for transparency and sustainability. At the same time, the food industry has to act in an increasingly complex environment of growing competition and must consider legal regulations and specific standards.

For society, the issue of whether these value chain activities are sustainable has become a frequently discussed topic. What adverse effects it has on the environment, the health effects associated with it, and whether people working in the sector can earn an adequate income are cited as concerns. These issues are of even greater importance when we consider that value chains are increasingly organised globally (Deloitte, 2013; Ericksen, 2008). Ultimately value chains are an expression of an increasing social division of labour. Value chain management today must find its place in both practice and in scientific discussion.

Types of value chains

A look at the fresh food supply of the population in industrialised countries shows that there are a large number of possible combinations resulting to different types of value chains. In nearly all countries, typical local value chains still exist, for example as direct selling agricultural holdings. This means production and consumption still take place locally or regionally to a large extent, although some of the necessary production inputs/resources is often sourced from other regions. In such local value chains, production, consumption and waste disposal occurs here. There are additional activities in the region, such as craft enterprises or service companies supporting the functioning of value chain activities.

Global value chains are often associated with large food manufacturers. Here there is a very clear decoupling of production and consumption, which occur far apart in in spatial terms. To bridge the gap across space and time, various actors must be involved to ensure product quality and freshness.

Today, so-called “coordinated value chains”, which have emerged through the growing importance of very concentrated organised food retailing, are much discussed. It is widely acknowledged that these food retail chains are taking a type of lead function in contemporary value chains. As an agent of the consumer, they determine the quality requirements and standards for delivery. However, due to intense competition in the food retail sector, they also have a strong focus on efficiency aspects which they try to implement in the coordination of the value chain. This topic is discussed in more detail in the section The need to coordinate value chains.

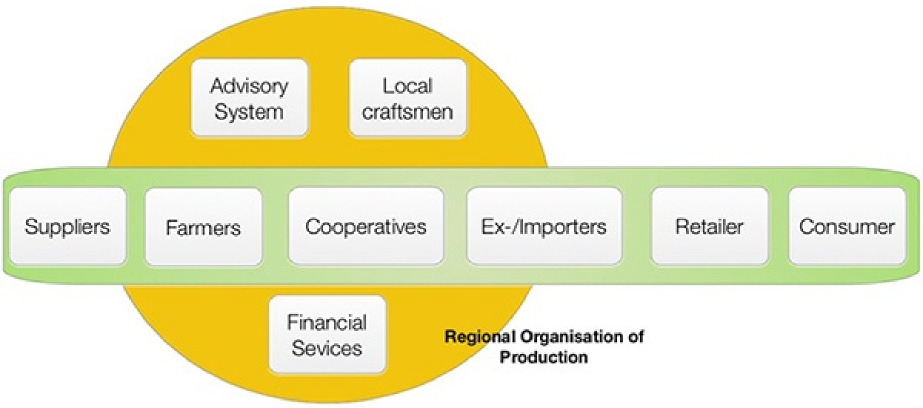

Figure 4.2. Coordinated value chains.

A systemic perspective

Value chains can be described via a simplified schema (see Figure 4.3). The chain typically includes supplier companies, producers, processors or, in the case of fresh products, wholesalers who then resell to the food retail industry. From there the product reaches consumers. In the field of fresh products, the importance of food retailers in Europe is quite huge. This is particularly true in northern Europe, where food retailers supply populations with 80% or more of their fresh produce. As such, retail chains are a dominant player in this system.

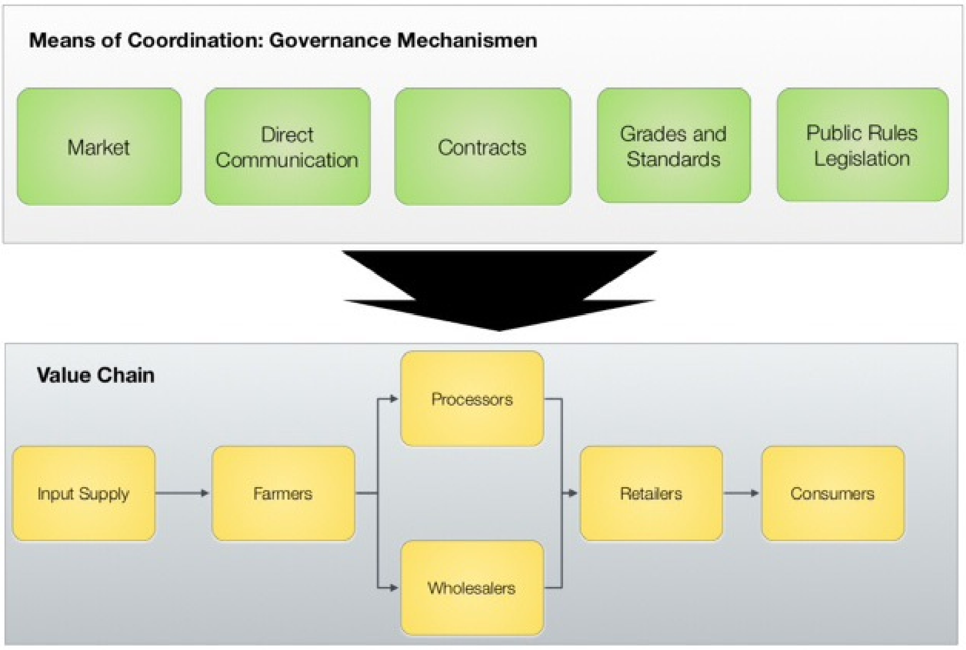

Figure 4.3. Typical value chain actors in modern food chains.

Explaining the outcomes of a food system by observing only the value chain members is an overly restrictive approach. Additionally, there are service companies, the finance sector and the increasingly important consultancy sector that must be taken into account; they all contribute to the functioning of value chains. Due to rising globalisation, logistics is facing major challenges. In many industrialised countries, the existing infrastructure is taken for granted, which may cause their importance for value chain development to be underestimated. This infrastructure includes research and education systems, information and communication technology, the entire transport system (including roads and railways), the cooling facilities across the value chain as well as the various control institutions that monitor compliance with certain product and process standards. The importance of infrastructure is especially clear when one considers the situation in developing countries, where it often constitutes an essential obstacle to the development of value chains.

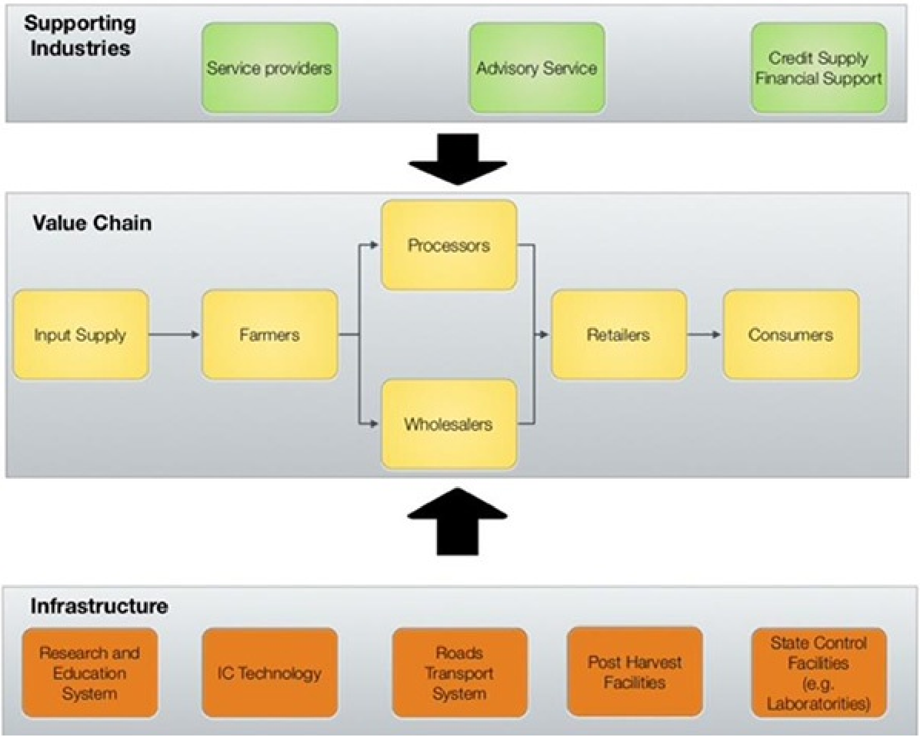

Figure 4.4. A broader value chain perspective.

The need to coordinate value chains

If one could assume that the coordination within value chains occurs exclusively via market transactions in ideal markets, then little thought would have to be given to coordination issues in value chains. However, the issues of quality and product safety remind us that such coordination on the market is insufficient to rule out opportunistic behaviour and careless product handling. There are often public and private efforts to ensure and control product promises and food safety.

If value chains are to be organised efficiently and cost effectively, transaction costs must be reduced. This can be achieved, for example, by creating commercial categories (grades). Direct information and communication also play a very significant role, especially in local food systems. Recently developed technologies like radio frequency identification (RFID) are expected to be important in the future (Bourlakis *et al.*, 2011).

The debate about climate change and the emissions generated by food systems also directed public interest to the externalities associated with supply chains. Market coordination frequently falls short while there are significant information problems at all stages of the value chain. Reducing external effects in supply chains is a major challenge for future value chain management. From a global perspective, the issue of whether our food systems can supply the growing world population with enough healthy foods must be addressed soon. This is a key issue which is also linked to the debate on environmental pollution.

In global value chains, coordination is also considered from a perspective of competitiveness. In some markets, there is an oversupply of products. Under these conditions, the question arises whether it is possible to generate benefits for consumers compared to other value chains, such as lower prices or certain user benefits through product and service differentiation.

Means of coordination: the governance perspective

To operate successfully in an international agricultural and food market, precise knowledge of the food and its production, as well as marketing strategies and information about consumers, are necessary. The high degree of complexity of the food chains from manufacturers to the end user through the plurality of parties, each with specific requirements and needs, requires a comprehensive management approach.

This leads to the question of how value chains can be governed in a targeted way. In particular, it must be determined how the various interdependencies can be managed (FAO). This problem is often discussed under the concept of governance or governance mechanisms of value chains. The aim here is to analyse the “rules of the game” in the system and from a practical perspective to define those rules.

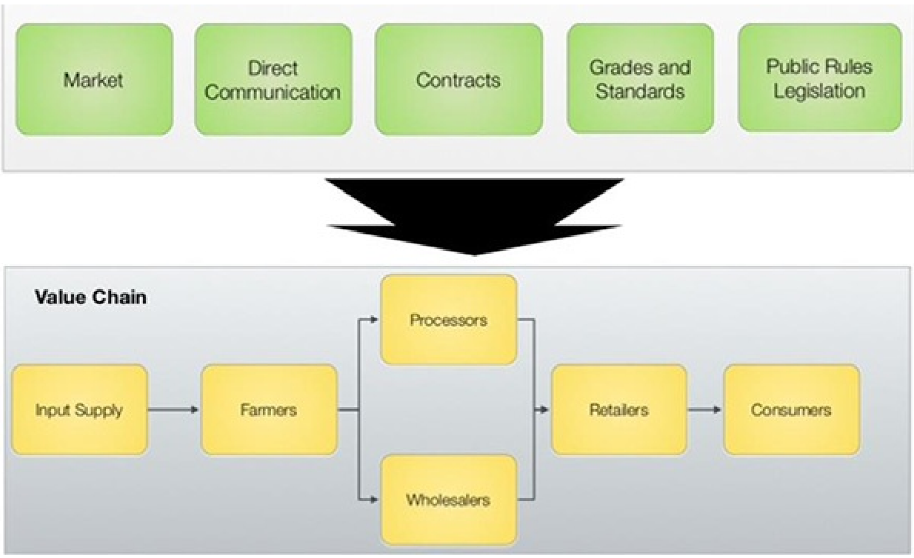

Figure 4.5. Means of coordination: the governance mechanism.

In poorly differentiated markets market coordination still plays an important role, and in more local value chains direct communication continues to be of great importance. With the introduction of private labels in food, retailing contracts between two partners are gaining increased significance. This is also true for food production and processing.

Large processing companies especially source their products often on a contract basis. Rather general forms of coordination are carried out through grades and standards. In this case, product standardisation must be addressed, such as in the form of commercial classes (grades). Standardisation is also applied to processes. Examples include quality management systems, which are expected to be increasingly used by producers. Finally, public and global rules also play a role, such as with the Codex Alimentarius. It would be fair to say that the coordination of value chains today relies on an increasingly close network of various arrangements. Relevant mechanisms are located between public and private institutions and always require intensive documentation on the production side. As such, they have a significant impact on the structure and structural changes in the agricultural sector.

Table 4.1. Changing focus in the development of food value chains.

	Cots orientation/Productivity		**Product safetiness**	**Strategi different**
Level	**Production**	**Logistics**	**Across the value chain**	**Retail/W sale trac**
Strategy technology	Economics of scale (growth, specialisation), productivity	Centralisation standardisation: GPS, RFID, JIT Outsourcing	Tracebility, documantation, transparency	Private bra producer-b price differentia
Institutions	Horizontal co-operation	Vertical co-operation, horizontal co-operation	Certification systems, grades and (private) standards globals GAP, QS	Individual contrats, I
Human-ressources/Infrastructure	Process management, corporate capabilities, Human resource development		Communication laboraties/food inspection infrastructure, consumer information, education	Communic consumer education

If we look at the focus of food value chain coordination efforts in recent years, we can distinguish several phases. When there was intense competition, the issues of cost reduction and productivity received considerable attention. Economies of scale, specialisation and increased productivity played a major role here and were supported by horizontal cooperation (marketing cooperatives). With regard to logistics, centralisation and standardisation were of greater significance while cooperation along the value chain (vertical) significantly intensified. As for corporate management skills, efficient process design played a more important role.

As concentrations in both the production and the retail value rose, chains always became less transparent and more anonymous. This became especially clear by the early eighties, when food scandals became increasingly frequent. Without neglecting cost and productivity, the need to increase consumer trust became ever more important. Transparency, documentation and traceability were only a few key issues that arose. Attempts were made to resolve these problems through certification systems and the development of process standards. In this context, the issue of communication with consumers has grown in importance.

However, increasing competition also meant that greater product differentiation was necessary to address all consumer segments. Both producer brands and food retailers' private labels received more attention, not just in agriculture but in the food industry as a whole. To avoid jeopardising investment in those brands, comprehensive contracts were concluded with suppliers. This process was supported by a huge increase in investment in advertising and other communication measures.

Currently, societal demands on the food system increasingly occur in public discussion, with strong attention being paid to the environmental problems and climate change linked to food production. New actors have emerged in the area of food systems, including non-governmental fair trade organisations and environmental organisations. Companies must act responsibly and enter into dialogue with society. Once again, trusted and genuine communication plays is key.

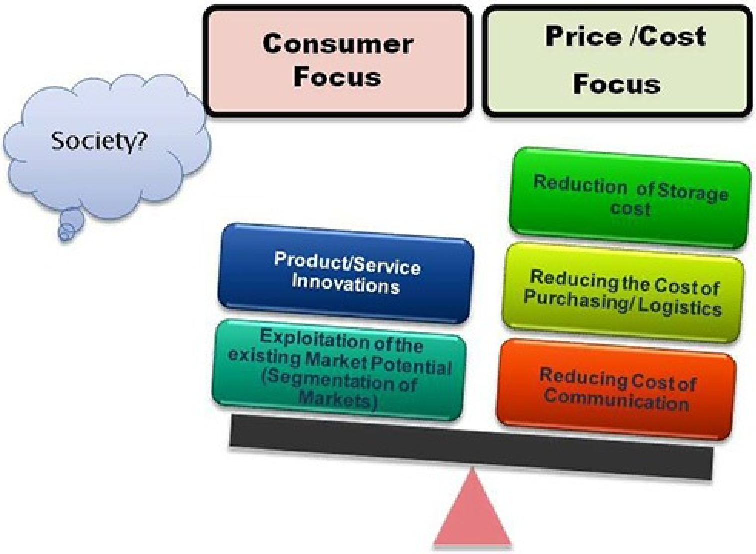

Figure 4.6. Balancing perspectives in the food system

A critical examination of whether efforts to reduce costs and boost production have come at the expense of consumers and societal needs must be carried out.

Future challenges

The following challenges should be considered in finding innovative pathways for food value chains:

— How can agricultural value chains be more closely aligned with the changing needs of society (e.g., food waste) (Wunder and Bausch, 2014)?

— How can agricultural value chains be adapted to global challenges, and especially climate change (FAO, 2008)?

— How can the potential resulting from societal shifts and income changes (distribution) be exploited to improve quality (Grunert *et al.*, 2008)?

— How can consumer trust be improved when value chains are increasingly anonymous?

— How can farms play a more active role in the design of value chains and improve their position as links in the chains?

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Chapter 5

Obstacles to the diffusion of innovation in the agricultural sector

Wolfgang Bokelmann, Bettina König

Innovation: the key to meeting future challenges

To meet the needs of the world's rising population, food production must increase significantly. Because resources are scarce and soils are being progressively degraded, production must happen in a way that preserves available resources for use by future generations. Development of the agricultural system, however, needs to take into account changing geophysical and socio-economic conditions. The consequences of climate change require major adjustments in agricultural production. Furthermore, increasing urbanisation in nearly all parts of the world requires well-organised food systems supplying urban populations with sufficient healthy food. In industrialised countries, the consequences of resource-intensive agriculture are increasingly visible. Following a number of food scandals, consumers consider our current form of agriculture to be a critical issue.

While the direction of innovation in agriculture has its critics, there is little doubt in society that the food sector needs innovation. International competition, globalisation, changes in the environment and the changing demands of consumers and society are all factors in the need for innovation to ensure a sustainable and healthy food supply for a growing population and success in the market (European Commission, Directorate-General for Research and Innovation, 2015; Garnett and Godfray, 2012; Godfrey *et al.*, 2010; Ingram *et al.*, 2013; Wunder and Bausch, 2014).

Driving forces of innovation

Current production, processing and marketing practices were once novel and innovative. There are a range of drivers of innovation and factors that affect the magnitude and direction of various innovations (see Figure 5.1). In the seventies, most changes were associated with increased competition associated with the opening of markets. The retail industry, processing industry and agricultural production reacted to this challenge by improving efficiency and productivity along with strong company expansion. As wages rose, labour-saving investments were made. The focus was on increasing of productivity, achieving "economies of scale" and "rationalisation", all of which aimed to reduce production and logistics costs. These developments are sometimes known as the "agro-industrial model" (Fournier/Champredone 2014).

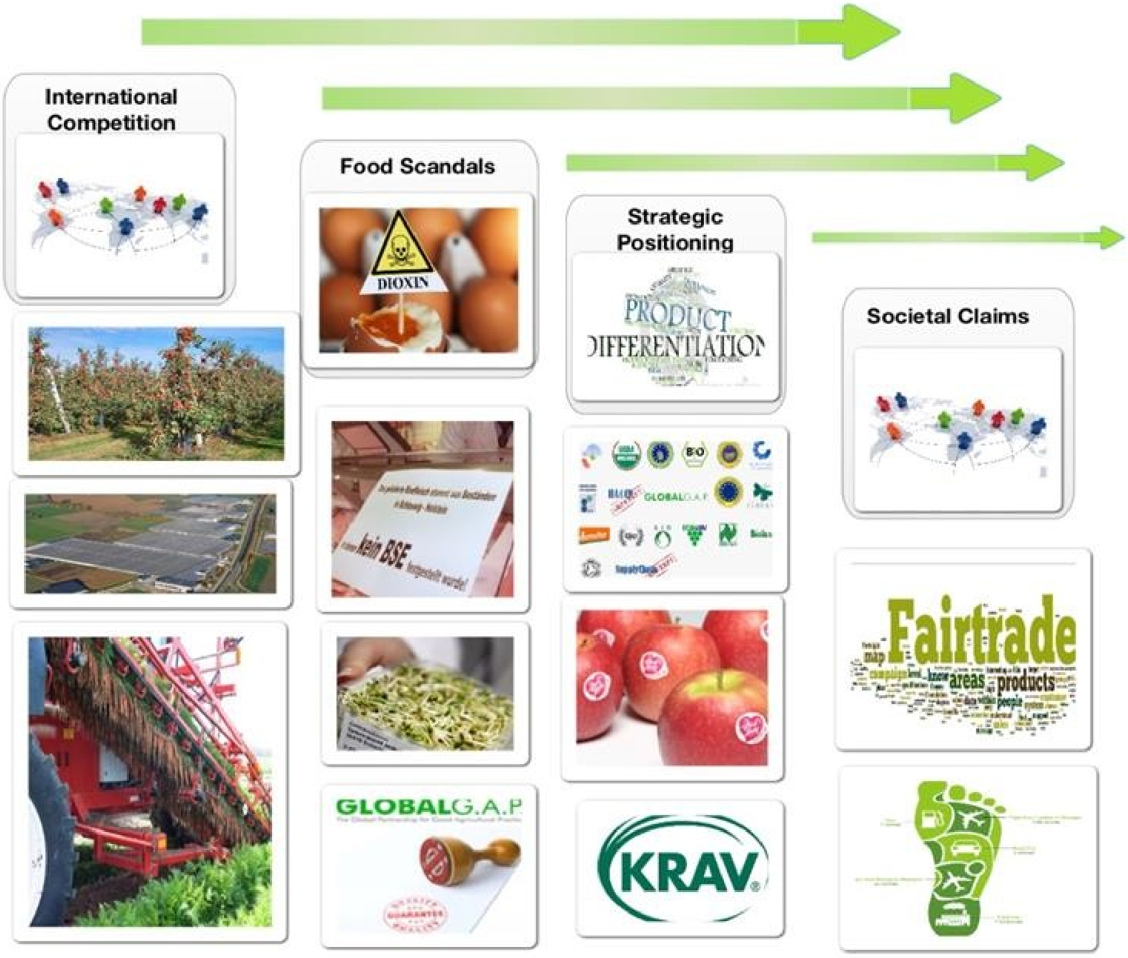

Figure 5.1. Driving forces of innovation in the agricultural sector.

With the gradual emergence more anonymous global value chains, the issues of food health and safety have entered public awareness. Food scandals in particular have shone a spotlight on the issue of food safety. There have been various initiatives in both at the state and the private sector levels to reduce consumer health risks. Organisational innovations such as certifications and process standards have increasingly been implemented. The market has grown considerably due to an expanding market supply and greater efforts to differentiate products. This development was also a result of strong consumer demand as incomes and income inequalities intensified sharply over time. All these trends have offered opportunities for product differentiation and processes, including organic products, local food, or producer and private label brands. Generally speaking, branding has played a role even in agriculture.

The current discussion on animal welfare and climate change reflects particular societal demands and the way food is produced, processed and marketed, resulting in specific marketing requirements. The marketing opportunities these trends offer can only be effectively exploited if trust is built among consumers. Because consumers are unable to verify whether such claims as “environmentally friendly” or “fair trade” are true, labels and certifications are a way for brands to be perceived as trustworthy by consumers.

These developments all exemplify very different driving forces of innovation. However, they also show that the concept of innovation is not restricted to new products. Product changes are often associated with process and social innovations, which will be discussed in further detail below.

Delving into the concept of innovation

In everyday use, the term “innovation” is applied to almost anything that appears to be new. This universal use makes scientific communication on the subject quite difficult. It is especially challenging to make general recommendations regarding the design of innovation processes. We must therefore come to a consensus on the use of the term and distinguish it from other similar terms.

Generally speaking, innovations are *new solutions that have already* been proven *usefulness in practice*. This means they have successfully passed different phases, from development to acceptance by the user: decisions to develop and introduce inventions onto the market, as well as the adoption of such inventions by users, have already been taken. From this perspective, it should be stressed that in addition to product innovations, process and social innovations are increasingly necessary. If we look to value chains, we will find that many innovations are aimed at improving processes within companies as well as cooperation between companies, thereby making the entire process more efficient. For social innovations, certification by non-governmental organisations are often required to gain the necessary acceptance of new or modified products.

Innovation also differs in whether it leads to incremental or radical changes (Figure 5.2), i.e., "new to the world". New plant varieties and pesticides would be an example of an incremental innovation: they do not require users to acquire much additional knowledge to be able to use them. New technologies, on the other hand, such as for precision farming or lighting for horticultural plants, are relatively radical changes and require a considerable amount of new knowledge for use. In addition to distinguishing between incremental and radical innovation, we can also look at whether changes are only needed for a subsystem or if far-reaching changes across the company as a whole are required. If production processes must undergo fundamental changes, how much and what type of new knowledge is needed and whether employees will need new qualifications are also factors that can be taken into account. Upon closer examination, many innovations are shown to be more systemic in nature. Incremental changes and narrowly focused innovations affecting only certain areas of a company's business need little support to implement and have a lower economic risk. The private sector generally manages this type of change very successfully.

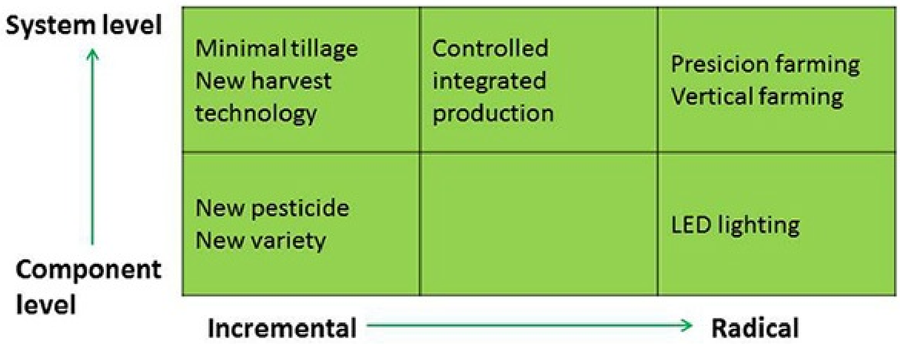

Figure 5.2. Types of innovations (changed according to Tidd and Bessant, 2009).

For radical changes on a system level, several technology components are combined to create value. This type of innovation requires a complex innovation network, which must often take an interdisciplinary approach. Rather than the level of innovation of individual components, the key to this system is their new combination. Larbig *et al*. (2012) considered that the generation of profound changes was a basic feature of system innovations: (1) they are inspired from the real world, e.g. social and environmental problems, and include a multidimensional degree of novelty, (2) they change market and stakeholder relations as well as existing knowledge, technologies and/or organisational forms, and (3) they need a strong customer focus as a driver. The viewpoint is based on a need (market pull). In the event of a comprehensive set of complex changes, e.g., in production or operational procedures, there is a greater need for knowledge and training for the whole innovation process. Additionally, acceptance by the company or customer is difficult to predict. Such innovations are associated with significantly higher economic risks. During the process, a large number of actors on different levels are involved or affected (see also Geels, 2005). When it comes to global challenges or meeting societal needs in a better way, *system innovations* play an important role.

System innovations require skills outside their core competencies and are often developed within inter-organisational networks. Sharing knowledge and joint influence within networks is important and can help limit risks.

Practical experience

Through various projects, we have dealt with the development and adoption of innovations in the agricultural and horticultural sector (Bokelmann *et al.*, 2012; König *et al.*, 2012). To get a complete picture, we worked through various case studies using a mixed method approach. In addition to the analysis of secondary statistical data and qualitative and quantitative surveys, we have conducted workshops with various value chain stakeholders in these fields. This is necessary because often all players in the value chain must accept the innovations. The following section summarises several experiences from our studies. The aim is to highlight the obstacles to the development and adoption of innovations and offer recommendations for overcoming those obstacles.

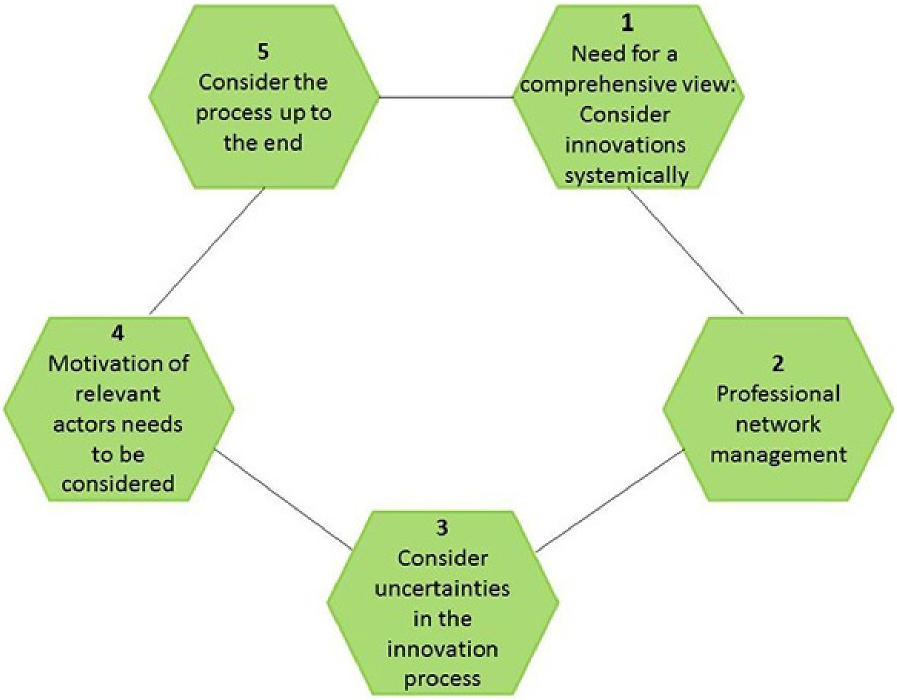

Figure 5.3. Success factors for systemic innovations.

Taking a systemic view

Given the background information previously given about systemic innovations, the actors involved in such processes and who are part of the innovation system must be considered. As already discussed, there are different framework conditions, organisations and individuals to support the adoption of innovations. The way these organisations and individuals interact determines how successful the innovation process will be. In agriculture especially, a wide range of mainly small-scale businesses is prevalent, and even the supplier industry is still dominated by small- and medium-sized enterprises (although there is a strong concentration process in the field of breeding and the production and distribution of fertilisers and pesticides). When it comes to societal demands (reducing greenhouse gases), pure market solutions often have limited success. As such, innovation also requires input from public research and development institutions.

Analysis should also take into account that agriculture today is part of value chains that can be very complex and that many new features of discoveries are based on technologies invented outside the agricultural sector. Experimental stations and demonstration farms where the practical use of such innovations can be proven are necessary. Moreover, actors who can support (broker) the adoption of innovations need to be involved, such as the media, education system and training institutions that are active in the sector (Klerkx and Leeuwis, 2009). Furthermore, educational stakeholders are just as important as independent consultants.

To capture all these actors and their interactions systematically, we used the sector-innovation model by Malerba (2002) in our studies (Figure 5.4). It shows the driving forces of innovation, such as intensified competition, as well as new technologies that have been developed and, even more important today, the changed demand structure (Edler, 2016; Rubik and Müller, 2016; Reisch, 2003). The actors and their interactions are shown with a special focus on the knowledge base or existing human capital. The system rules ensure that institutions and policies are able to play a role. In our study the Malerba model was extended so that the various phases of the innovation process were itemised separately. It is clear that the importance of the different actors during innovation process can change substantially.

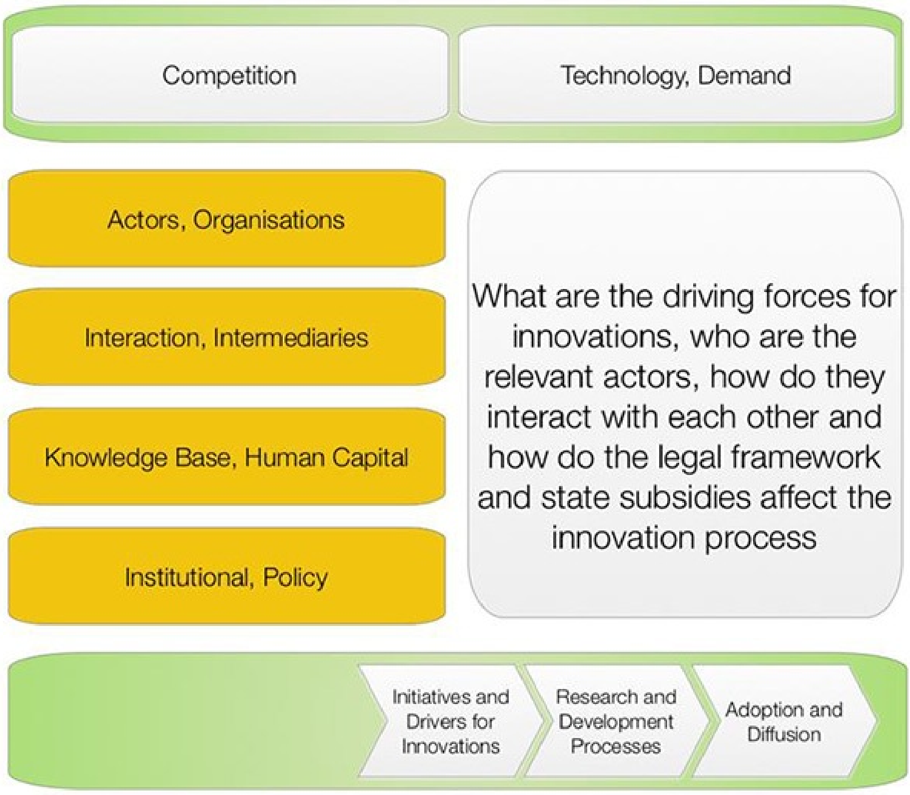

Figure 5.4. The sectoral system of innovation (changed according to Malerba, 2002).

Innovation networks

The vast number of companies participating in the group discussions showed that the role of networks in the innovation process is very important. Networks can pool resources of the actors involved and promote the rapid dissemination of information within the group to initiate and promote learning processes (Weyer, 2011). However, there is often little information on existing networks and potential partners are not always known, such as when basic technologies for innovations are developed outside the agricultural sector. However, all the functions can only be fulfilled when such networks are professionally managed. To this end, sufficient financial resources must be made available.

Uncertainty in the innovation process

A second important factor is uncertainty in the innovation process. Uncertainly plays an essential role in research and development as well as in the adoption of innovations by agricultural companies. The majority of players in the sector, including suppliers, are small- to medium-sized enterprises that do not have extensive research capabilities or staff planning. Innovations are also dependent on other actors in the value chain being willing to accept them.

For adoption itself, it is important that innovations have already been shown to be useful. This can take place through demonstration projects as well as by leading companies in the sector using the technology and sharing their experience. In principle, reliable information (e.g., from independent consultants) is of the utmost importance. In individual cases, especially combined with societal demands, government subsidies are helpful for reducing uncertainty and guiding how to put new technology into place.

Incentives in the innovation process

A more thorough analysis of essential activities of innovation networks shows that a precondition for the success of innovations is for actors to be motivated to cooperate. In this respect, it is also important to consider the incentives of actors more precisely. For example, there little interest for scientists to actively engage in innovation networks when their home institutions are more focused on high-ranked scientific publications than on practical research and writing for business magazines. For farmers, social challenges such as climate change are seen as relevant but remain relatively abstract. For them, it is important that the economic benefits of the adoption are clearly shown.

In Germany, the role of the advisory system has changed significantly in recent years. Previously the focus was on independent advice while today the fulfilment of sovereign tasks is increasingly important. It should be noted, however, that there is a certain contradiction between control functions and independent advice.

Considering the entire process

Policymakers are often asked to set clear and reliable targets that allow for long-term investments in new technologies and products. Often, a special focus of innovation policy lies in funding research and development. To successfully launch an invention, additional obstacles must be considered, especially those related to the adoption phase. New technologies and new process innovations require improved knowledge and as such, appropriate levels of education and training must be included. Additionally, the integration of the so-called lead users in the entire process is increasingly recognised in innovation research. They can contribute to the development process and have direct contact with farmers to demonstrate the advantages of innovations. A similar function is expected from practical experimental stations. To reduce uncertainty and convince farmers to adopt innovations, they must have successfully demonstrated economic or social benefits.

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Chapter 6

Confrontation of knowledge transfer models between advanced innovation systems and post-socialist regions in Central Europe

Niclas Rüffer

Introduction

This chapter gives a brief overview of the findings of a large research project concerning the effectiveness of knowledge and technology transfer in the regional innovation system of Opole Voivodship in southern Poland.[3] The analysis of successful regional innovation systems in Western Europe and China serves as a backdrop to that project. While vertical and horizontal knowledge sharing is prevalent in high-performing innovation systems and tertius iungens orientation was frequently identified, the relatively low-performing innovation system of Opole Voivodship is characterised by "low collaboration/low trust/low productive" equilibria. Trust between different organisations is rare and knowledge is deliberately held back from partners in other organisations and even within hierarchies, leading to slow knowledge flows and few innovations.

The generation of innovation is undisputed and is regarded as one of the key success factors for the growth of firms, regions and nations in contemporary economic literature. Innovation is viewed as the result of interactive learning processes (Nelson and Winter, 1982) embedded in institutional frameworks of national (Nelson, 1993; Freeman, 1987; Lundvall, 1992) and regional (Cooke *et al.*, 2004) innovation systems. The transfer of knowledge and technology between the central actors of the triple helix, the scientific subsystem, firms and the public policy system is essential for the generation of innovation in the innovation system (Etzkowitz, 1993; Etzkowitz and Leydesdorff, 1995). A whole web of knowledge transfer channels such as publications, formal and informal networks, mobility of human capital, formal and informal R&D collaborations, etc. (Bekkers *et al.*, 2008; Brennenraedts *et al.*, 2006) is in use between the scientific and the business system in successful regional innovation systems.

European innovation leaders, such as the German state of Baden-Württemberg base their economic success on dense networks of collaboration and knowledge sharing between business and science, high R&D expenditures and ever-accelerating efforts of policymakers, universities and businesses to improve further collaboration and innovation. Leading European universities and those they work with (policymakers and a range of scientific and business associations) are very active in promoting the transfer of knowledge and technology from science to business and vice versa. The Technical University Eindhoven, located in the world's most innovative city according to the number of patents (Deutsch-Niederländische Handelskammer 2013), the Karlsruhe Institute for Technology or Cambridge University have highly professional technology transfer offices in place and are constantly striving to improve them. Incubators with professional support for academic spin-offs are working to boost the transfer of ideas developed in academia to the business world through entrepreneurship work in each of these universities. The largest technical university in Germany, RWTH Aachen, is embedded into the "GründerRegion Aachen" (founder region Aachen) and is endeavouring to promote entrepreneurship and technology transfer in collaboration with several partners from the public and private sectors. Dense formal and informal vertical and horizontal networks facilitate knowledge transfer in these highly innovative regions. However, not only do traditionally strong regions in Europe (or in the US) maintain their highly competitive position in the generation of innovation, but newcomers such as certain Chinese regions have become innovative hotspots over the past decade. While the scientific system was literally destroyed in the Cultural Revolution, when Deng Xiaoping came to power in 1978 scientific research and technology began to rank higher on China's political agenda (Vogel, 2011). In an astonishingly short period of time China brought its R&D investment up to a competitive 2% of GDP (OECD, 2015) and leading Chinese universities such as the Tsinghua University in Beijing grew to world class status in the field of technology and knowledge transfer to the business community.

Meanwhile peripheral regions in post-socialist Central Europe lag considerably behind in generating innovation and wealth. Although similar to innovative hotspots such as the

Scandinavian countries, Great Britain, the Benelux Countries and Germany in terms of culture and size and closely linked with these European innovation leaders through EU institutions, spillovers seem to be rare with regard to innovativeness. The internal GDP of the Silesian Voivodship Opole in south Poland is approximately €7,700 – only a fraction of regions in the Netherlands, Great Britain or Germany – and can be closely linked to poor R&D and innovation efforts (just 0.3% of the region's internal GDP is dedicated to R&D). According to nearly all measures Opole Voivodship can be regarded as a weak regional innovation system in comparison with European standards (European Commission 2014; Statistisches Landesamt Baden-Württemberg 2015). The Opole Voivodship lags considerably behind, not only in comparisons with European innovation leaders such as the Stuttgart region, but also when compared to strong Polish regions such as the Masovian Voivodship, which includes the capital city of Warsaw (see Rüffer *et al.*, 2015, p. 95).

The central research questions for this chapter can be formulated as the following: What distinguishes a low-performing regional innovation system such as the Opole Voivodship from high-performing innovation systems in Western Europe and quickly accelerating regions in China? What are the main obstacles and bottlenecks for innovation, technology and knowledge transfer in post-socialist Poland? Which key lessons and potential policy measures can unleash the innovation potential of Polish universities and businesses?

Research design and methodology

The research project "Effective knowledge transfer from science to industry in the Opolskie Voivodship" simultaneously followed two tiers: (1) the regional innovation, technology and knowledge transfer system of the Voivodship Opole was studied in depth, and (2) international best practice cases in technology transfer and innovation were analysed. The international best practice cases of Baden-Württemberg (with a special emphasis on Karlsruhe and the Rein-Neckar region in the north-west), Eindhoven, Cambridge, Aachen, Shanghai and Beijing were chosen for several reasons. All these regional innovation systems are internationally highly competitive with regard to the generation of innovation while being different in several regards. While some regions, such as Baden-Württemberg, are long-time innovation leaders, other regions such as Shanghai and Beijing only recently grew to frontier status in terms of innovation and technology transfer. Furthermore, the configurations between and the orientation of the actors of the triple helix in the development of the chosen regional innovation systems vary. Central actors of the regional systems, such as universities, have different orientations. For instance, Mannheim University, one of the central actors in the Rein-Neckar region, is one of the leading German universities in the areas of social science and economics while the RWTH Aachen is specialised in technical fields. While some organisations that were studied (such as Karlsruhe Institute of Technology) focus on larger firms, other transfer organisations (such as the Steinbeis Society) focus mainly on SMEs.

The analysis followed a modified version of the holistic, multi-dimensional six-step policy evaluation protocol introduced by Magro and Wilson (2013). University policy, innovation policy and cluster policy were holistically analysed for the Opole region, while for the best practice cases only selected policy areas were chosen. The analyses followed a mixed method approach. The first stage was an in-depth literature review regarding the regional innovation and technology transfer system of the respective region. For the second stage, multiple actors (university scientists, technology transfer offices, policymakers and businesses) were interviewed on a qualitative base. With regard to the international best practice cases between five and fifteen qualitative interviews were conducted. Regarding the Opole region, interviews with 35 actors were conducted. Finally, the results were discussed during several workshops with university scientists and policymakers from the Opole region. Within these workshops moderated focus group discussions were organised, quantitative questionnaires were distributed among the participants and the results were subsequently analysed.

Effective knowledge and technology transfer – high-performing regional systems vs. the Opole Voivodship

Central characteristics that were identified in high-performing regional innovation systems are dense vertical and horizontal networks and intensive collaboration and knowledge sharing between different actors within the triple helix, as predicted by the innovation system approach. A whole web of specialised transfer organisations service special branches and niches (e.g., small- and medium-sized firms) and all actors of the triple helix exchange knowledge and collaborate through different formal or informal councils, associations or clubs. A general tendency for knowledge sharing as well as dense social networks and a tertius iungens orientation is the prevailing tendency of individuals in the high-performing regions analysed (Obstfeld, 2005). Tertius iungens refers to the tendency of individuals in broker positions, i.e., connected with two other unconnected actors, to connect these actors with each other (as opposed to a tertius gaudens orientation, where a broker exploits their position). Obstfeld (2005) is able to show in his seminal work through his multi-method case study of an automotive manufacturer's engineering division, actors with tertius iungens orientation appear to be involved in more innovations. From the qualitative work conducted within this research project, one might hypothesise that this predication also holds true for the analysed high-performing regional innovation systems.

In the low-performing regional innovation system in southern Poland, which was analysed in the research project, generally speaking, actors seem not to trust each other and are unwilling to collaborate. Professional horizontal networks are rare and vertical networks are common, restraining knowledge sharing and efficient decision-making. Knowledge flows – if at all – from the bottom up, from lower levels of organisations to higher levels. However, even vertical knowledge sharing between different levels of the same organisational hierarchy is poor. Critical information is withheld from lower levels, even if this information is vital for the execution of tasks or projects. Actors seem to deliberately withhold knowledge in order to exploit their superior information even in collaboration with their colleagues within an organisation, and especially with their subordinates. Consequently, many subordinates also appear to try to guard their knowledge from their superiors, providing only selected information. Attempts to collaborate with other organisations at lower levels are thwarted by those at higher levels. The regional innovation system is stuck in a "low collaboration/low trust/low productive" equilibrium. Organisations with great potential to generate surpluses by collaborating with each other due to complementary strengths in fact compete against each other and appear to prefer project failure over profit sharing.

The following subchapters will, following the modified version of the analysis proposed by Magro and Wilson (2013), analyse university policy, innovation policy, and cluster policy, exemplifying the diagnoses. It is not always possible to draw clear borders between these policy fields.

University policy

In successful regional innovation systems, teaching in universities is oriented towards the regional economy and there is constant knowledge exchange between university staff and businesses to adjust the teaching to the needs of the regional, national and international labour markets. In different forms of interactions, university scientists have the opportunity to identify, describe and document the skills demand in the labour markets and transform this demand into pedagogical content. In projects with businesses, university staff learn to understand the needs of the local business community. There are various exchange platforms, which may either be informal, such as personal ties between business and science, or formally organised through continual research on labour demand by universities or platforms created by industry associations. The long common trajectories of individuals on both sides lead to common values and as such generate higher adoption due to trust (Arthur 1994). The orientation of teaching towards the actual needs of the regional labour market is promoted on an individual level by university professors maintaining steady contact with the business community. Additionally, at an organisational level, entire universities are constantly updating their curricula or developing new degree programmes to meet changing labour demand. Advanced training focused on the needs of regional labour markets (and sometimes for international labour markets as well, e.g., in double degree programmes) is offered at business schools. There are also lifelong learning programmes set up by industry associations or chambers of commerce, for instance, which can help people continually enhance their skills. The regional supply of human capital is constantly developed, thereby leading to stronger innovativeness and a direct transfer of state-of-the-art scientific knowledge into the business community. At the same time, links between business and science not only transfer knowledge on the needs of labour markets (reinforcing universities' role of providing qualified human capital), but also share information about the demand for basic and applied research in the region. Furthermore, the interaction of such partnerships plays a crucial role in the identification and capturing of exogenous innovations, adopting them to local needs and guaranteeing rapid diffusion processes. Many different incentive systems are in place for university researchers to engage in university-industry collaborations (see, for example, the attempt of the Research Excellence Framework in Great Britain to include not only purely scientific research in the evaluation of British universities, but also the impact of scientists on social, cultural and economic issues).

In the regional innovation system of Opole Voivodship, there is little contact between business and staff from the two local universities. Exchanges between businesses and academics about local labour market needs are much less frequent than in successful regional innovation systems. This is true at both the individual level with many scientists having no contact with the business world and at the organisational level with relatively few attempts to orient curricula and the research agenda towards the needs of the local economy. While in successful regional innovation systems, bachelor, master and PhD theses are often of direct practical relevance or directly conducted with – or even within firms – this is very rare in the Opole region. The universities do not participate in lifelong learning programmes and as a result forgo the chance to inject knowledge and technology into the local economy and enhance the innovative capabilities of firms. The academic incentive system is strongly in favour of basic research, with practically no value seen in collaborating with businesses.

Innovation policy

Successful regional innovation systems constantly strive to improve the networks between the actors of the triple helix. Structures and fulfilment of functions of the regional innovation system are frequently analysed and new vehicles to further improve the system are created jointly by science, business and policymakers. Many broker institutions are in place to mediate between the different sectors of the triple helix as well as between the organisations within each sector (e.g., between different universities). Collaboration between lower levels of different organisations is strongly encouraged and there seem to be high levels of independent decision-making and trust, even at lower levels of organisations. Government plays a crucial role in innovation policy by subsidising innovative projects, often in collaboration with science and businesses, as well as by introducing and reinforcing regulations, (e.g. in the environmental field) which helps create incentives for additional innovations.

In the Opole region's innovation system, a variety of flaws hinder firms and universities from being more innovative and policy measures are insufficient to address these flaws. Innovation policy all too often appears to exclude deliberate consultation processes of all parties involved (i.e., consultation with associations of triple helix members). Management and innovative capabilities of Opole firms are low, and R&D expenditures are, as previously mentioned, only a fraction of the EU average and remain low even when compared against strong regions in Poland. The orientation towards R&D and innovation is not provided in many companies, especially among SMEs. Furthermore, the hierarchical organisational structure and insufficient knowledge sharing within organisations lead to inflexible structures, which hinder innovation activities. Many layers of organisations (e.g., within universities) have to be involved in decision-making processes, consuming time and excessive human resources which cannot be engaged in innovative processes. For the business community especially, working with research organisations on innovative projects demands quick decisions and timely solutions, which are severely hampered by high transaction costs when dealing with university administrations.

Cluster policy

Research on the regional dimension of innovation has a long tradition in economic research, starting with Marshall's (1890) observations of industrial districts. Since Michael Porter (1998), the term "cluster" has quickly become a part of the scientific and political discussion. Cluster refers to "geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialised inputs such as components, machinery, and services, and providers of specialised infrastructure" (Porter, 1998). Policy makers from Europe (see, e.g., Falck *et al.*, 2010) to East Asia (see, e.g., Nishimura and Okamuro, 2011) try to deliberately create clusters to improve the innovativeness of regions. In successful regional innovation systems, cluster initiatives include all relevant actors right from the beginning. Universities, businesses and local policies identify common themes and future technologies, create councils or associations and possibly apply for funding from state or federal governments. By contributing considerable resources, however, commitment from all participating entities is assured. Oftentimes government funding is only supplied if firms and universities agree to contribute substantial own resources. Generally speaking, there are broad attempts to create public-private partnerships (PPP) at regional and national levels. Common idea sharing communities often based on virtual integration rely on well-grounded motives for being in the same flow. Trust is high between individuals and organisations and a tertius iungens attitude is prevalent in several kinds of broker organisations (tangible or virtual) and in profit-oriented firms. This helps to ensure that cluster governance and strategy serve the target group, i.e., the local economy and research community.

In the Opole region, several cluster projects have been introduced as well. However, a large majority of them have ceased to exist after the initial governmental funding ran out. Of the 15 clusters identified here (Rüffer *et al.*, 2015, S. 124), only one was undisputedly identified as a success story during the interviews. Central to the failure of these clusters appears to be a top-down orientation by public policymakers without including any other relevant triple helix parties into decision-making about cluster formation. Clusters were initiated by central authorities, and firms and university researchers are only invited to participate. Because they are set up by central authorities, this leads to passive consumption of the possible benefits of the cluster rather than active participation and co-creation of collaboration surplus.

Conclusion

For the Opole Voivodship to catch up with leading regional innovation systems with regard to knowledge and technology transfer and innovation, trust and collaboration in the region must be improved and fundamental reforms must be made in the public and university bureaucracy. However, improving trust in regional systems is not an easy task, if possible at all. Cultural features such as participation in voluntary organisations and trust in non-family members of a society have deep roots in a society's history (Putnam *et al.*, 1994; Fukuyama, 1996). Improving such features can only be successful if undertaken as a collective long-term endeavour.

The findings of this research are mainly qualitative and have not been tested quantitatively. Therefore, the results introduced above should be considered hypotheses. Although limiting, this can also offer promise for the road ahead for new research in the field of technology transfer and innovation systems. While there has been much qualitative and quantitative research published in the international literature on highly successful regional innovation systems such as Silicon Valley, or strong regions in Western Europe or Japan, the post-socialist countries in Central and Eastern Europe have been largely neglected. The results discussed in this paper can certainly not be generalised for all of Eastern Europe, or even for all of Poland. However, it highlights a potential way forward for scientific literature and improving public policy to shed light on regional and national innovation systems and knowledge sharing in post-socialist countries. The European Union is investing considerable resources in Eastern Europe to improve the local economy and local innovation systems. However, the fundamental flaws and bottlenecks in these innovation systems are not yet fully understood. More research that takes into account cultural factors could be scientifically useful and have the potential to improve the effectiveness of economic policy programmes.

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[3] This chapter is based on research conducted within the EU's European Social Fund project "Effective knowledge transfer from science to industry in the Opolskie Voivodship" (*Efektywny Transer Wiedzy Z Nauki Do Premyslu W*

Wojewodztwie Opolskim). The project and its results are described in detail in Rüffer *et al.* (2015). This chapter summarises some of those results and offers a reinterpretion of them.

Chapter 7

Agricultural knowledge chain – Examples from SLU, Alnarp, Sweden

Lena Ekelund

Introduction

SLU Partnership Alnarp is a regional partnership between research and industry, active at the Swedish University of Agriculture (SLU) in Alnarp, in southern Sweden. The initiative was established in 2004 to meet demand for research results driven by the need for solutions to problems experienced in the agricultural and horticultural sectors[4]. The initiators identified a need for innovation and launched the partnership in collaboration with partners, or members, either from within the value chain or from supporting organisations. The initiative came from the Faculty of Landscape Architecture, Horticulture and Crop Production Science[5], and the core purpose was to create an interface where project ideas and other possibilities for co-operation could be discussed and realised so as to be fruitful for all partners.

Most of the individual partners/members are either connected to primary production, or to what Porter refers to as “the supportive industry”. The Porter Diamond framework (1990) suggests that a firm does not exist in an isolated context, but is influenced by four factors: factor conditions, demand conditions, related and supporting industries, and firm strategy and structure. The framework also takes government and uncertainty into consideration. In the Partnership Alnarp (PA) context, SLU counts as a governmental force together with regional governmental bodies (Region Skåne) and local communities. This much-used framework is a way of illustrating a successful cluster, or region, which corresponds well with the aim of PA, with growth as the ultimate goal. In later years, the concept of innovation has been introduced as a driving force for growth.

The knowledge chain versus the knowledge innovation system

Historically, the framework of knowledge development has often been described as a linear model of intellectual tasks, often called the knowledge chain. However, in recent years a new approach has become more frequent and considers the knowledge model as a system, or network, rather than a chain (EU SCAR, 2012, pp.17-18).

A well-known model of collaboration is the triple helix model, which is built on interlinkages between three pillars – academia, industry and government – and co-operation between them. The concept emerged from a workshop described by Leydesdorff and Van den Besselaar (1994), and became important in the description of partnerships among university, industry and government. Leydesdorff (2005) describes the institutional differentiation of the state from civic society that began in the 19th century and led to science and technology shaping a knowledge-based industry, and, thus, how “knowledge production and control functions increasingly ceased to be the exclusive domain of academia” (Noble, 1979). Science was transformed from a public good to a useful industrial tool and matters in industrial production led to pragmatic solutions to scientific problems. American universities were quick to adopt the functions of an entrepreneur or an innovation organiser (Larsson *et al.*, 2009).

These three pillars, or structures, have been included in PA as trilateral networks and hybrid organisations have long been described as the most prosperous. A recent report from the European Commission describes how these three “interact from time to time with each other, steered rather autonomously by their own development” (EU SCAR, 2012, p. 17) and how this framework stresses the dynamics of networks in the mutual creation of knowledge.

In an OECD-study from 1995, Mårten Carlsson, professor of horticultural economics at SLU, examined the agricultural knowledge system (AKS) in 18 member countries (Carlsson, 1995). The mutual relationship between research, higher education and extension (advisory services) and their relation to industry – and society as a whole – was described. Carlsson argued that the orientation of the knowledge system had traditionally been caused by the development of science and problems within the agricultural sector, where the flow of information went from basic research through basic agricultural research, applied research and development work, to advisory services and professional education of farmers and growers. During the 1990s, research topics became increasingly initiated by other researchers, and at the same time, government funding of applied research and advisory services were cut back. SLU received directives that most applied research should be financed by the agricultural sector or other non-governmental sources. Knowledge networking became a new tool.

Carlsson (1995) describes the AKS as a complicated system built on research, higher education and extension. One of the challenges was the lack of clear correspondence between function and institution:

"These functions (research, education and extension) of the AKS are carried out by different institutions (organizations) like universities, research institutes, experimental stations, advisory service organizations, agricultural schools, and [...] there is no longer a clear correspondence between function and institution." (Carlsson, 1995, p. 3)

Knowledge networking and collaboration has since continued and accelerated. Carlsson's theory was novel at the time of publishing, but later became an established model in the field of agricultural research and education. The focus of the model was to identify a problem in the field of agriculture and find means to solve it.

In recent years, the AKS model has been developed to also include innovation, which can be described as a new way of using knowledge. AKS has been replaced by AKIS, or agricultural knowledge and innovation system. The AKIS concept has been thoroughly presented and developed by the Standing Committee on Agricultural Research (SCAR). The word "innovation" is relatively new, and does not appear frequently in literature until the beginning of the new millennium. However, the underlying mechanisms appear to have been consistent – instead of innovation, focus was on how to make knowledge from research accessible to the target group. With AKIS, the focus has switched from solely solving a problem of farmers or other actors in the agricultural sector to considering the innovation aspect. Here, students can act as a strong driver of innovation, and consumer-driven innovation can also be part of AKIS. For example, horticultural and agricultural producers, who market their products directly to consumers, enjoy unique possibilities of developing innovative products and services (Ekelund and Tjärnemo, 2009). Stenger *et al*. (chapter 8) also describe active and early involvement of all stakeholders as a key success factor to innovation.

Carlsson described AKS as a system for communication and creation of knowledge, for use by the sector and industry. This implicitly indicates what would today have been defined as innovation. In comparison, the EU SCAR report (2012) describes innovation:

"Innovation starts with mobilising existing knowledge. Innovation is a social process, more bottom-up or interactive than top-down from science to implementation. Even pure technical innovations are socially embedded in a process with clients, advisors etc. Very often partners are needed to implement an innovation." (EU SCAR, 2012, p. 9)

Further, the EU SCAR report describes that little is known about the performance of AKIS in the EU, as the systems are built differently in different countries, regions and sectors. There are also different difficulties within the same AKIS system; for example, education and research face different challenges. The report states initially:

"Different parts of AKIS, such as education, extension and research face different challenges. [...] Education is often weakly connected to research, extension and business. Applied research is often reviewed on scientific output, much less on practical relevance. Networking and cooperation between research and extension or farmers groups is crucial and to be promoted. Agenda setting by farmers and food business is more important than just more research dissemination. We therefore advocate a distinction between science driven research and innovation-driven research in the motivation of research." (EU SCAR, 2012, p. 7)

Thus, two problems are identified; lack of involvement by education, and lack of reward for applied science.

Organisation of collaboration

Policies on academic partnerships look different in different counties. In horticultural research and in discussions about competitiveness between countries, the Netherlands is often cited as an example of success and progress. It could be noted that one of the first scientists in horticultural economics was W. Sangers, who in 1968 described the success of Dutch horticulture in terms of a “centre-function”, including business actors as well as research and schools, which would today be called a cluster and put in an innovation context (Sangers, 1969, pp. 18-21).

The EU SCAR report (2012), which presents findings from Finland, the UK, France, Denmark, Germany, the Netherlands, Belgium, Turkey, Estonia, Switzerland, Italy, Latvia and Ireland, but not Sweden, describes the situation as follows:

“Some countries (like the Netherlands and Switzerland) see research and innovation programmes as a policy instrument to reach certain public goals (e.g. regarding the environment) and combine them with other types of regulation. The interaction with innovation in the private sector (like the food industry) is often weak, and not very clearly taken into account in designing policies.” (EU SCAR, 2012, p. 77)

Pannekoek *et al.* (2005) describe how the Dutch greenhouse industry organises its entrepreneurial innovation with a strong focus on co-operation between different stakeholders, such as “chain partners, knowledge institutions and colleague firms”. The clustering of greenhouse companies has been proven to lead to successful innovation and the authors suggest that the more actors along the horticultural production chain are actively involved, the bigger the chances of success. Collaboration between firms and knowledge institutions is described as rapidly increasing and is “becoming the rule, rather than the exception”. (Pannekoek *et al*., 2005)

The tradition from the days of Sangers (1969) is still strong. In one aspect, the Dutch industry seems to have changed, as the authors conclude: “Only the contribution of knowledge institutions is rather limited both in incremental as well as in radical innovation.” (Pannekoek *et al*., 2005, p. 47)

If we turn to Sweden, a regulation (Högskolelagen, 1992) stipulates that universities (and other institutions for higher education) are set up by the state with aims for education, research and development. In 1996, an addition was made, stating that universities shall also “collaborate with the surrounding society and communicate its activities”, which in practice forces the universities and their academic staff to collaborate. Several evaluations have been conducted and have concluded that collaboration has become strongly integrated in research and education.

The responsibility of the agricultural sector has long been at the centre of SLU’s societal focus. One difference compared to many other countries is that Sweden has no special independent institutes for agricultural and horticultural research. The government has demanded that SLU produce knowledge applicable to agriculture, forestry and horticulture to fulfil the policy goals of efficiency, productivity and, later, sustainability. In 2008 SLU’s Board decided that the university should carry out a comprehensive evaluation of its research. This evaluation, Quality and Impact (KoN 09), covered two main aspects: assessment of scientific quality by peer review, and assessment of the utility for society and the sectors as perceived by the stakeholders (industry, public authorities, organisations). SLU was considered to have great potential with public interest and research needs growing in the fields in which the university works. However, SLU was criticised for “conducting research focusing more on problems than on solutions”. The evaluators concluded that “Stakeholders call for greater emphasis on the ‘big picture’, a systemic and more proactive approach, as well as communication adapted to meet the needs of the user and the context.” (SLU, 2016)

In the work that followed at SLU, Partnership Alnarp and other collaborative bodies are often held up as examples of how responses to this criticism have been found. As for “research focusing more on problems than on solutions”, the EU SCAR report (2012) suggests that research can be science driven or innovation driven. The diffusion of science-driven research is linear and is focused on individual organisation, with an economic line of thinking developed with a macro-economic approach. The quality criteria for science-driven research is to obtain high scientific quality. Innovation-driven research instead takes a systems approach where networks are the key focus. Here, the economic line of thinking involves systems of innovations. The quality criteria in innovation-driven research are measured in relation to the sector or the region (EU SCAR, 2012, p. 101). Viewed in this perspective, SLU has taken these aspects into consideration.

How Partnership Alnarp works

The PA project was launched in 2004 with the purpose of creating an interface where project ideas and other possibilities for co-operation can be discussed and realised in a way that is fruitful for all partners. The key stakeholders are actors of the faculty (researchers, teachers, students), agricultural and horticultural firms and organisations, and authorities and sector associations in the region. Among the around 80 partners/members are producer organisations, financial institutions and advisory service organisations, the county government and the Federation of Swedish Farmers (LRF).

PA is organised into six different subject groups: Fruit and Vegetables, Food Crop Production, Bioindustry Production, Animal Husbandry, Marketing and Management, and – more recently – Forestry. In the ten-year period since it began, there have been over 900 activities, including research projects, meetings on-demand (seminars, workshops), annual conferences, student projects (support, thesis projects) and a student mentoring program.

A typical PA project starts with a company/organisation or a researcher having an idea or a problem. The company/organisation or the researcher contacts PA to discuss who should be involved. Once the concept of the project is clear, a formal application can be filed, including a summary, a funding plan and a communication plan. More than 50% of funding must come from the company/organisation. When the application has been processed by a subject group, the Steering Committee takes a decision and the project is ready for implementation. The realisation involves a contract between the partners, as well as a final report, usually discussed with the partners.

Henrik Stridh, former adviser, now director of the biggest fruit grower co-operative Äppelriket:

"Five years ago, scientists in Alnarp were involved with what they thought was fun, usually something that was of little benefit to us. With Partnership Alnarp we are seeing big differences. Now researchers are solving problems we face in the horticultural industry and are keeping in regular contact with us."

Partnership Alnarp is unique in its field, as it combines research with teaching and education. In the EU SCAR report, education is often described as being weakly connected to research, extension and business (EU SCAR, 2012). In Partnership Alnarp, however, students are involved in business cases from the early years of their university education. At the end of their studies, students are invited to conduct their theses or graduation projects at some of the partner companies.

The EU SCAR report also describes online platforms as important tools in the innovation network, to enable the exchange of information and training, as well as communication and networking (EU SCAR, 2012, p. 39). Additionally, the PA platforms for information were found to be important, but onsite meetings of different sizes and face-to-face gatherings are the crucial means of communication. In an evaluation of PA, conducted in 2008, the partners stated that PA's key strength was its role as a meeting point for actors in the sector and within the region. Seminars and conferences were also described as valuable occasions for the partners involved to meet and discuss current issues. Furthermore, the heads of departments at SLU described PA as the most important tool used to communicate research findings to industry, as well as to develop professional networks. Students also described the project as keeping them up-to-date with recent industrial activities and helping them develop their networks (Schroeder, 2008, p. 2).

Other forms of collaboration

Apart from PA, two other forms of collaboration are currently active within SLU in Alnarp.

The first is Partnership Horticulture (Tillväxt Trädgård, TT, http://www.slu.se/en/faculties/ltv/collaboration/1/tillvaxt-tradgard/), a national collaboration between academia and the horticultural industry. The project, set up in 2008, aims to foster growth and sustainable development through such actions as increasing the value of products and increasing competitiveness through innovation. Creating new ways of thinking and collaborating is another objective to TT. The partnership conducts research and development projects and organises other activities, such as newsletters and seminars. TT is funding projects related to horticulture, often including external collaboration with meetings in different regions in the country.

The second is the Swedish Centre for Agricultural Business Management (Kompetenscentrum Företagsledning, KCF, http://kcf.slu.se), a national collaboration that started 2015 which brings together farmers and rural companies with researchers. The aim is to find new ways of improving knowledge and implementing knowledge in business management. The importance of business and marketing was stressed by a government report on the agricultural sector's competitiveness (Konkurrenskraftsutredningen, 2015). The initiative involves a project leader as a bridge to advisory and education (e.g., PhD students). In comparison, PA aims to improve the agricultural industry's competitiveness as well as research and education at SLU Alnarp.

Partnership Alnarp has been an important tool in the development of the agricultural and horticultural industry in southern Sweden over the past decade. Several benefits from the cross-disciplinary collaboration have been achieved and the project is expected to continue contribute to development. However, some recommendations to future improvements of PA can be made. The PA models are expected to be developed further within the near future and project applications are expected to become even more strategic. PA could also be taken from a regional to a national level and applied to other sectors outside the agricultural industry. Improved communication, e.g., through social media, as well as new, business-focused research are also expected to be used to aid development. As previously explained, PA was an initiative from SLU's Faculty of Landscape Architecture, Horticulture and Crop Production Science. There have been discussions about taking the model to the university level to include other faculties as well. As of spring 2016, a part of forestry research (located in Alnarp) has been incorporated, but attempts have not been further developed by SLU.

One problem with science-driven research is that researchers engaged in PA are subject to the same reward system as researchers in general, where scientific publications are counted and judged as quality. Hence, it is not as rewarding for scientists to work on applied science and innovation. This type of work also involves rather small but relatively time-consuming projects, making researchers reluctant to engage in them.

PA solves one of the problems identified by the EU SCAR report (2012) – the involvement of students in the process – while the second – a lack of reward for researchers – remains.

The more applied side of research has become more important, as has the policy goal of increasing the number of students in higher education. The broader goal is to increase democracy. EU policy promotes science in society and the Bologna declaration stresses student employability. The role of the university has thus changed from an institution of "culture and refinement"[6], of the blending of knowledge and education, or research and studies, in the Humboldt tradition, to a motor of innovation for the competitiveness of a region or sector. One might add that there may be a risk in becoming "too applied" in research and education.

To sum up, the challenges for universities are producing both quality and impact as well as providing research-based education; prioritising specialisation and systems thinking and combining different kinds of knowledge from research and from practice; and solving the problem of financing and creating incentives for academics.

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4 The earlier development of Partnership Alnarp (PA) has been described in a conference paper by Larsson *et al.* (2009).

5 Known at the time as the Faculty of Landscape, Horticulture and Agriculture.

6 Swedish: *Bildning.* German: *Bildung.*

Chapter 8

New strategic approaches for promoting the diffusion of innovations within the horticultural sector

Myriam Stenger, Marianne Altmann, Monika Schreiner

Introduction

The diffusion of innovations has become an increasingly important theme in the horticultural business. Within the dynamic environment of rapidly changing socioeconomic and global market factors, a platform that promotes and supports innovation is essential for ensuring constant progress and providing sustainable solutions that lead to a competitive edge within this important sector. In this regard, the German horticultural sector aims to maintain a competitive edge by initiating a range of measures that promote the diffusion of innovations, thereby fostering this sector's future successful development. However, to ensure the sustainable development of innovations, all actors involved in the horticultural value chain must provide a valuable contribution (Bokelmann and König, 2013; Bokelmann *et al*., 2012; and chapter 4). Achieving this requires not only a close exchange between horticulturalists, researchers and politicians, but also an intensification and professionalisation of exchanges between these key stakeholders. Partnership Alnarp in Sweden (chapter 7) provides evidence that this type of close collaboration along with a clear readiness to engage in dialogue will enable knowledge transfer into marketable products as well as the application of new technologies. Moreover, present-day market forces and emerging needs from the horticultural industry should lead to additional ideas and further impetus for new research projects.

Of note is that the importance of close cooperation between research scientists and those involved in the horticultural value chain as well as having multi-actor projects for developing and spreading innovations has been highlighted by the Europe 2020 Strategy (European Commission, 2010). Based on the strategy's objective for strengthening research and innovation, European Innovation Partnerships have been established as a "new interactive approach to innovation" (European Commission, 2015). By bringing together researchers and actors along the horticultural value chain, the agricultural European Innovation Partnership (EIP-AGRI) and the Horizon 2020 framework (European Commission, 2011) aim to ease knowledge transfer between research and industry, thereby increasing efficient and effective innovation processes. However, although the importance of multi-actor projects in innovation processes is widely recognised, few examples of such projects are found in current scientific literature.

This chapter discusses practical experiences and lessons learnt when involving scientific, industrial and political partners in strategic planning processes within the horticultural sector. Based on a project example – the development of a future strategy for the entire horticultural sector in Germany (Schreiner *et al*., 2013) – a detailed strategic approach for innovation diffusion in horticulture is introduced, recommendations for successful innovation diffusion are given, and implications of a targeted strategic approach are discussed.

Forming the future in German horticulture – the mandate

The Federal Ministry of Food and Agriculture (BMEL) provided the mandate to develop a strategy for the entire horticultural sector in Germany. Reduced natural resources, climate change, globalisation and dramatic demographic changes are some of the current challenges facing German horticulture. Our mandate was to devise and develop workable solutions for German horticulture in the future. To this end, the BMEL needs to be (1) provided with detailed recommendations for a master plan and (2) given evidence-based decision-making support from a range of actors. To help optimise horticulturally relevant processes in the future, the participating partners decided to disseminate their newly found knowledge and gain experience as well as provide helpful guidelines for other future actors and partnerships.

Mode of diffusion – structured and participative

The conscious decision of highly inclusive participation was the central methodical approach for developing the future strategy. Involvement of all horticulturally relevant players included experts from directly related as well as cross-cutting fields in the kick-off meeting, strategic workshops and a planned conference in 2013. Considering every opinion and viewpoint led to a general consensus and broad acceptance of the future strategy. Ultimately, this approach helped in the successful diffusion of these innovations.

To ensure the conditions of success from the start of this project, all actors of the horticulture value chain (e.g., suppliers, producers, wholesalers, retailers) and of cross-cutting fields of actions (e.g., communication, education, technology, cooperation) were involved in the development of a future strategy. At the kick-off meeting, experts from different fields were gathered: fresh and convenience products, European horticulture, trade, (chemical) industry, labour market representatives, demographical development and human resources, politicians, consultants and scientists from various economic, natural and engineering sciences. The involvement of a comprehensive and wide range of experts and stakeholders in the kick-off meeting ensured cross-party definition of future challenges to be addressed by the strategy and was regarded as the first step of implementation, and thus the first step of innovation diffusion.

The project future strategy development included five simultaneous subprocesses (Figure 8.1):

— Evaluation of existing academic literature
— Conducting strategic workshops of horticulturally relevant topics identified by the experts at the kick-off meeting
— Reviewing the results of each strategic workshop by the supervising expert committee (SEC)
— Integration of the strategy identification process via various online tools, including a newly formed XING group and online surveys
— Use of press relations, including press releases in journals and newspapers

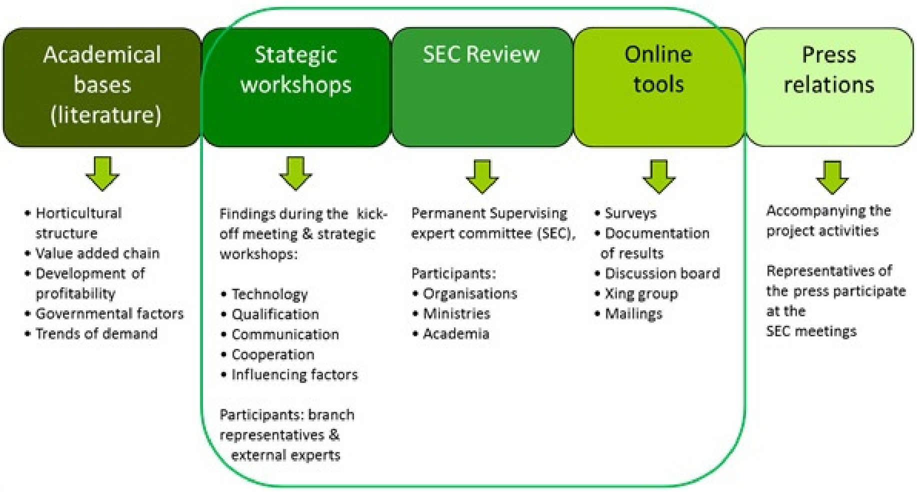

Figure 8.1. Design of the project "Future strategy for the entire horticultural sector in Germany" comprising five simultaneous subprocesses.

In the three core subprocesses – strategic workshops, SEC review and online tools – we again included all horticulturally relevant players as a further step of overall implementation. During the future strategy development process, seven strategic workshops were conducted accompanied by four SEC review meetings. The SEC was composed of a multitude of representatives originating from various stakeholder organisations, ministries and academia, who also acted as informative multipliers. The SEC was envisioned to also support the innovation diffusion process. At the beginning and at the end of the whole process, a conference was organised to initiate and finalise the future strategy elaboration. In all, nearly 300 experts were involved in the entire process for developing the future strategy for the entire horticultural sector in Germany (Figure 8.2).

Figure 8.2. Timeline of the activities in the project "Future strategy for the entire horticultural sector in Germany", SEC.

Since active and inclusive participation was our goal, all stakeholders involved this project were invited to participate in online surveys for implementing suggestions, opinions and additions to the SEC's and other experts' views from the workshops, meetings and conferences. In addition to this online activity, we used the latest technology to help better dissemination of our knowledge and ideas to the public in general and to the younger generation in particular. For this purpose, we set up a new XING group and details of the future strategy were published on Facebook, Hortipendium, Hortigate and Grüne Branche (Green Sector).

Achieving successful innovation diffusion

To address the challenge of developing a future strategy for the entire horticultural sector in Germany, it is important to enforce successful innovation diffusion processes across the entire German horticultural sector. Overall implementation can only be achieved with cooperation from the many stakeholders in the horticultural value chain. From our direct experience of this process, we have distilled seven key guidelines about how to achieve effective innovation diffusion.

— Active involvement is the first step to overall implementation. Active involvement of all stakeholders from the very beginning of the project widens the scope of ideas, creativity and input of existing knowledge in the innovation process. This approach allows the resulting vision to exceed the single contributions of sole actors. Participants experience and are involved in the growing creative stage of the project and become familiar with the innovation process. They also increasingly view themselves as part of the group of innovators rather than as a "lonesome expert". Such development is generally known as the "interactive innovation model". Identification is the crucial point in this phase as it evokes the desire for successful implementation of innovation in the market. This is particularly true for industrial stakeholders who want to implement "their" innovation and do not show any fear of contact. When convinced by the innovation, they take up the role of gatekeepers among their colleagues.

— The research design must be flexible to account for changing requirements. Integrating experts and practitioners from various backgrounds and supporting their collaborative efforts is a learning experience for everyone. Stakeholders must get to know each other and rules for communication and collaboration need to be defined, tested and accepted. Progress depends on the members involved. Therefore, the research design plan should be set up to identify milestones, set timeframes and priorities, define procedures and allocate resources. However, all plans need to allow for adaptations to the "real process" underway. Some groups may require more meetings to implement working modes; others are only successful if experts can work as independently as possible. Sometimes additional experts with their particular expertise should be included at a later stage of the process. The research design must be flexible enough to react quickly to any changing requirements in the innovation process.

— Actively involve practitioners and invest time and a budget for this task. The development of a future strategy for the horticultural sector in Germany included a workshop about technical innovations. Workshop participants quickly brought up a challenging gap between the development of a prototype and market entry, i.e. the starting point for the diffusion of innovation. They discussed various reasons for this issue, such as insufficient financial resources or the fact that research funds are only available until the prototype is tested, or differences in language and viewpoints between scientists and practitioners. Integrating practitioners in innovation processes helps to overcome several of the abovementioned problems, although this is a challenge in and of itself. In this context, our experience was that most practitioners are not spontaneously willing to participate since any involvement in innovation processes takes them away from management and operational tasks in their respective companies. This was found to be particularly true for small- and medium-sized enterprises. Thus, several pre-discussions, convincing arguments and solutions for operational challenges must be considered if these practitioners are to be involved. There is significant risk for underestimating the investment required to make this essential step successful.

— Provide a competent moderator and share ongoing results as soon as possible. If participants recognise that their investment of time, ideas as well as other contributions and resources lead to concrete results, they look at the output and progress rather than at the inputs and costs. Positive results are among the best motivators to encourage further participation in the process. A competent moderator ensures that results become visible in the exploratory stage and are documented afterwards. In addition, adequate moderation supports communication, ensures that everyone gets involved and uncovers critical points which otherwise might be neglected.

— Stick to a proper workshop method. The quality of results and the success of the project are partly based on the workshop method chosen. For developing the future strategy, an open method which allows as much input from the participants as possible was found to work best. The workshop was carried out in such a way that every participant could openly discuss topics with other participants in a nearly all-day conversational environment. Results were collected and reflected on at regular intervals by the whole group, which again enhanced the quality of results.

— Allow adequate time for the innovation developmental process. More than two years were spent on the actual development of the strategy. This is a reasonable time frame for such a large and important undertaking. Key subjects were identified in the working phase and needed to be adequately addressed. In other words, their priority and place in the process had to be defined and experts on this subject, interdisciplinary complementary partners and participants from the whole horticultural value chain also needed to be identified. Time is not only necessary for the preparation of meetings, but also when specific experts are required.

— Take advantage of multi-channel communication. Communication is the channel by which project ideas are disseminated in respect to recognition, appreciation and diffusion of project ideas. Since the target audience usually shows a diverse pattern of information-seeking behaviour, communication policy must include various channels. In the case of the development of the future strategy for the horticultural sector in Germany, an industrywide discussion needed to be initiated. Using social networks, online queries and existing horticultural communication platforms ensured the possibility of feedback and reaction from those who could not be invited to the workshops or SEC meetings.

A multitude of factors will always exist that affect the adoption of the decision of each individual stakeholder in respect to each particular innovation. However, considering the abovementioned key guidelines, we predict that the stimulus for adoption or the changing resistance to adoption (Kemp and Volpi, 2008) will be positively influenced in ultimately accepting the proposed innovations (chapter 2).

Well-equipped for the future – strategic guidelines

The “Future strategy for the entire horticultural sector in Germany” led to three strategic guidelines, generally valid for all branches of the horticultural sector (Schreiner *et al.*, 2013).

The future of horticulture in Germany depends not only on economic, societal and ecological settings, but on active participation by the protagonists in the horticultural value chain as well. To achieve a future outlook that is as positive as possible for the multiple actors involved, they all should position themselves strategically and pool their strengths and resources to enhance their global competitiveness. This approach assumes (1) a clear primary goal including subgoals and (2) the specification of action strategies for which strategic measures comprising various activities must be developed (Figure 8.3).

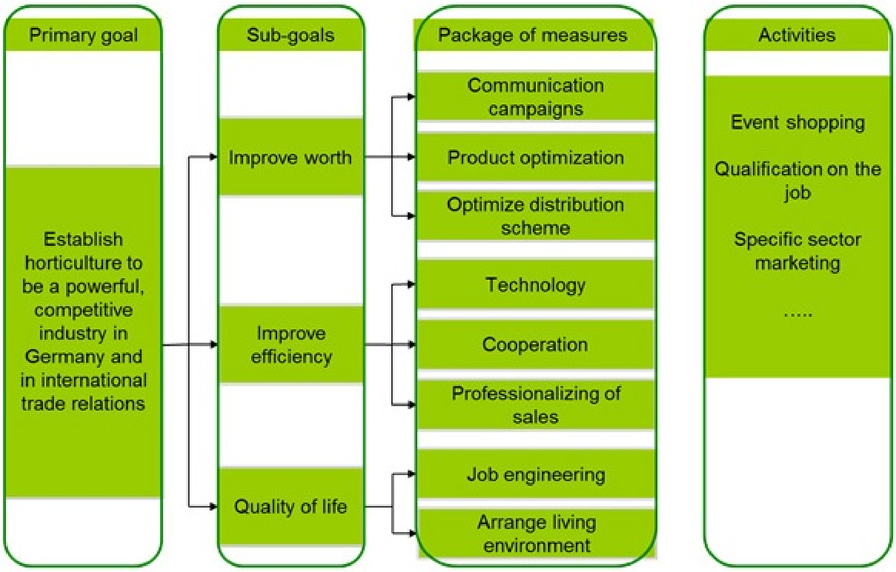

Figure 8.3. Primary goal and subgoals as well as strategic measures comprising various activities of the "Future strategy for the entire horticulture sector in Germany".

The action strategies are defined as guidelines by which the different actors as well as horticultural sector businesses and organisations can develop a dynamic evolution.

It is the primary goal of the future strategy to establish horticulture to be a powerful, competitive industry not only in Germany but also in international trade relations. This primary goal comprises three subgoals:

— Horticulture makes a large contribution to quality of life within German society (strategy to improve quality of life).

— The German horticultural sector has available competitive structures for production and marketing, thereby leading to increased value creation in the horticultural supply chain (strategy to improve efficiency).

— The estimation of horticultural products and performances in horticulture is increased (strategy to improve worth).

Never before in the entire sector of German horticulture was such a comprehensive process for generating knowledge initiated and accomplished with the implementation of a multitude of experts from horticulture and cross-cutting areas. The results of the project "Future strategy for the entire horticultural sector in Germany", such as the strategic guidelines, can be immediately used to promote future performance.

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Final conclusion

Carole Crumley, Bettina Heimann

The numerous and valuable contributions during the conference showed that scientists throughout Europe have taken the need for knowledge distribution and diffusion as a basis for innovation within the agri-food sector and beyond very seriously. Many efforts have gone into trying to include the different players, aspects, drivers, interests and respective problems of creating a platform of mutual understanding and exchange. Clear interest has been shown by our contributors and imperatives have been outlined to identify and tackle the many (moral) dilemmas, trade-offs and constraints that climate change and continued global population growth imposes on our societies and changing demands. The arising opportunities, social as well as technological, were expressed and weighed against the costs, both cultural and economic, and potential pathways for innovations were outlined (Griffon, Bitsch and Ekelund). Specific cases and practical solutions where successful communication was achieved were shared while tools for cooperation between different “knowledge” contributors were developed.

All the contributions in this book share one major message: there is no one solution; multiple strategies must be employed, depending on the particular case and/or area of knowledge creation (Etgen). But knowledge is fodder for developing these solutions and strategies. Diffusion of innovation does not follow a uniform scheme but needs to be adapted to specific obstacles within specific networks of players in specific areas of activity (Bokelmann). Not least, regional specificities of innovation systems require diverse approaches to successfully implement innovation and/or remedy unsustainable “ways of doing” (Rüffer).

Furthermore, innovation must be implemented across the entire value chain (Bokelmann); the primary producer is part of the story told/to be told by the salesman. This will also determine the “value” created by the value chain beyond the purely financial/commercial, including the cultural, geographic and sustainability aspects of a given product and/or service.

However, how is it possible to foster an innovative climate? Innovation requires networks of interested parties that focus on the “whole” problem with its multiple facets and complexities. Multi-stakeholder approaches in research have been introduced into H2020 and the European Innovation Partnerships (EIPs) aim to engage farmers in problem formulation. And yet, the complexity of the problems to be tackled within a complex matrix of players with very different, complex and far from symmetric power relations in very different areas is scientifically, commercially, geographically and socially challenging. Fostering sustainable innovations that can be implemented is a substantial challenge that goes beyond knowledge creation and diffusion.

The involvement of social sciences and the humanities (SSH) in the formulation of many research approaches would be greatly supportive. For example, they can help with methods, perspectives and in-depth interviews for stakeholder involvement (Rüffer). Existing networks link environmental sciences, economics, anthropology, history and geography within an ethical framework, but they need to be applied more widely. And last but not least the natural sciences must include SSH beyond the merely economic dimension in its solution-oriented thinking to improve the diffusion and impact of its research.

The different actors in diffusion and innovation matrices are not only hampered by limited interactions between players but also by conflicting regulations and other constraints beyond their influence that narrow their room to manoeuvre. Private-public partnerships are gaining in popularity and may overcome and/or make visible some of the related problems (Ekelund).

In order to overcome all these challenges the bioeconomy is and should act as necessary vision (Griffon). It will give guidance where direction can easily be lost; when the forest is difficult to see for all the trees.

The authors

Marianne Altmann
CO CONCEPT, 17, rue Glesener, 1631 Luxembourg, Luxembourg

Pascal Bergeret
CIHEAM-IAMM, 3191, route de Mende, 34093 Montpellier cedex 5, France

Vera Bitsch
Economics of Horticulture and Landscaping, Technical University of Munich, Alte Akademie 16, 85354 Freising, Germany

Wolfgang Bokelmann
Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany

Gianluca Brunori
University of Pisa, Italy

Michael Carus
Nova Institute, Chemiepark Knapsack, Industriestraße 300, Gebäude 0611, 50354 Hürth, Germany

Carole Crumley
The Stockholm Resilience Center, Stockholm University, Kräftriket 2B, SE-10691, Sweden

Lena Ekelund
Swedish University of Agriculture (SLU), Sundsvägen 5, Alnarp, Sweden

Michel Griffon
Agence Nationale de la Recherche (ANR), France

Bettina Heimann
EURAGRI, c/Department of Chemistry and Bioscience, Fredrik Bajers Vej 7h, 9220 Aalborg Ø, Denmark

Christian Huyghe
Direction Scientifique Agriculture, Inra, 147 rue de l'Université, Paris, France

Bettina König
Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany

Erik Mathijs
KU Leuven, Celestijnenlaan 200 E, 3001 Heverlee, Belgium

Luisa Last
Zurich-Basel Plant Science Center, Switzerland

Niclas Rüffer
Centre for SME Research and Entrepreneurship – Mannheim University, L9, 1-2, 68161 Mannheim, Germany

Monika Schreiner
Leibniz Institute of Vegetable and Ornamental Crops Grossbeeren and Erfurt e.V. (IGZ), Theodor-Echtermeyer-Weg 1, 14979 Grossbeeren, Germany

Myriam Stenger
CO CONCEPT, 17, rue Glesener, 1631 Luxembourg, Luxembourg

Uno Svedin
Stockholm University, Department of Computer and Systems Sciences and The Stockholm Resilience Center, Stockholm University, Kräftriket 2B, 10691, Sweden

European Agricultural Research Initiative (EURAGRI)

EURopean AGricultural Research Initiative (EURAGRI) is a not-for-profit organisation that acts as a forum for representatives from public research and innovation institutes, universities, funding bodies and ministries engaged in research and innovation in the agri-food sector and the broader bioeconomy. It encourages and stimulates debate on relevant research and innovation policy issues of strategic importance on EU, member state and organisational levels.

It provides members with a network where they can freely exchange views on the impact of policies and technological and societal developments on public research and innovation activities, trends and infrastructures within the field.

The annual EURAGRI conference, hosted in rotation by members in different countries, is the main event when representatives gather to exchange views and ideas. The programme reflects the specific situation of the host but includes a European dimension and often goes beyond.

Additional workshops on pressing and specific issues that require in-depth discussion, as well as input from domains outside the agriculture and food sector, further broaden the knowledge base in which EURAGRI operates.

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