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Common Agricultural and wider bioeconomy reSearch Agenda

SCAR akis
Agricultural Knowledge and Innovation Systems

INVENTORY OF RESEARCH & INNOVATION INFRASTRUCTURES

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The overall objective of CASA, a Coordination and Support Action (CSA), is a **consolidated common agricultural and wider bioeconomy research agenda** within the European Research Area.

CASA will achieve this by bringing the Standing Committee on Agricultural Research (SCAR), which has already contributed significantly to this objective in the past, to the next level of performance as a research policy think tank. CASA will efficiently strengthen the strengths and compensate for the insufficiencies of SCAR and thus help it evolve further into “SCAR plus”.

Executive summary

Research and innovation infrastructures (RIIs) are currently gaining momentum in the debates and approaches to improving knowledge flows in Agricultural Knowledge and Innovation Systems (AKIS). Highlighting the recent trends, this study outlines the main directions on this respect. It elaborates definitions and typologies of the RIIs and develops an inventory of some of them existing in Europe. Moreovover, it draws a broader picture of the RIIs landscape in the selected 5 EU countries: Greece, Italy, Hungary, Netherlands and Poland. Simultaneously, in 3 countries beyond the EU, some major trends in RIIs set up EU were observed: China, India and Israel.

The study revealead profound challenges in defining and mapping RIIs. The main reasons behind these were little specific state of the art in the agricultural context and early stage of RIIs as policy focus in the domestic agendas. Reflecting upon the major achievements from the SCAR-AKIS work, the EU policy documents and FP7-funded projects, as well as vast academic and non-academic literature, main lines in defining and set up of RIIs were identified. In addition, the results of this study derived from the contributions of the SCAR-AKIS members, a thorough desk research and survey with the selected RIIs representatives.

Basing upon the various knowledge streams, this report concludes with highlighting the main trends in the RIIs development and recommendations for improving the current practice. On these regards, the results of this initial study show that the renewal of European R&I policy and the management of innovation funds under the Common Agricultural Policy has undoubtedly contributed to the proliferation of a variety of infrastructures devoted to facilitating knowledge flows and strengthening the functions of know-how co-creation, through their participation in partnerships for innovation (EIP-AGRI).

One of the key challenges to be met in this respect is to recognise the capacities of stakeholders involved in RIIs at the national level. Understanding the ongoing transition processes, especially the shifts from the traditional research-oriented infrastructures towards the ones based on the innovation as central objective remains an ambitious task. However, there is a visible transition in several countries in this respect. An increased attention needs to paid also to improving the knowledge flows in the AKIS, based on the knowledge transfer, exchange and co-creation.

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1. Introduction

A specific issue regarding interactive innovation approaches, is cross-border collaboration as each country has its own science and rural development policy to address specific issues and challenges. A major challenge to realising a European Research Area (ERA) is to focus to common rules and procedures between EU MSs for R&I programmes and in that way create a real European 'market' for science and scientists as well as innovation and development. This could facilitate researchers to match proposals from different programmes by opening the market to institutes and actors from other countries. That does not mean that national or regional authorities should give up their R&I strategy and agenda-setting processes. Yet, R&I programming based on national agendas could be organised in such a way that EU added value is generated and that the best results are obtained.

This includes an optimal level of international collaboration to prevent overlap and duplication in R&I and investments in R&I infrastructures, to benefit from efficiency of scale and spill-overs and to create further specialisation in the research system. The aim should be to organise R&I in such a way that it is supported by the pooling of resources (such as in the ERA-NETs and JPIs). However, the EU AKIS are still as diverse as its 28 Member States, leading to different R&I agendas per country and diverse strategies to reach impact. Various AKIS actors in different countries work on similar broad objectives, namely sustainable agricultural production and consumption. However, they work apart from each other, even on challenges which are identical to other member states. The EU is currently investing nearly 4 billion euro in agricultural R&I within Horizon 2020. Yet, building the ERA is still in its initial phase and a long-term process (European Commission, 2016). Research exchange between EU Member States remains limited, which may be partly due to a lack of national financial means.

The study described in this chapter (3.3) was oriented on mapping existing practices and highlighting R&I Infrastructures (RIIs) within AKISs in the EU to improve knowledge flows. The study was assigned to the SWG SCAR AKIS[1] and. A vast number of RIIs were identified at both domestic and transnational level. This section presents an overview of inspiring examples in the EU and beyond, as well as the strengths, weaknesses and highlights of RIIs to learn from within an EU perspective. The international examples presented from outside the EU, are situated in the countries that are leading investors in agricultural R&I: China, India and Israel. The results of this study feed into: (1) improving the integrated approach within the EU agricultural knowledge and innovation systems (AKIS) and the Implementation of the European Innovation Partnership (EIP), (2) the identification of synergies between RIIs, including facilities i.e. AKIS supportive infrastructures.

2. Lessons learnt from earlier AKIS studies

[1] Funded by the EU CASA project of the H2020 Programme under the Grant Agreement no. 727486

While studying the role of RIIs, it is first of all important to have a better overview of knowledge flows in multi-actor interaction, AKIS and the impact of agricultural R&I as background information. Therefore, we reviewed the lessons from previous related EU studies. Collaboration between multiple actors in learning and innovation networks, is essential for both developing knowledge together and exchanging results and experience to valorise knowledge in practice. AKIS in EU differ and have unique characteristics. Therefore, we need to gather better insight in the structures and interconnections between the different AKIS in the member states. Furthermore, we need to understand more about the impact of agricultural R&I projects and actions.

The 2010-2013 **SOLINSA** project aimed to identify barriers to the development of Learning and Innovation Networks for Sustainable Agriculture (LINSA[2]). SOLINSA provided recommendations on strengthening LINSA potentials, self-awareness and capabilities, improving alliances between LINSAs and AKIS and enhancing the LINSAs scope in new networks and in the EIP context. In enhancing LINSAs, it is required to take into consideration: the process character and powerful dynamics of social learning, the various phases of the diffusion of innovations and the complexity of networking and the diversity in multi-actor-networks. To improve alliances between LINSAs and AKIS, dissemination of LINSA activities and results, authors recommended the recognition of LINSAs to be promoted. Support should be provided to intermediary persons who have the authority and trust of the LINSAs for further development. Transdisciplinary and participatory research projects should enable collaborations between LINSAs, researchers and other sectors. Cross-sectoral participatory trainings and conferences could be established to support LINSA. The networks need open, but protected spaces for creativity, experimentation, for trial and error to set impulses for the development of innovation. Links with EIP-AGRI can be established, e.g. because certain LINSAs could offer a long-term structure which allows to continue what was developed in projects in the EIP context.[3]

The **PRO-AKIS** project compiled an inventory of the AKIS organisations, institutions and their linkages in the 28 EU countries (www.proakisinventory.eu). Although there are similarities between AKISs, we are far from a unified EU AKIS system. Each MS has its own (based on the regulatory framework) ownership of research institutions and advisory system, structure of education, sources of financing, characteristics of farm-holding and farm-holders, their needs and expectations as well as the necessity of the implementation of CAP and local agricultural policy. They differ, among others, in: historical conditions, the number of actors, the number of levels (national, regional or mixed level), sources of knowledge and information, sources and system of funding, ownership of advisory service organisations / companies, models of AKIS organisation, leadership and management. As a result, linkages between AKIS' actors vary from formal to informal, and from strong to weak. All, this differs per MS, therefore the PRO-AKIS project could not draw general conclusions on the overall EU AKIS. However, from the exchanges on the diversity in AKIS systems a lot can be learnt, and the results of the study also illustrate the relevance of building on existing knowledge systems rather than starting from scratch.

[2] www.solinsa.org
[3] http://www.solinsa.org/fileadmin/Files/newsletter/FACTSHEET_6.pdf

From the **IMPRESA** project[4] and the **SCAR SWGs Policy Brief on Programming R&I for improved impact**[5], we learn that the estimated internal rates of return of investment of agricultural research are between 7% and 15%, and the time lag of research effect on productivity takes many years. If we look at innovation in particular, the cycle from initial research to effects on ultimate beneficiaries is sometimes longer than the career span of the lead researcher because of institutional constraints (particularly the need to predict impacts before projects begin), stifle creativity and innovation and unplanned coincidences, along with the role of motivated individuals which is key. Innovation intermediaries play an important role in reaching impact. While private research mostly affects improved and consolidated output (on the short term), publicly financed research in general addresses more the global strategic development goals on the longer term which makes it more difficult to monitor and evaluate effectivity.

Furthermore, there is no coherent information about the multiple actors involved, nor their involvement in agricultural research which leads to duplication risks, gaps in R&I and inefficient knowledge valorisation. To improve efficiency in impact of agricultural research, the development of a culture of impact is required. Changes into co-design and co-delivery approaches, novel procedures for selection and review of research projects are required, Greater engagement of multiple actors in the research process and improved agricultural R&D statistics and understanding of trends in research structures, topics and capacities are essential, as well as changes in ex-ante and ex-post evaluation. Public expenditure on agricultural research needs to be better targeted. And to that effect, researchers should be trained in multi-actor and co-creative working methods. Furthermore, researchers should get improved incentives for their role in innovation processes in society, rather than the dominant current incentives limited to the scientific world.

3. Definitions of R&I infrastructures

Defining RIIs is a challenging task. Most definitions (solely) refer to research infrastructures (RIs) and additionally, knowledge infrastructures (KIs). Since 2006, the EC has used the following working definition on RI: “facilities, resources and services that are used by the research communities to conduct research and foster innovation in their fields. Where relevant, they may be used beyond research, e.g. for education or public services. They include: major scientific equipment (or sets of instruments); knowledge-based resources such as collections, archives or scientific data; e-infrastructures, such as data and computing systems and communication networks; and any other infrastructure of a unique nature essential to achieve excellence in research and innovation. Such infrastructures may be 'single-sited', ‘virtual’ or 'distributed” (European Roadmap for Research Infrastructures, 2006).

This definition covers major equipment or sets of instruments, as well as knowledge resources such as collections, archives and databases. RIs may be ‘single-sited’, ‘distributed’, or ‘virtual’ (the service being provided electronically). They often require structured information systems related to data management, enabling information and communication. These include technology-based infrastructures such as grid, computing, software and middleware. The role of RIs is to offer high quality research

[4] Information about the H2020 IMPRESA Project is available at: www.cordis.europa.eu/project/rcn/110944/factsheet/en.
[5] www.scar-europe.org/index.php/akis-documents

services, thus helping the scientific community and playing a key role in the construction of an efficient R&I environment. Because of their ability to assemble a 'critical mass' of people, knowledge and investment, they contribute to national, regional and European economic development (Borgman et al., 2013). These research infrastructures can be single-sited or distributed or an e-infrastructure and can be part of a national or international network of facilities, or of interconnected scientific instrument networks.

To allow EU funding, the infrastructure should offer top quality scientific and technological performance that is recognised as being of 'more than-national relevance', offer access to scientific users from Europe and beyond through a transparent selection process based on excellence and have stable and effective management. According to DG R&I's6 the action plan on long-term sustainability of RIs the following elements should be included: (1) ensuring R&I at the forefront of scientific excellence; (2) configuring European RI as skills development and mobility actors; (3) unlocking RI potential and stimulating industry engagement; (4) boosting RI impact, value and benefits of RI; (5) enhancing RI as the pillar for data production and sharing ; (6) ensuring effective governance and sustainable life-cycle management and (7) promoting European RI in the international arena.

In recent decades the definitions of infrastructures have flourished, expanding from physics-based machines to incorporate any centre of knowledge or facility which is the core of a particular research discipline, such as a database or a collection. In a technological view of research, RIs are identified as cyberinfrastructures and digital infrastructures. The term **cyberinfrastructure** is used by Unsworth (2006)[7] 'to denote the layer of information, expertise, standards, policies, tools, and services that are shared broadly across communities of inquiry but developed for specific scholarly purposes. A cyberinfrastructure is something more specific than the network itself but it is something more general than a tool or a resource developed for a particular project, a range of projects, or, even more broadly, for a particular discipline. For example, digital history collections and the collaborative environments in which to explore and analyse them from multiple disciplinary perspectives, might be considered to be cyberinfrastructures. Whereas fibre-optic cables and storage area networks or basic communication protocols would fall below the line of cyberinfrastructure' (Unsworth, 2006). **Digital infrastructures** are defined as 'shared, unbounded, heterogeneous, open, and evolving sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities' (Tilson, Lyytinen & Sørensen, 2010).

In a more cultural perspective, Badenoch & Fickers (2010) define infrastructures as mediating structures within the research ecosystem. They 'are the structures in between that allow things, people and signs to travel across space by means of more or less standardised paths and more or less standard protocols for conversion or translation. Thinking of infrastructures as mediating interfaces, as points of interaction and translation on material, institutional and discursive levels, allows us to get to the heart of the dynamics we seek to capture.' Edmond (2013) states that 'in its widest sense, an infrastructure allows us as finite individuals to achieve beyond our individual capacity to know, to do, to see'. In this view, infrastructures are seen as something which allows people to go beyond their own capacity to know and to do, thus increasing their potential.

[6] http://ec.europa.eu/research/infrastructures/pdf/ri_policy_swd-infrastructures_2017.pdf

[7] "https://www.ideals.illinois.edu/browse?type=author&value=Unsworth,%20John"

Edwards et al. (2007) focus on the knowledge creation processes. 'Infrastructures get below the level of the work, i.e. without specifying exactly how work is to be done or exactly how information is to be processed. Most systems that attempt to force conformity to a particular conception of a work process, have failed to achieve infrastructural status because they violate this principle. By contrast, email has become fully infrastructural because it can be used for virtually any work task.' Alongside the definitions of RIs, we also find various descriptions of KIs. Edwards (2010) describes knowledge infrastructures as 'robust networks of people, artifacts and institutions which generate, share, and maintain specific knowledge about the human and natural worlds.' This definition is very similar to the early definition on AKIS given by Röling (1990): the Agricultural Knowledge and Information Systems (AKIS) is 'a set of agricultural organizations and/or persons, and the links and interactions between them, engaged in such processes as the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working synergistically to support decision making, problem solving and innovation in a given country's agriculture or domain thereof.'

Based on the definitions from literature, **we broaden the definition of RII** to the conglomerate of people, institutions, tools, facilities, which are engaged in the generation, capturing, preservation (organisation, storage, retrieval) and diffusion of different resources with the purpose of empowering and extending innovation in EU agriculture (Figure 1). This definition does not only focus on knowledge and innovation development as the centre of attention but looks beyond research communities by identifying flows of knowledge for co-creation, knowledge exchange, transfer and learning between multiple actors. Tools and facilities (the technological and technical elements of infrastructures) are components of a larger mechanism which include the generation, capture, preservation and diffusion of resources (knowledge management) (Weinberg, 1963). They allow to share and maintain resources, while other entities, both at an individual level and institutional level, provide the social elements necessary to capture and sustain knowledge production, through networking for both practical and theoretical collaboration (Weber, 2011).

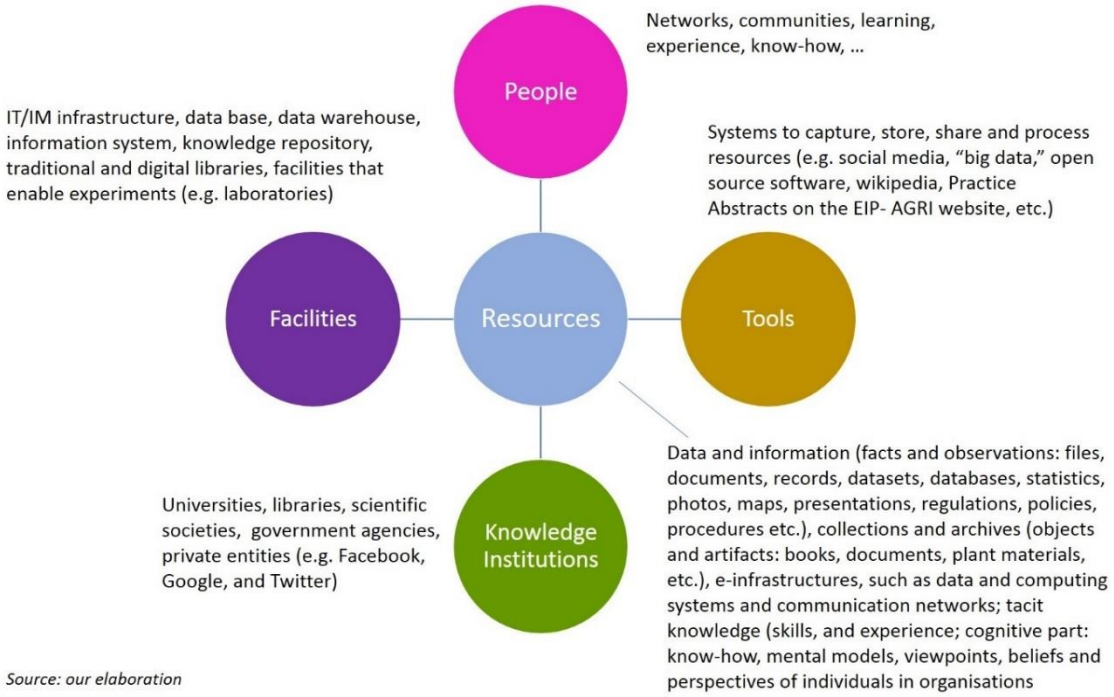


Figure 1 Definition of RIIs.

4. Typology of R&I Infrastructures in the EU

To enhance learning and innovation between multiple actors in networks, to improve knowledge flows in AKIS and to increase the uptake of project results for innovation, a shift is required from linear driven research for innovation to demand driven, multi-actor R&I. Three types of interconnected knowledge processes can be distinguished: co-creation, knowledge exchange and knowledge transfer (adapted from Lans et al., 2006[8]; Geerling-Eiff et al., 2006[9]). The nature of the R&I demand determines whether co-creation, knowledge exchange or transfer is dominant (see Figure 2)

[8] https://edepot.wur.nl/29235
[9] http://library.wur.nl/WebQuery/wurpubs/fulltext/42190

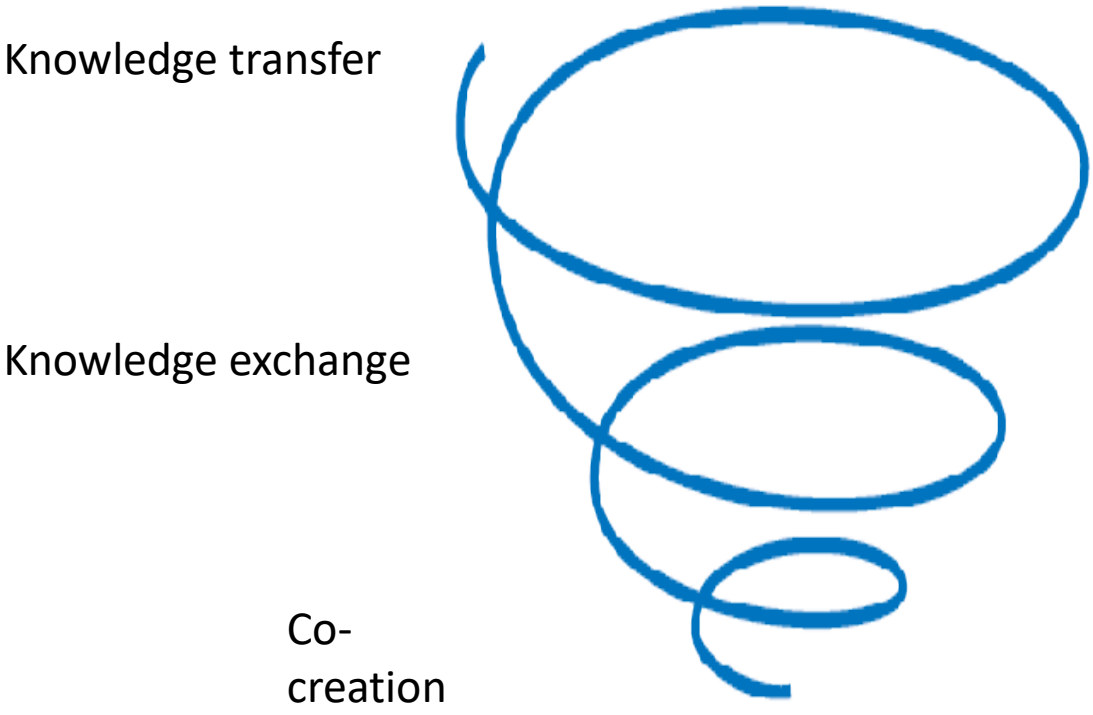


Figure 3 Knowledge process. Source: own elaboration

1. Co-creation: is the process in which multiple actors search together when there is uncertainty about the direction of development, in a co-decisive process ('multi-actor');
2. Knowledge exchange: refers to ccommonly seeking certainty through sharing and combining existing knowledge. The aim of the solution is (still) unknown
3. Knowledge transfer: occurs when the solution is decided and known but may still need to be adapted to its intended use. Transfer refers to the communication of explicit knowledge.

During the SWG SCAR AKIS meeting in Brussels on 30 and 31 October 2018, several RIIs in the MSs were identified in a participatory exercise with the participants. Based on our definition of RIIs and this inventory, different institutions, networks, enabling tools and facilities were distinguished which all support co-creation, knowledge exchange and knowledge transfer in R&I. Research institutes have their own infrastructure to disseminate the knowledge created by their researchers, often in cooperation with other actors, as well as networks create an appropriate infrastructure together with multiple actors and organisations. Enabling tools need institutions and networks to co-create, exchange and transfer knowledge and vice versa. While networks and institutions are considered as the organisation by teams of people making knowledge valorisation possible, enabling tools can be considered as the hard (physical) and soft (approaches, strategies) supportive infrastructures. Naturally most 'knowledge' cannot be 'transported' that easily. Each actor has his/her role in knowledge co-creation and valorisation. In

studying different RIIs, we distilled the following six RII types, including some subcategories. Note that in practice, these types not always function in separation and that different mixed situations exist.

1. *Applied Research Institutes (ARIs)*	ARIs are organisations which focus on making research results applicable for different target groups. This work can be either based on scientific research or applied research. The output of applied research institutes depends on the demand of the end-user, which could be products, services or processes which can be implemented in practice. ARIs are not or not as restricted to scientific output, since science is not the main target field as universities. Projects are often assigned by policy makers, the industry or NGOs. R&I activities and projects are either publicly, public-privately or privately financed. Many EU countries have institutes which perform applied research for agriculture, next to agricultural universities.
2. *Research Infrastructures*	RIs are facilities, resources and services used by the science community to conduct research and foster innovation. By pooling effort and developing RIs, European countries can achieve excellence in highly-demanding scientific fields and simultaneously build the European Research Area (ERA) and Innovation Union. They include: major scientific equipment, resources such as collections, archives or scientific data, e-infrastructures such as data and computing systems, and communication networks. RIs can be single-sited (a single resource at a single location), distributed (a network of distributed resources), or virtual (the service is provided electronically).' There is no EU research infrastructure which addresses agriculture specifically (yet).
3. *Experimental or Research Stations*	An agricultural experimental station (AES) or agricultural research station (ARS)[10] is a centre where researchers cooperate with agricultural entrepreneurs, chain partners, advisors, extension agents and other actors on difficulties, potential improvements, competences and skills on agri-food production and agribusiness. Many agricultural experimental stations are (linked to) national or regional agricultural universities or are applied research institutes.

[10] https://en.wikipedia.org/wiki/Agricultural_experiment_station

4. *Innovation Hubs (digital innovation hubs, agri-business parks)*	The most well-known and probably one of the oldest Innovation Hub is probably Silicon Valley which is referred to as 'a community which fosters technological trends, innovation, and industry-specific insights'[11] Within the EIP-AGRI framework, member states have invested in innovation support services or "innovation hubs" to help emergence and development of EIP-AGRI Operational Group innovative projects. In such hubs, a common feature are "innovation brokers", who help actors with an innovative idea to connect with other actors having complementary knowledge who can help developing the solution. EIT[12] Innovation Hubs 'focus on developing innovative products, services and training in a specific area of their Innovation Community, taking targeted actions to help overcome key challenges in that field. Each Innovation Community operates with its own management, legal structure and business plan and has its own clear, measurable objectives to deliver value to its partners and EU citizens. EIT Innovation Hubs constitute the backbone of their Innovation Community and should have a strong management, enabling collaboration within the Hub itself and with partners from other hubs. There should be an inbuilt simplification agenda to keep overheads and management costs low.' Innovation hubs can be both physical locations such as agri-business parks or campuses or virtual such as digital innovation hubs.
5. *Dissemination infrastructures and Repositories*	Infrastructures and repositories for knowledge dissemination are both hard and soft enabling facilities and tools or settings, to support the collection and transfer of knowledge. Types of infrastructures for knowledge transfer are: (1) *Databases:* a database is an organized collection of data generally stored and accessed electronically from a computer system. Where databases are more complex they are often developed using formal design and modelling techniques[13]; (2) *(Digital) libraries:* a digital library, digital repository, or digital collection, is an online database of digital objects that can include text, still images, audio, video, or other digital media formats. In addition to storing content, digital libraries provide means for organizing, searching, and retrieving the

[11] https://medium.com/@RussellMoopa/silicon-valley-innovation-hub-of-the-world-1925278c6289.
[12] https://eit.europa.eu/eit-innovation-hubs
[13] https://en.wikipedia.org/wiki/Database

	content contained in the collection[14]; (3) *Knowledge reservoirs:* a participative tool to host all existing knowledge developed by research or derived from practical experience. All actors involved who want to share their documented knowledge can contribute to this web archive, by uploading videos, images and documents to disseminate their insights to multiple end-users.
6. *(Other) R&I Networks and Clusters*	R&I Networks and Clusters are groups of actors, homogenous or heterogeneous, who collaborate on co-creating, circulation and/or transfer of knowledge. They can have a formal or informal character and work on various technology readiness level (TRL) R&I activities.

5. Types of RIIs in 5 EU member states

In this section several RII types in 5 different EU member states are described as cases. In some case descriptions some RII types are lacking because either they are not present in the respective country or insufficient information could be retrieved in our analysis.

[14] https://en.wikipedia.org/wiki/Digital_library

5.1 Greece

Introduction

The Greek AKIS is highly fragmented. At the national level the main actors are the Ministry of Rural Development and Food (MRDF), ELGO DIMITRA (incorporating the ex-semi-autonomous organisations NAGREF, OGEEKA, AGROCERT and ELOGAK), Higher Education Institutes (HEIs), private companies (branches of transnational companies) and PASEGES (Pan-Hellenic Confederation of Unions of Agricultural Co-operatives). At the local (municipality) level, the main actors are the Municipal Agricultural Production Offices (ex-Agricultural Extension/Rural Development Offices), local cooperatives (Coops Union branches) and, of course, individual farmers.

Such a structure, along with the breakaway of research and (farmers') training from the Ministry into semi-autonomous organisations, has led to extremely weak linkages among the main public AKIS components. Agricultural R&I in Greece is characterised by a high concentration of research and competences in universities and the underperformance of the private sector, mostly due to difficult access to finance. The public research system, as a whole, is largely insulated from the private sector. Knowledge and service provision is largely carried out by private companies (branches of transnational companies) through private agronomists and input shop owners at the local level, since the Greek Extension Service has been gradually involved in fulfilling administrative bureaucratic tasks to access EU programmes (Koutsouris, 2014).

In the programming period 2014-2020, RDP measures have been applied to shape up AKIS. Particularly, M01, M02, M16 have been moved under one Implementing Authority for closer planning and implementation links. New actions have been undertaken to enhance knowledge flows within the AKIS and to strengthen links between research and practice, such as the organisation of national thematic networks aimed at gathering all the AKIS actors and the setting up of systems of exchange of information. This includes the development of e-infrastructures. Among the other measures are the establishment of an advisory and monitoring group bringing together research and universities, the MRDF, ELGO-DIMITRA and chambers of commerce.

Applied Research Institutes

In Greece, applied research in agriculture is mainly performed by ELGO-DIMITRA[15] which provides scientific and technical support to the MRDF in planning and supporting the implementation of national and both Common Agricultural and Fisheries Policies. It is directly involved in research, knowledge and technology dissemination, advisory services and agricultural vocational education and training. It is also actively involved in the creation (new varieties), conservation, production and marketing of seed. Through its laboratories, facilities and technical equipment, it provides also analysis services and targeted advice. It runs six schools, which are specialized in different sectors and a number of vocational training centres, covering almost all the Regional Units of the country. ELGO-DIMITRA interacts with a relevant number of other R&I infrastructures and actors (farmers, farmers' associations, producer groups, cooperatives, municipalities, regions, input producers, food industries, universities and other private and public bodies), due to the different activities and services it provides. Because of

[15] http://www.elgo.gr/

that, ELGO-DIMITRA promotes and facilitates the exchange of knowledge among the AKIS' actors, co-produces and co-disseminates knowledge.

Experimental and/or research stations

A good number of experimental and/or research stations operate in Greece, reporting to ELGO-DIMITRA and the Ministry of Agriculture. The independent Benaki Phytopathological Institute[16] is also a research station.

Innovation Hubs

The Development Agency of Karditsa (AN.KA[17]), aims at implementing programmes and projects for the development of both rural and urban areas of the Karditsa district. It works on a regional scale. AN.KA has established a permanent cooperation with Research Centres, Universities, Technological Institutes, Development Agencies in Greece and in Europe, as well as services of both the public and private sectors. Such cooperation ensures effectiveness, transfer of know-how and follow-up of the recent development process. AN.KA includes an *incubator service*[18] within its activities. The incubator provides pre-startup services, offers space for the head office, raises awareness of candidate members, provides secretarial support and inform visitors who are interested in the initiative. The incubator supports or hosts more than 15 collective schemes, among which 5 agricultural cooperatives that are part of a local network transformed into the '*ecosystem of collaboration*'.

Another hub for innovation is AGROECOPOLIS[19], a very young, grassroots non-profit, non-governmental organisation. It is the Hellenic Network for Agroecology, Food Sovereignty and Access to Land. It actively promotes different models of connecting consumers and producers, such as the Community Supported Agriculture (CSA), the safeguard agricultural land through practices of communal ownership and usage, as well as participatory action research. AGROECOPOLI acts as a hub for networking, experience sharing, training, facilitation and provision of resources for groups (formal or not) which work on similar fields. It helps existing initiatives and start-ups by providing counselling and training on ethical solidarity economy and human relations issues. Furthermore, it works for farmers' autonomy and self-sustainability by teaching farmers how to be independent in the growing practices based on the principles of agro-ecology, permaculture, biodynamics, regenerative agriculture and natural farming. So far, it has no other connections.

Dissemination infrastructures and Repositories

OPENSCREEN-GR[20] is an open-access infrastructure for the discovery of bioactive molecules, using molecular target-based screening technologies. It develops new technologies and provides access to the service, application and product developing sectors of the national economy, as well as spin-off companies, SMEs and larger companies interested in producing innovative products and applications. This is realised in collaboration with academic researchers by enhancing interactions and promoting collaborations between the academic and industrial communities, to which it also offers extensive training opportunities. OPENSCREEN-GR facilitates the exchange of

[16] www.en.bpi.gr
[17] www.anka.gr
[18] www.forum-synergies.eu/bdf_fiche-experience-178_en.html
[19] www.forum-synergies.eu/bdf_fiche-experience-151_en.html
[20] www.openscreen.aua.gr

knowledge and promotes technology transfer to be used for developing innovative solutions to specific problems in both Human and animal health and agriculture.

Furthermore, the Mediterranean Agronomic Institute of Chania (CIHEAM-IAMC[21]) is the 4th constituent institute of CIHEAM, a Mediterranean intergovernmental organisation which is devoted to the sustainable development of agriculture and fisheries, food and nutrition security and rural and coastal areas. CIHEAM-IAMC provides post-graduate specialised education, networked research, facilitation of regional debate. It offers laboratory services and manages a seed bank, holding collections of endemic, rare and threatened wild plants as well as other wild and landraces of cultivated plants. The Botanical garden holds a collection of endemic and threatened plants for demonstration and education purposes. The herbarium preserves specimen of Mediterranean plants and provides all the required facilities for taxonomic identification of plants of the Eastern Mediterranean region. CIHEAM-IAMC also hosts a broad library on agricultural knowledge.

5.2 Hungary

Introduction

The Hungarian AKIS is fragmented in terms of structure and cooperation between its different elements is still insufficient. Apart from relevant ministries for agriculture and environmental concerns, the main players are: Hungarian Chamber of Agriculture (NAK, the most important producer association representing diverse agricultural sectors), extension services, consisting of a farm advisory system, a farm information service, a network of village agronomists, partial and commercial service providers. The education sector includes mainly agricultural, horticultural and veterinary universities and research centres in Debrecen, Szeged; Gödöllő; Kaposvár; Kesz-thely, Budapest and Mosonmagyarovár. Other important players involve dedicated vocational schools (46), mostly belonging to the Ministry of Agriculture. Research sector is mainly concentrated in the National Agricultural and Innovation Center (NARIC), the Hungarian Academy of Sciences and Universities.

Hungary took a strategic approach to developing RIIs through setting up the National Research Infrastructure Committee (NKIB), established on the initiative of the President of the National Research Development and Innovation Office..[22] A national Roadmap was developed in this framework, highlighting the key directions for the Hungarian R&I.[23] Agricultural RIIs became embedded into two distinct domains: (1) the domain of health and food sciences: the Hungarian Academy of Sciences Centre for Agricultural Research[24] – coordinating body for agriculture and food research; and (2) the domain of environment: the Hungarian Academy of Sciences Centre for Ecological Research[25] – coordinating body for biosphere, ecology and agriculture.

From the establishment of BIOEAST initative the Ministry of Agriculture and the HCA have being operated as an informal sectoral RII working group, the NAKIT. The

[21] www.iamc.ciheam.org/
[22] Nemzeti Innovacios Hizatal (2014): Research infrastructures in Hungary. Report
[23] Hungarian National Research, Development and Innovation Office (2018): National Research Infrastructure Roadmap. Documenthttps://www.esfri.eu/latest-esfri-news/hungary-publishes-its-national-research-infrastructure-roadmap
[24] http://www.agrar.mta.hu/en/main_page
[25] https://www.okologia.mta.hu/en/node/2

agricultural research and innovation working group is an effective coordinative tool which ensures communication between national stakeholders, common determination between strategic research and innovation orientation, verification of regulations and laws, motivation to participation in international calls, finally knowledge transfer for farmers about the most relevant and latest research results. Its main objective is to guarantee the enforcement of sectoral and governmental interests and the coordinated operation of domestic agricultural research. On the NAKIT platform coordinated by the Ministry of Agriculture all the research institutes and their annual working plan can be found in order to provide information to the stakeholder for better national research program's synergy.

Applied Research Institutes

The most important applied research institutes in Hungary are grouped under the National Agricultural Research and Innovation Centre (NARIC, supervised by the Ministry of Agriculture) and several faculties and research institutes of the agricultural universities. It operates through a network of diverse institutions located across the country and characterized by different quality standards. The central objective of the infrastructure is to coordinate the efforts in a systematic way. Another key player are the MTA ATK consisting of several research institutes. One of the applied research institutes in Hungary is the Agricultural and Food Research Infrastructure Group. The group consists of 9 units, experimental systems of the MTA ATK institutes, several research institutes of the National Agricultural Research and Innovation Centre[26] (supervised by the Ministry of Agriculture) and several faculties and research institutes of the agricultural universities. It operates through a network of diverse institutions located across the country and characterized by different quality standards. The central objective of the infrastructure is to coordinate the efforts in a systematic way. The thematic scope comprises numerous fields of basic research such as: physiology, genetics, genomics, molecular biology etc., as well as applied research on: plant breeding, production technology, precision agriculture, the food industry, etc. Dedicated projects supporting the development of this infrastructure are also implemented, such as the 'Creation of metabolomics platform in support of agricultural research'. Further development of the infrastructure is expected, based on the elaborated plans. The group is also intended to strengthen the participation of Hungary in the international R&I networks. Hence, efforts are undertaken to coordinate this and consequently make Hungarian research more competitive. The coordinator is the Hungarian Academy of Sciences Centre for Agricultural Research.

Another group of applied research institutes in Hungary is the Biobanks and Animal Core Facilities Research Infrastructure Group. The Hungarian biobank network is a distributed R&I infrastructure consisting of 35 members operating under the license of the State Public Health and Medical Officer Service. Within the group, 7 animal core facilities have been identified. However, not all existing biobanks in Hungary joined the network. The group is coordinated by the Semmelweis University. The main tasks are supporting the collaboration between the biobank facilities across the country, harmonization of their facilities, quality assurance and Hungary's participation in the relevant international networks (such as BBMRI ERIC and MOLMEDEX). The infrastructure has a strong focus on the digital technologies and developing a large national database focused on the storage of genomic data. Affiliated biobanks are used by the universities for basic and applied research, providing data and facilities. The structure of data within each of the

[26] https://www.naik.hu/en/organizations/national-agricultural-research-and-innovation-centre

participating entities is highly diverse, which normally makes the interoperability between different biobanks very difficult. This RII has the task to improve it.

Research Infrastructures

ELIXIR 'coordinates and develops life science resources across Europe so that researchers can more easily find, analyse and share data, exchange expertise, and implement best practices. This makes it possible for them to gain greater insights into how living organisms work.[27] The European Strategy Forum on Research and Innovation (ESFRI) identified ELIXIR in its roadmap as one of the few research infrastructures of global significance.[28] The Bioinformatics Research Infrastructure Group, ELIXIR-HU has a strong interdisciplinary focus, involving scientific domains such as human genomics, agri-genomics, proteomics, veterinary sciences (virology) and ecology (biological networks). Despite this diversity, the core objectives of participating institutions and scientists, is a harmonized handling, processing and interpreting of large datasets from biological measurements. The infrastructure is coordinated by the MTA TTK Institute of Enzymology and it aims to promote applications of bioinformatics across all the life sciences in Hungary, including agriculture and related domains. It participates in the international activities and networks, such as ELIXIR, an intergovernmental organisation that brings together life science resources from across Europe. These resources include databases, software tools, training materials, cloud storage and supercomputers. The goal of ELIXIR is to coordinate these resources so that they form a single infrastructure. ELIXIR includes 23 members and over 180 research organisations. It was founded in 2014, and is currently implementing its first five-year scientific programme.

Dissemination infrastructures and repositories

EIP platform developed and operated by AM és AKI: At the end of 2016 the Ministry of Agriculture launched its EIP-AGRI website developed by the Research Institute of Agricultural Economics (AKI). The website permits the potential Hungarian Operational Groups (OGs) to register their innovative ideas and for the selected OGs to publish the results on the progress of the projects. Also, the website provides useful information and news on the European EIP network. Currently, the Chamber of Agriculture is working on building up a knowledge *reservoir* collecting successful innovative solutions that are suitable for use for farmers who want to modernize their production methods.

NAK online knowledge reservoir - e-KR (planned): NAK knowledge-based datasystem will be set up to gather relevant practical knowledge (from Thematic Network projects, but also directly from researchers, or other AKIS actors who have something to share) and introduce it in an attractive way for the use of the practitioners of the agri-food sector, in a publicly available form. The main target group would be foremost the advisors, however, since farmers do not use such online tools regularly, but interested advisors could be reached easily (FAS has an active internal communication flow) and even trained for the use of the platform. The concept is ready, now the IT specification writing is going on. The e-KR is being developed and will be operated by NAK. It will have 4 modules:

- the reservoir itself: first we collect, translate and unify (shorten, put into a practice abstract form, make it understandable for our advisors/farmers) the relevant

[27] https://elixir-europe.org/about-us/what-we-do

[28] http://ec.europa.eu/research/infrastructures/pdf/esfri-strategy_report_and_roadmap.pdf

knowledge gathered by TNs. But also write practice abstracts by ourselves, with the help of our experts. On the platform these practice abstracts will be searchable thanks to labelling.

- question and answers: if the end user cannot find relevant information at module 1, it can ask his/her question, and in the background our experts will answer. If it make sense, we create also a practice abstract (in modul 1) targeting the challenge in question.
- expert introductory: in Hungary there are 1,100 registered advisors. We would like to make them available by introducing their profile on this platform. Also researchers and other knowledge-providers can introduce themselves, if they would like to.
- calendar+map: for relevant events and the related materials.

Bioeast platform: The BIOEAST initiative has developed by now into a very important and active network of the Central and Eastern European macro-region for the identification of common research needs and focus areas in the bioeconomy. The initiative has its own website permitting to follow the latest developments of the collaboration, as well as publishing relevant studies and presentations which provide useful information not only for policy makers but for research institutes, companies, producers who are interested in the bioeconomy

MTMT database: The Hungarian National Scientific Bibliography (MTMT) is a database created and maintained by the Hungarian Academy of Sciences. MTMT presents the scientific output of Hungarian researchers together with the repositories containing the full text, wherever available. The database is accessible for non-commercial use.

(Other) R&I Networks and Clusters

NAK KFI munkacsoport: AKIS working group operates from the beginning of 2017, organised by NAK and AM in cooperation. The group consists of ~100 AKIS actors from the agri-food sector (representatives of research institutes, universities, advisors, farmers, NGOs, the Ministry and the NRN) at national level to discuss AKIS related issues, share experiences, and strengthen the links between actors. Meetings are held on a quarterly basis. Functions also as a relevant innovation network.

BayZ most hoz létre klasztert: The Bay Zoltán Nonprofit Ltd. for Applied Research (BZN) is a public company aiming tocontribute to the competitiveness and efficiency of Hungarian companies by providing services in innovation and technology transfer in cooperation with Hungarian and foreign partner institutions. BZN has started to set-up a bioeconomy cluster to help the cooperation and communication between the actors of biomass production and processing, with a particular focus on innovation.

The International Territorial Water Management and Climate Adaptation Instruments Centre, which is coordinated by the University of Debrecen (Water and Environmental Management Institute), has a strong international dimension. It is expected to be launched in 2019 and provides state of the art research facilities for Hungary and the Central Europe region in agricultural water management. A hydrological measuring lab and a controlled greenhouse for research, will be the key available facilities. Among others, available tools will be watershed monitoring devices, field drainage planning equipment, devices gauging geophysical and hydrological properties of soil, hydrological and hydraulic model tools. Computerized data processing will be supported with an IT network, which will also support planning water management and decision-making. Transboundary Tisha River basin is considered as a special area of interest and

investment, from which particularly neighbouring countries will also be able to benefit. The research will have a multidisciplinary focus.

5.3 Italy

Introduction

The Italian AKIS is characterized by a large number of entities and a high level of fragmentation. The main priorities of R&I policies and financial resources are largely determined at national level and involve different ministries. The Italian Regions oversee the promotion of applied research, innovation, and technology transfer programmes and projects.

Agricultural research in Italy is funded by European programmes, by the government and a minimal part is funded by the Regions. Higher and university education policy is determined and funded at national level, while agricultural training is under regions' jurisdiction and is mainly carried out by private and farmer-based training organizations. Extension services are also under the Regions' jurisdiction. They are increasingly managed by private bodies and generally funded by EAFRD. In this regard, it should be noted that in the wake of the new agricultural innovation policies during the last two programming periods of the CAP the regional agricultural development agencies were relaunched (e.g. ASSAM[29]). These organisations traditionally carried out research and extension services, through the delegation of functions to support the implementation of innovation policies concerned with the analysis of needs, innovation brokerage, the selection of project proposals, the administrative management and the use of demo farms. See Table xx.

	Public → private	Centralised /decentralised	Concentrated/ fragmented
Research	Public	Decentralized	Fragmented
Extension	Public → private	Decentralized	Fragmented
Education	Public (education), private (training)	Decentralized	Fragmented
Support systems	Private/Public	Decentralized at regional level	Concentrated for input-related services / fragmented for other services

Table 1 National AKIS in Italy

R&I policies have been long characterised by fragmentation of strategies, with many initiatives at both national and regional levels, delays in the implementation of measures and instability regarding budget availability and allocations. The level of business R&I activities is quite low and characterized by territorial disparities. Significant typologies of

[29] www.assam.marche.it

public-private partnerships have emerged within the cooperation projects 2007-2013 and EIP-AGRI operational groups OGs).

Applied Research Institutes

AR in Italy is mainly performed by public institutes (such as CREA and CNR) and the universities, which are involved in applied research by participating in local/regional innovation projects funded by the Regions or by EARDF. However, several public-private organisations and private research centres are active within cooperation projects (2007-2013) and OGs. These are foundations (e.g., FIRAB – the Italian Foundation for Research in Organic and Biodynamic Agriculture[30]), university spin-offs (e.g., HORTA srl[31]), polyvalent analytical laboratories (e.g. ISVEA[32]), Technological Parks and clusters (e.g., Puglia Food Technological District[33]). They are in general connected or work synergistically with the main public research institutes.

CREA is the leading Italian applied research organization and it is directly involved in research, technology transfer and, extension services which are carried out through its 100 experimental farms and advanced laboratories. Some instruments and tools managed by CREA can be considered as R&I infrastructures by themselves (e.g., Agritranser, National Rural Network, FADN). CREA works in synergies with many other national and regional R&I organizations, due to its competences and intermediary role between different R&I organizations. CREA promotes and facilitates the exchange of knowledge among the AKIS' actors, co-produces and co-disseminates knowledge.

Experimental and/or research stations

Experimental and/or research stations in Italy are owned by both public research bodies (e.g. CREA, Universities) and private farmer-based organizations. Over 1.000 experimental farms across Italy are owned by CREA. This allows CREA to carry out research and to facilitate the implementation of results and dissemination to practitioners. At regional level, despite the cuts in public expenditure and the closure of many Regional Agencies for Agricultural development, a relevant number of regional experimental stations and demonstration farms are increasingly engaged in innovation processes financed by the EARDF, through playing functions related to dissemination and leadership. The Stuard farm[34] is a significant example in this typology, as it is able to foster different knowledge processes.

Innovation Hubs

Innovation Hubs are probably the most under-represented RII types in Italy. The most significant R&I hub in Italy is the Edmund Mach Foundation[35], which is also a unique example of an agri-food campus. Clusters and agri-food districts generally represent intermediate infrastructures with the task of fostering public/private research cooperation and building national/regional policies in areas of strategic interest. However, in many cases, their knowledge processes are limited to knowledge exchange between a limited group of members, mainly Universities and big agro-food companies. They seem to act

[30] www.firab.it
[31] www.horta-srl.it/sito
[32] http://www.isvea.it/
[33] www.darepuglia.it
[34] www.stuard.it
[35] www.fmach.it

more as lobbying groups rather than as catalyst tools for regional development: in very few cases, they are active in co-innovation projects at territorial level.

Dissemination infrastructures and Repositories

A number of private micro-enterprises provide information transfer and innovation brokerage at local/national level. Among them is Vinidea[36] which developed a unique expertise by putting together a wide range of information about viticulture and oenology, as well as an international network of stakeholders all over the globe. As repositories, many experimental stations manage seeds and germplasm banks. Among them is the Institute of Biosciences and Bioresources (IBBR[37]) which manages the Mediterranean Germplasm Database, the reference database for the agro-food plant germplasm and the Perennial Plant Germplasm Repository (PPGR), the reference collection for the perennial plant germplasm collection.

(Other) R&I Networks and Clusters

A number of R&I partnerships emerged from cooperation projects (2007-2013) and EIP-AGRI OGs. In many cases, these partnerships developed into consolidated territorial networks, such as the Rete Semi Rurali (RSR) – Italian Farmers' Seeds Network[38]. It can be considered a best practice, as it is able to capitalise the competences that have been acquired within European projects at local level, by acting as innovation support service for a number of OGs.

5.4 Netherlands

Introduction

Dutch agriculture is characterised as a highly innovative sector and technologically advanced, including start-ups and innovative SME's. Its AKIS is strong but fragmented[39] and operates at international level. According to the OECD (2015) the Dutch AKIS is a global forerunning system in production oriented technology and processes, aiming at input efficiency and sustainability[40]. This strength is due to long term public-private investments in triple helix partnerships, meaning the collaboration between research, industry and governments[41]. However, the Dutch AKIS is also facing the challenge of becoming a more and more complex system. It has to deal with dynamic roles of diverse and new actors and intertwined, cross-sectoral issues and dilemmas. Agricultural R&I in particular faces changes such as[42]:

- more large-scale firms and intensification providing for more private R&I investments, but a larger gap with small and medium enterprises

[36] www.vinidea.it
[37] https://www.cnr.it/en/institute/041
[38] http://www.semirurali.net/
[39] PRO-AKIS study
[40] https://read.oecd-ilibrary.org/agriculture-and-food/innovation-agricultural-productivity-and-sustainability-in-the-netherlands_9789264238473-en#page1
[41] Etzkowitz, H. and Leydesdorff, L. (2000): The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-Industry-Government Relations. Research Policy 29 (2), 109-123. https://doi.org/10.1016/S0048- 7333(99)00055-4;
[42] Presentation for the SWG AKIS, Strategic Working Group on Agricultural Knowledge and Innovation Systems: the Dutch AKIS (2018). M. Plantinga, Ministry of Agriculture, Nature and Food Quality & F. Geerling-Eiff, Wageningen Economic Research.

- cuts in public funding, resulting in the transition of knowledge as a public good to knowledge as a marketable product on a global scale.

On national level transdisciplinary, triple helix R&I in agriculture, is mostly stimulated by public private partnership (ppp) collaboration in projects, programmes, including cross-sectoral cooperation, coordinated by the topsectors Agri-Food, and Horticulture & Starting Materials. Topsectors are triple helix institutes which, among others, coordinate public-private partnerships in R&I for the 10 sectors which have been identified as economically leading in the Netherlands. On regional (provincial) level, multi-actor cooperation R&I in agriculture is stimulated by Operational Groups under EIP-AGRI, managed by the Provincial authorities. Furthermore, there are several generic and specific subsidy instruments promoting innovation, mostly targeted at SMEs. An influential actor in agricultural innovation on behalf of the agricultural sector is LTO Nederland, the farmers' organisation. Approximately 60% of all Dutch farmers are member of LTO which is financed through fees of its members.

Applied Research Institutes

Most applied academic research in agriculture in the Netherlands is performed by the Wageningen Research institutes (as part of Wageningen UR[43]). There are 4 universities for applied sciences (also called 'higher vocational education' in Dutch) specialised in agriculture: Van Hall Larenstein[44], HAS Den Bosch[45], Aeres[46] and Inholland[47]. Next to education, these schools also conduct applied research, in teams coordinated by lectors. A variety of other organisations, including public, private and non-profit institutes, carries out research in agriculture and food production. For some, research is their main task, while for others, it supports their main task.

Research Infrastructures

The EU RICHFIELDS[48] project (2015-2018) was indicated as a research infrastructure by ESFRI to contribute to a sustainable agri-food system from agricultural production to consumption[49]. RICHFIELDS was one of the building blocks50 towards a EU food, nutrition and health research infrastructure (FNH-RI), coordinated by WUR. The FNH-RI 'aims to develop a European platform for data, tools and services for research in food, nutrition and health in which the consumer acts as link between the agri-food and health sector. The platform will provide research data, tools and services on food production and sustainability, as well as consumer behaviour, nutrition and health. Unique is the integration of consumer data into the platform. The research infrastructure aims to be fully operational by 2024.'51 Furthermore, WUR is involved in ELIXIR (see also the Hungarian case).

Experimental or Research Stations

[43] www.wur.nl
[44] www.hvhl.nl
[45] www.hashogeschool.nl
[46] www.aeres.nl
[47] www.inholland.nl
[48] http://www.richfields.eu/
[49] http://roadmap2018.esfri.eu/media/1054/rm2018-part2-hf-20.pdf
[50] https://www.wur.nl/en/Research-Results/Research-Institutes/Economic-Research/Research-topics-1/Consumer-Food/Research-infrastructure-for-health-and-nutrition.htm
[51] https://www.wur.nl/en/newsarticle/Building-a-research-infrastructure-for-food-nutrition-and-health-research-FNH-RI-in-Europe.htm

The privatisation of the former DLO institutes (agricultural applied research) and their merger with the agricultural university into Wageningen UR, led to the closure of many regional experimental stations and demonstration farms. Many experimental farms were closed or relocated and the ones which were left had to start working on a more commercial basis. They target practical research performance and demonstration which cannot be done on individual 'normal' farms that lack these research facilities. Next to the privatisation of these infrastructures, other commercial experimental stations developed, for instance with regard to cultivation in greenhouses (Hermans et al, 2011). Examples of commercial experimental or research stations in the Netherlands are: the R&I Demonstration Centres in Horticulture[52], knowledge transfer centres (KTCs Zegveld[53] and De Marke[54]) for demonstration on dairy farming R&I and the High Containment Unit (HCU)[55] on contagious animal diseases, the Swine Innovation Centre (VIC) in Sterksel[56], de Rusthoeve for arable farming[57], Stichting Proefboerderijen Noordelijke Akkerbouw, for arable farming[58] and ZILT[59] on possibilities for growing crops in salt or brackish water.

Innovation Hubs

Agro business park BTC Wageningen in the Netherlands has been set up to increase the chances of success for starting, innovative organizations. In short, organizations that want to be at the centre of new activities that benefit from a dynamic interplay[60]. Wageningen Business and Science Park is specifically intended for companies in life sciences, food and health and it is situated in the area of Wageningen Campus[61].

There are more incubator facilities focused on agri-food initiatives but Wageningen UR Campus houses StartLife is solely specialised in fostering entrepreneurship in Food and Agtech. StartLife supports entrepreneurs and their teams as they build their innovative business ideas into global enterprises with lasting impact. Their approach is to: 1) host a community of start-ups, investors, corporates and experts, 2) develop entrepreneurial competences of students and start-up teams, 3) offer mentoring trajectories within the StartLife Incubation Program, 3) provide pre-seed capital to promising start-ups and 4) providing access to follow-up capital.[62]

Dairy Campus (www.dairycampus.nl) carries out innovative projects and activities in order to generate new information and knowledge to drive innovation in the dairy chain where science and practice go hand in hand. Dairy Campus is part of Wageningen University & Research, but moreover is also linked with organisations as Van Hall Larenstein university of applied science, vocational education Nordwin College, national farmers organisation LTO Nederland, dairy coop FrieslandCampina, RUG Campus

[52] https://www.wur.nl/en/newsarticle/IDCs-innovation-engine-for-horticulture.htm
[53] http://www.ktczegveld.nl/
[54] https://www.wur.nl/en/Research-Results/Research-Institutes/livestock-research/Innovation-centres-and-facilities/Knowledge-Transfer-Centre-De-Marke-2.htm
[55] https://www.wur.nl/en/Research-Results/Research-Institutes/Bioveterinary-Research/Facilities/High-Containment-Unit.htm
[56] https://www.wur.nl/en/Research-Results/Research-Institutes/livestock-research/Innovation-centres-and-facilities/Swine-Innovation-Centre-VIC-Sterksel.htm
[57] www.proefboerderij-rusthoeve.nl
[58] www.spna.nl
[59] www.ziltproefbedrijf.nl/zilt-proefbedrijf
[60] www.agro-btc.nl
[61] https://www.bspw.nl
[62] www.start-life.nl

Fryslân, city of Leeuwarden and the province of Fryslân. Dairy Campus is part of the national Agrifood cluster and connected also with other Dutch clusters like Food Valley Wageningen, Water Campus Leeuwarden and the Sino Dutch Dairy Development Centre in Beijing - China.

The Brightlands Campus Greenport Venlo (www.brightlands.com/brightlands-campus-greenport-venlo), which is developed to facilitate innovators from business, science and education to collaborate on innovations in healthy nutrition, plant breeding and growing, and alternative raw materials and food sources. The Campus is located in the region Venlo (Limburg, Netherlands). Primary focus is on healthy nutrition;

As an example of international interconnections, it is worthwhile mentioning that WUR coordinates the European Horizon 2020 SmartAgriHubs project which enables a broad digital transformation of the European farming and food sector. The project started end 2018. With a €20 million budget from the European Union, the project aims to build an extensive pan-European network of Digital Innovation Hubs (DIHs). The aim of SmartAgriHubs is to establish 140 Digital Innovation Hubs, 9 regional cluster and 28 flagship innovation experiments. The project is expected to influence the adoption of digital solutions by the farming sector, drastically. SmartAgriHubs should leverage, strengthen and connect local DIHs and 2.000 Competence Centres (CCs) throughout Europe. SmartAgriHubs put together a large network of 140 DIHs by building on existing EU projects and ecosystems such as Internet of Food and Farm (IoF2020), which was also coordinated by WUR. All DIHs are aligned with 9 regional clusters, which are led by organizations that are closely related to national or regional digitisation initiatives and funds across the EU. This multi-layer approach is supported in each MS by 28 Innovation experiments in which ideas, concepts and prototypes are further developed and introduced into the market. More than 2 million farms are expected to be involved through 4.000 experiments, bringing the process of digitisation closer to the specific needs of the farmers.[63]

Dissemination infrastructures and Repositories

Many dissemination infrastructures and repositories exist. In this case, we describe the particular dissemination channels of WUR research. This is being supported by WUR library and in particular 'knowledge online' for applied research, assigned by the ministry of agriculture. WUR library includes search functions for (academic) publications for WUR staff and students, a web of science, pubmed, CAB abstracts, scifinder, LexisNexis, ABI Inform, ASFA, links to other recommended databases, special collections, image collections, course reserves, the WUR journal browser and a collection of websites for agri-food and other 'green' knowledge. Furthermore, WUR is connected to 'Green knowledge net' (GKN) an online library and repository platform which focuses on education as a primary target group but forms a useful infrastructure for other end-users in agriculture too. GKN contains 25 portals on diverse topics regarding animals/livestock, the environment, plants/crops food and agri-food and 'green' economy. Furthermore, 'green knowledge net' facilitates diverse teaching material among others, constructing knowledge dossiers to collect multiple information on a topic in a pedagogic structured manner. Wiki's are another example, which are being constructed by teachers and/or students to evolve information on a certain subject.[64]

[63] https://www.wur.nl/en/newsarticle/EU-accelerates-the-digital-transformation-of-the-European-agri-food-sector.htm
[64] www.groenkennisnet.nl

(Other) R&I Networks and Clusters

Numerous other public, public-private and private R&I networks and clusters exist in the Netherlands, we describe the most remarkable example in this case description. The largest regional agri-food R&I cluster in the Netherlands can be found in the region Foodvalley, concentrated around Wageningen UR Campus. Since 2004, a cluster organisation entitled Food Valley NL is funded by the Dutch business community and government to promote the innovativeness of Dutch companies by fostering cooperative links between business, knowledge institutions and governments (Geerling-Eiff et al., 2014). Foodvalley includes many private agricultural companies with research centres. Education is organised in the informal Platform for Foodvalley Education, in which different types of schools and the university cooperate on simulating R&I and human capital. Within a 50-km radius, the Foodvalley cluster includes over 70 food enterprises and around 1,400 other companies associated with the food industry. With 15,000 scientists and engineers engaged in R&I activities, the valley is characterised by its high density of food scientists and researchers.

5.5 Poland

Introduction

The AKIS in Poland is composed of various actors from public organisations, private and non-governmental organisations , each of them playing different roles. The Ministry of Agriculture and Rural Development deals with information, while other parties are more engaged in education and research (i.e. universities, research institutes, NGOs). The farm advisory services form a specialist domain of the Provincial Advisory Centers (16), which also fulfil other knowledge functions within the AKIS. These centres are public, independent organisations without a central supervising body. Their government funding is decreasing gradually while farmers' fees are increasing. In addition, private advisory services are available to farmers.

The Polish Roadmap for Research Infrastructures was developed by the Ministry of Science and Higher Education in 2011 and updated in 2014. It targets various fields of science, lists investments areas and projects. In the field of agro-food, the Roadmap proposed the establishment of the (1) Centre for Research on Environment and Innovative Food Technologies for Quality of Life – National Research Centre at the Warmia and Mazury University in Olsztyn, and (2) the European Centre for Bioinformatics and Genomics[65] – National Research Institute at the Institute of Biorganic Chemistry of the Polish Academy of Sciences in Poznan. Both R&I infrastructures are currently in a conceptual phase.

Financing R&I is one of the key challenges in Poland and various mechanisms have been developed to improve it. This includes legal changes in public procurement especially, the possibility of donating 1 percent CIT to the best research units and shifting the responsibility for financing R&I from the ministries to the dedicated agencies. Particularly important are the National Centre for Research and Development and the National Centre for Science, which deal with financing, capacity building and facilitation of the international collaborations. Dedicated programmes and financial instruments were created such as Bridge AC[66], the Top 500 Innovators Programme[67] and the training

[65] https://www.put.poznan.pl/en/organizations/european-centre-bioinformatics-and-genomics
[66] http://alfa.ac
[67] http://top500innovators.org/program-top500

of innovation brokers for which some attention has been specifically paid to agriculture and food innovations. However, in financial terms agricultural R&I remains rather marginal in the strategic orientations of broader R&I directions in Poland, where other fields of science and practice are preferred.

In the previous EU financial perspective (2006-2013) around 4.1 billion euro was granted for the research sector in Poland, while 1.3 billion euro was directed to the development of R&I infrastructures. With FP7, approximately 40 million euro was granted to 13 Polish institutions, which significantly contributed to strengthening their potential. A considerable proportion of this amount was designed for the purchase of world-class research equipment. Investment in research infrastructures was also supported by funds from the national budget for research. However, the scope of the direct R&I investments in agriculture is very low compared to other fields of science, especially exact sciences in which Poland is very competitive globally (i.e. mathematics, physics, informatics). [68]

An important R&I instrument is BIOSTRATEG[69]: a strategic programme for agricultural research and innovation. Launched in 2013, BIOSTRATEG focuses on the three main areas of intervention: natural environment, agriculture and forestry. It is aligned with the Polish National Research Programme and targets several priorities through the dedicated funding instruments: (1) Food security and safety, (2) Rational management of natural resources, particularly water, (3) Mitigation and adaptation to climate change, particularly in agriculture, (4) Protecting biodiversity and sustainable development of agricultural production area, and (5) Forestry and timber production. Within the programme calls for R&I projects are organized, which should fit into its strategic orientations. The overall budget committed to its implementation amount to approx. 87.5 M euro.

Applied Research Institutes

The agricultural R&I landscape in Poland comprises 12 research institutes under the supervision of the Minister of Agriculture and Rural Development, 7 of those with the status of a National Research Institute. At 9 universities 47 faculties are located and 9 scientific institutes are associated under the umbrella of the Polish Academy of Sciences. Some cross-cutting institutions are supervised by the Minister of Environment, Minister of Economy and Minister of Health. The main sources of R&I were previously managed by these respective ministers.

Experimental and/or research stations

An interesting example in this context is the Renewable Energy Research Infrastructure at the Białystok University of Technology[70]. It was developed with the support of the European Regional Development Fund during the programming period 2007-2013. It offers a laboratory infrastructure for research into renewable energy, with a multidisciplinary approach. It supports the identification of methods for improving renewable energy efficiency, suitable for use in the wider economy, such as for instance high-performance agro-fuel. The infrastructure consists of 8 new laboratories, while 3 older laboratories were modernized with the dedicated project. In addition, an

[68] http://www.wz.uw.edu.pl/portaleFiles/6133-wydawnictwo-/Polish_systems_of_innovations-Klincewicz,Marczewska_ebook.pdf
[69] https://www.ncbr.gov.pl/programy/programy-strategiczne/srodowisko-naturalne-rolnictwo-i-lesnictwo-biostrateg/
[70] https://ec.europa.eu/regional_policy/en/projects/poland/new-renewable-energy-research-infrastructure-at-biaystok-poland

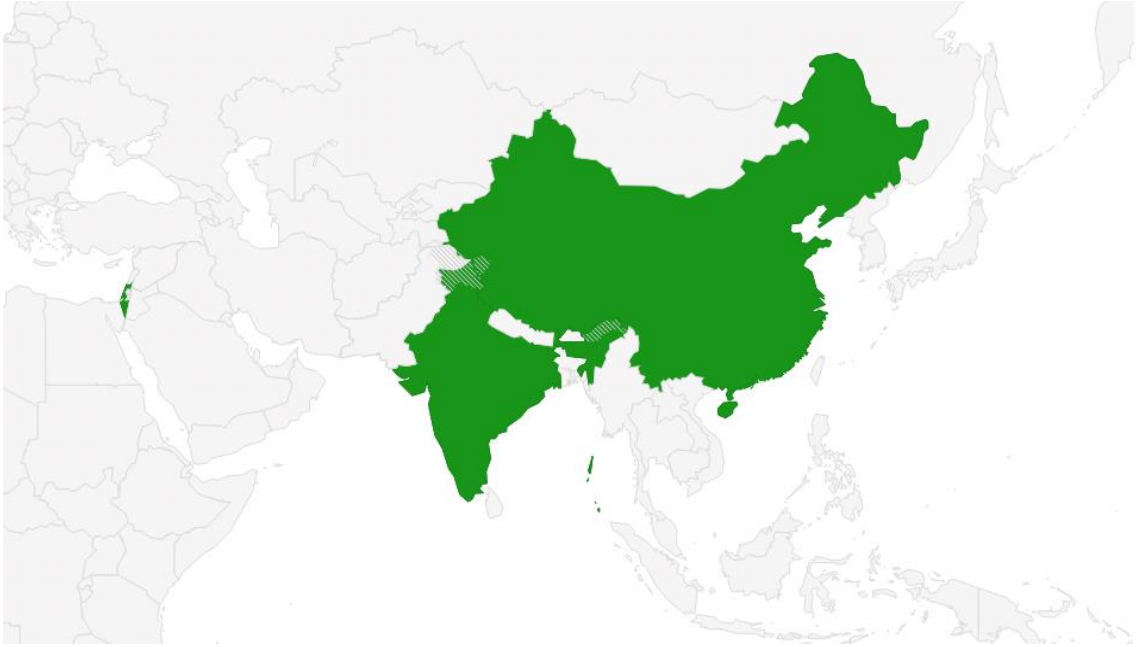
experimental biogas plant and oil pressing and refining machinery were created. Thanks to these, analysis of energy efficiency in various systems, the use of renewable energy, biogas and biofuel production became possible. Consequently, new solutions were developed to produce environmentally friendly technology and adapting this to the regional needs. The innovation potential of the host University was also boosted significantly. Businesses use the laboratory services and make use of the facilities. The facilities are located on the farms in the region, and apart from the R&I activities. Results of the research that was performed at these, helped to modernise agriculture.

(Other) R&I Networks and Clusters

Several thematic clusters have been set up in various regions of the country. For instance, in the Mazovia Region two agriculture relevant clusters were created, i.e, AgroBioCluster[71] and the Center for Development and Transfer of Technologies for Food Industry FOOD4GOOD[72]. They provided laboratory services, online B2B and B2C, research and facilitates on technology transfer in the Mazovia region. In addition, they offer advisory services on financing R&I for the interested entities and undertake efforts to scale up innovative products and services internationally, and participate in the relevant international networks.

6. RIIs in R&I systems: cases beyond the EU

Next to studying RII types in 5 EU MSs, we also analysed R&I systems beyond the borders of Europe. In the following cases we describe how RIIs feed into these international R&I systems. We focused on the three countries which are global leaders in the spending on agricultural R&I.



[71] http://agrobiocluster.pl/?lang=en
[72] https://www.food4good.pl

6.1 China

With the world's largest population and rapidly growing economy, China has become an important player in the agricultural R&I in recent years. It is expected that in 2019 China will become the world's leader in agricultural R&I spending. There is a visible growth in many areas in which R&I performance is measured, such as the number of patents and scientific publications. Yet, too few research results are turned into innovative and competitive products, and many Chinese enterprises depend on the foreign sources for core technologies.

The Agricultural Science and Technology Innovation Program (ASTIP)[73] was launched in 2013 under the direct support of the Chinese central government. The core idea behind the ASTIP is to establish a new funding paradigm, dedicated to supporting four specific objectives over the next thirteen years: (1) Supporting Long-term and Interdisciplinary Research, (2) Capacity Building, (3) Expanding Research Support Facilities and Infrastructure and (4) Fostering International Cooperation.

The Chinese agricultural R&I system, has been undergoing intense transformations in the recent years. Currently, national level research centres account for 10% of the total research staff and 15% of the total budget. The structure is organized according to the territorial administration, with central, provincial and prefecture levels, responsible for the coordination tasks. Provincial research centres account for 41% of total research staff and 51% of total budget, while the prefecture level employs 32% of research staff and consumes 34% of the total budget. China also has the largest public agricultural extension system in the world.

Since 2017, China follows the strategy to establish the Modern Agricultural Industry Technology System. The main goals are to solve the problem of disconnection between research and production from the source, and to make research more focused on the needs of industry. The evaluation of scientific performance is no longer focused on paper outputs, but rather on the industry. Hence, applied research is highly encouraged.

At the national level, an approach called the Modern Agricultural Industry Technology System was created, which involves the creation of agricultural innovation platforms bringing together various actors who are oriented on innovating within a certain agricultural specialisation. For instance, in the Yunnan Province, 8 agricultural networks of the Yunnan Modern Agricultural Industry Technology System were established at the end of 2009. Their focus include rice, corn, potato, oilseed, sugar case, sericulture, pigs and cows. Figure XX below represents the main actors involved in the sericulture innovation platform.

[73] http://www.caas.cn/en/research/research_program/index.html

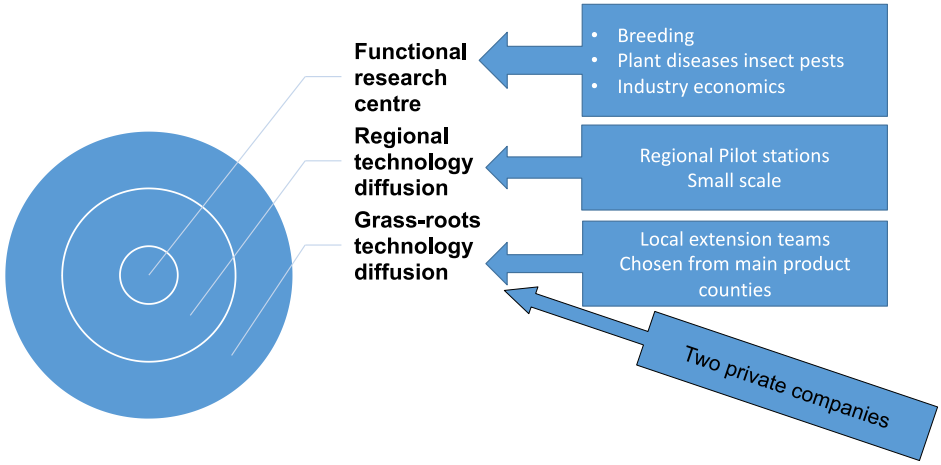


Figure 4. Yunnan Sericulture innovation platform. Source: Hong (2016)[74]

The Chinese Academy of Agricultural Sciences (CAAS) is responsible for several RIIs. As China is confronted with a huge diversity of natural and climate conditions, a dedicated network of field stations has been set up. The CAAS developed several experimental field and observation stations throughout the country, as well as introduced state-of-the-art equipment into its key laboratories. The second largest crop gene bank is also hosted within its premises. There are seven national reference laboratories at the CAAS, three of which belong to the World Organisation for Animal Health (Office International des Epizooties, OIE) network. Furthermore, the food quality and safety monitoring centres are under construction (CAAS Booklet, 2013)[75].

Figure 5: Distribution of the CAAS institutes. Source: Chinese Agricultural Academy of Sciences.

[74] Hong, J. (2016) The Reform of Agricultural Innovation System in China: a case in Yunnan sericulture sector. Unpublished presentation.
[75] https://www.sciencemag.org/site/products/CAAS_low.pdf

Examples of dedicated RIIs at the CAAS include for instance Technological Innovation Facilities

hosted by various CAAS institutes, i.e. 6 key state laboratories, 18 national centres (and sub-centres) for improvement of plant and animal varieties, 5 national engineering centres, 19 comprehensive key laboratories and 23 specialised key laboratories of the Ministry of Agriculture. Moreover, 13 ministry's laboratories are dealing with quality and safety risk assessment of agro-products. Two national-level key Scientific Support Facilities were also created, which include 1 national long-term gene bank, 10 medium-term gene banks for storing crop germplasm, 5 national experimental field stations, and 24 experimental field stations. All of these are oriented on providing data and infrastructure support for the ongoing research of the CAAS.

Over the years, CAAS invested in the development of the advanced biosafety laboratories, remote sensing application laboratories, bioreactors, modern plant factories, a microorganism culture and a collection centre, as well as environmental controlled chambers for animal nutrition. Further ongoing developments concern the establishment of the national foot-and-mouth disease reference laboratory, specialized biosafety laboratory for research on animal disease prevention and control and a dioxin research laboratory.

China is also intensively investing in the development of international collaborations with the leading global agencies (e.g. FAO) and through bilateral relations and strategies (e.g. EU-China Partnership). Strong bilateral networks have been fostered particularly with Australia which resulted in the creation of several joint agricultural RIIs, i.e. (1) Australia-China Centre for Wheat Improvement (with Chinese Academy of Agricultural Sciences), (2) Australia-China Joint Centre for Postharvest Grain Biosecurity and Quality Research (with Academy State Administration of Grains), (3) Australia-China Joint Centre for the Management and Eradication of Exotic Invasive Species (with Chinese Academy of Agricultural Sciences); (4) Joint Research Centre for Abiotic and Biotic Stress Management in Agriculture, Horticulture and Forestry (with Northwest Agriculture and Forestry University); (5) Australia-China Joint Research and Training Centre for Veterinary Epidemiology (with Huazhong Agricultural University, with support from the Chinese Ministry of Agriculture's Veterinary Bureau, the China Animal Health and Epidemiology Centre, and FAO Beijing office).

6.2 India

Being one of the leading investors in agricultural R&I, India also has one of the largest AKIS in the world. A vast number of actors are involved in the system. The most prominent public players are the Indian Council for Agricultural Research (ICAR) and the State Agricultural Universities (SAUs). SAUs are agricultural universities located across India which were developed following the land-grant universities model of the USA. They are occupied with teaching, research and agricultural extension and have a territorial jurisdiction. In terms of RIIs, ICAR institutes are usually better equipped than the SAUs.

The ICAR is an autonomous organisation under the Department of Agricultural Research and Education (DARE) of the Ministry of Agriculture and Farmers Welfare, Government of India. With a headquarter in New Delhi, it has been operational since 1929. It serves as a body for coordinating, guiding and managing research and education in agriculture, including horticulture, fisheries and animal sciences in the entire country. It comprises 101 ICAR institutes and 71 agricultural universities, spread across the country (see

Figure xx). It pioneered the Green Revolution and subsequent developments in Indian agriculture through its research and technology development. This enabled the country to significantly increase the production of food grains, horticultural crops, fish, milk and eggs, thus significantly impacting national food and nutritional security. It is engaged to promote higher education on agriculture and cutting edge areas of science and technology development.

Figure 6: Network of the ICAR Institutes. Source: ICAR.[76]

In addition to ICAR and SAUs, private sector research, ICFRE, organizations such as CSIR, UGC, and BARC, IITs, IIMs, and agriculture-related faculties and departments at general universities, play important roles in agricultural R&I[77]. Private sector research is more active in the development of agribusiness. Among important investments, multi-national companies contributed to research on seed, agrochemicals and agricultural machinery. The consolidation chemical, seed and biotechnology companies is directly related with the increase of the private sector investment in agricultural R&D. The advances in biotechnology-strengthened IPRs, globalization of markets, and new opportunities to collaborate with public sector institutions, are also important drivers in this process.

Finally, India is also a location for a number of International Agricultural Research Centres (IARCs), such as the ICRISAT which advanced the knowledge base and application of innovative solutions in rain-fed farming. The CGIAR[78] centres such as

[76] https://icar.org.in
[77] Ramasamy, C. (2013). Indian Agricultural RD: An Introspection and Way Forward. *Agricultural Economics Research Review*, *26*(347-2016-17081), 1.
[78] https://www.cgiar.org

IRRI, IFPRI, CIMMYT and other international centres, are strongly connected with the Indian agricultural research system.

6.3 Israel

The agricultural sector is of high importance in Israel, despite the natural conditions which are highly unfavourable for farming. More than half of the country is covered by desert and water resources are very scarce. Even though only 20% of the land is arable naturally, Israel is one of the major exporters of fresh produce and leaders of the high technology driven farming. Apart from modern practices, religious traditions are playing an important role. In addition, two unique organisation systems, based on the cooperative principles, dominate the farming landscape: kibbutz and moshav, created by Jewish immigrants returning to Israel from all over the world. Overcoming natural barriers, Israel is gradually expanding its arable lands and pioneering efficient solutions in water management.

Israel is one of the world leaders in the investments devoted to its research and innovation. Israeli expertise has been especially revolving around the following main areas: (1) Agricultural biotechnology and crop protection; (2) Drip irrigation and water management; (3) Farm management; (4) Alternative protein; and (5) Food safety and traceability. Research and innovation advancements, making Israel an important global player, are particularly visible in precision agriculture, drip irrigation, seeds, breeding and plant genomics. A large number of greenhouses is also set up across the country, including the desert and many innovations are oriented around specialized plastic films, heating, ventilation and structure systems, enabling Israeli farmers to achieve superior results[79].

An important element of the AgriFood-Tech Ecosystem is financing. 189M dollars were raised alone in 2017 to support start-ups, comparing to 102M dollars in 2016, which gives an increase of 85% within a year, a truly impressive figure. Much of the support is directed to the companies in the incubation stage. Alone, the companies operating in the area of smart farming raised 115M dollars over the last four years and 7% of global funding in 2016, which indicates a large demand on the market and strategic importance in the entrepreneurial landscape in agriculture. As of mid-2018, there were over 500 Agri-Tech and 250 AgriFood Israeli companies active on the market, that benefitted from participation in this R&I infrastructure. The Start-Up Nation Central, is another infrastructure through which this ecosystem is supported. It operates in the broader arena of building capacities of enterprises, while agriculture is one its core domains. This is a hub that collects relevant data and supports connections between the multiple actors and has a strong focus on attracting foreign investments in particular, since local investments are often insufficient.

The Agricultural Research Organisation (ARO)[80] is located at the Volcani Center campus (Bet-Dagan, near Tel Aviv). It comprises 6 institutes responsible for the following thematic areas: Plant Sciences, Animal Science, Plant Protection, Soil, Water and Environmental Sciences, Agricultural Engineering, and Postharvest and Food Sciences. Four research stations are also operational in various parts of the country, and testing facilities provide for the agricultural production and equipment. A major infrastructure

[79] https://www.startupnationcentral.org
[80] https://www.agri.gov.il/en/home/default.aspx

hosted by the ARO is also Israel's Gene Bank for Agricultural Crops[81]. The ARO has particular focus on arid zone agriculture and plays a key role in supporting Israel's globally leading position in R&I in this area.

Agriculture, and agricultural technology in particular, is seen as one of the leading fields for economic development of the country. Israel has thus created important research and innovation infrastructures concentrated around supporting entrepreneurship in this field: an AgriFood-Tech Ecosystem. This type of infrastructure is oriented on multiple functions serving creation of the entrepreneurial culture and consequently new companies in the field of agriculture and food technologies. It brings together various institutional players that provide know-how, financial incentives and research facilities. The ecosystem is built around 5 main types of players : (1) Academia (universities specialising in agriculture, biotech and IT); (2) Accelerators and incubators; (3) Venture capital funds; (4) Corporates; (5) Multinationals; and (6) Technology Transfer Offices.

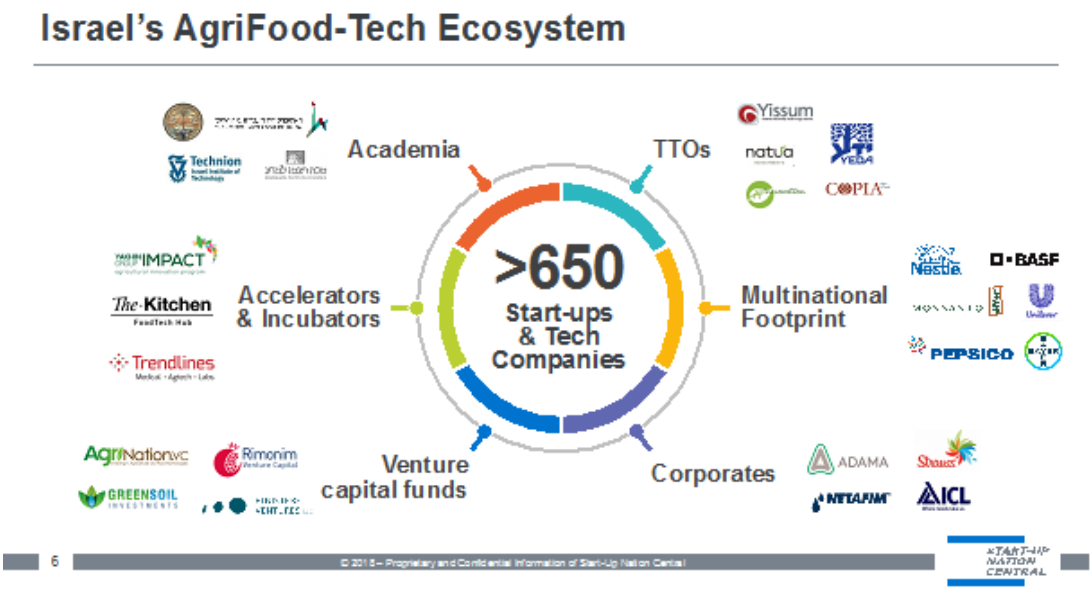


Figure 7: Israel's AgriFood-Tech Ecosystem. Source: Kandel (2018)[82]

At the heart of this R&I infrastructure lies the creation of start-ups and technology companies operating in the fields of agriculture and food, whereby knowledge flow is enabled between the diverse actors. To date, several achievements were possible with these approaches, notably the creation of over 650 enterprises, 35% of which were founded in the last 5 years, and 50% in the last ten years. In the area of AgriTech, the efforts resulted in emergence of the new enterprises covering smart farming, crop protection, livestock, pharmaceutical crops, agribiotech, aquaculture, irrigation and water management, novel farming, machinery and robotics, post-harvest, waste-tech and market management. In the field of FoodTech, start-ups are mainly focused on e-commerce and restaurants, nutrition advice, ingredients, food safety and traceability, kitchen apps and food as marketing, supply chain and logistics, alternative protein, packaging, production and processing.

[81] https://igb.agri.gov.il/web/?page=25&lang=en
[82] Kandel, E. (2018) AgriFood-Tech Ecosystem. Unpublished presentation, Start-Up Nation Central https://www.startupnationcentral.org

7. Conclusions and recommendations

The development and transformation of RIIs for agriculture are currently subject to several domestic and transnational efforts. We deepened our study into just a few examples, which were facilitated by EU funding and/or national resources. A brief overview was provided for the 5 selected EU MSs: Greece, Hungary, Italy, Netherlands and Poland. An annex contains a more detailed list of some RIIs that were not covered in the case studies, including those from other Member States. Moreover, we presented a few examples of RIIs which are functioning in non-EU international countries and are leaders in the agricultural R&I investments globally: China, India and Israel.

It is visible that investments in R&I infrastructures are gaining momentum in each of the countries and that they are fostered with national and transnational coordination efforts. Several agendas emerged at EU level and arising platforms support a better collaboration between the R&I entities of the MSs. We tried to capture the diversity of the R&I infrastructures with a dedicated typology, which was a challenging task since they are still very varied and fragmented across the countries which makes comparisons very difficult, lacking a standard approach.

Several RIIs, which are highlighted in the national strategic documents, are still not operational in the given countries, thus we were not able to obtain detailed insights on these. This partially explains the challenges we encountered with defining them and elaborating a consistent typolgy. Furthermore, this suggests that the RIIs are in a dynamic phase and need to be observed for the years to come with more attention.

Most participants in RIIs are engaged in a public research setting, which is however increasingly complemented with the engagement of a variety of industrial and other actors. In the countries we studied in more detail, we observed a general tendency to decentralize the decision making and consult the needs of the research and industry communities for the types of infrastructure required. However, this does not necessarily translate into the scope of the public financing dedicated to developing RIIs in specific countries (e.g. Poland and Hungary). Also, several financial instruments emerged in this context (e.g. BIOSTRATEG in Poland). In the Netherlands and Italy, the system of R&I infrastructures is more advanced in terms of multi-actor involvement, demonstrating a strong involvement of other entities beyond the conventional research partners.

Increased interaction has been especially visible, among others in the agriculture and food clusters, which bring different types of partners in innovation processes together. For example, research stations and experimental farms are increasingly acquiring a more active role in agricultural development paths and carrying out more functions in dissemination and demonstration of results, thanks to their participation in co-innovation processes.

Some interesting examples could be also observed beyond Europe in this respect, where in general private industry plays a dominating role. For instance, in India the technological progress has shifted emphasis to prioritize the types of investments towards the application for the industrial farming systems, to feed one of the world's biggest and growing populations. Similarly, in China R&I efforts have been more aligned with the needs of the industry and platforms bringing diverse R&I actors together. This was also reflected at regional level. In Israel, a complex AgriFood-Tech ecosystem was

set up, which brings all interested actors to leverage their resources and capacities, and has a strong focus on facilitation of the access to finance and start-up creation.

Another visible tendency in the RIIs set up is a strong demand for interdisciplinary focus. Several new entities emerged which combine agriculture and / or food innovations with those relevant for other industries, such as for instance the energy sector. Important drivers for setting up new RIIs are often rooted in the overall progress in Information Technologies (IT). This is reflected in launching of the new centres dealing with big data and making use of techniques which rely upon them, e.g. bioinformatics, genomics. DNA databanks and large catalogues of various data are structures and efforts undertaken to ensure their systematization and interoperability. The exchange and coordination is fostered at national (e.g. between different institutions in Hungary) and international levels (e.g. the ELIXIR network, the SmartAgriHub EU project).

Investments into both physical and non-physical infrastructures are needed on the long term, so as to keep the technologies up-to-date and retain institutional knowledge flows between the people engaged into the R&I infrastructures. Since many interesting developments in R&I infrastructures are being observed currently, we consider this as a field for further study and enhancement as relevant national and international agenda topics. As in most of the countries' roadmaps have been developed, which outline the possible directions for RIIs, investments at present and / or in the coming years, are in many places still in a nascent phase. It would thus be recommended to monitor these efforts, share and promote relevant examples, both good and less good practices or issues encountered. Further effort is also needed at EU level, for which for instance H2020 funding could be supportive (e.g. through dedicated calls). Engagement with the non-EU countries could be useful to learn about their experiences and enhance formal collaborations. However, this could be also challenging due to the current geo-political settings, notably in the trade arena.

Further indications could be given by the studies and initiatives relating to the responsible R&I, and measuring the societal impacts of those. Notable work has been undertaken in this area by the European Commission (DG RTD) and the OECD, with its recent publication providing the guidelines for assessing the scientific and socio-economic impact of research infrastructures[83]. This work streams could be also reflected in the overall considerations of the agricultural RIIs.

The study has revealed the opportunity, and the need, to define appropriate arrangements, to capture the experiences of RIIS, to facilitate benchmarking and transfer of good practices and, also, to analyse the types of knowledge flows for each type of RIIs and their effects. In this respect, the results of this initial study show that the renewal of European R&I policy and the management of innovation funds under the Common Agricultural Policy has undoubtedly contributed to the proliferation of a variety of infrastructures devoted to facilitating knowledge flows and strengthening the functions of know-how co-creation, through their participation in partnerships for innovation (EIP-AGRI). We recommend to further analyse the impacts of European policy on the strengthening and consolidation of knowledge and innovation infrastructures, at different levels in their implementation.

[83] OECD (2019), "Reference framework for assessing the scientific and socio-economic impact of research infrastructures", *OECD Science, Technology and Industry Policy Papers*, No. 65, OECD Publishing, Paris, https://doi.org/10.1787/3ffee43b-en

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Annex: Inventory of R&I infrastructures in the EU

This Annex presents an overview of the main R&I infrastructures indicated by the participants of the SCAR-AKIS workshop in Brussels (December 2018), though desk survey and an online questionnaire.

Applied research institutes

AT: Bio Forschung Austria (https://www.bioforschung.at) is a non-profit, non-university research institution research institute for organic farming. It carryies out innovative research results for practice, knowledge transfer by lectures, field days and seminaries. It is run by an association whose board is composed by competent personalities from the city of Vienna, the province of Lower Austria and from the circle of organic farmers in the fields of environment and agriculture.

BE: ILVO (https://www.ilvo.vlaanderen.be /). ILVO is an internationally renowned, scientific institute of the Flemish government. It stands for multidisciplinary, independent research and specialized services related to agriculture, fishing and food in Flanders.

BE: The Centre de Recherches Agronomiques de Wallonie (http://www.cra.wallonie.be/en) is one major applied research institute in Wallonia. It is financed by the Walloon government

DE: R&I coordinated by the German Ministry of Agriculture (BMEL) is closely linked to future-centric topics climate protection, renewable resources and feeding the global population. One of the main goals is to protect the natural environment through sustainable agricultural production. One of the R&I institutes is the Julius Kühn Institute (JKI, julius-kuehn.de), the Federal Research Centre for Cultivated Plants. The Julius Kühn Institute promotes the sustainable production and use of crops as basic nutrients, as renewable resources and as essential elements in our living environment. At the same time they aim to maintain plant diversity in cultural landscapes. The institute is specialised in issues regarding genetics and breeding research and the cultivation, nutrition, protection and health of cultivated plants. They carry out research in these areas and consolidate this knowledge at the JK Institute. This puts them in a position to be able to perform our governmental tasks on a scientific basis and to provide comprehensive scientific advice to the Federal Government. Research – assessment – advice: this JKI triad describing our commitment to cultivated plants is so far unparalleled in Germany. All three are legally grounded responsibilities. The primary task is to advise the federal government quickly, purposefully and competently. National: 10 locations in Germany.

EE: In Estonia, agricultural research is carried out mainly by the Jõgeva Plant Breeding Institute (Jõgeva Sordiaretuse Instituut), the Estonian Research Institute of Agriculture (Eesti Maaviljeluse Instituut), the Rural Economy Research Centre (Maamajanduse Infokeskuse) and the Center for Agricultural Research (Põllumajandusuuringute Keskus). The Center for Agricultural Research (PMC) is a state agency administered by the Ministry of Rural Affairs, which supports agriculture and rural development, which brings together various laboratories and test centers and departments dealing with agricultural monitoring, rural economy analysis and rural networking. http://pmk.agri.ee/

ES: The National Institute for Agricultural and Food Research and Technology (INIA) is an autonomous Public Research Organisation (OPI) of the State Secretariat of Research, Development and Innovation of the Ministry of Economy and Competitiveness. It's the only public research organisation of the National State Administration exclusively dedicated to agrifood and forestry research. http://wwwsp.inia.es

ES: The Centre for the Development of Industrial Technology (CDTI: https://www.interregeurope.eu/policylearning/good-practices/item/1136/danube-transfer-center-dtc/ The CDTI fosters technological development and innovation activities of Spanish companies. It is the entity that channels the funding and supports applications for national and international RDI projects of Spanish companies. Among other, the CDTI fosters international business technology transfer and support services for technological innovation and supports the setting up and consolidating technological companies. The CDTI is a Public Business Entity, answering to the Ministry of Economy and Competitiveness.

FIN: The Ruralia Institute (https://www.helsinki.fi/en/ruralia-institute) operates under the auspices of the Faculty of Agriculture and Forestry of the University of Helsinki. It carries out its duties by conducting multidisciplinary research and providing instruction, developing solutions that promote entrepreneurship and wellbeing, networking and constructing open learning environments, promoting research and teaching in the co-operative sector

FIN: The Natural Resources Institute Finland (LUKE, https://www.luke.fi) is a research and expert organisation that works to advance the bioeconomy and the sustainable use

of natural resources. MTT Agrifood Research Finland (https://portal.mtt.fi), which is part of the Natural Resources Institute Finlan is leading research institute developing sustainability and competitiveness of the food system.

FIN: The Finnish Environment Institute (SYKE) is a broad-based research and expert institute on environmental changes https://www.syke.fi

GR: ELGO-DIMITRA (http://www.elgo.gr/) is directly involved in research, knowledge and technology dissemination, advisory services and agricultural vocational education and training. It is also actively involved in the creation (new varieties), conservation, production and marketing of seed. It runs six schools, which are specialized in different sectors, and a number of vocational training centres, covering almost all the Regional Units of the country.

HU: National-agricultural-research-and-innovation-centre (https://www.naik.hu/en/). The institutes integrated by NARIC conduct high-quality basic and applied research and development activities related to plant and animal biotechnology/genetics, animal breeding, reproduction and nutrition, aquaculture and fisheries, food and meat science, plant and vegetable production, viticulture and enology, forest research and management, climate change and biodiversity, agro-environmental research and technologies, and agricultural engineering. The organisation, by employing nearly 200 researchers, is of significant size even at international level. It is able to join the world's scientific circulation and increase the recognition of Hungarian agricultural research.

IT: The Italian Council for Agricultural Research and Economics (CREA, https://www.crea.gov.it / en) is the leading Italian applied research organization and it is directly involved in research, technology transfer and farm advisory service implementation. Some instruments and tools managed by CREA can be considered as R&I infrastructures by themselves (e.g., Agritranser, National Rural Network, FADN). Most of experimental and/or research stations in Italy are owned by CREA. The allow CREA to carry out research and to facilitate results implementation and dissemination to practitioners and, in several cases, they act as germplasm banks.

IT: FIRAB: http://www.firab.it/site/about_us/ FIRAB promotes applied research in low input farming through a participatory approach, and through farmer-to-farmer exchange too, and operates technical and scientific dissemination. FIRAB competencies range between agronomic and economic research in the field of organic and sustainable farming. Merging by the organic sector organisations (Associazione Italiana per l'Agricoltura Biologica – AIAB – and Associazione per l'Agricoltura Biodinamica, the main national environmental association (Legambiente) and one labour union (Unione Lavoratori Italiani dell'Agroalimentare – UILA) meant to enable the Foundation to operate on innovation with and for organic farmers within the larger framework of agroecology and social respect.

LT: The Lithuanian Research Centre for Agriculture and Forestry is a State research institute operating as a budgetary institution. The Centre's strategic objective is to conduct R&D in the fields of agronomy, forestry, as well as related fields of ecology and environmental sciences, biology, biophysics, botany and zoology. Including open access centres. It runs two experimental stations; the Perloja Experimental Station (https://www.lammc.lt/en/regional-branches/joniskelis-experimental-station/2002) and the Rumokai Experimental Station (https://www.lammc.lt/en/regional-branches/rumokai-experimental-station/2004)

NL: Wageningen Research (www.wur.nl). The Research Institutes of Wageningen University & Research carry out application-oriented and field-based research in the fields: biovetenary, development innovation, environment, socio-economic, food & biobased, plants, livestock, marine, food safety and health.They are commissioned by the government, industry and non-profit organisations. WR collaborates with several other research institutes, universities, industry, policy makers and NGO's on both national and international level. International: 10 WR institutes and research hubs and projects globally.

RO: NARDI Fundulea is recognized as the main agricultural research unit from Romania, due to the results obtained in research - development field regarding the cereals, industrial and forage crops, http://www.incda-fundulea.ro/index_en.html. NARDI continues the tradition of agricultural research performed in Romania since the end of 19th century, in using scientific approach to solve the priority problems of Romanian agriculture.

SK: The AgroBioTech Research Centre of the Slovak University of Agriculture (ABT RC, www.agrobiotech.sk). The ABT is a university-wide, specialized facility which performs concentrated innovative research in the relevant fields aimed at conducting new methods and procedures in research, especially within applied research, with the purpose of transferring its results into practice. Three universities and research institutes.

R&I platforms

AT: The Austrian Agricultural Cluster (AAC, www.aac.or.at). A dynamic and innovative agricultural cluster to support the transformation and innovation of farming through quality products and services, driving sustainable and responsible growth with a stronger and closer integration of agribusiness stakeholders. Through the network of qualified companies in various sectors of agriculture, food-processing and renewable energy, the AAC is a competent partner for integrated agricultural projects including corporate finance combined with EU subsidy programs. The core competence lies in the provision of scientific know-how, consulting and latest technologies of leading Austrian companies and organisations. Austrian producers of agricultural, food processing and renewable energy technologies. In close collaboration with the Austrian Ministry of Agriculture, Forestry, Environment and Water Management and of the Austrian Federal Chamber of Commerce, the Delegations and regional offices of the European Union and the associated memberships of Universities and Federal Agricultural Institutes for Rsearch, Education and Economics.

AT: FFOQSI : http://www.ffoqsi.at Aim is to make food and food production better, safer and more sustainable to accomplish this mission, they examine relevant steps along the value chains feed - food and combine the expertise of well-known Austrian research institutions with the know-how of more than 30 innovative enterprises from several countries, with high affinity to research.

ES: RuralCat is a new concept of Internet-based communication. It combines a number of different features: an information portal, a website with services conceived for Catalonia's rural and agrifood sector and a system for channelling through Internet both the formal training provided by the Ministry of Agriculture, Livestock, Fisheries and Food and lifelong learning programmes. In addition, RuralCat users also have access to

powerful communication tools: e-mail, forums, etc. Above all, RuralCat seeks to be a virtual community where groups of people with common interests (farmers, livestock breeders, people working in the agrifood industry, students, consultancy professionals, etc.) can share information and documentation and foster relationships, using the communication tools with complete independence within the work group. https://ruralcat.gencat.cat.

FR: Laboratoire d'Innovation Territorial (LIT) Ouest Territoires d'Elevage is a living lab, platform consortium of actors from the three regions of Brittany, Normandy and Pays de la Loire, and the agricultural and agri-food sectors of the Greater West (GO) of France. They seized the opportunity to work on the construction of the Territorial Innovation Laboratory "West Livestock Territories". It focuses on the development of farms that better meet the expectations of consumers, citizens and policies on farming conditions, specifically in terms of improving the welfare of farmed animals. and less use of medication in breeding processes. It comprises: 3 multipurpose and multi-species animal cooperatives from the West: Agrial, Terrena and Triskalia, the Valorial competitiveness cluster, the 3 Regional Chambers of Agriculture of Brittany, Normandy and Pays de la Loire, the 3 agricultural technical institutes (ITAs) of the animal domain: Ifip for pork, Itavi for poultry, Idele for ruminants and stakeholders in research and higher agricultural and veterinary education in the West: Inra, Irstea, Agrocampus West, Oniris. Regional: West France

GR: gaiasense is a Greek smart farming system that continuously records and analyzes data and measurements from the field, the satellite, the scientist, and the farmer, and provides the tools to the agricultural advisor, the researcher and the farmer in order for them to take advantage of every opportunity to produce better, more and economical agricultural product from the Greek land. http://www.gaiasense.gr

IE: Agricultural Science Association: http://www.asaireland.ie/about-asa/about-us/ The ASA is a voluntary organisation and is the professional body for graduates in agricultural, horticultural, forestry, environmental and food science. These graduates have a level 8 degree from UCD, WIT, DkIT and other recognised foreign Universities. With almost 1,600 members from every discipline of the agri-food sector, we are the voice of the Agricultural profession in Ireland. Our members operate across the entire agri-food sector both in Ireland and internationally including government departments, research, advisory/consultancy, education and training, agri-business, rural organisations, banking and the media.

IT: National Technology Agrifood Cluster CL.A.N.: https://www.clusteragrifood.it/en/ A multi-stakeholder network of the key national players of the entire agrifood chain - a partnership of companies, research centres and institutions set up to promote sustainable economic growth, based on research and innovation in the industry and acting as partner for Italian and European Institutions.

IT: Agritransfer is an online innovative tool for the collection and the transfer of knowledge and innovations of CREA. Agritrasfer allows to access to: 1) a catalogue of innovations (information regarding the research results and intellectual property of CREA), 2) a Community of Practice - CoP (discussion forum to share information and experiences between researchers, regional organizations, technical and other stakeholders), 3) E-learning (dedicated site to thematic courses realized by CREA researchers on topics discussed in the Community of Practice). Agritrasfer also allows to activate tutoring and animation actions in favour of the transfer, demonstration and testing of the CREA results, through the support of research facilities of CREA.

LT: e-geba is the Lithuanian Farm Advisory Service (LŽŪKT) computer farm management program, developed on the basis of long-term work experience, best international practice and recommendations of Lithuanian scientists. http://www.egeba.lt/

LT: The electronic science gate for Lithuania, MTEPIS (R&D information system), provides advanced electronic services to help Lithuanian and foreign business undertakings, science and study institutions, researchers and other stakeholders to ensure closer cooperation while seeking common objectives. E-science gate helps Lithuanian and foreign business to find and order: scientific research; specific inventions; technologies; feasibility studies; new methodologies; prototypes or products. https://www.e-mokslovartai.lt/about

PT: Rede Inovar (www.redeinovar.pt) is a Portuguese network created in 2011 with the mission of promoting a stimulating environment for knowledge and technology exchange between researchers, farmers, entrepreneurs and associative structures connected to the agriculture, food and forestry sector, at a national level. It is currently the leading national platform supporting innovation and exchange of knowledge and technology in agriculture, food and forestry sector. Researchers, farmers, entrepreneurs etc.

EU:TP Organics: https://tporganics.eu/about-us/ TP Organics is one of the 40 European Technology Platforms (ETP) officially recognised by the European Commission. Its mission is to strengthen research & innovation for organics and other agroecological approaches that contribute to sustainable food and farming systems. To achieve this mission, it unites large companies, small & medium enterprises, researchers, farmers, consumers, and civil society organisations active in the organic value chain from production, input & supply to food processing, marketing, and consumption. The platform identifies the research needs of the organic and agroecological sector and then relays research priorities to the policy-makers in Europe and beyond. TP Organics also informs its members about funding opportunities for research & innovation and promotes knowledge exchange between farmers, companies, and researchers.

EU: Danube Transfer Centre Network (DTC), www.interregeurope.eu/policylearning/good-practices/item/1136/danube-transfer-center-dtc/. DTC focuses on innovation, technology transfer, information society, competitiveness of enterprises, education, labor market and marginalized communities. DTC offers an internationalization support package concerning innovation and technology transfer for both academia and SMEs. Even though there is a large variety of internationalization support services already offered, does not mean that they are also widely available for all SMEs within the EU. Considering regional, cultural and entrepreneurial disparities, supporting measures may work in one region but are not sufficient enough in another region. The DTC concept responds to this challenge as it is locally embedded. As such, the DTC sub-centres are not exclusively applicable within Danube macro-region. Its structure & services can be adapted and transferred to other EU countries, always according to the needs of regional actors. The effectiveness of the concept has been recognized even beyond EU borders. The concept has further been acknowledged as Best Practice example within the INTERREG Programme for Alpine Region. Industry, research institutions and governments from 9 member states: Germany, Austria, Hungary, Czech Republic, Slovakia, Slovenia, Bulgaria, Romania, Croatia and 5 non-EU countries: Serbia, Bosnia and Herzegovina, Montenegro, Ukraine and Moldova. EU Danube region.

Experimental or research stations

BE: Research Stations for Vegetable Production (www.proefstation.be). The Research Station for Vegetable Production has more than 50 years of experience (°1963) in research on the cultivation of greenhouse and field vegetables. It is located in the center of one of the most important production regions of fresh vegetables in Flanders (Belgium). It is a non-governmental and a non-profit organization.

BE: Centres Pilotes and Filières. Centres Pilotes regroup all the R&D actors related to a certain crop (fodder crop, corn, fruits, cereals...), or technique (organic farming…). There are 11 centres pilotes: the Royal Belgian Institute for the Improvement of Sugar Beet (KVIVB) www.irbab-kbivb.be, the Fourrages Mieux www.fourragesmieux.be (for fodder crops and grasslands), www.fiwap.be (for potato), www.centre-pilotemais.be (for corn), www.gembloux.ulg.ac.be/pt/cepicop (for cereals and oilseeds), www.walhorti.com and www.uap.be (for ornamentals), www.legumeswallons.be and CPL –Vegemar (for vegetables), and Cepifruit asbl and Groupement desfraisiéristes wallons asbl (for fruits). Experimental Poultry Centre (EPC, https://www.poultryworld.net), National Centre for Witloof (NPW), Hooibeekhoeve, Inagro, Hoogstraten Research Centre, PCG – Vegetable Research, PCS- Ornamental Research, PCA-Potato Research, Research Station for Fruit (pcfruit), Flanders Center of Postharvest Technnology (VCBT), Experimental and Educational Center for Agriculture (PVL), Experimental Center PIBO. Filières coordinate the different actors within different supply chains (potato, beef, pork, rabbit, milk).

FR: The Experimental stations of the Chambers of Agriculture offer expertise close to and responsive to the expectations of professionals. The synergy between the experimental stations, the advisers and the farmers' groups guarantees a quality development. The Chambers of Agriculture rely on the work of about fifty experimental stations spread over the entire territory. They cover productions as varied as fruits and vegetables, viticulture, cattle breeding, palmipeds, pigs, horticulture or field crops. The themes worked concern plant material, food autonomy, reduction of inputs, energy or agro-machinery. https://chambres-agriculture.fr/recherche-innovation/experimentation/

GR: A good number of experimental and/or research stations operates in Greece reporting to ELGO-DIMITRA and the Ministry of Agriculture. The independent Benaki Phytopathological Institute (https://en.bpi.gr/) is also a research station. Established in 1929, Benaki Phytopathological Institute was the first Greek research institute to have a broad scientific basis in plant health and plant protection. Alongside our many other roles and tasks, we at BPI specialize in risk assessment and advice on the safe usage of agricultural chemicals with regards to the protection of human health and that of the environment more generally. Benaki Phytopathological Institute is a Legal Entity of the Public Sector, donated by the National Benefactor Emmanouel Benakis. It operates under the supervision of the Hellenic Ministry of Rural Development and Food.

IT: Experimental Station of San Pietro Avellana (Isernia - Italy). Since 1967 the Experimental Station has been established network of research forests where it has been set out 35 permanent experimental protocol consisting of some hundreds of plots. These research forests embrace different climatic and vegetation zones. These research activities are realized thanks to the cooperation of several different administrative bodies (CFS-State Forest Corp, Regions, Comunità montane, Municipalities) and private forest owners.

IT: The Stuard farm (http://www.stuard.it) has been operating as an experimental farm since 1983: it has developed research and experimentation projects at regional, national and EU level in collaboration and on behalf of the Emilia Romagna Region, the University, the Ministry of Agriculture, the European Community and private enterprises. The farm disseminates its activities to farmers and technicians through meetings, field visits, newsletters, scientific publications, television broadcasts. The farm hots the educational activities of an Agrarian Institute, with which there are ongoing forms of mutual collaboration such as summer camps and guided tours, University masters, stages and specialization courses. The Stuard farm collaborates with a local training agency for the realization of training courses and stages. It is also involved in several Operational Groups. An important activity of the farm is also the recovery and maintenance of local germplasm. The farm collaborates with private organisations and agro-food industries, Italian and foreign seed companies, organisms for technology transfer and farms located in the Parma area.

NL: The Poultry Expertise Centre (https://www.poultryexpertisecentre.eu). Within the Poultry Expertise Centre the expertise from education, research and the business community is united and transferred to entrepreneurs and young professionals, working in the poultry industry (national and international). Topicality and innovation are key factors in this.PEC includes the Poultry Innovation Lab in which companies from the sector and the region are working together to create innovation and to share knowledge. The Poultry Innovation Lab is used for practice training, research and sharing knowledge. The Lab offers an environment in which professionals, companies and (international) students can learn and innovate. I tis a partnership between companies, government bodies and educational institutions, all working in or involved with the poultry industry

NL: R&I Demonstration Centres in Horticulture. Physical buildings where both research developments and innovation are shown to different actors, how they can be applied in practice. By demonstrating the different developments various actors meet and discuss their implications which also leads to follow-up developments, projects and network building[1]. Good communication with businesses is an essential part of the concept. Where are the opportunities for horticulture professionals and which challenges do they face? We support them in developing these opportunities, and try to solve any problems together in a step-by-step process. The constant interaction between the expertise of the scientists and the horticulture sector leads to progress, and will eventually help to realise implementation in practice. Wageningen Research, Greenports Horticulture, horticulture and starting material sector, regional and national government. The R&I Demonstration Centres received EU funding from EARDF. Regional, with international outreach

SE: Field Research Stations such as https://www.slu.se/en/departments/agricultural-research-northern-sweden/infrastruktur/research-station/ Ability to perform field research in a variety of areas such as agricultural science, biology, agroecology, soil science and environmental science. Swedish University of Agricultural Sciences Expertise in Agro-ecological field research. Access to land, personnel, basic data on soil and climate, workshop, machinery and measuring equipment, lab and offices for research. Access to the long-term field experiments by studying past performance or to take new, own samples.

UK: Agri-Tech Centres (ATC). The centres are essential catalysts for change. They provide a gateway for business to access the best scientific expertise, stimulating new research, practice and technology for the agrifood sector. The Centres focus on data analysis (Agrimetics), crop and soil health and protection (CHAP), engineering and precision technologies (AgriEpiCentre) and innovation excellence in livestock (CIEL).

They build capabilities that can lead the world in delivering sustainable food and farming solutions. The Centres harness leading UK research and expertise as well as build new infrastructures and innovation. The Agri-Tech Centres are a triple helix collaboration between government, academia and industry to drive greater efficiency, resilience and wealth across the agrifood sector. It is financed by the UK's strategic innovation agency (Innovate UK).

R&I Hubs

BE: Inagro is the knowledge partner of agricultural and horticultural businesses in the areas of innovation and sustainability. Within its own optimised professional research infrastructure, Inagro's scientific and technical teams devise farming and cultivation techniques ready for practical use. It cooperates with universities, university colleges and businesses.Inagro's advisers take the new know-how to the agricultural and horticultural businesses and guide the businesses in how to implement these insights, all of which is supported with professional communication tools.

BE: Flanders Innovation & Entrepreneurship is the contact point for entrepreneurs in Flanders.

DK: SEGES is a professional knowledge and innovation house that works with everything related to farming. From the major agricultural subjects in the fields of plants, environment, nature conservation, animal husbandry and ecology to economics, tax, law, IT, architecture, accounting, HR and teaching. This is done in close cooperation with universities, ministries, companies and interest organizations in both Denmark and abroad. SEGES translates the newest national and international research results into new knowledge for all Danish farm advisers and farmers; participates in innovative projects and develops new advisory and implementation of methods and practices. https://www.seges.dk. Alongside SEGES is the SEGES Pig Research Centre, that operates like SEGES within the area of pig production http://www.pigresearchcentre.dk/.

DK: GTS-institutes (Authorised Technological Service Institutes) are non-profit organisations who have the task of supporting the creation of more innovative and competitive Danish companies. The AgroTech Division delivers research-based consultancy and technological services for the farm and the agro-business industry. The seven Danish GTS institutes are grouped in the the GTS network. https://gts-net.dk/

FIN: ProAgria is a Finnish expert organization providing an extensive network of specialists and a wide range of services to rural entrepreneurs. It serves various customers from several rural sectors (agriculture, tourism, food preparation, horses, contracting, services, and bioenergy). ProAgria assists the customers completely during the whole business life-cycle. Assistance is offered in planning a new business, business start-up, investments and business revitalisation. The entrepreneurs vary from farmers to small business owners who run businesses mainly in rural Finland. Additionally, it provides expertise to customers in Russia and the Baltic region. Moreover, ProAgria is an active partner in cooperation with other Nordic counties as well as in development cooperation. https://www.proagria.fi

GR: The Development Agency of Karditsa, AN.KA (http://www.anka.gr), aims at implement programmes and projects for the development of both rural and urban areas of Karditsa district. AN.KA include an *incubator* (http://www.forum-

synergies.eu/bdf_fiche-experience-178_en.html) that provides pre-startup services, offers space for the head office, raises awareness of candidate members, provides secretarial support and inform visitors who are interested in the initiative.

IE: Food Hub Ireland: http://thefoodhub.com/. The Food Hub is a best practice food production and education facility. It has emerged as Ireland's premier artisan multi-tenant food production enterprise centre, established by a social enterprise.

IT: The most significant R&I hub in Italy is the Edmund Mach Foundation (https://www.fmach.it/), that is also the unique examples of agri-food campus. The Edmund Mach Foundation promotes and carries out research, scientific experiments, education and training activities as well as providing technical assistance and extensions services to farms, both in the Trentino region and in other Italian regions. It is organised in three different structures: the Centre for Training and Education, the Research and innovation centre and the Technology transfer centre It also runs a that plays a supporting role for the experimental, educational and demonstrative activities carried out by the other centres of the Edmund Mach Foundation.

PT: INOVISA (www.inovisa.pt). Its aim is to lead the development of innovation and excellence in the agricultural, food and forestry sector with a focus on the community of Portuguese speaking countries. INOVISA functions as an open interface structure by teaming up with several scientific/academic settings and businesses, in particular start-ups.

RO: Tehimpuls – The Regional Innovation and Technology Transfer Centre (www.tehimpuls.ro). The role of Tehimpuls is to act as a regional interface between the innovation demand and offer, with the purpose of increasing the competitiveness of the economic environment in the West Region by implementing innovative solutions in companies and increasing efficiency in the field of research, by promoting and commercializing of existing innovative products. The Regional Innovation and Technology Transfer Center addresses to the economic environment by providing consultancy services for implementing innovative solutions in companies, as well as the academia by providing commercialization services of research results and intermediation of technology transfers.

SK: National platform AgroBioFood Nitra (http://www.uniag.sk/en/national-platform-agrobiofood). Establishment of the platform was one of the first steps to present Slovakia to the consortium Food, Nutrition and Health Research Infrastructure (FNHRI). Its objective is to create research infrastructure in the field of nutrition, food systems and health care system in relation to the consumer and health. Slovak University of Agriculture in Nitra, National Agricultural and Food Centre and the association Bioeconomy Cluster, supported by the Ministry of Education, Science, Research and Sport.

RO: Agro Transilvania Cluster – the mission of the Agro-Food-Ind Napoca Cluster is to promote collaboration and cooperation between business entities in the agricultural industry and encouraging competitive restructuring of the sector, as well as ensuring participation in multiple commercial project, both national and international. In this regard, members of the "Agro-Food-Ind Napoca Cluster" decided to join forces to support the development of the agro-industrial sector, with the aim to build on the competitiveness of the association – both on the national and international markets.

HU: National Research, Development and Innovation Office (NRDI Office) http://nkfih.gov.hu. It aims to create a stable institutional framework for the Government

coordination and predictable funding of research, development and innovation (RDI) in Hungary, ensuring efficient and transparent and value-creating use of available resources. The Office wants to establish a coordinated, predictable and sustainable system for research funding in which, through supporting excellent scientific research and promoting innovation, Hungary can ensure its RDI resources to be utilised not only in a legitimate but also an expedient manner, to increase Hungary's global competitiveness and foster its most fruitful integration in the European Research Area (ERA).The Office develops our nation's strategy for scientific research, development and innovation as a policy-maker, manages the National Research, Development and Innovation Fund as a funding agency and represents the Government of Hungary as well as the Hungarian researcher community in international and European RDI organisations. The NRDI Office aims to reinforce the national innovation system, to foster a dynamic cooperation between scientific centres and enterprises, to create an inspiring environment for innovation. project-based financed by the Ministry of Agriculture.

Dissemination infrastructures and Repositories

GR: The Mediterranean Agronomic Institute of Chania (CIHEAM-IAM) (https://www.iamc.ciheam.org/) is the 4th constituent institute of CIHEAM, a Mediterranean intergovernmental organisation devoted to the sustainable development of agriculture and fisheries, food and nutrition security and rural and coastal areas. Its Botanical garden holds a collection of endemic and threatened plants for demonstration and education purposes. The herbarium preserves specimens of Mediterranean plants and provides all the required facilities for taxonomic identification of plants of the East Mediterranean region. CIHEAM-IAM also hosts a wide Library.

GR: OPENSCREEN-GR (http://www.openscreen.aua.gr) is an open-access research infrastructure (RI) for discovery of bioactive molecules using molecular target-based screening technologies. It facilitates the exchange of knowledge and promotes technology transfer to be used for developing innovative solutions to specific problems in Human and animal health and agriculture.

IT: Many experimental stations manage seeds and germplasm banks. Among them, the Institute of Biosciences and Bioresources (IBBR) https://www.cnr.it/en/institute/041) manages the Mediterranean Germplasm Database, which is the reference database for the agro-food plant germplasm, and the Perennial Plant Germplasm Repository (PPGR) is the reference collection for the perennial plant germplasm collection.

IT: VINIDEA s.r.l. is a private micro-enterprise that provides information transfer and innovation brokerage to the wine sector. VIN looks for scientific and practical news from all over the world and then makes it available to agronomists and oenologists. VINIDEA takes part in many research and innovation projects, both H2020 and OGs. It acts as innovation broker at national level. Vinidea developed a unique expertise by putting together a wide range of information about viticulture and oenology, as well as an international network of stakeholders all over the globe. www.vinidea.it

LT: www.agroakademija.lt is the Lithuanian Agricultural Advisory Service (LŽŪKT) educational website for farmers. It publishes practical information to help farmers to develop their business profitably and to protect nature.

R&I Networks and Clusters

BE: Agreon is a network of West Flemish SMEs that develop innovative products that can be used in the agricultural sector. It brings farmers and SMEs together with the aim of making the agricultural sector greener and economically strengthening SMEs. Agrocleantech includes all technologies, products, processes and services that make it possible for farmers and horticulturists to minimize their impact on the environment on the one hand and to produce economically profitably on the other. The Agreon innovation network is a go-between between the independent independent agencies POM and Inagro and is coordinated from Inagro, the provincial research and information center for agriculture and horticulture in West Flanders. http://www.agreon.be

ES: INIA and agro-food research regional centres work closely so that the number of signed agreements is significant, both among themselves and with other public and private institutions. Some agreements led to joint centres, such as AGROALIMED (Institute for Agricultural Research of the region of Valencia, Polytechnical University of Valencia, CSIC and INIA), Agri-biotechnology Institute (Public University of Navarra, CSIC and the Regional Government of Navarre); Institute for Research in Food Sciences - CIAL (CSIC and the Autonomous University of Madrid); Centre of Biotechnology and Plant Genomics – CBGP (Polytechnical University of Madrid and INIA); Science Institute of the Vine and Wine – ICVV- (University of La Rioja, Regional Government of La Rioja and CSIC). In Catalonia there is a dense network of join centres, such as Centre of Agro-Genomic Research (Institute of Research and Agro-Food Technology-IRTA, CSIC, Autonomous University of Barcelona and University of Barcelona), and Economics and Agro-Food Development –CREDA- (private NGO created by the Polytechnical University of Catalonia and IRTA).

ES: Thematic network of the national programme for plant genetic resources (http://wwwsp.inia.es/en-us/Investigacion/centros/crf/Paginas/CRF.aspx). The network of collections of the National Programme brings together the collections of plant genetic resources maintained in ex situ conditions as seed or as vegetative reproductive material by Public Administration bodies which benefit from the “permanent activities” projects of the National Programme for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. This Network is a decentralized and coordinated system which currently contains more than 30 institutions under the Central Administration, the Regional Administrations and public universities that maintain not only seed collections but also field collections.

FR: CIVAM network (Innovative Centres for the Valorisation of Farming and Rural areas) brings together 140 groups (about 13000 agricultural and rural stakeholders) on French territory. CIVAMs are groups of farmers and rural actors who, through information, exchange and collective dynamics, innovate in their territories. They develop initiatives and test new practices on topics such as: territory-based farming and food systems, sustainable agriculture (autonomous, cost and energy-saving production systems), reception of newcomers and exchanges in rural areas, creation and maintenance of rural activities. http://www.civam.org

GR: AGROECOPOLIS (http://www.forum-synergies.eu/bdf_fiche-experience-151_en.html) is a very young, grassroots non-profit, non-governmental organisation. It actively promotes different models of connecting consumers and producers. AGROECOPOLI acts as a hub for networking, experience sharing, training, facilitation

and provision of resources for groups (formal or not) that work on its similar fields and helps existing initiatives and start-ups by providing counselling and training on ethical solidarity economy and human relations issues.

IT: Rete Semi Rurali (RSR) – Italian Farmers' Seeds Network – was established in 2007 and consists of 42 associations. It supports farmers in the creation and dissemination of self- and truly sustainable organic farming systems. It is involved in several H2020 multiactor projects and Thematic Networks and it is able to capitalises the competencies that have been acquired within European projects at local level, by acting as innovation support service for a number of Operational Groups. www.semirurali.net