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The role of research bodies, from leaders of the system to responsible partners

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Abstract. They were once the central element in state-funded research, but now the research bodies need to redefine their role as partners in the innovation process, responding more efficiently to the needs of society and businesses. In agriculture, the concept of innovation was dominated in the past by linear knowledge transfer in the form of new technologies that were essentially generated by public research (research institutes or universities), transferred to the agricultural extension services, and hence to the farmers for adoption. Therefore, the knowledge generated was transferred between the actors by means of mechanisms that were mostly one-directional (conferences, articles in scientific journals or technical publications etc.). This model has achieved successes, but it is equally undeniable that the innovation context in agriculture has changed radically in three ways. The challenges are increasingly complex, many new actors have burst onto the innovation stage in agriculture, e.g. the third sector organisations and producers' associations, and the general public is also demanding a more active role in the decision-making processes related to the adoption of technological innovations. The chapter offers an outlook for renewal of the agricultural innovation systems based on the Responsible Research and Innovation pillars (RRI).

Keywords. Research – Social responsibility – AKIS and AIS approach – Responsible research and innovation (RRI).

Le rôle des organismes de recherche: de pivot du système à partenaires responsables

***Résumé**. Autrefois élément central de la recherche financée par le secteur public, les instituts de recherche sont appelés à redéfinir leur propre rôle comme partenaires du processus d'innovation, pour répondre d'une manière plus efficace aux besoins de la société et des entreprises. Traditionnellement, le concept d'innovation en agriculture a été centré sur le modèle de transfert linéaire de connaissances, sous forme de nouvelles technologies issues pour la plupart de la recherche publique (instituts de recherche ou universités), transférées aux organisations de vulgarisation agricole et transmises ensuite aux agriculteurs pour leur adoption. Le transfert des connaissances générées au niveau des acteurs s'appuyait sur des mécanismes de communication le plus souvent unidirectionnels (conférences, articles dans des journaux scientifiques ou revues techniques, etc.). Ce modèle a connu un grand succès, mais il est tout à fait évident que le contexte de l'innovation agricole a changé radicalement, en particulier en ce qui concerne trois aspects. Les défis sont de plus en plus complexes, beaucoup de nouveaux acteurs ont fait irruption sur la scène de l'innovation agricole, comme par exemple les organisations du tiers secteur et les associations de producteurs, en plus de la demande croissante de participation active du grand public au processus décisionnel en matière d'adoption d'innovations technologiques. Ce chapitre propose une perspective de renouvellement des systèmes de l'innovation agricole reposant sur les piliers de la « recherche et innovation responsables » (RIR).*

***Mots-clés:** Recherche – Responsabilité sociale – Approche AKIS et SIA – Recherche et innovation responsables.*

I – Introduction

In recent years, new technologies have enabled significant progress to be made in understanding where, how, when and why certain occurrences take place, and society has never felt such a need to be less of a spectator and more of a leader in decisions about the future (Sykes and MacNaghten, 2013). In a world where information can reach every corner of the world in real time, it becomes crucial to reflect on the actual quality of the information shared, to enable society

to make the right decisions. This is also true for the scientific community, which has an extra responsibility towards society, since it possesses complex information that is not promptly and easily understandable, but which has a great potential impact, at various levels.

Scientific knowledge and the technology derived from it should be considered the most evident product of a society that is becoming highly complex. This complexity is also demonstrated by secondary occurrences, often devastating in the impact of human activities on the environment. Predicting these impacts and minimising them without jeopardising development needs is one of the most difficult challenges human society has ever faced in its entire history. The scientific community is playing a leading role in this challenge, as a possessor of knowledge and essential information for promoting environmentally sound and socially sustainable development. However, the changes that occurred during the last century are challenging the driving role of science, often seen as an opponent and unable to withstand the weight of society's growing demand for participation. The scientific community has begun to ask itself questions about a series of aspects that concern not only its relationship with society but also the dynamics within the research community.

In the agricultural sector, the concept of innovation was dominated in the past by an approach based on the linear transfer of knowledge. This meant that new technological developments were mostly generated by public research bodies (research institutes or universities), and then transferred to the agricultural extension services that transmit them to farmers for adoption. This model was based on the contract between science and society in force for much of the 20th century: in exchange for public funds, research bodies produced new knowledge and ensured its reliability via internal quality guarantee mechanisms (Gibbons, 1999). Hence research bodies, state administration, intermediate organisations (for agricultural systems, extension services and private firms producing and distributing fertilisers, plant protection products and agricultural machinery) developed quite independently, in a relationship based on mutual trust. The knowledge generated was thus transferred between actors using traditional, mostly one-directional, communication mechanisms (conferences, articles in scientific or technical journals, etc.)

It is undeniable that this model achieved notable successes, enabling the constant growth of agricultural productivity (Esposti, 2014). Between 1961 and 2011, agricultural production actually increased proportionately more than the world's population, thus satisfying the dramatic rise in demand for food, and this increase in production was largely obtained thanks to the technical and organisational innovations adopted by the world agricultural production system (Sonnino, 2014).

It is however equally undeniable that the agricultural innovation context has profoundly changed because of at least three kinds of closely related factors. First of all, agricultural research is currently confronted with increasingly complex challenges, such as the need to further increase food production to deal with population growth and urbanisation and the subsequent increase in food demand, and the need to reduce pressure on the natural resources that are the basis of agricultural production in order to ensure long-term sustainability (Sonnino, 2015). The existing challenges are then aggravated by the need to reduce agriculture's contribution to greenhouse gas emissions and to adapt production systems to climate changes, as well as by the growing importance of adapting production systems to the rapid evolution of global market needs.

Secondly, many new players have burst onto the scene of agricultural innovation, such third sector organisations and producers' associations, while others have greatly increased their roles, like private companies producing seeds and other means of production. In any case, the new and existent actors in agricultural innovation processes have shifted their roles and importance: agricultural and industrial businesses in the agrifood system express a strong and more explicit demand for innovation, which has become a major driver to scientific research and innovation. This reduces the weight of new available knowledge in triggering innovation (Viaggi, 2015), and emphasizes the importance of participatory and multidirectional communication mechanisms (Ekong *et al*., 2015).

Thirdly, today's general public demands more active participation in decision-making related to the adoption of technological and social innovations, and urges for a shift from procedural (or representative) to deliberative (or participatory) democracy models (Sonnino and Sharry, 2015). A recent work by MacNaughten *et al*. (2015) analyses the public's responses to emerging technologies by studying its acceptance of nanotechnology. The concerns expressed are related to five basic categories:

1. *Be careful what you wish for* (fear of wasting opportunities under conditions of scarcity of resources);
2. *Pandora's box* (fear of unexpected and irreversible negative consequences);
3. *Going against nature* (fear that artificial elements prevail over natural elements);
4. *Left in the dark* (fear of not being able to exercise control over technological changes);
5. *The rich get richer* (fear that private interests damage social equity).

Whatever the public's concerns are, it is evident that the social contract between science and society requires that the new knowledge generated by the research system be not only scientifically sound, but also aligned with the dominant social values, i.e. it must be socially sound (Gibbons, 1999). Research and demonstration projects have demonstrated that it is possible to achieve significant results through direct involvement of the social players concerned (see, for example, Carrabba *et al*., 2012). Again in this case, traditional communication mechanisms become rapidly obsolete and need to be integrated with new multidirectional tools.

II – Responsible Research and Innovation (RRI) and its six pillars

In Europe the problem of how innovation processes should meet the expectations of civil society has been discussed since the definition of EUROPA 2020 contents (European Commission, 2010) within the EU research and innovation Framework Programme *Horizon 2020* (European Union, 2013). In 2013, the European Commission published a report by a group of experts on Europe's state of the art regarding responsible research and innovation (*Responsible Research and Innovation* – RRI), in order to promote and further support the debate on these issues (European Commission, 2013). Based on the work done within initiatives promoted by some member States and the Commission, it has emerged that alignment of research with society's needs requires a more comprehensive approach to research, targeted at innovation but also responsible, in the etymological sense of this term (*responsum abilis* or able to respond to the explicit or tacit needs of society). Responsibility lies, for example, in the capacity to involve stakeholders from the early stages of research, so as to make them fully aware of the consequences of outcomes and of the potential opportunities, and to allow them to assess (and choose responsibly) different options according to the needs and the moral values expressed by society. This consciousness of choice becomes crucial when society is reorganised, as is the case now, in order to find new forms and new paths towards development. The wish to create a *smarter* and greener economy, combining growth with a healthier environment and a more equitable society, necessitates tools involving primarily the leaders of growth, i.e. the research and technological innovation bodies that have always acted as drivers of development. In 2012, the European Commission indicated Responsible Research and Innovation (RRI) to the scientific community as a strategy for bridging the gap with society (European Commission, 2012). Responsible Research and Innovation (RRI) is defined as "*a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper scientific and technological advances to permeate our society appropriately)*" (von Schomberg, 2013).

The principles of RRI were officially relaunched by the Rome Declaration (Italian Presidency of the Council of the European Union, 2014). The suggested pathway is clear and consists of six priority areas for action, aimed at incorporating the theme of responsibility into research and innovation. Applying the RRI approach means enabling different societal actors to work together during the entire research and innovation process, so that results are attuned to the values, needs and expectations expressed by society. The six areas for action, called "pillars", may be summarised as follows:

1. Taking responsibility (*Engagement* – "Choosing together"*)* of all societal stakeholders. As the problems to be addressed become increasingly complex, it becomes more difficult to take decisions. If this is combined with poor knowledge of the problem, the decision becomes nearly impossible. Thus, "*information, communication and citizens' involvement cannot happen (…) by chance, but must be part of the decision-making process"* (Valentini *et al*., 2015). This is also true for the process of identifying the objectives of research and technological innovation. Allowing society to actively participate in choosing the objectives and technological solutions is the only way to promote the realisation of collective responsibility that will make individual technological choices actually applicable. This will make the process of moving towards a more sustainable development model easier and more feasible.

2. Gender equality (*Gender equality* – "Fully exploiting the potential") means making sure that important resources for societal development do not remain unused or else used "below their potentials". This is intended not only as a traditional gender concern (for example, the establishment of female quotas) but it involves recognising that different components of society can make original contributions to development processes (hence to science and innovation) that could otherwise be recovered only through the direct and full involvement of human resources. Equity means recognising all merits and contributions related to gender, age, culture and the capacity of accepting and integrating these contributions for a more general development of an increasingly complex society.

A specific aspect of equity related to research and innovation is that they can make available technological solutions that can free entire groups of people from toil and enable them to express their potential for greater societal development. This is the case, for example, of the technologies that over the years have freed people from the heaviest work in agriculture, while giving an increased agricultural income, and so enabling farmers' children to have access to better education. Another example is the technologies that have relieved women of the heaviest housework, giving them more time to work outside the home, a higher income, and a potential of ideas directed at societal development.

3. Science education (*Science education* – "Creative learning, fresh ideas"). Science education means instilling a passion for research and innovation in young people, thus preparing the new generations of scientists to look at the development of new knowledge as an uncharted and fascinating future. Science education should also improve the level of future research by improving the current level of student preparation, supplying them with better knowledge and learning tools, and creating a close link between primary and secondary education institutions and the scientific community. This is obviously linked to the attractiveness of the scientific careers proposed to young people, as explicitly mentioned in the previous item. Scientific preparation is actually worth nothing if the economic and career difficulties of scientific contexts prove discouraging to young people. However, science education should not be directed only at future scientists and researchers, but at all society's *stakeholders*, who may thus become more actively involved in the challenges of shared governance, thanks to their improved scientific and technological understanding.

4. Open access to the outcomes of research ("Complete transparency and sharing of outcomes to boost growth and confidence") Sharing scientific data and having open access to the outcomes of research is a long-standing issue. The cost of research and the possible commercial use of its

outcomes has always encouraged data protection. Promoting a responsible vision of research and technological innovation towards society requires transparency and accessibility, in order to allow stakeholder involvement in decision-making related to development (governance). Open access to data and outcomes should be fully guaranteed, at least to publicly funded research, by removing all obstacles preventing or limiting knowledge diffusion. It is expected that the sharing of scientific data can give a decisive boost to the stakeholder use of the information and technological results, and allow growing awareness of the value of science and of the opportunities it offers. This would also align with the need to educate society about science and increase confidence in the institutions.

5. Ethics ("Doing the right thing and doing it right"). The ethical aspects of this discussion are obviously essential and concern the context of values and rules enabling the achievement of concrete results in terms of responsibility in research and technological innovation. But who decides what is the right thing to do? Europe shares a common cultural root (identity), whose society has co-evolved over hundreds of years. This gives a language and legacy that are not exactly identical, but are very similar or familiar. These aspects can represent a starting point for the development of a new set of shared rules in a profoundly changing society. The fundamental aspect is however "doing it together", considering differences an asset rather than an obstacle. This may be considerably aided by science education and by open access to data and outcomes. Being able to rely on a common culture can further help to enhance the richness and the development potentials offered by differences. In addition, a clear idea of the accepted areas and limits ethically shared by society can enable the scientific community to choose research directions more effectively, to obtain results actually usable for development. A strong mandate in this sense makes it possible to overcome doubts and reserves that civil society often has about innovations in areas that are considered to be on the border between what is largely perceived as lawful and what is not.

6. Governance ("Designing science with and for society"). Governance represents the prerequisite of the whole process described so far. How to achieve the desired outcomes in the involvement of citizens, the achievement of equity and science education, in allowing free access to data and outcomes, in achieving an ethically shared vision? It is important to envisage and implement a process made up of rules, directed at achieving a strong and shared objective. This last item is of particular importance, as it indicates that it is not possible to achieve any kind of result without a process involving the careful evaluation of the policies to be implemented and a strong commitment to them. Although the start-up and management of governance initiatives are the responsibility of-government, it is evident that such a new "extended" process aimed at identifying a vision and a new way to development, should necessarily include the wishes and tacit and explicit needs of society as a whole. It is the responsibility of political decision-makers not to exclude anyone from this inevitable process that will hopefully be as virtuous as possible.

The six themes identified are not separated from each other, but should be considered as different parts of a single strategy, aimed at identifying the best way to ensure the continuity of society's general development, despite the exponential increase in its complexity.

The interdependence of the six RRI pillars may also be seen indicating the complexity of the problem. The fact that it is possible to describe even a complex evolutionary pattern of governance means that our society is probably ready to achieve this transition towards a more sustainable development.

III – Innovating the notion of innovation in agriculture (including agricultural players)

Innovation in general, and innovation in agriculture in particular, has many definitions. The FAO defines agricultural innovation as "a system of individuals, organizations, and enterprises focused on bringing new products, processes and forms of organization into social and economic use (to improve efficacy, efficiency, competitiveness, resilience or environmental sustainability), in order to achieve food and nutrition security, economic development, and sustainable natural resource management" (FAO, 2014). In other words, innovation is the complex creative process by which social entities transform knowledge into economic, social or environmental value. As pointed out in the Strategic Plan for Innovation and Research in Agriculture, Food and Forestry (MIPAAF, 2014), innovation does not only concern technology, but all phases of the production process as well as the context where it takes place. The FAO definition, like other widely accepted definitions, does not refer to research as a source of innovation; this does not its importance is overlooked (Vagnozzi, 2013), but underlines the multiple possible origins of creative ideas (scientific knowledge, traditional knowledge, tacit knowledge, and business knowledge, etc.)

Table 1 summarises the evolution of the agricultural innovation interpretation models applied over recent decades and compares the four successive approaches that were not always mutually exclusive, with long overlaps and periods of coexistence. In fact, although the model of linear technology transfer has proven unsuitable for new contexts, it is still applied by some scientists, while subsequent approaches have never fully replaced the previous ones. The two first approaches (linear and circular transfer) prioritise the supply of technologies, whereas the two last emphasise, the demand for innovation (Ekong *et al*., 2015).

Both the AKIS (Agricultural Knowledge and Information Systems) approach and the AIS model (Agricultural Innovation Systems)[1] recognise the complexity of innovation processes and promote the collective creation of knowledge. The AKIS model considers as actors only research, education and extension service organisations, and focuses on spreading knowledge and information, via the analysis of knowledge flows (Spielman and Birner, 2008). The AIS approach also includes farmers and their organisations, agrifood businesses involved in the distribution and international trade of fresh or processed food, producers and distributors of means of production, the public administration, certification and inspection agencies, and third sector organisations (Fig. 1). The result is a much more complex framework, not restricted to merely rural areas but also including the market and the general context (Klerkx *et al*., 2012). AIS are actually defined as "networks of single organisations to use in order to bring about social, economic, or environmental effects, together with the regulations and policies affecting the system's behaviour and performance" (World Bank, 2006). Hence, the AIS analytical approach recognises the important role of research bodies in creating and transferring knowledge, but also attempts to understand the contribution of each single actor involved in the agricultural innovation process and, above all, the dynamics of their interactions.

Table 2 shows the tasks of the most important players in the AIS. In this framework, the role of research bodies must be fully re-considered: from being the initiators and leaders of innovation, whose task was mainly to create new knowledge and new inventions and to find suitable channels to spread knowledge among final users, to being partners in complex processes involving collective learning and the transformation of rules and pre-existing behaviours to adjust agricultural production systems to environmental, social and market changes. This role is no less important, but has a different nature and requires different professional skills, such as the ability to communicate, mediate and facilitate, and to carry out systemic analysis and inter-disciplinary work. It is worth mentioning that the innovation process is an engine fuelled by different kinds of knowledge (Bessant, 2013) and that research bodies are in any case called on to keep feeding the sources of scientific and technological knowledge.

Table 1. Main features of agricultural innovation interpretation models (translated and modified by: Klerkx *et al*., 2012).

	Technology transfer	Farming System Approach	Agricultural Knowledge and Information System (AKIS)	Agricultural Innovation Systems(AIS)
Period	‘1960s	‘1970s and ‘1980s	Since ‘1990s	Since ‘2000s
Purpose	Transferring innovative technologies	Supplying solutions to farmers’ problems	Collaborating in research and extension service projects	Developing research jointly
Research agenda	Defined centrally	Defined centrally based on surveys	Defined based on consultancy	Defined by a participatory approach
Objective	Increase in production per Ha	Increase in production per input unit	Improved living standard, product quality	Agriculture sustainability
Model	Linear transfer	Circular transfer (Farmers to Farmers)	Knowledge triangle	Network
Communication channel	Top-down, One-directional	Bi-directional	Multi-directional	Documentation and knowledge management, facilitation
Innovators	Researchers	Researchers and agricultural technicians	Farmers, researchers and agricultural technicians	Multiple
Role of farmers	Adoption of technologies	Supply information and adopt technologies	Test technologies	Are partners; express innovation demand
Role of researchers	Innovators	Experts	Collaborators	Partners
Changes caused	Adoption of technologies by farmers	Solution to farmers’ problems	Promotion of the role of farmers	Innovation
Area	Farm	Farm	Farm; rural area	Supply chain, production system, territory
Integration in the market	None	None	Low	High

Figure 1. AIS Diagramme

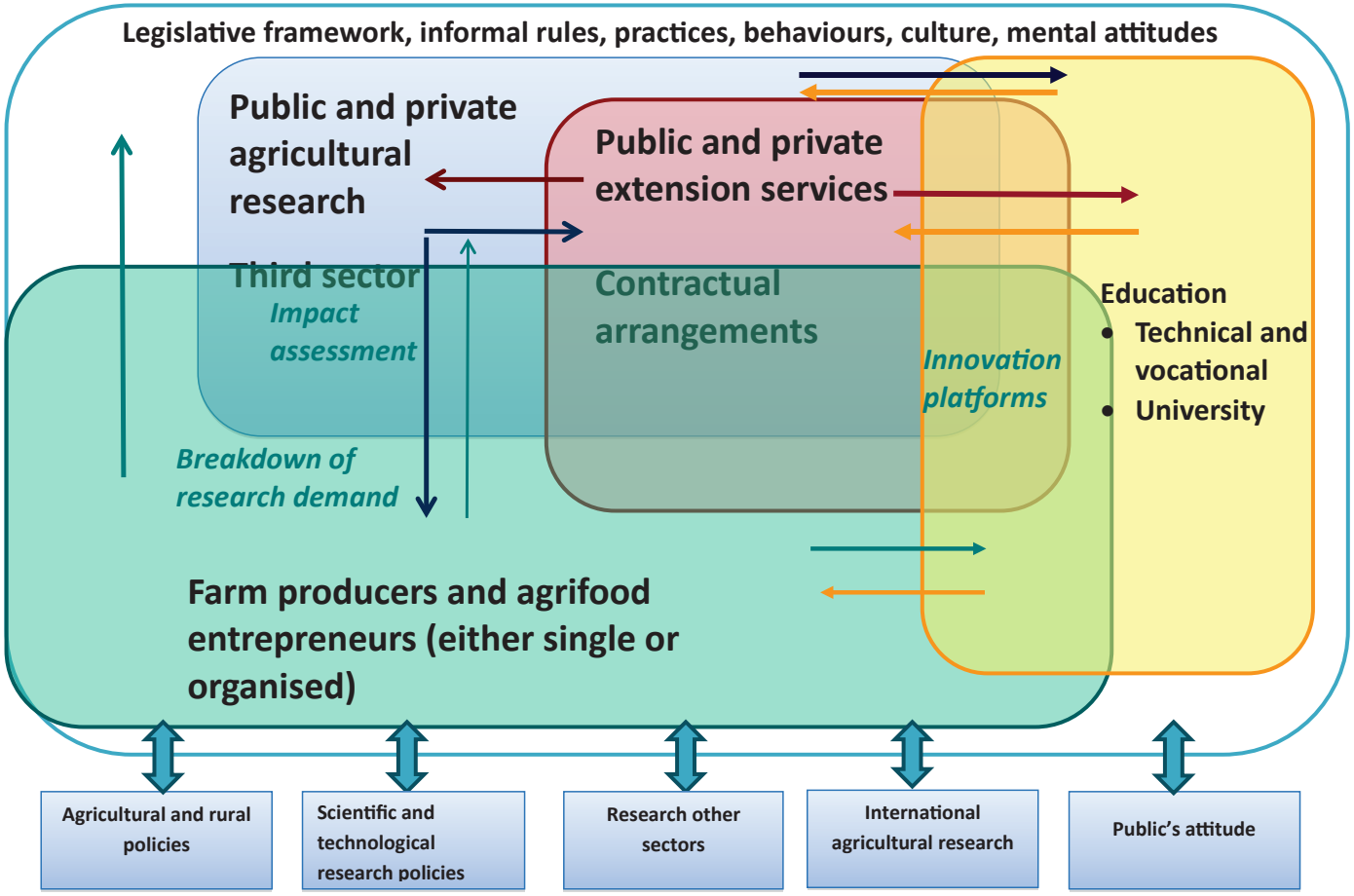

Table 2. Tasks of the most important players in the AIS (Translated and modified by Gildemacher and Wongtschowski, 2015).

Actor	Role in the AIS
Farmers	• Creation, testing and adaptation of new practices • Adoption of new practices and management of the related risks • Expression of innovation demand
Farmers' and producers' organisations and cooperatives	• Meeting innovation demand • Mediation of knowledge sharing among farmers and the other actors • Facilitation of the access to information, technology, means of production, credit and the market • Identification and implementation of new marketing practices • Representation of farmers in political institutions and in research and extension service management bodies
Extension services (involving the public, private and third sectors)	• Mediation of knowledge sharing among farmers and the other actors • Transfer ofknowledge to farmers and the other actors • Facilitation of access to information, technology, means of production, credit and the market • Promotion of gender equality • Mediation for conflict resolution (for access to resources)
Distributors of means of production (fertilisers, mechanisation, plant protection products, etc.).	• Distribution of innovative means of production • Provision of technical assistance
Wholesalers, processing industry (and their professional organisations)	• Identification and opening of new market opportunities • Search for new markets • Definition of quality standards for agricultural products • Development and application of new technology (for storage, cooling, packaging, logistics, processing, etc.)
Research bodies	• Identification and understanding of farmers' needs and priorities • Identification of innovation opportunities • Development, testing and adaptation of new technologies • Bringing the new promising technologies to production scale (via a participatory approach) • Sharing results obtained (even if negative) • Assessment and recording the socio-economic and environmental impacts of innovation
Institutes of technical, vocational and tertiary education	• Education and training of agricultural technicians at various levels
Public administrators	• Development of research and innovation policies • Formulation and implementation of rural development plans • Creation and implementation of a favourable legislative and regulatory framework for innovation • Provision of incentives for innovation

In particular, besides conducting their traditional scientific and technological research activities, research bodies are asked to involve final users in designing research and to incorporate their values, needs and priorities. They are also required to identify innovation opportunities directed at satisfying these needs, to share the results obtained, to make practices developed applicable, and to assess the socio-economic and environmental impacts of the innovations introduced, in addition to using participatory methods.

Until now, the concept of AIS has mostly been applied as a tool for describing agricultural innovation processes, especially following the introduction of a specific innovation (Spielman and Birner, 2008). There has been a recent proposal to use the AIS approach in the projects aimed at strengthening the innovation capabilities of developing countries (Ekong *et al*., 2015).

IV – Conclusions

The RRI approach is adressed to the general public, and responds to the needs analysed by MacNaughten *et al.* (2015) that were mentioned in the introduction to this article; it builds the bases for a renewed relationship of trust between science, technology and society. The AIS approach considers a more limited group of stakeholders, and is the strategy for promoting the adoption of technological, social and organizational innovation in a complex system like that of agrifood production. Both RRI and AIS approaches can and must be integrated into a new innovation paradigm, and they agree on the need for a profound cultural change summarised in Table 3. In other words, it is the social contract between science and society that must be modified, shifting from a relationship involving the supply of knowledge and technology to a partnership in processes of collective reflection aimed at giving collective responses to social, economic and environmental needs.

Table 3. Cultural changes made necessary by the new context of agricultural innovation.

	From	To
Ultimate aim of research	Creation of knowledge	Social, economic and environmental change
Social contract	Science for society	Science with and for society
Scientific approach	Reductionist (understanding the system's components)	Systemic (understanding the relations between the system's components)
Knowledge created	Scientifically sound	Scientifically and socially sound
Assessment	Indicators of result (publications, patents)	Impact indicators (social, economic and environmental change)
Relationship with society	Consultation with potential beneficiaries	Direct involvement of the parties concerned in decision-making processes
Type of communication	One-directional	Participatory
Communication tools	Scientific communication (conferences, scientific and technical papers)	Facilitation, recording, management and sharing of knowledge
Area of innovation	Farm	Territory
Type of training	Education	Collective learning
Work organisation	Individual merit and competition between research institutes	Teamwork and collaboration within and between research institutes and between research institutes and society

Lastly, it should be recalled that the previously mentioned needs for change reflect not only a mere social or ethical need but also specific economic requirements. In a period like the present, in which a generalised recession makes the allocation of economic resources a particularly critical process, it is essential to choose research guidelines that respond effectively to societal needs and whose results, once ac hieved, can actually be utilised for the positive general development of society.

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Notes

1 Some Authors refer to AKIS as Agricultural Knowledge and Innovation System, with a similar meaning to Agricultural Innovation System, and use the term AKS as Agricultural Knowledge System (EU SCAR, 2012). For the purposes of this article we prefer the terms AIS and AKIS, as suggested by the World Bank, the FAO, the IICA and other international organisations.