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RESEARCH ARTICLE

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Governance of knowledge and innovation in the Ibero-American agri-food system

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Abstract

Aim of study: Governance and the knowledge and innovation system (KIS) are interrelated concepts. Knowledge management best practices are linked to KIS performance. This article explores the governance of the leading research, development, and innovation institutes in Ibero-American agriculture, food, and agro-industry sector. The paper reports mapping of the governance of 20 agricultural research institutes.

Area of study: Latin America and the Caribbean, Spain and Portugal.

Material and methods: In total, 51 strategic objectives for effective governance were identified. Self-evaluation by the National Agricultural Research Institutes (NARIs) was validated at a workshop backed by FONTAGRO, a cooperation mechanism amongst Latin American and the Caribbean countries, Portugal and Spain, and the Ibero-American Network of NARIs.

Main results: As a strength, the key dimension of NARIs appears to be *coordination and cooperation*. This result was acknowledged in the internal and external evaluations and supports previous research on the relevance of innovation networks in Latin America. By contrast, as a challenge, the key dimension appears to be *demand articulation*, followed closely by *capacity building*. Most of the institutes are also well-positioned to develop deeper ties with social and environmental challenges.

Research highlights: In the medium and long term, NARIs should make efforts to improve the processes of organizational evaluation and learning, demand articulation, and strategic direction of the institutions. Improvement in management processes, in addition to best practices for social responsibility and gender equality, appear to be short-term priorities.

Additional key words: agriculture and agri-food research; national institutes for agriculture and agri-food research; knowledge and innovation systems; R&D resources; thematic analysis.

Abbreviations used: ASTI (Agricultural Science and Technology Indicators); CGIAR (Consultative Group on International Agricultural Research); CIAT (International Center for Tropical Agriculture); CIMMYT (International Maize and Wheat Improvement Center); FONTAGRO (Regional Fund for Agricultural Technology); IICA (Inter-American Institute for Cooperation on Agriculture); INIA-SP (National Institute for Agricultural and Food Research of Spain); KIS (Knowledge and Innovation System); LAC (Latin America and the Caribbean); NARIs (National Agricultural and Agri-food Research Institutes); NARS (National Agricultural Research System); R&D (Research and Development); SDG (Sustainable Development Goals).

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Introduction

To achieve their aims, innovation policies must be capable of putting into practice responsible processes geared towards anticipation, participation, transparency, and efficiency (Edler & Fagerberg, 2017). This article aims to analyze and evaluate these functions in the context of Ibero-American agricultural research and development (R&D) systems. National agricultural and agri-food research institutes (NARIs) have played a crucial role in providing solutions to the economic, social, and climate-related challenges that face the Ibero-American agricultural, agri-food, and agribusiness sector.

Two deeply interrelated concepts are fundamental to analyze and evaluate the functions of NARIs: 'system' and 'governance'. Like other regions, Latin America and the Caribbean (LAC) has experienced a conceptual shift concerning the term 'system'. Over the last 30 years, this shift has involved changes in approach about the role of the public sector in the processes of knowledge generation and transfer. Initially, the academic literature offered the framework of national agricultural research systems (NARS). This framework was often associated with a linear approach to research, development, and extension (for further detail, see a critical review by Spielman, 2005). This approach implicitly followed the leadership of public agricultural research centers, which became providers of knowledge that was largely external to users, particularly farmers. The perspective of the agricultural knowledge and information system (AKIS) emerged later. It is less linear than that of NARS because of its focus on knowledge flows amongst actors. This perspective (Chema & Roseboom, 2003) managed to address the heterogeneity of users and their behaviors, as well as their approaches to learning and innovation. More recently, the innovation system approach was introduced. In this study, this approach is extended to the knowledge and innovation system (KIS).[1] According to the OECD (1999: p.9), the KIS avoids following a linear approach by considering the set of interrelated agents, their interactions and the institutions that condition their behavior for the common objective of generating, disseminating and using knowledge and/or technology.

The KIS approach has received numerous criticisms. For instance, Delvenne & Thoreau (2017) noted the risk of designing a KIS that is detached from local and social contexts, and that focuses excessively on economic growth. They questioned how the model has been applied in LAC. Datta (2018) proposed that the concept of KIS should evolve to cover not only formal knowledge production networks but also informal social networks such as local associations or communities. Carayannis *et al.* (2018) extended the analytical framework to the 'quadruple helix' and 'quintuple helix', where government, business, academia, and civil society participate together in a democratic innovation model. Here, the 'innovation ecosystem' is a key concept, exploring how innovation processes take place within a social and natural environment that should be conducive to the co-evolution of knowledge by a host of actors.

Francis & Van Huis (2016) noted that the discourse surrounding agricultural innovation systems is evolving from a narrow view of knowledge generation and adoption processes to one that embraces an institutional context that encourages agricultural innovation. However, the concept of the innovation system may have a weakness in that there is a lack of inclusion of social objectives and the most vulnerable groups (Pound & Conroy, 2017). Nevertheless, if well oriented, it could be useful in the context of the agricultural, agri-food, and agribusiness sector in LAC countries.

The theoretical debate is influencing R&D strategies in LAC, as reflected by the Bogota Manual from the year 2000 (Jaramillo *et al.*, 2000). The manual highlights the specific nature of innovation processes in Latin American countries. As noted by Dutrénit & Natera (2017: p. 13), 'The formulation of science, technology and innovation policy in the region has gone from being government policy to defining elements of state policy, which extends beyond the realms of each government.'

Governance and the knowledge and KIS are interrelated concepts. Interest in knowledge management best practices is linked to KIS governance in the agricultural, agri-food, and agribusiness sector. The concept of governance has several meanings. For the purposes of the current research, the approach by the UNDP (2004) is particularly relevant. Under this approach, governance is defined as 'the system of values, policies, and institutions by which a society manages its economic, political and social affairs through interactions within and amongst the state, civil society, and private sector'.

This idea may well encompass the concept of good governance adopted by the new public management (NPM) school, which includes the principles of participation, accountability, efficiency, and effectiveness. It also includes a form of governance that serves as a guide for various actors involved in complex innovation processes through the rules and incentives that encourage the creation, application, and dissemination of knowledge and technologies (Hartwich *et al.*, 2007; Hillman *et al.*, 2011). A traditional way of analyzing KIS governance is using the 'hierarchy-market-network' trichotomy, which focuses on the debate between hierarchical management, a vision of the market where companies are solely responsible for the

[1] In the European Union, the abbreviation 'AKIS' is used to refer to the agricultural knowledge and innovation system within the scope of Horizon 2020.

development and 'governance without government' based on self-organized networks of actors (Steurer, 2007).

Material and methods

Theoretical framework

For the purposes of this study, the conceptual elements described in the introduction are complemented by the approach described by Lupova-Henry & Dotti (2019). These scholars examined KIS governance under the three-pillar framework of 'who' is governing, 'what' are they governing, and 'how' are they governing, also considering the interrelations between these three dimensions (see Fig. 1). The approach in this study shares this broad view of governance. Regarding 'who' is governing, a range of actors may be involved in activating and coordinating projects and institutions. However, given the history and leadership of NARIs and other public centers of the KIS in LAC, the first few sections of this study focus on the public sector itself. This does not mean following a hierarchical or linear analysis of knowledge but rather focusing on how public centers are embedded in a more complete knowledge system.

The question of 'what' is being governed is related to a strategic direction of knowledge and innovation policies and a non-neutral approach to the agricultural, agri-food, and agribusiness sector KIS in relation to the role of the system in achieving the Sustainable Development Goals (SDG) and beyond. In this regard, Bortagaray (2016) underscores the need to make substantial progress in policies that explicitly link science, technology, and innovation to sustainable development and social inclusion. Here, governance of the KIS is thought to be a more fundamental concept than public innovation policies. As explained by Howlett (2009), *'high-level government goals and implementation preferences are not random but rather tend to cluster over time into favored sets of ideas and instruments, or governance modes .....while the specific content of abstract policy goals will change from context to context'* (p. 76).

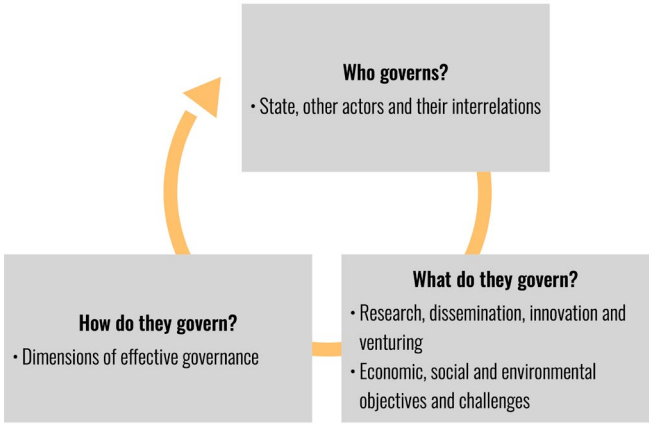

Figure 1. Key questions for effective governance of the knowledge and innovation system. *Source*: authors' elaboration

The vision of how NARIs relate to the rest of the KIS and the interactions amongst actors requires analysis of 'how' governance is approached. This analysis is based on six identified dimensions to assess NARI governance. Examples of set-ups for cooperation amongst the KIS are also introduced later. A future challenge is not who will lead the KIS but how stakeholders and institutions will relate to each other within the KIS.

Systemic analysis of governance

This study takes a systemic view that links NARIs to other providers and users of technology. This view is addressed by presenting an analysis of governance in which it is interpreted as a system of values that shape the actions of institutes and provide interactions with the society around them. In this analysis, the 'who' of governance refers to the institutes themselves, although the networks of actors they interact within both sub-national and international collaborative settings are also important. 'What' is being governed has to do with the strategic guidelines of the research centers, which will be discussed in a separate section. Finally, to establish 'how' to govern, several dimensions are identified. These include strategic objectives that should be pursued by R&D-oriented organizations.

This analysis considers various contributions concerning the proposed functions and conditions that scholars consider fundamental for the effective governance of the organizations within the KIS (Bergek *et al.*, 2008; Borras, 2009; Hillman *et al.*, 2011; Kilelu *et al.*, 2013; Borrás & Edler, 2014; Havas & Weber, 2017; Schot & Steinmueller, 2018). For Ibero-America, the following dimensions or conditions are proposed as necessary for effective governance (i) *directionality*, or the existence of strategic direction and anticipation; (ii) *demand articulation*, which entails the rapid adaptation of the institutional framework and the organization's actions for constantly evolving social needs or demands; (iii) *cooperation and coordination* with other KIS actors to account for the complexity of public and private interactions; (iv) *evaluation and learning* so that the institutes and their staff can take stock of their activities and can improve and adapt to any new needs; (v) *capacities*, providing resources, infrastructure, and qualified staff; and (vi) *management*, which grants the organization autonomy, transparency, and accountability, whilst streamlining processes.

Each of these dimensions can be divided into components or strategic objectives that may be desirable. A priori, 51 objectives are considered. These are detailed in the evaluation tables and are summarised in Table 1.

Table 1. Dimensions of effective governance and strategic objectives to include in each dimension

Dimension	Strategic objectives
Directionality Anticipatory strategic direction and coherence with economic policy. Smart specialization and dynamization of innovation ecosystems.	Anticipation of technological trends Formulation of a participatory strategy Consistency with economic policy Smart specialization Dynamization of the innovation ecosystem Promotion of spin-offs Conducive legal framework KIS leadership
Demand articulation Rapid adaptation to evolving social needs and real demands, practical approach, and technological dissemination	Flexible adaptation to an evolving world Smart technologies Balance between knowledge and practice Dissemination of technological capabilities Competitive selection for grants
Coordination and cooperation Multi-actor governance and collaboration have the complexity of public and private interaction	Plural governance Collaboration with universities in research and training Participation in innovation platforms International partnerships Linkage and transfer offices Creation of hubs to interface with firms
Evaluation and learning Institutional evaluation an improvement, impact assessment, and technological validation	Management, research, and transfer evaluation systems Validation of methods and technologies Impact assessment Structure of staff incentives
Capacity building Stable funding and resources, infrastructure and qualified staff	Basic financing Project stability Diversification of sources of resources Local presence Infrastructure Suitable size Qualified staff Excellence Staff mobility Generational renewal
Management Organisation autonomy flexibility, internal communication, transparency and accountability, gender equality and social responsibility.	Autonomy and accountability Stability throughout the political cycle Agile processes Internal communication Intellectual property management Transparency Social responsibility Gender equality policy

Source: Compiled by the authors

These objectives are evaluated under an integrative view of NARI participation in the KIS.

Methodological approach

In collaboration with Ecuador's National Institute for Agricultural and Fishing Research (*Instituto Nacional de Investigaciones Agropecuarias* or INIAP) and FONTAGRO, the National Institute for Agricultual and Food Research of Spain (*Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria* or INIA-SP) organized and chaired the 17th meeting of the Ibero-American NARI system in Guayaquil, from 1 to 3 October 2018. The main theme of the meeting was the governance of the institutes that make up the Ibero-American Network of NARIs. To map this governance, INIA-SP previosuly run a semi-structured survey so that each institute could further explain its governance characteristics at the meeting in Guayaquil. All 20 participating institutes were asked to submitt the results of the survey to INIA-SP's team and to present them at the meeting.

The survey addressed the institutions' challenges, mission and vision, organization and structure, human

resources, material and technical means, funding, R&D output, and collaborations and partnerships. This information was presented, compared, and discussed during the meeting. Specific sections of the survey aimed to identify the institutions' scope, strengths and challenges. A thematic anaysis on strengths and chalenges was carried out from institutes' answers. The thematic categorization was made according to the 51 pre-defined strategic objectives, following an increasingly used approach in social sciences that identifies the themes within pieces of text and oral presentations supplied by a sample of individuals or organizations (Braun & Clarke, 2006; Guest *et al.*, 2011). The pieces of information were submitted in form of texts prepared by each institute. The workshop was useful to clarify the meaning of institutes' contributions which were also enriched during the workshop's discussions.

Internal evaluation

The strengths and challenges identified in the institutes' reports were matched with a list of 51 strategic objectives spanning the six governance dimensions, so for each objective the institute's statements were subdivided into "strengths" and "challenges". This procedure shows whether each institution cited the pre-defined strategic objectives allowing to count them as strengths or challenges. The group of 20 institutions that provided information comprised 13 national institutes from LAC, four from Spain and Portugal, two international institutes of the CGIAR system (CYMMIT and CIAT), and IICA with a regional scope.

Table 2 shows the participating research institutes. Table 2 also shows the number of objectives reported as strengths and challenges by each one. The self-assessment

Table 2. Total times the consulted institutes mentioned strategic governance objectives as strengths or challenges

	Challenges	Strengths
Bolivia (INIAF)	8	3
Chile (INIA-Ch)	5	9
Colombia (AGROSAVIA)	18	9
Costa Rica (INTA-CR)	8	6
Dominican Republic (IDIAF)	21	6
Honduras (DICTA)	23	3
Mexico (INIFAP)	4	5
Nicaragua (INTA-N)	2	1
Panama (IDIAP)	2	
Paraguay (IPTA)	11	5
Peru (INIA-P)	16	2
Uruguay (INIA-U)	8	13
Spain (CICYTEX)	7	9
Spain (IRTA)	4	4
CIAT	6	8
CIMMYT	2	
IICA	7	2
Spain (INIA-SP)	12	4
Portugal (INIAV)	4	4

AGROSAVIA (Colombian Corporation for Agricultural Research); CICYTEX (Scientific and Technological Research Center, Extremadura); DICTA (Agricultural Science and Technology Directorate, Honduras); IDIAF (Dominican Institute of Agricultural and Forestry Research); IDIAP (Institute of Agricultural Research of Panama); INIA-Ch (Institute of Agricultural Research, Chile); INIA-P (National Institute of Agricultural Innovation, Peru); INIA-U (National Institute of Agricultural Innovation of Uruguay); INIAF (National Institute of Agricultural and Forestry Innovation, Bolivia); INIAP (National Institute for Agricultural Research, Ecuador); INIAV (National Institute for Agricultural and Veterinary Research, Portugal); INIFAP (National Institute of Agricultural and Livestock Forest Research, Mexico); INTA- CR (National Institute of Innovation and Transfer in Agricultural Technology, Costa Rica); INTA-N (Nicaraguan Institute of Agricultural Technology); IPTA (Paraguayan Institute of Agrarian Technology);); IRTA (Catalan Institute of Agri-Food Research and Technology). *Source*: Compiled by the authors based on the meeting of Ibero-American NARIs in Guayaquil (October 2018)

reports on governance presented by each institute as part of the workshop provided a key data source. These reports were used to record how each institute referred to each specific objective (challenge or strength). The overall trends are of greater interest than the individual results for each country.

External evaluation

Based on the contributions by the representatives of the participating organizations, the team from Universitat Politècnica de València and FONTAGRO performed an external evaluation. Benchmarking was used to assess and prioritize the objectives in each dimension. Three criteria were used. The first criterion was the relevance of each strategic objective. The scores ranged from 1 (*not relevant at all*) to 9 (*fully relevant*). The second criterion was the development of the objectives in the Ibero-American area. The scores also ranged from 1 (*not at all developed*) to 9 (*fully developed*). The third criterion was the difficulty of implementing these objectives or dimensions. The scores ranged from 1 (*not at all difficult*) to 3 (*very difficult*).

Results

Characterizing the public R&D system: history matters

In recent decades, the predominant approach has been an R&D system led by public research centers. To some extent, this is still the case. As various authors have reported (Diaz-Bonilla *et al.*, 2014; Villalobos *et al.*, 2017), Latin America has pioneered the development of the NARS, with institutes that are accountable to the agricultural ministries and that are aimed at improving agricultural development, among other objectives. Whilst the NARIs were being established, international centers in the CGIAR system were also being created. Examples include the International Centre for the Improvement of Maize and Wheat (*Centro Internacional de Mejoramiento de Maíz y Trigo* or *CIMMYT*), the International Center for Tropical Agriculture (*Centro Internacional de Agricultura Tropical* or *CIAT*) and the International Potato Center (*Centro Internacional de la Papa* or *CIP*). The complexity of the system grew in terms of the number and range of entities, funds, and networks for regional cooperation, such as FONTAGRO, IICA, CATIE (Tropical Agricultural Research and Higher Education Center), CARDI (Caribbean Agricultural Research and Development Institute), and the Network of Ibero-American NARIs (*Red de INIAs de Iberoamérica*).

Towards the end of the 20th century, the situation was one of state-centered governance. Since then, governance has evolved towards a more diversified and complex system. Not only does the private sector play a more active role, but NGOs, and universities have also become important actors.

Between the generation and application of technologies

The actions of public centers, particularly NARIs, has blurred the line between the generation of technologies and their application. However, there has been a stronger orientation towards applied technologies. This applied orientation places most NARIs in what Ruttan (2001) refers to as 'Rickover's quadrant'.[2] This relates to the development of technologies in areas where the commercial benefits of R&D are neither immediate nor evident because of the difficulties for private initiatives to appropriate these benefits.

The key role of NARIs does not hide the growing diversification of the research capacity of individual countries. Therefore, the question of who governs the system does not have an easy answer. According to the ASTI database, the total R&D funding in the agricultural, agri-food, and agribusiness sector from government, universities, and non-profit foundations and associations indicates that NARIs accounted for between 20% (Mexico) and 82% (Panama) of resources allocated to agricultural R&D in 2013. In any case, the NARIs in each country are sufficiently sized to highlight their contribution to the KIS.

The role of government: public funding

Does the government play a crucial role in R&D funding? Most NARIs are financed primarily with government resources. However, in some cases, there is a large contribution from cooperation funds (*e.g.* Bolivia) or a diversified structure with public and private contributions (*e.g.* Uruguay and Chile). A limitation of our data is that R&D spending by agribusiness is insufficiently accounted in the ASTI database and other available sources, so non-governmental resources mainly consider universities, private foundations and NGOs. Nevertheless, ASTI provides a first picture of the degree of the government's involving in R&D spending.

Figure 2 isolates two clusters of countries. The first cluster includes the eight countries with the highest

[2] Admiral Hyman Rickover developed the first nuclear plant not for commercial use but as an energy source for naval vessels.

agricultural R&D intensity in the region (> 0.8%). In this cluster the research intensity increases at a rate of 0.19 points when the share of government funding increases by 10 points, with a significant linear relation between both variables (p=0.0037). In the four countries with the highest R&D intensity (Argentina, Brazil, Chile and Uruguay at least 50% of agricultural R&D resources come directly from government sources. The second cluster includes nine countries where the R&D intensity is under 0.8% but the share of government resources is over 50%. In this cluster, a significant share of government funding appears not sufficient to achieve a higher R&D intensity and the relation between research intensity and the share of government funding is not significant (p=0.1407). The cases of Honduras and Peru, not belonging to the defined clusters, are of countries with very low R&D intensity (<0.4) but also with a low share of government in the agricultural R&D spending (<35%).

In short, these findings suggest that increasing government funding in the resource pool is necessary to reach higher rates of R&D intensity, but it does not seem sufficient in some countries with low R&D intensity. Possible reasons, to be further explored, are the insufficiency of total public R&D spending and the lack of complementary resources where the KIS is not sufficiently diversified.

Technological challenges and qualified people

Another important aspect of the system is the provision and characteristics of qualified people to meet technological challenges. Stads *et al.* (2016) showed that there is a tendency towards institutional diversification in agricultural research. By 2013, 45% of researchers were not in specialized government centers. The ASTI database shows notable dispersion in the characteristics of researchers in the LAC countries. A brief analysis of the database for these research staff indicators yields the following results:

- The rate of full-time equivalent (FTE) researchers is 63 per 100,000 farmers. The FTE per million inhabitants is an indicator of the prominence of agricultural R&D in society. There are, on average, 35 researchers per million inhabitants. Again, there is a wide range. Guatemala and Ecuador have fewer than 10, whereas Costa Rica and Chile have more than 50, and Argentina and Uruguay have more than 100.
- The number of researchers with PhDs in LAC 30 years ago was low. The situation has improved substantially (Esquivel *et al.*, 2017). However, ASTI data show that in 2013, only one in five researchers in the agricultural, agri-food, and agribusiness sector had PhDs. The rate of researchers with PhD was above 30% in only three countries (Chile, Mexico, and Brazil) and was below 10% in six countries.
- The rate of young researchers (aged<31 years) is 8%. Colombia has the highest rate, with 24%. At the other extreme is the issue of generational renewal, which is reflected by the percentage of researchers aged over 60 years. This is a challenge in countries such as Peru, Brazil, Argentina, Chile, Mexico, and Uruguay.
- The average percentage of women researchers is 30%. However, in five countries, this percentage is less than 20%, and only three countries have more than 40%.

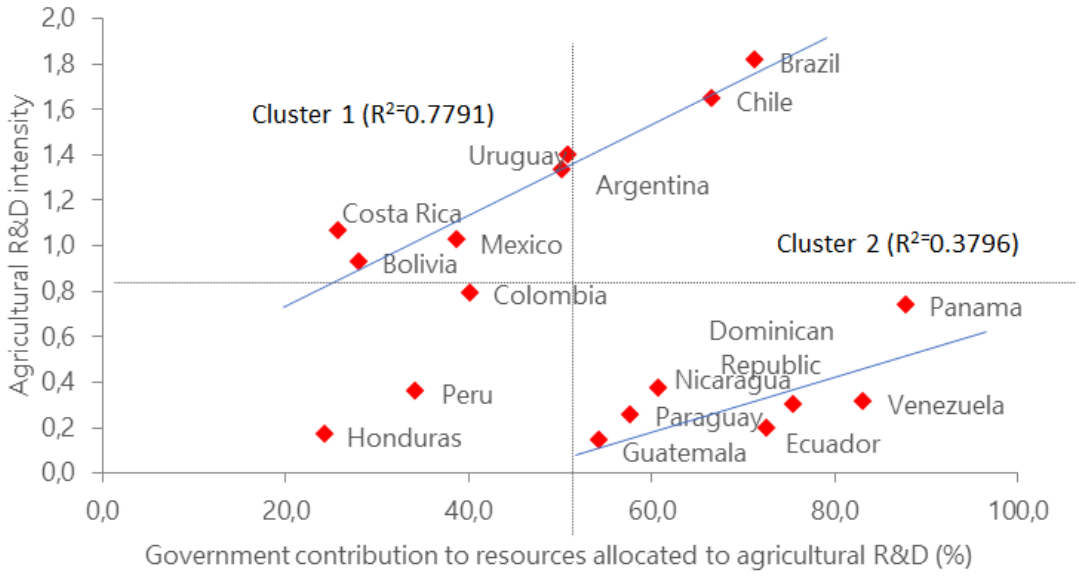

Figure 2. Agricultural R&D intensity *vs* government contribution to total resources for agricultural R&D in LAC countries. *Source:* Authors' ellaboration based on data from the ASTI database (2013)

Therefore, gender equality remains a challenge for the system.

- Based on the information from the NARIs for this study, the percentage of PhDs grew in five of the seven NARIs that provided data for the period between 2013 and 2018. There were substantial increases in Chile and Uruguay, with the Uruguayan NARI reporting that it has more than 50% PhDs.

What is being governed?

A considerable portion of the data from the institutes refers to their strategic directions: their vision, mission, and objectives. These data have been used to gather the concepts that appear explicitly in these strategic directions. The fact that an idea is not explicitly stated in an institute's strategic direction does not mean that it has not been paid sufficient attention. It is also possible that a specific concept is considered to be closely related to others. All institutes form part of the science policy. Therefore, it is assumed that research and dissemination of knowledge is their *raison d'être*. The explicit reported strategic directions are presented in Table 3.

The most prominent concepts are those of research, knowledge generation, innovation, and technology development and transfer. Many institutes have strategic directions related to promoting sustainability, citizens' well-being, and development. The improvement of productivity and competitiveness was expressly mentioned by 11 institutes, nine of which showed an explicit interest in companies in the agricultural, agri-food, and agribusiness sector. The objectives relating to food security and sovereignty were shared by five institutes. Those relating to nutrition and consumption were likewise expressed by five. One of these also expressed a strategic interest in food security.

Some directions might be in the minority either because they were considered to have been covered implicitly or because they were not historically considered priorities amongst the objectives of the NARIs. This group includes directions related to inclusiveness, multiculturalism, resilience, and SDG. A few institutes also cited internationalization and support for the public administration as key aspects. Finally, 10 of the 20 institutes expressed a desire to continue acting as a model within the NARS.

Results of the internal evaluation

For each of the six governance dimensions, the analysis was performed to calculate the number of institutes which

Table 3. Number of mentions of the main concepts used in their goals, vision, mission and strategic objectives of the 20 consulted institutes

Number of mentions	Concept
15	Conduct research and create knowledge
13	Encourage sustainability, make sensible use of resources, and improve ecosystem services and natural resources
12	Innovate and develop technologies
12	Enable the adaptation and/or transfer of knowledge
12	Encourage the development and well-being of citizens
11	Improve the productivity and competitiveness of the agricultural, agri-food and agribusiness sector
10	Act as a model organization in terms of R&D
9	Support the private business sector in adopting R&D outcomes
7	Engage in training, personal development, and talent management
5	Achieve food security and/or sovereignty
5	Improve nutrition and analyze demand
5	Support policies and administration
4	Develop an international vision
3	Ensure inclusiveness and multiculturalism
3	Build resilience to climate change
1	Ensure alignment with SDG

Source: Compiled by the authors based on the 17th Meeting of Ibero-American NARIs (*XVII Encuentro de INIA de Iberoamérica*) in Guayaquil, October 2018

Table 4. Average number of mentions of an objective as a challenge or strength for each governance dimension

Number of mentions	Challenge	Strength
Directionality	3.4	2.4
Demand articulation	4.0	2.0
Coordination and cooperation	3.7	2.8
Evaluation and learning	2.2	1.3
Capacity building	3.9	2.5
Improvement in management	2.6	0.5

Source: Compiled by the authors from the reports presented by the institutes participating in the Guayaquil workshop

expressed strengths or challenges in relation to each strategic objective (see Table 4). In each dimension, the arithmetic mean was calculated for the number of mentions of objectives in terms of strengths or challenges within each corresponding dimension. For example, a value of 3.4 in the *directionality* dimension means that an average of 3.4 institutes (out of a maximum of 20) mentioned a strategic objective in that dimension as a strength.

As for strengths, the three dimensions with the highest average number of mentions were *directionality*, *capacity building*, and *coordination and cooperation*. The three dimensions with the lowest average number of mentions as strengths were *demand articulation*, *evaluation and learning*, and *improvement in management*, with the latter receiving the lowest number of mentions.

The most rarely mentioned challenges (fewer than three mentions) were *evaluation and learning and improvement in management*. The four dimensions most frequently considered challenges were *directionality, coordination and cooperation, capacity building,* and *demand articulation.*

The specific strategic objectives with the highest number of mentions as a strength or challenge are shown in Table 5. The strategic objectives can be placed into four groups. This grouping yields four types of recommendations:

- First, there are objectives that some countries consider a strength but few or none consider a challenge. These objectives are to be 'maintained'. Specifically, these objectives are 'to achieve a country-wide presence and cooperate with regional actors', 'to be supported by a legal framework as the coordinator of the KIS in the agricultural, agri-food and agribusiness sector' and 'to formally participate in complex international partnerships'.
- Second, there are objectives that few countries consider a strength but some see it as a challenge. These objectives are to be 'driven forward'. In total, 16 objectives have these characteristics.
- Third, there are objectives that few countries mention as either strengths or challenges. For these objectives, the recommendation would be for 'reflection'. It is unclear whether these are actually unnecessary or whether the institutes are simply unaware that they are necessary. There are 21 such objectives.
- Fourth and finally, there are objectives that some countries mention as a strength and others as a challenge. There are 11 of these objectives. Here, the recommendation would be to 'cooperate'. This means

Table 5. Most frequently mentioned strategic objectives

Dimension	As a strength	As a challenge
Directionality	Reach a position as a leader in the agricultural, agri-food and agribusiness sector KIS	
Demand articulation	Achieve a systematic association between knowledge and practice	
Coordination and cooperation	Participate formally in complex international partnerships	Strengthen public-private partnerships to catalyze value chains
Evaluation and learning		
Capacity building	Hire qualified and up-to-date human resources with PhDs and MScs	Ensure that support facilities and services are adapted to new technological challenges
	Achieve a country-wide presence and cooperate with regional stakeholders	Hire qualified and up-to-date human resources with PhDs and MScs
Improvement in management		Modernize management processes and have an appropriate, agile organizational structure
		Streamline human resource management with a suitable incentive structure

Source: Authors' ellaboration from the reports presented by the institutes participating in the Guayaquil workshop

establishing partnerships to join forces or exchange experiences.

Correlations between reported mentions to challenges for each pair of strategic dimensions were estimated for the sample of NARIs.[3] The highest correlation coefficients were found between capacity building and evaluation and learning (0.942), and between capacity building and coordination and cooperation (0.854). Improvement in management shows the lowest correlations with the other dimensions, with a maximum correlation of 0.408 with coordination and cooperation. Management is therefore considered as hardly linked with the rest of strategic dimensions. Directionality shows a correlation coefficient of 0.742 with coordination and cooperation suggesting a possible association between both dimensions, in particular through networking with private and public actors.

Results of the external evaluation

The results of the external evaluation are examined using mapping (Fig. 3). This mapping shows the evaluations made by the work team. The dimensions in the upper right quadrant are highly important and highly developed. These are the key factors. Those located in the lower right quadrant are factors that should be maintained.

Similarly, important opportunities or areas in the short, medium, and long term can also be identified. The strategic objectives or dimensions located in the upper part of the lower right quadrant are medium-term priorities. The strategic actions or dimensions located in the lower right quadrant are long-term priorities. Hence, the strategic importance of these factors is still at an early stage. Taking the average for each dimension by strategic objective shows that the key factors (relatively high importance and high stage of development) are *capacity building* and *coordination* and *cooperation*. *Improvement in management* is a short-term priority. *Evaluation and learning and demand articulation* are medium-term priorities. Finally, *directionality* is a long-term priority.

The dimensions can be classified into three groups according to the average difficulty of implementation: (i) low difficulty (*directionality, coordination and cooperation,* and *demand articulation*), (ii) medium difficulty (*improvement in management*) and (iii) high difficulty (*evaluation and learning and capacity building*).

The *coordination and cooperation* dimension is cited as a key factor. However, its implementation does

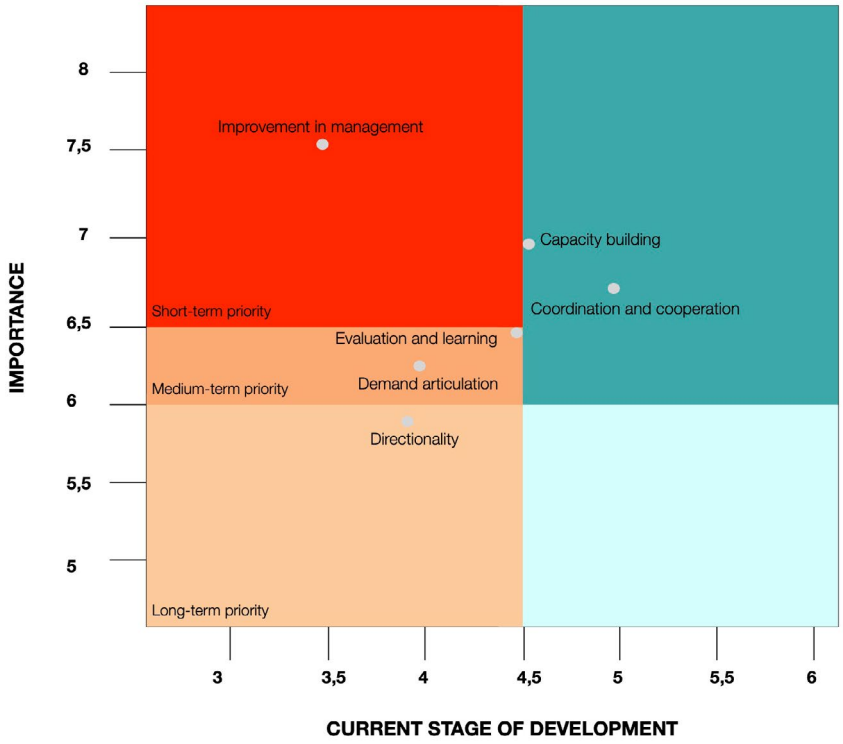

Figure 3. Assessment of strategic dimensions of NARIs by importance and stage of development. *Source*: Authors' elaboration based on the external evaluation of NARIs' governance.

[3] The basic data for correlations and the correlation matrix can be supplied at authors' request.

not seem to entail a high degree of difficulty. *The capacity building* continues to require special attention (PhDs and laboratories cannot be created on an ad hoc basis). In the short term, *improvement in management* is of medium difficulty and is at a low stage of development. The areas that should be planned for as medium- and long-term objectives are *evaluation and learning, demand articulation, and directionality.* Implementing suitable mechanisms to evaluate processes and results might prove more difficult. These mechanisms require a strong commitment from the institutions and communities involved.

Discussion

A KIS comprises multiple public and private actors that interact with one another. A deal of published research on innovation systems in Latin America has emerged in recent years (Hartwich *et al.*, 2007; Villalobos *et al.*, 2017; Devaux *et al.*, 2018). Most of this studies emphasize how linear and hierarchical transfer systems are progressively being abandoned. In general, this paper corroborates the NARIs' position as an essential node in the KIS in most Ibero-American countries.

The role of public investment as the driver of agricultural research in Latin America remains fundamental. As observed in the first part of the Results section, the the absence of public funding of R&D resources is an important factor behind relatively low R&D intensity, although a high share of government funding is not always sufficient for high R&D intensity. Private investment in R&D plays a key role. The literature provides detailed discussions of the complementarity or substitutability of public and private R&D spending (David *et al.*, 2000; Mas-Verdu *et al.*, 2016) and the present study underlines that a significant share of public funding is not sufficient per se to increase R&D intensity. Recent studies (Marino *et al.*, 2016; Choi & Le 2017) have also indicated the absence of the substitutive effects of private and public investment in R&D. Our research suggests that the public sector and the NARI in particular can provide the right infrastructure to support research and innovation.

Nevertheless, there is a shortage of high-quality statistics on the role of companies in innovation activities that target the agricultural, agri-food, and agribusiness sector. Timely data on the volume of R&D expenditure by the private business sector are lacking, and should continue the efforts initiated by previous databases (Norton, 2011; Stads *et al.*, 2016).

The analysis of the governance of NARIs identified 51 strategic actions or objectives for effective governance. The proposed method can provide a basis for further strategic analysis and monitoring of the institutes based on the six governance dimensions of *coordination and cooperation, capacity building, improvement in management, evaluation and learning, demand articulation, and directionality.*

As a strength, the key dimension of NARIs appears to be *coordination and cooperation*. This result was acknowledged in the internal and external evaluations and supports previous research on the relevance of innovation networks in Latin America (Geldes *et al.*, 2017). In the agricultural and food sector, there are consolidated regional networks such as FONTAGRO, which articulates more than 167 public-private innovation platforms, MasAgro (Sustainable Modernization of the Traditional Agriculture, a participatory improvement of maize with the National Institute of Agricultural and Livestock Forest Research, Mexico, and CIMMYT), or Network of Ibero-American NARIs.

By contrast, as a challenge, the key dimension appears to be *demand articulation*, followed closely by *capacity building*. Most institutes are enhancing the integration of public research within the KIS. However, this is achieved through close links with users and social demands, as well as a strong supply of highly qualified human resources.

Comparing the external and internal evaluations reveals some discrepancies. For example, internally, many of the evaluated institutes do not perceive *improvement in management* to be a high priority, except of project management. However, the external evaluation highlights it as a clear priority for short-term implementation. The administrations might still have to internalize certain objectives such as transparency, gender equality, and social responsibility.

Many of the specific strategic objectives with high scores in the internal and external evaluations refer to the way the institutes are linked to the KIS, R&D capabilities, and effective process management. The strategic objectives in Table 6 were considered high-priority challenges in the internal evaluation and highly important in the external evaluation. They are specific strategic objectives from the dimensions of *directionality, demand articulation, improvement in management, and capacity building.*

Certain strategic objectives received a few mentions as strengths. This low number of mentions might not necessarily imply that the institutions are weak in these areas; they might simply not have considered the objective relevant enough to highlight in the report. This is true of those related to *evaluation and learning*. These objectives received a few mentions as strengths or challenges. Notably, there was also little or no mention of objectives such as 'to promote spin-offs and technology-based companies', 'to promote staff mobility in firms and the private sector' or 'to build suitably sized research teams'. While multi-actor participatory approaches are becoming more and more common in agricultural research (Waddington & White, 2014; Devaux *et al.*,

Table 6. Specific objectives considered high-priority challenges

High-priority challenges	Frequency of mentions as a strength	External evaluation as a priority	Strategic recommendation
Modernize management processes and secure suitable and agile organizational structure	Low	Short term	Drive forward
Strengthen public-private partnerships to catalyze value chains	Low	Key factor	Drive forward
Achieve sufficient and stable basic financing	Low	Short term	Drive forward
Ensure that support facilities and services are adapted to new technological challenges	Low	Key factor	Drive forward
Hire highly qualified and up-to-date human resources with PhDs and MScs	High	Key factor	Cooperate
Streamline human resource management with a suitable incentive structure	Low	Short term	Drive forward
Achieve a suitable intensity of talent renewal and capture	Low	Short term	Drive forward
Undertake participatory processes with multiple actors in the formulation of technological priorities	Low	Short term	Drive forward
Diversify financing with resources from external, public and private sources	High	Short term	Cooperate
Strengthen transfer units and linkages with the private sector and other actors	Medium	Key factor	Drive forward

Source: Internal and external evaluation reports of the agricultural research institutes.

2018), NARIs have not yet become fully operational as innovation platforms, considered as knowledge intermediaries (Kilelu *et al.*, 2013). Neither the *improvement in management* objectives related to social responsibility nor those related to gender equality were mentioned as strengths or challenges, though these aspects are increasingly considered an asset for international research institutions (McCluskey, 2019).

Table 7 reflects the key recommendations arisen from the results for the whole Ibero-american network of NARIs previously summarised. The two columns include the required strategic actions, derived from the internal evaluation, and the priorities, derived from the external evaluation. Some dimensions that are more frequently cited as strengths and challenges are posible areas of inter-institutional and international collaboration. Among these, coordination and cooperation, and capacity building are considered key priorities, and directionality as a long-term priority. Demand articulation is more frequently mentioned as a challenge, suggesting the need to move forward towards more applied knowledge transfer. The external evaluation considers this dimension as a medium-term priority. Evaluation and learning, and improvement in management, are not frequently considered internally as major challenges or as strengths. However, the external evaluation confirms the short-term priority of improvement in management and the need to improve evaluation and learning with a medium-term perspective, so the institutes should not avoid to reflect on upgrading both dimensions in their goverance strategies.

Table 7. Recommended actions and priorities for the Ibero-American network of NARI.

	Recommended action	Priority
Directionality	Inter-institutional collaboration	Long-term
Demand articulation	Drive forward	Medium-term
Coordination and cooperation	Inter-institutional collaboration	Key priority
Evaluation and learning	Reflect	Medium-term
Capacity building	Inter-institutional collaboration	Key priority
Improvement in management	Reflect	Short term

Source: Internal and external evaluation reports of the agricultural research institutes (see Table 4 and Fig. 3).

Six fundamental policy implications can be drawn from this study:

1. Capacity building keeps a key dimension for NARIs, oftenly linked to demand articulation and collaboration in innovation activities. It would be advisable to extend strategies to generate income to enhance and complement public support and provide firmer financial sustainability. Actions may consist of public-private consortia to handle research programs as well as small-scale initiatives. Private contributions can be made to provide applied solutions to benefit agricultural and rural communities.
2. Governance models should encourage greater involvement by the private sector, businesses, foundations, universities, and agricultural and rural communities. The approach should not be one of rivalry but rather of synergy between public and private undertakings in order to update research directionality and to collaborate in innovation activities.
3. Setting up effective administrative and financial management systems, as well as systems for linking or managing research, is a clear short-term priority for NARIs. While improvement in management is not usually considered as a dimension linked with the rest of strategic dimensions, it is essential to identify areas where the administrative system can be simplified to remove obstacles that prevent linking the institutes with the rest of the system and engaging in international cooperation.
4. The implementation of suitable mechanisms to evaluate processes and outcomes appears to be essential. A strong commitment is needed from the institutions and the communities that work with them. The IDB (Inter-American Development Bank), CGIAR, and national research institutions in Ibero-America should continue collaborating to strengthen the ASTI database to provide statistics on the R&D system for LAC, at least every two years.
5. It is important to reflect on the scope, vision, and mission of the research institutes so that they can adapt to the challenges of this century. The NARIs strategic mission must be determined by a deeper asssessment of the roles of the state in the agricultural KIS (Borras & Edler, 2020). As for the scope, the importance of directions related to inclusiveness, multiculturalism and resilience is highlighted by the growing literature on agricultural innovation. The NARIs should consider more explicit guidelines on climate change, SDG, and inclusive development, with an ongoing focus on areas related to famine, nutrition, and family farming.
6. We recommend to prioritize areas of governance where cooperation between institutes can have positive outcomes. In our inquire to NARIs, certain objectives were mentioned as a challenge by some institutes and as a strength by others. Examples include the objectives 'to hire qualified and up-to-date human resources with PhDs and MScs', 'to diversify funding with resources from external, public and private sources', 'to anticipate long-term technological trends and make them a strategic priority' and 'to achieve a systematic link between knowledge and practice'.

Our method of analysis nonetheless has certain limitations. First, the method allows to count the institutes' references to the strategic objectives but not the intensity of contributors' support to each objective. Second, a subgroup of specific objectives were mentioned as neither a strength nor a challenge. Governance practices whose importance was not highlighted or was considered to have already been achieved should not be overlooked. Examples are the objectives referring to social responsibility and gender equality. Further research is needed to identify the underlying social and cultural factors behind the apparent lack of consideration of such objectives. Third, as mentioned earlier, some institutes provided more detailed information than others. These differences led to a varying number of dimentions of certain objectives. A fourth caveat is that the external evaluation identified some objectives that might be relevant for strategic planning, despite not being highlighted in the internal evaluation. Fifth, differences in strategic objectives expressed by the NARIs can be further studied to define commonalities of challenges and priorities. Finally, a deeper consideration of all the drivers of R&D intensity in the agri-food sector is needed to understand country differences in the effectiveness of public R&D funding. In spite of these limitations, this study offers a starting point to discuss and eventually implement standardized questionnaires within the framework of the strategic planning backed by FONTAGRO for 2025 and for the monitoring of the Ibero-American NARIs' network.

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