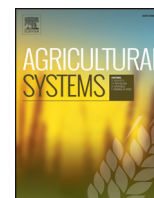


Contents lists available at [ScienceDirect](http://ScienceDirect.com)

# Agricultural Systems

journal homepage: [www.elsevier.com/locate/agsy](http://www.elsevier.com/locate/agsy)

Short communication

## The “efficient boundaries” of international agricultural research: A conceptual framework with empirical illustrations

Josey Kamanda <sup>a,\*</sup>, Regina Birner <sup>b</sup>, Cynthia Bantilan <sup>c</sup><sup>a</sup> Africa Rice Center (AfricaRice), East and Southern Africa, P.O. Box 33581, Dar-es-Salaam, Tanzania<sup>b</sup> Division of Social and Institutional Change in Agricultural Development (Hans-Ruthenberg-Institute), University of Hohenheim, Germany<sup>c</sup> Research Program on Markets, Institutions and Policies (MIP), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502324, Telangana, India

### ARTICLE INFO

#### Article history:

Received 21 March 2016

Received in revised form 26 September 2016

Accepted 24 October 2016

Available online xxxxx

#### Keywords:

Agricultural innovation

Comparative advantage

Governance

Transaction cost economics

Food security

CGIAR

### ABSTRACT

The international agricultural research centers known as CGIAR have played an important role with regard to global food security. Yet, their mandate remains debated: Should they concentrate on producing global public goods, for which they arguably have a comparative advantage, or should they engage in “downstream” activities of the research-development continuum and promote technology adoption on the ground, so as to increase their impact? This paper contributes to resolving this debate by developing a new conceptual framework, which is based on transaction costs economics and makes it possible to identify a range of factors that determine the comparative advantage of international versus national organizations. The different transactions involved in the development and uptake of products from international agricultural research are illustrated by an empirical case study of the legume improvement program of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Data collection involved a participatory mapping technique (Net-Map) as well as key informant interviews. The paper draws attention to the governance problems involved in downstream activities, which influence the comparative advantage of international versus national organizations in the research-development continuum. Policy implications are derived for the ongoing reform of the CGIAR and for future research on this topic.

© 2016 Elsevier Ltd. All rights reserved.

### 1. Introduction

The first two Sustainable Development Goals (SDGs) aim to end extreme poverty and hunger, achieve food security and improved nutrition, and promote sustainable agriculture (UN General Assembly, 2014). The strategy and results framework of the CGIAR also identifies three system level outcomes (SLOs): reducing rural poverty, improving food and nutrition security for health, and improving natural resources and ecosystem services (CGIAR, 2015). The 2008 World Development Report (World Bank, 2007) stressed the importance of agriculture-led growth to achieve these targets. Although there are differences across regions, productivity growth closely linked to investments in agricultural research and development (R&D) has driven agriculture's global success (Alston et al., 2000; Pardey et al., 2006; Raitzer and Kelley, 2008; Renkow and Byerlee, 2010). International agricultural research (IAR) plays an important role in exploiting advances in agricultural science to improve the lives of the poor in developing countries (Zeigler and Mohanty, 2010).

The international agricultural research centers (IARCs) that form the CGIAR evolved as the main international system of agricultural research.

The CGIAR centers struggle to find a balance between basic and strategic research activities located on the upstream side, and delivery programs located downstream. The general view has been that the CGIAR should concentrate on the upstream side, conducting research that produces international public goods (IPGs) (TAC Secretariat, 2000; Harwood et al., 2006; Sagasti and Timmer, 2008; CGIAR Science Council, 2005, 2008, 2009). However, there is often no functional research-development (R-D) pathway, which would ensure that CGIAR research results are implemented on the ground. Financial constraints and the requirement by bilateral donors to show impact have pushed centers down the R-D continuum, inducing them to engage in more location-specific research and promotion activities (Pingali and Kelley, 2007; Bertram, 2006; Katyal and Mruthyunjaya, 2003; Anderson, 1998; Alston et al., 1998).

To improve its structure and functions, the CGIAR system has attempted reform efforts for decades (McCalla, 2014). In the latest reform, the work of the 15 centers is organized under the cross-cutting CGIAR Research Programs (CRPs) (BCG, 2009:5; CGIAR Independent Review Panel, 2008). Donors are expected to channel their funds through the CGIAR Fund, which has three funding windows. Window 1 provides unrestricted contributions to be allocated to CRPs, while Window 2 allows donors to target specific CRPs (CGIAR SRF, 2011). Even though these two windows provide the opportunity to finance

\* Corresponding author.

E-mail address: [kamandao@gmail.com](mailto:kamandao@gmail.com) (J. Kamanda).

research in accordance with the strategy and results framework (SRF), a significant proportion of funding is still allocated through Window 3. Furthermore, bilateral<sup>1</sup> projects still constitute a large proportion of funding to the CGIAR. This indicates that, so far, a major objective of the reform has not yet been achieved.

It is therefore crucial, as the CGIAR undergoes another phase of reform, to analyze the outstanding debate on what activities the centers should focus on. This paper aims to contribute to this debate by developing a framework based on concepts of the New Institutional Economics<sup>2</sup> to identify the factors that determine the comparative advantage of IARCs.

From a normative point of view, the comparative advantage of IARCs is related to the question as to what governance structure is best suited for the different types of transactions involved in research and in the implementation of research findings. Transaction cost economics (Shelanski and Klein, 1995; Brown and Potoski, 2003), a branch of the New Institutional Economics, offers an analytical approach that aligns transactions that differ in their attributes with governance structures that differ in their costs and competence so as to achieve a cost-effective result (Williamson, 1991). The paper adapts this framework to the specific features of agricultural research organizations to provide conceptual guidance on how impact from IARCs can be achieved in the most cost-effective way. To use this approach, it is necessary to specify the different transactions involved in the development and uptake of products from IAR. An empirical case study of an important area of agricultural research was conducted for this purpose: research that aims to improve legume crops, which is supported by one of the CGIAR centers, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

In the case study, an innovative research tool called “Net-Map” was used. Net-Map is a participatory mapping technique (Schiffer and Hauck, 2010), which was applied to identify the different activities (transactions) and organizations involved in research on improved legumes and their promotion. After developing a typology of transactions based on the empirical study, a transaction cost economics framework was developed and used to analyze the comparative advantage of different organizations in conducting the different types of transactions. By integrating contextual factors, the framework also serves to identify why international centers engage in activities for which they are not expected to have a comparative advantage vis-à-vis national or local organizations.

## 2. Assessing the comparative advantage of CGIAR centers

The question of the comparative advantage of the CGIAR has been subject to long-standing debate. Two concepts have been developed in this context: the concept of a research - development continuum, and the concept of International Public Goods.

### 2.1. The agricultural research - development continuum

The concept of the research-development continuum is displayed in Fig. 1 (Craswell and Penning de Vries, 2001; cited in CGIAR Science Council, 2006, p. 74). Four types of research are identified: basic, strategic, applied and adaptive.

According to this concept, the CGIAR should concentrate on strategic research generating technologies that fit relevant ecological and production conditions across the developing world. The centers should collaborate with ARIs, who have their focus on basic research, and with the National Agricultural Research and Extension Systems (NARES), who

cover the spectrum from strategic to applied and participatory-adaptive research.

### 2.2. The concept of international public goods (IPGs) in the CGIAR

Economists differentiate pure public goods from private goods by the two criteria of being non-rivalrous<sup>3</sup> in consumption and non-excludable<sup>4</sup> (Samuelson, 1954:387). The rationale for public sector involvement in agricultural research is based on the fact that agricultural technologies have characteristics of public goods, especially if they are not embodied in a particular technology, or – as in case of seeds – if they can be reproduced by the farmers themselves. Integrated Natural Resource Management (INRM) technologies in particular involve benefits that accrue to the entire community or watershed. Private firms have limited interest since they do not have the capacity to capture much of the benefit through proprietary claims (Pingali and Kelley, 2007; Spielman, 2007). Publicly funded research centers at national and international level are expected to step in to fill this gap (Pineiro, 2007).

The view that CGIAR centers should focus on provision of public goods at the international level (IPGs) began to be explicitly mentioned in the late 1990s and early 2000s (Sagasti and Timmer, 2008; Kanbur, 2001). This concept has since been subject of discussion in various fora (CGIAR Science Council, 2006, 2008; Harwood et al., 2006).

The IPG concept can be more easily applied to traditional CGIAR research, like germplasm improvement and development of new crop varieties, for which economies of scale and spill-over effects can be determined more easily compared to other types of technologies or knowledge, such as natural resource management (Ryan, 2006). Some critics consider the IPG criterion as a conceptual barrier with an unrealistic division of labor between research and development that does not give sufficient attention to institutional constraints (CGIAR Science Council, 2008). Besides, going by the basic definition of public goods, every document placed on the internet with free access would fulfill this IPG criterion whether or not it leads to achievement of CGIAR system level outcomes.

These arguments show that there are contrasting views on whether the IPG concept is refined enough to be the key criterion that offers strategic direction on what the CGIAR centers should do or not do. Against this background, this paper develops a more refined framework to provide conceptual guidance for assessing the comparative advantage of IARCs.

## 3. Methodology

The research presented in this paper consists of two components: (i) A case study, which aims to provide a detailed account of the research and dissemination process of improved technologies produced by IARCs, and (ii) a conceptual framework, which defines the functional boundaries of IARCs based on their comparative advantage, taking the case study results into account.

To develop a transaction costs framework, it was important to understand all transactions involved in the R-D process. In order to achieve this in a participatory manner, the Net-map procedure was chosen. It involved asking a series of questions regarding the main actors, their linkages, and the level of influence of each actor on the intended outcome (adoption of new varieties). Follow-up questions were asked on governance challenges involved in the process.

To develop the conceptual framework, the case study was combined with an application of the fiscal federalism literature (Oates, 1972) and

<sup>1</sup> In 2015, contributions through the CGIAR Fund represented 59% of total funding (\$554 million) and bilateral project grants represented 41% of funding (\$389 million) (CGIAR Fund Office, 2015: 4).

<sup>2</sup> The New Institutional Economics is a multidisciplinary field that focuses on the role of institutions in economic theory. It includes aspects of economics, history, sociology, political science, business organization and law (Kherallah and Kirsten, 2001).

<sup>3</sup> The non-rivalry criterion means that any one person's consumption of the public good has no effect on the amount of it available for others.

<sup>4</sup> Non-excludability implies that it is either impossible or very costly to exclude those who do not pay for the good from utilizing it, and once the good has been produced its benefits (or harm) accrue to everyone.

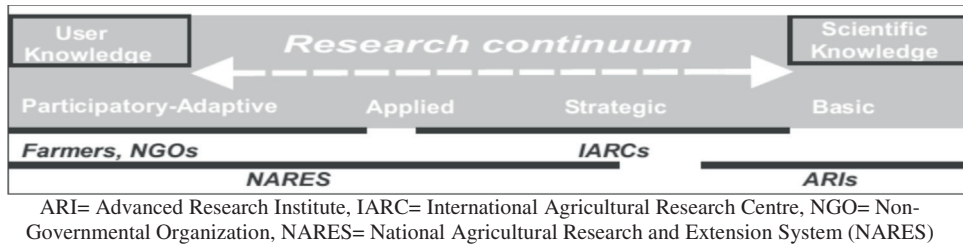


Fig. 1. Primary domains across the research continuum of Integrated Natural Resource Management. Source: CGIAR Science Council, 2006, p. 74.

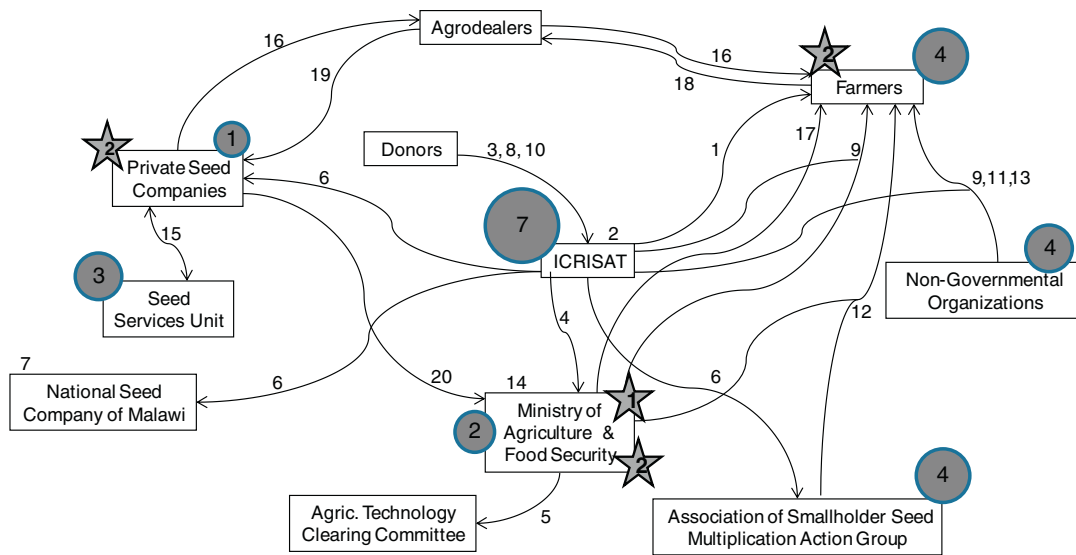
transaction cost economics (Williamson, 1991; Birner and Wittmer, 2004). This approach follows earlier applications of the fiscal federalism literature and transaction costs economics to analyze the appropriate level of decentralization for different types of rural services (Bardhan, 2002; Birner and von Braun, 2009).

4. Case study: The legumes improvement program at ICRISAT

The research and uptake process of CG7 groundnut variety can be understood from the results of the Net-map tool presented in Fig. 2. The arrows indicate the different activities (transactions), and the numbers indicate their sequence. The circles indicate the rating of influence

of the actors (on a scale of 1–8) by the respondents. They rated their influence on the final outcome, which was defined as the goal that the improved seed varieties are adopted by the farmers. The stars represent governance challenges that were identified in extension and seed systems.

The Net-map exercise served to identify the governance challenges involved in the different transactions. As the capacity of the national system was limited, ICRISAT posted a groundnut breeder to Malawi to initiate and coordinate regional testing of material and facilitate varietal release. CG7 was a typical case of a variety that remained on the shelf long after its release even though it had a proven yield advantage. As can be seen from steps 8–13 in Fig. 2, the variety was only adopted



- 1. Identification of Breeding Objectives
- 2. Initial Crossing at ICRISAT, India
- 3. Funding for Adaptive Research
- 4. Regional Trials under Collaborative SADC Program
- 5. CG7 Release in Malawi, later Zambia and Tanzania
- 6. Breeder and Foundation Seed Production and Supply
- 7. Seed Multiplication and Supply; Low Demand
- 8. Funding for Projects with Promotion Components
- 9. Seed Exchange Model with Local Varieties, Community Seed Banks, On-Farm Demonstrations, Buy-Back
- 10. Seed Revolving Fund
- 11. Seed Production, On-Farm Demonstrations, Promotion, Aflatoxin Testing, Market Opportunities
- 12. Seed Production, Processing, Marketing, Farmer Education
- 13. FFS on Conservation Agriculture, Legumes in Rotation
- 14. Inclusion of Legumes in Subsidy Program
- 15. Certified Seed Production
- 16. Seed Sales
- 17. Seed Coupons Provided to Target Farmers
- 18. Seed Coupon and Top-Up to Agrodealer
- 19. Coupons to Seed Company that Supplied Seed
- 20. Coupons for MoAFS for Payment



Fig. 2. Process-influence map for research and promotion of groundnut variety CG7 in Malawi. Source: Authors.

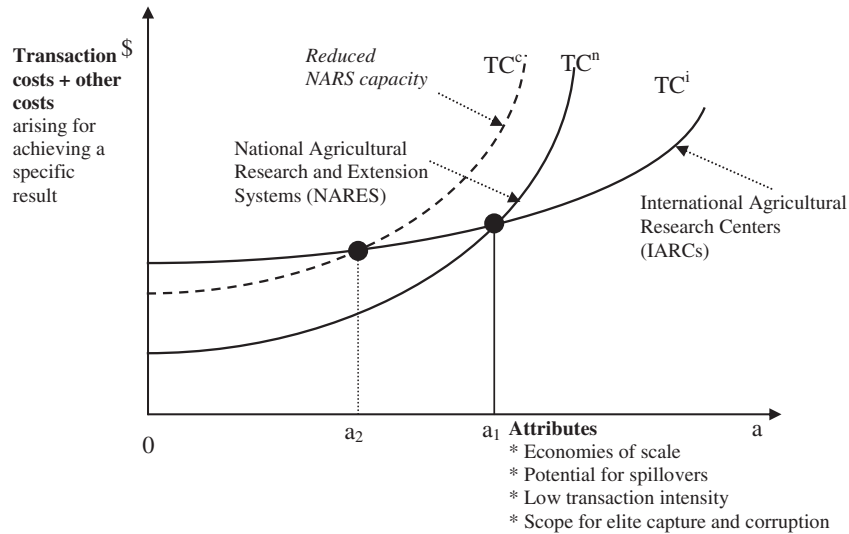


Fig. 3. Comparative cost-effectiveness of conducting research by IARCs versus NARES. Source: Based on Williamson (1991), Birner and Wittmer (2004) and Birner and von Braun (2009).

after donors provided resources for seed multiplication and promotion to ICRISAT, NGOs and other seed producers. To date, even though government institutions like the Extension Department and Department of Agricultural Research Services (DARS) do exist, capacity gaps still remain and the ICRISAT Malawi office continues to be engaged in downstream activities. This explains why during the Netmap exercise (Fig. 2) the center was ranked highest in terms of level of influence on the desired outcome, i.e. wide adoption of CG7 among farmers.

5. Conceptual framework

The transaction cost economics approach used here is based on the so-called “discriminating alignment hypothesis” developed by Williamson (1991), according to which “transactions that differ in their attributes are aligned with governance structures that differ in costs and competence so as to achieve an economizing result” (Williamson, 1991, p. 281). The first sub-section introduces the basic structure of this framework, and the following sub-sections apply the framework using the case study results.

5.1. Determining the comparative cost-effectiveness of IARCs versus national systems

The decision on whether a transaction should be carried out by an IARC or a national organization can be conceptualized as a choice between a more centralized (international) and a more decentralized (national) governance structure. The choice between these governance structures is influenced by the attributes of the respective transactions. Fig. 3, which is based on Williamson’s (1991) original approach, illustrates this choice problem in a cost-effectiveness<sup>5</sup> diagram.

The vertical axis displays the total cost involved in achieving a specified result of the respective transaction, including transaction costs and other costs. The horizontal axis depicts the level of the attributes that influence the comparative advantage of different governance structures. The figure displays two hypothetical cost curves,<sup>6</sup> which show how the total costs arising for achieving a specified result change, depending on the level of the attribute displayed on the horizontal axis. One curve

depicts the costs arising for carrying out the transaction by an IARC ( $TC^i$ ), and the other depicts the costs for carrying out the same transaction by NARES ( $TC^n$ ).

The fiscal federalism literature (Oates, 1972) identifies economies of scale and potential for spillovers as important factors, which influence the appropriate level of decentralization. These factors are considered as attributes of transactions here. In the example displayed in the figure, the costs of providing the transaction increase more rapidly for the governance structure of the NARES (i.e. to the more decentralized governance structure), if the level of the respective attribute, for example, *economies of scale*, increases (moving to the right-hand side on the horizontal axis). This is indicated by the relatively steeper slope of the  $TC^n$  cost curve. If the potential for economies of scale is low (moving to the left-hand side on the horizontal axis), the transaction is more economically provided by NARES. From point  $a_1$  onwards, it is more economic to assign the transaction to the IARC (i.e. to the more centralized governance structure), because the IARC will achieve the same result at a lower cost. Phrased differently, the diagram shows that from point  $a_1$  onwards, the governance structure of the IARC has a comparative advantage over NARES for carrying out the respective transaction.

Following the considerations of the IPG criterion explained above, the rationale is that the IARCs have higher set-up costs and higher running costs than NARES. Taking the case study as example, the salaries of ICRISAT researchers are much higher than those of staff employed in the NARES in Malawi. IARCs have a comparative advantage if they use their more expensive set-up to engage in activities with high economies of scale, such as applying expensive breeding techniques for crops that can be grown in different regions.

The same argument applies to the attribute of *spill-over effects*, as indicated above. Technologies are said to have spillover potential if they have applicability to other agro-ecological locations or for a different crop (Davis et al., 1987; Bantilan and Davis, 1991; Deb and Bantilan, 2001; Shiferaw et al., 2004). Since the CGIAR centers have a global mandate, the research objectives and associated outputs are more likely to benefit other regions or countries (i.e. the potential impact domain is wider). It can, therefore, be expected that more farmers will be reached resulting in lower costs for a given outcome (level of adoption).

The framework also identifies the role of contextual factors, in particular, the capacity of the respective organizations carrying out the transaction. In a cost-effectiveness diagram, low levels of achievement due to capacity constraints are depicted in form of a higher level of costs, since the diagram displays the costs for a defined unit of output.

<sup>5</sup> Costs associated with achieving a set outcome are analyzed the outcome being held constant

<sup>6</sup> While the above comparison considers IARCs and NARES, we recognize that there are many other actors in the agricultural R&D process. IARCs often work in collaboration with partners on joint research projects.

Fig. 3 displays a case of low capacity of NARES, resulting in an upward shift of the respective cost curve ( $TC^c$ ). Accordingly, the point from which IARCs have a comparative advantage over NARES moves towards the left-hand side to  $a_2$ . A reform or investment that results in increased capacity of the NARES would have the opposite effect (moving the  $TC^n$  curve downwards and shifting the intersection of the curves to the right-hand side).

The application of the transaction costs framework to the question of decentralization has shown that the effect of some attributes on the level of decentralization depends on contextual factors (Birner and von Braun, 2009). This is in particular the case for the following two attributes:

- **Transaction-intensity:** This attribute refers to transactions that have to be carried out frequently (transaction-intensity in terms of time) and in large areas (transaction-intensity in terms of space). Transaction intensity has been used to characterize transactions in service delivery (Pritchett and Woolcock, 2004; Birner and Linacre, 2008; Birner and von Braun, 2009). The effect of transaction-intensity is ambiguous: On the one hand, this attribute increases the comparative advantage of NARES, because they have lower costs for carrying out a large number of transactions. On the other hand, the costs of supervising and ensuring the quality of activities with high transaction-intensity are high. This increases the comparative advantage of organizations with high capacity that are able to provide strong performance incentives for their staff. In case of low capacity of the NARES, transaction-intensity will increase the comparative advantage of the IARCs.
- **Scope for elite capture and corruption:** If transactions are subject to these hazards, the extent to which a more centralized or a more decentralized organization has a comparative advantage depends on the capacity of the respective organizations to deal with these issues (Bardhan, 2002; Birner and von Braun, 2009).

## 5.2. Types of transactions and their attributes

### 5.2.1. Overview

This section discusses how the approach outlined above can be applied in determining the comparative advantage of IARCs versus NARES in carrying out the agricultural research and development activities identified in the case study. For simplification, one can classify the types of transactions identified in the case study into the following types:

- **Planning and priority setting:** The identification of breeding objectives (Step 1 in Fig. 2) can be considered as a planning and priority setting transaction. Some breeding objectives can be considered rather universal, such as yield potential, while others are affected by a diversity of local preferences, such as taste and color.
- **Technology development:** This includes activities related to the actual breeding. In Fig. 2, activities from the initial crossing at the ICRISAT headquarters until the variety was incorporated into national breeding programs for evaluation (steps 2–3) can be classified under technology development transactions.
- **Field testing and varietal release:** Promising cultivars were tested at the ICRISAT experiment stations before further testing in different agro-ecologies, and later in farmers' fields. Varieties were approved for release if data from multi-locational testing indicated that they performed better compared to the existing best variety (steps 4–5 in Fig. 2).
- **Multiplication:** To obtain the required volumes of improved seed for sale/distribution, seed multiplication was carried out in seed company farms or by using contract growers. Many of the activities between steps 6–15 in Fig. 2 involved seed production, processing, storage and distribution.
- **Certification:** Seed certification, usually by an independent body such

as the Seed Services Unit (SSU) in Malawi, is used as a means of quality control (Byerlee et al., 2007).

- **Promotion:** Details of the activities promotion conducted by ICRISAT together with NGOs and various departments under Ministry of Agriculture and Food Security (MoAFS) can be seen in steps 8–13 of Fig. 2.
- **Evaluation and impact assessment:** Impact assessments (ex-post or ex-ante) are carried out to measure the economic, social, and environmental consequences resulting from a project's interventions (Walker et al., 2008). Ex-post evaluations serve as a means of showing accountability to donors and other stakeholders, and also help in learning on how to make agricultural research more effective (Horton and Mackay, 2003).

Having categorized the activities (transactions) identified from the case study, we can now make an assessment of the relevance of each attribute identified in Section 5.1 for each of the transactions. The results are summarized in Table 1.

### 5.2.2. Planning and priority setting transactions

Priority setting activities together with resource mobilization require interaction with donors and other stakeholders who have knowledge on constraints facing the farming communities. These activities are associated with costs of attending meetings and time spent in donor relations. The new system under CRPs was expected to exploit economies of scale and reduce transaction costs of interface activities. Whether this has been realized or whether the requirement that the centers work more closely together in CRPs has increased transaction costs is an empirical question for further research.

Planning transactions at the centers' level can be associated with attributes of economies of scale and potential for spillovers and a more centralized approach is likely to reduce the costs. However, planning for the purpose of pursuing location-specific goals can be done more cost-effectively by national agencies as it would otherwise involve high transaction intensity for the centers.

### 5.2.3. Technology development transactions

The running costs for research activities conducted by national system scientists may be lower compared to IARCs. However, depending on the sophistication of techniques required, failure costs may be incurred if the research is delegated to a partner that does not have the required skill sets. Where technical knowledge is relevant, such as basic research activities (Fig. 1), IARCs may be more suited to exploit economies of scale in providing or utilizing this knowledge. An example is the ICRISAT genomics research that is based at its headquarters in India, but serves the needs of both Asia and sub-Saharan Africa. Where the potential for spillovers is high, research programs and infrastructure can be centrally set up with assurance that the products can be transferred and applied in similar environments elsewhere (Maredia and Byerlee, 1999; Alston et al., 2011; Brennan, 1986; Brennan and Bantilan, 2003; Brennan et al., 2003; Pardey et al., 1996; Shiferaw et al., 2004).

Basic and strategic research transactions can therefore be associated with attributes of high economies of scale and high potential for spillovers. Since a lot of interaction with farmers or travel to dispersed field locations is not required at this stage, basic and strategic research activities can be characterized by low transaction intensity. In this case, a more centralized approach is likely to reduce transaction costs. However, participatory and adaptive research activities having low economies of scale and low potential for spillovers and involving evaluation of breeding lines in different agro-ecologies across the country can be carried out most cost-effectively by the decentralized national systems.

**Table 1**  
Transactions and their attributes.

Transactions	Relevance of attributes Economies of scale (incl. asset specificity)	Spillover potential	Transaction intensity	Scope for elite capture and corruption
<b>Planning and priority setting</b>				
Generic goals	High	High	Medium	Low
Location-specific goals	Low	Low	High	Medium
<b>Technology development</b>				
Basic - strategic	High	High	Low	Low
Adaptive - participatory	Low	Low	High	Medium
<b>Field testing and varietal release</b>	Low	Low	High	Medium
<b>Multiplication</b>	Low	Low	High	Medium
<b>Certification</b>	Low	Low	Medium	High
<b>Promotion</b>	Low	Low	High	High
<b>Evaluation/impact assessment</b>	Medium	Medium	Medium	Medium

Source: Authors

#### 5.2.4. Field testing and varietal release transactions

Field testing transactions have similar attributes to participatory and adaptive research since they involve testing of selected varieties across environments. However, the application of tight controls on variety release and seed trade involves scope for elite capture and corruption. Plant breeders from the public sector are protected from competition as only varieties approved by the varietal release committee can be sold. These committees are composed of officials from the same monopolies and release is based on yields documented in government-run trials (Tripp and Rohrbach, 2001). In the case of groundnut variety ICGV91114 in India, although the performance of the variety was evident, it may not have been released without lobbying from ICRISAT and the intervention of the Chief Minister (Birthal et al., 2012). This means that even though NARES should ideally have a comparative advantage in field testing and varietal release based on the attributes of low economies of scale and potential for spillovers and high transaction intensity, the scope for elite capture and corruption make this decision less straightforward.

#### 5.2.5. Multiplication transactions

Breeder seed is produced by research stations while foundation and certified seed is produced by state corporations and private firms. Seed production under centralized seed company farms may have higher economies of scale but depending on the location of processing, storage and distribution facilities there will be additional costs of transportation. Use of decentralized systems such as contract growers has high transaction intensity as constant supervision is required. These factors imply that seed multiplication can be carried out most cost-effectively by NARES rather than IARCs.

However, as was observed in Malawi, these organizations often lack the resources and incentives to perform this function as required. Breeder seed production is not funded separately from the actual breeding activities, the NARES have insufficient numbers of research and seed technicians, they lack processing, storage and distribution infrastructure, and breeders are rewarded for varieties they release and not seed multiplied. For this reason, ICRISAT was forced to engage in seed production activities even though they have high transaction intensity.

#### 5.2.6. Certification transactions

Seed certification has high transaction intensity as it involves field inspections of the seed crop to guarantee the identity of the variety (Cromwell et al., 1992; Tripp and Louwaars, 1997). The fact that certification agencies are mostly financed by the government makes them vulnerable to budgetary constraints.

#### 5.2.7. Promotion transactions

Technologies that are available for dissemination require local adaptation, which makes it difficult to standardize extension and reduces the economies of scale and likelihood of spillovers. Promotion programs

also have high transaction intensity as they require frequent interactions with farmers and the deployment of multiple staff throughout the country. These transactions should therefore be the responsibility of national systems who have local offices to facilitate monitoring and supervision and reduce transaction costs.

#### 5.2.8. Evaluation and impact assessment transactions

Impact assessment and project reporting activities involve costs for data collection, analysis and write-up. These costs escalate when the centers have a large number of bilateral projects with small budgets that need to be reported separately.

We can conclude from the examples in the case study that the attributes of economies of scale and potential for spillovers, which are also recognized in the literature in international public goods, increase the comparative advantage (cost-effectiveness) of IARCs over NARES in carrying out the transaction. In addition, we identify transaction intensity and the scope for elite capture and corruption as important - but ambiguous - attributes that depend on the context and make the decision on comparative advantage less straightforward.

## 6. Conclusions

In agricultural research for development, there is no market mechanism which ensures that the most efficient governance structures survive. Research managers therefore have to define the most appropriate institutional structures to achieve impact with a given set of resources. The analysis undertaken in this paper deals with long-standing concerns regarding the governance of IARCs, which the currently ongoing CGIAR reform process also aims to address. The review of past discussions in the literature and in various fora identified a gap in the available methodologies that would allow the CGIAR to objectively tackle the dilemma of how the centers should position themselves in the R-D spectrum.

The framework presented in this paper is consistent with earlier approaches, especially the IPG criterion, but it provides additional insights, especially regarding the role of governance challenges and capacity constraints in influencing the comparative advantage of the CGIAR. Based on the consideration of the relevant attributes of transactions, and contextual factors, the framework makes it possible to assess the trade-offs involved in cost-effectively assigning an activity to IARCs, NARES or other actors in the innovation system. Transactions with high economies of scale and spillover potential should be ideally assigned to a centralized institution (IARC) while those with high transaction intensity to a more decentralized institution (NARES or other partner). While these implications are easier to derive for research and strategic research, the other activities involve trade-offs depending on the context, technology and intended objective.

An important factor emerging from the case study and the hypothetical cost curves above is the influence of contextual factors, especially capacity of the national systems. The lack of core funds and political

pressure, e.g., donor preferences, will influence the decision by CGIAR centers to carry out specific activities. Donors have the goal to achieve impact in poor areas, but the main problem is the capacity gap of national organizations. There is a choice to be made between investment in the tedious and long-term task of strengthening local capacity, or avoiding these capacity challenges by driving international centers into downstream activities. The latter option reduces the incentives for national governments to overcome the governance challenges in their national systems. Ultimately, to make international investment in agricultural research sustainable in the long-term, the centers and their donors should devise ways of addressing the capacity challenges of NARES.

## Acknowledgements

We would like to acknowledge the support of the Food Security Centre at University of Hohenheim and by extension the German Academic Exchange Service (DAAD), the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Foundation Fiat Panis. The CGIAR Research Program (CRP) on Policies, Institutions and Markets (PIM) also made financial resources available for this study. The funding sources had no role in the study design, data collection, analysis and write-up, and in the decision to submit the article for publication. We thank Dave Hoisington, John Ilukor, Jeff Davis and Rupsha Banerjee for their comments on earlier versions of this paper.

## References

- Alston, J.M., Andersen, M.A., James, J.S., Pardey, P.G., 2011. The economic returns to U.S. public agricultural research. *Am. J. Agric. Econ.* 93 (5), 1257–1277.
- Alston, J.M., Chan-Kang, C., Marra, M.C., Pardey, P.G., Wyatt, T.J., 2000. A meta-analysis of rates of return to agricultural R&D, ex pede hercules? IFPRI Research Report 113. International Food Policy Research Institute, Washington DC.
- Alston, J.M., Pardey, P.G., Roseboom, J., 1998. Financing agricultural research: International investment patterns and policy perspectives. *World Dev.* 26 (6), 1057–1071.
- Anderson, J.R., 1998. Selected policy issues in international agricultural research: on striving for international public goods in an era of donor fatigue. *World Dev.* 26 (6), 1149–1162.
- Bantilan, M.C.S., Davis, J.S., 1991. Across-commodity spillover effects of research and opportunity costs in a multiproduct production environment. ACIAR/ISNAR Project Paper Series no. 30. Australian Centre for International Agricultural Research and The Hague: International Service for National Agricultural Research, Canberra, Australia.
- Bardhan, P., 2002. Decentralization of governance and development. *J. Econ. Perspect.* 16 (4), 185–206.
- BCG, 2009. Design and Establishment of the Consortium of CGIAR Centers Final Report. Boston Consulting Group and Alliance of the CGIAR Centers, Boston.
- Bertram, R., 2006. Beyond international public goods: but just how far? Brief Prepared for the Workshop on "Positioning the CGIAR in the Global Research for Development Continuum", the Hague, Netherlands, 19 May 2006
- Birner, R., Linacre, N., 2008. Regional biotechnology regulations: design options and implications for good governance. IFPRI Discussion Paper 753. International Food Policy Research Institute, Washington, DC.
- Birner, R., von Braun, J., 2009. Decentralization and public service provision: a framework for pro-poor institutional design. In: Ahmad, E., Brosio, G. (Eds.), *Does Decentralization Enhance Poverty Reduction and Service Delivery?* Edward Elgar, Cheltenham, UK, pp. 287–315.
- Birner, R., Wittmer, H., 2004. On the 'efficient boundaries of the state': the contribution of transaction costs economics to the analysis of decentralization and devolution in natural resource management. *Environ. Plann. C. Gov. Policy* 22 (5), 667–685.
- Birthal, P., Nigam, S., Narayanan, A.V., Kareem, K.A., 2012. Potential economic benefits from adoption of improved drought-tolerant groundnut in India. *Agric. Econ. Res. Rev.* 25 (1), 1–14.
- Brennan, J.P., 1986. Impact of wheat varieties from CIMMYT on Australian wheat production. *Agricultural Economics Bulletin* No. 5. Department of Agriculture New South Wales, Sydney.
- Brennan, J.P., Bantilan, M.C.S., 2003. Price and yield effects of spillovers in international agricultural research: evidence from ICRISAT and Australia. *Agric. Econ.* 28 (2), 87–97.
- Brennan, J.P., Aw-Hassan, A., Nordblom, T.L., 2003. Influence of spillovers to Australia on impacts of the International Center for Agricultural Research in the dry areas. *Food Policy* 28 (5–6), 471–485.
- Brown, T.L., Potoski, M., 2003. Transaction costs and institutional explanations for government service production decisions. *J. Public Adm. Res. Theory* 13 (3), 441–468.
- Byerlee, D., Spielman, D.J., Alemu, D., Gautam, M., 2007. Policies to promote cereal intensification in Ethiopia: a review of evidence and experience. IFPRI Discussion Paper 00707. Development Strategy and Governance Division (June 2007).
- CGIAR, 2015. CGIAR Strategy and Results Framework 2016–2030: Redefining how CGIAR Does Business until 2030. (Accessed 13 March 2016). <https://library.cgiar.org/bitstream/handle/10947/3865/CGIAR%20Strategy%20and%20Results%20Framework.pdf>.
- CGIAR Fund Office, 2015. CGIAR Financial Report, Prepared by the CGIAR Consortium Office and the CGIAR Fund Office, June 2016. Accessed online on 19 August 2016 available at: <http://library.cgiar.org/bitstream/handle/10947/4452/2015%20CGIAR%20Financial%20Report.pdf?sequence=1>.
- CGIAR Independent Review Panel, 2008. Bringing together the best of science and the best of development. Independent Review of the CGIAR System. Report to the Executive Council, Washington, DC.
- CGIAR Science Council, 2005. System Priorities for CGIAR Research 2005–2015. Science Council Secretariat, Rome, Italy (Reprint).
- CGIAR Science Council, 2006. Positioning the CGIAR in the Global Research for Development Continuum. Science Council Secretariat, Rome, Italy.
- CGIAR Science Council, 2008. Workshop on international public goods. Special Session at AGM 08, Maputo, Mozambique, 27 November 2008.
- CGIAR Science Council, 2009. Report of the Sixth External Program and Management Review (EPMR) of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), February 2009.
- CGIAR SRF, 2011. Changing agricultural research in a changing world. A Strategy and Results Framework for the Reformed CGIAR (Accessed 20 June 2012). <http://cgiarweb.s3.amazonaws.com/wp-content/uploads/2011/08/CGIARSRFBrochure.pdf>.
- Cromwell, E., Friis-Hansen, E., Turner, M., 1992. The seed sector in developing countries: a framework for performance analysis. ODI Working Paper 65.
- Davis, J.S., Oram, P.A., Ryan, J.G., 1987. Assessment of agricultural research priorities: an international perspective. ACIAR Monograph No. 4 (85 pp.).
- Deb, U.K., Bantilan, M.C.S., 2001. Spillover impacts of agricultural research: a review of studies. Working Paper Series no. 8. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India (32 pp.).
- Harwood, R.R., Place, F., Kassam, A.H., Gregersen, H.M., 2006. International public goods through intergrated natural resources management research in CGIAR partnerships. *Exp. Agric* 42 (4), 375–397.
- Horton, D., Mackay, R., 2003. Using evaluation to enhance institutional learning and change: recent experiences with agricultural research and development. *Agric. Syst.* 78 (2), 127–142.
- Kanbur, R., 2001. Cross-Border Externalities, International Public Goods and their Implications for Aid Agencies. Cornell University.
- Katyal, J.C., Mruthyunjaya, 2003. The CGIAR at 31: An Independent Meta-Evaluation of the Consultative Group on International Agricultural Research - CGIAR Effectiveness - A NARS Perspective from India. The World Bank Operations Evaluation Department, Washington, DC.
- Kherallah, M., Kirsten, J., 2001. The new institutional economics: applications for agricultural policy research in developing countries. Markets and Structural Studies Division Discussion Paper 41. IFPRI, Washington, DC.
- Maredia, M.K., Byerlee, D. (Eds.), 1999. The global wheat improvement system: prospects for enhancing efficiency in the presence of spillovers CIMMYT Research Report No. 5. International Maize and Wheat Improvement Center (CIMMYT), Mexico, DF.
- McCalla, A.F., 2014. CGIAR Reform - Why So Difficult? Review, Reform, Renewal, Restructuring, Reform Again and then "The New CGIAR" - So Much Talk and So Little Basic Structural Change - Why? Department of Agricultural and Resource Economics, UC Davis Retrieved from: <http://escholarship.org/uc/item/7h04960c>
- Oates, W.E., 1972. *Fiscal Federalism*. Harcourt Brace Jovanovich, New York.
- Pardey, P.G., Alston, J.M., Christian, J.E., Fan, S., 1996. Hidden Harvest: U.S. Benefits from International Research Aid, Food Policy Report. International Food Policy Research Institute (IFPRI), Washington, DC.
- Pardey, P.G., Alston, J.M., Piggott, R.R. (Eds.), 2006. *Agricultural R&D in the Developing World: Too Little, Too Late?* International Food Policy Research Institute, Washington, DC
- Pineiro, M., 2007. Agricultural Technology Transfer to Developing Countries and the Public Sector. Science and Development Network, Policy Brief.
- Pritchett, L., Woolcock, M., 2004. Solutions when the solution is the problem: arraying the disarray in development. *World Dev.* 32 (2), 191–212.
- Prabhu, Pingali, Tim, Kelley, 2007. The role of international agricultural research in contributing to global food security and poverty alleviation: the case of the CGIAR. In: Evenson, R., Pingali, P. (Eds.), Volume 3. *Handbook of Agricultural Economics*, Elsevier, pp. 2381–2418.
- Raitz, D.A., Kelley, T.G., 2008. Benefit–cost meta-analysis of investment in the international agricultural research centers of the CGIAR. *Agric. Syst.* 96 (1–3), 108–123.
- Renkow, M., Byerlee, D., 2010. The impacts of CGIAR research: a review of recent evidence. *Food Policy* 35 (5), 391–402.
- Ryan, J., 2006. International Public Goods and the CGIAR Niche in the R for D Continuum: Operationalising Concepts. Revised Draft of a Discussion Paper Prepared for a Brainstorming Session between some Members of the Science Council of the CGIAR and the Centre Deputy Directors' Committee (CDDC) of the Future Harvest Centres of the CGIAR at the CGIAR Annual General Meeting in Morocco, 3 December 2005.
- Sagasti, F., Timmer, V., 2008. An approach to the CGIAR as a provider of international public goods. Paper Submitted as a Contribution to the Work of the Independent Review Panel (IRP) of the CGIAR.
- Samuelson, P.A., 1954. The pure theory of public expenditure. *Rev. Econ. Stat.* 36 (4), 387–389.
- Schiffer, E., Hauck, J., 2010. Net-map: collecting social network data and facilitating network learning through participatory influence network mapping. *Field Methods* 22 (3), 231–249.
- Shelanski, H.A., Klein, P.G., 1995. Empirical research in transaction cost economics: a review and assessment. *J. Law Econ. Org.* 11 (2), 335–361.

- Shiferaw, B., Bantilan, M.C.S., Gupta, S.C., Shetty, S.V.R., 2004. Research spillover benefits and experiences in interregional technology transfer: an assessment and synthesis. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India (140 pp. ISBN 92-9066-469-X. Order Code: BOE 033).
- Spielman, D.J., 2007. Pro-poor agricultural biotechnology: can the international research system deliver the goods? *Food Policy* 32 (2), 189–204.
- TAC Secretariat, 2000. A Food Secure World for All: Toward a New Vision and Strategy for the CGIAR. TAC Secretariat, FAO, Rome (40 pp.).
- Tripp, R., Louwaars, N., 1997. Seed regulation: choices on the road to reform. *Food Policy* 22 (5), 433–446.
- Tripp, R., Rohrbach, D., 2001. Policies for African seed enterprise development. *Food Policy* 26 (2), 147–161.
- UN General Assembly, 2014. Report of the open working group of the general assembly on sustainable development goals. Sixty-Eighth Session, 12 August 2014 (Agenda items 14, 19 (a) and 118. Available online at <<http://undocs.org/A/68/970>>. Accessed on August 17, 2015).
- Walker, T., Maredia, M., Kelley, T., La Rovere, R., Templeton, D., Thiele, G., Douthwaite, B., 2008. Strategic guidance for ex post impact assessment of agricultural research. Report Prepared for the Standing Panel on Impact Assessment, CGIAR Science Council. Science Council Secretariat, Rome, Italy.
- Williamson, O.E., 1991. Comparative economic organization: the analysis of discrete structural alternatives. *Adm. Sci. Q.* 36 (2), 269–296.
- World Bank, 2007. Agriculture for Development: World Development Report, 2008. Agriculture for Development. The World Bank, Washington, DC.
- Zeigler, R.S., Mohanty, S., 2010. Support for international agricultural research: current status and future challenges. *New Biotechnol.* 27 (5), 565–572.