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Governance of International Networks: Understanding Access and Benefits Sharing (ABS) of Knowledge among International Plant Genetic Resource Institutions

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Abstract

Governing in the modern times has become more complicated and complex, with an array of new governing structures encompassing the globe. Discrete institutions are increasingly intertwined and embedded in governing networks at sub-national, state and international levels. This paper investigates this new reality and uses it to examine the international governing system for plant genetics and genomic resources. Over the last century, issues have surfaced with technological progress and innovations that add complexity in the governing challenge, such as research management, intellectual property ownership, risk regulation and international trade in knowledge-intensive products. This paper explicitly examines one of the foundational issues of global knowledge management in the area of biotechnology—policies, practices and structures to support access and benefit-sharing (ABS) related to traditional knowledge (TK) and capacity-building in indigenous communities and developing countries. This paper uses social network analysis to investigate the complicated and complex interactions among a network of 108 international institutions and programs involved in ABS and TK. Using multiple layers of social network analysis, the structures and underlying meanings of the relationships in the governing network are studied and investigated for their structure, effectiveness and resiliency.

Keywords:

Networked governance; innovation; social networks; plant genetics and genomics; access and benefits sharing; traditional knowledge; agriculture

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1. 0 Introduction

The world is confronted by a new model of 'governance' where the objectives, laws and methods of governing have largely moved away from "absolutism, authoritarianism and even the autarkic conception of the modern state" (Weiss, 2000:9). British political scientist Rod Rhodes (1995:1) suggests that governance should not be viewed as simply a recasting of analysis, but actually "a new process of governing; or a changed order condition of ordered rule; or the new method by which society is governed." It is not simply a synonym for government but rather involves a new system of "self-organizing networks or 'governing without government'." Others suggest government remains an actor in governance, but it goes beyond government to a variety of non-traditional actors playing key roles in the governing system. Rhodes suggests we are seeking the emergence of networks or systems of a distributed and 'centreless' socio-cybernetic system, involving subsidiarity, absence of a single sovereign authority, multiplicity of actors, interdependence and blurred boundaries.

One area where we are seeing the emergence of a less ordered sort of governance (especially centreless or networked systems) is in the national and international structures and substructures of research, development, commercialization and knowledge management that have emerged in the past generation in the global agri-food system. One area that warrants further investigation through the governance lens is the use of genomics to extract valuable genetic material from plants, animals and microbes that are inextricably intertwined with traditional knowledge in indigenous communities around the world. The related concerns about access and benefits sharing have precipitated development of new capacity in many countries and a community of more than 100 international actors, programmes and initiatives, all addressing one or more aspects of the access and benefit-sharing / traditional knowledge (ABS/TK) challenge.

This network of international institutions contributes to policy and programming in support of access, benefit-sharing and capacity-building at the international level. Given their overlapping and interlocking relationships, it is not clear how they operate. Using a layered SNA approach reveals the structures and underlying meanings of the relations in the governing network. Some organizations exercise overt, relational power (i.e. the ability to get the other party to do something they might not otherwise do) while others exert soft, structural power (i.e. set the rules of engagement and define the goals, methods and rewards).

This paper examines the concept of networked governance and uses the case study of the ABS/TK community to test its efficacy. This paper has four further sections. Section 2 discusses the scope and direction of the international effort to deal with access and benefits sharing of traditional knowledge. Section 3 investigates the concept of networked governance and discusses use of social network analysis to investigate the phenomena. Section 4 examines the ABS/TK networks in question; reviewing the individual actors and sub-networks both in terms of the entire population and in terms of the targeted goals and functions of the system. Section 5 offers some concluding observations.

2.0 Genomics and access and benefits sharing of traditional knowledge

There is increasing interest in the nature, value, use, preservation and ownership of a wide range of genetic resources that are embodied in populations of microbes, plants, animals and humans. These resources can be found *in situ* in organisms in all climates and cultures on land, in the sea and in the air or *ex situ* in botanical gardens, gene banks and public and private research collections. Genetic resources are inextricably intertwined with the environment (including human populations as hosts and conservators), complicating an already difficult discussion about how to manage them and how to arrange appropriate access and benefits sharing to both the primary genetic resources and any complementary or resulting inventions and innovations.

The debate about access and benefits sharing (ABS) is highly complex and fully engaged by a wide range of groups in the global society. The modern debate is embedded in the history of the science and the institutions designed to advance and use that science. The roots of the issue go back beyond recorded time, as communities and cultures around the world identified, improved, adapted and adopted a range of native plants and animals as foods or industrial products (Diamond, 1997).

These improved plants and animals became the basis for a succession of agricultural and social revolutions over the millennia. Especially during the Age of Exploration and Discovery (15th-17th centuries), when European states extended themselves into Asia, Africa, the Americas and the Oceania, a large assortment of traditionally isolated organisms were collected, moved between ecosystems and tested for their value and use in alternate systems. These organisms were then either introduced (with intent or inadvertently) into new ecosystems or stored and preserved in an array of public and private collections.

Science has been a major driver for the ABS debate. Although only a small share of the agricultural revolution in Europe in 1700-1900 can be traced to the introduction of new species and varieties of plants from other ecosystems, the major advances in the 20th century are directly attributable to the collections of landraces and germplasm collected during colonial times. Combined with the modern tools of Mendallian plant breeding, forced crossings, hybrids, mutagenic breeding and now transgenic modification, there has been a renewed interest in examining the stock of indigenous genetic resources around the world—regardless of whether they are located *in situ* in traditional settings or *ex situ* in modern seed banks—to identify and use any 'useful' genes. The current 'omics' revolution—involving, among others, genomics, proteomics and metabolomics—has increased the interest in our genetic resources. In some instances, this increased interest has enhanced the value of genetic resources. Alternatively, some worry that the new process of discovery through *ex situ* research and dry simulations of genetic structures may break the, albeit tenuous link between the traditional sources of these genes and the modern effort to isolate, modify and use the properties of the genes.

Although individual countries have attempted to control access to their genetic resources for hundreds of years, recently there has been a diffusion of effort. A number of private concerns have claimed intellectual property rights (mostly patents in the US) on a variety of genetic resources (from plant cultivars to human genes), which has precipitated a few legal disputes in domestic courts (e.g., Moore v. Regents of the University of California 793 P.2d 479, Cal. 1990) and with domestic patent offices (e.g., EU Patent Office decision to revoke a patent on a fungicide derived from the Neem tree).

More recently there has been significant debate and effort invested in negotiating a range of international conventions or treaties to delimit and protect indigenous rights to genetic resources, involving the International Labor Organization, the United Nations and InterAmerican Draft Declarations on Rights of Indigenous Peoples, the United Nations Development Program (UNDP)/United Nations Conference on Trade and Development (UNCTAD) and the European, Asian and African Development Banks. In the context of plant genetic resources, in particular, there are a number of special institutions involved in delimiting rights and facilitating access and benefits sharing. These include the Convention on Biological Diversity (CBD) (1992), Agenda 21 and the Cartegna Protocol on Biosafety (CPB) (2000), the International Undertaking on Plant Genetic Resources (IUPGR) (1983) and International Treaty on Plant Genetic Resources (ITPGR) (2001), the Consultative Group for International Agricultural Research (CGIAR) centres and related genebanks and various national programs (e.g. Canadian International Development Agency).

In the context of ABS, a wide range of issues have been examined (see Phillips and Onwuekwe, 2007; Bubela and Gold 2012). Perhaps the most significant focus has been on the political discussions about what are or should be the rights related to these resources. This debate has been continuing for many years at an array of venues under the aegis of a variety of institutions, including the WTO TRIPS Art. 27.3(b), the Doha Declaration Art. 17, the Convention on Biological Diversity Art. 8j and the World Intellectual Property Office (WIPO). There is a large body of scholarly work on this topic. A second and related effort has involved legal and common law studies of the roles of patents and copyright and the potential for using *ordre public* in patent systems to address conflicting claims. Third, economists have examined the incentive or disincentive effects of the current incomplete property system and assessed how large the benefits are that might be shared while sociologist and economists have been examining the potential impacts of different rights regimes on countries and indigenous communities. Crosscutting all of these efforts, a range of legal and social scholars and non-governmental organizations (NGOs) has interjected their concerns about the ethical underpinnings of the current or any prospective system of access and benefits sharing. Although these issues are all valid and important, they are all largely normative investigations into what ought to be. They largely ignore the positive issue of how ABS systems currently operate.

This investigation uses new governance theory and the tools of social network analysis to examine the here and now - what are we doing and how does it work?

3.0 The theory and methods of investigating governance

Governance in the modern world refers to largely self-organizing, inter-organizational networks which exhibit interdependence, sustained game-like exchanges where the interactions are rooted in trust. In essence, central authority is replaced by self-organizing networks. Amaral and Ottino (2004) assert there are three types of systems. Simple systems have a small number of components acting according to well understood laws—there are few actors and the system operates using well-known laws. Much of the literature about governing starts from that premise. Complicated systems, in contrast, have a large number of components each with well-defined roles and governed by well-understood rules. In complicated systems, parts work in unison to accomplish a function—a defect in a critical part could cause a system failure, which is why redundancy is often built into the design. Complicated systems have a limited range of responses to environmental change. Increasingly we are seeing the emergence of complex systems which have a large number of components that act according to rules that can change over time and that may not be well understood; the configurations of actors often changes and their roles may be fluid.

Complex systems have been defined as involving a large number of elements, building blocks or agents, capable of interacting in a wide variety of ways with each other and with their environment (Amaral and Ottino, 2004). Interactions may occur with either immediate neighbors or distant ones and agents can be identical or different and may move in space or occupy fixed positions. The common characteristic of all complex systems is that they display organization without any obvious external organizing principle being applied. Such systems, although very difficult to analyze or predict, exhibit high degrees of adaptability.

Network theory offers potential insights into the various distributed authorities in a world of communities. Networks define the permutations of actors (or nodes) through relationships (connections or links), where networks of different density can have either central nodes or distributed relationships (the nature and stability, or volatility, of networks can often be modeled through small, discrete behavioral models, such as the 'game of life' cellular automata model). Analysis of a variety of small world networks, such as power grids, ecosystems and epidemics has revealed that most human built systems are seldom the result of a single design but rather are part of an evolutionary process of competition, merging and mutating of many self-organized sub-routines.

This paper uses social network analysis to investigate the interconnections among and between different actors. It is possible to identify the relative position and functions of individuals and organizations using social network analysis (SNA). Ryan (2008) suggests that social network analysis can track "…how knowledge intensive work is done and is used to assess the complex communication channels within a network" (41-42). SNA views actors and actions as interdependent units; it acknowledges that the 'relational ties' between actors are channels flow of resources which can provide opportunities for or constraints on individual action. Social network analysis identifies boundary spanners, gatekeepers, knowledge bottlenecks and as well as under- and over-utilized individuals or organizations within a given network. The guiding principle behind social network analysis is concerned with the relationship between agents, nodes and actors and in how such units affect one another. The method enables the identification of subgroups in a given network such as clusters or cliques or to pinpoint isolates or those agents or nodes that appear to be disconnected from the larger network. Such analyses also enable the characterization of such networks into categories such as core-peripheries or emergent groups.

Relevant to this study, a number of measures related to density and centrality in social networks are used to examine communities. Valente *et al.* (2007:15), for example, explored density as it relates to community coalitions in health-programme delivery, finding that too much density may indicate network-centric connections that 'do not provide sufficient pathways for information and behaviours to come from outside the group.' In contrast, a low density may make a network less effective at mobilizing resources for adoption of prevention strategies. At both extremes, path dependency or group-think can limit network-based learning.

In general, centrality measures are used to "…describe and measure properties of 'actor location' in a social network" (Wasserman and Faust 1994: 169). Applied at the node level, centrality is a family of measures each answering a different theoretical question. Three somewhat different measures of centrality are used in this paper. 'High degree centrality', in this case, refers to the capacity of a node for informal leadership according to the number of ties that the node has—high degree central actors are "in the know" or as Ryan (2008: 61) suggests "…is an indicator intra-network connectedness." 'Betweenness centrality' identifies the critical route for flows in the network and the dominant node or agent that has more close relationships to other groups or dyads. According to Ryan (2008), it is an indicator for knowledge flow capacity or 'influence' within the network. A higher betweenness centrality measure implies a greater level of control over information pathways of interaction between actors or nodes. Power, in the network sense, is not just how many connections an agent or node has, but how central other actors or agents are that it is connected to is measured through 'eigenvector centrality' (Bonacich, 1972) Ryan (2008) suggests that nodes with higher eigenvector centrality measures are 'powerful' connectors within the network. In many cases, an actor having a higher eigenvector ranking suggests that this individual or organization may have greater diversity in terms of sources of and uses for information.

Although one might think that the theory and analytical methods should lead to a deductive set of experiments that ultimately should explain evolution over time, it is far from clear whether there is one, or even a range, of stable, optimal configurations of different systems. Some density is required but more is not always better. One hypothesis is that while uniform density may assist with the 'normal business' of policy development and implementation, such a configuration could stifle potential transformative changes. Transformative changes may require what has come to be called 'structural holes,' that is areas where there is a gap in the governance system that allow truly revolutionary ideas and approaches to germinate and emerge (Burt, 2005).[1] Similarly, although some central actors are needed, it is far from clear who they should be and what types of roles they should play.

The remainder of this paper applies the social network analysis to the international community of institutions interested in access and benefits sharing (ABS) and traditional knowledge (TK). Between 2007 and 2008 a research assistant was tasked with data mining the web to identify, confirm, delimit and code the international agencies and programs that are engaged in ABS/TK activities. A snowball method of database mining was adopted following references and links between the core and periphery actors and doing subject word searches until there were no incremental institutions or programs identified. We made a judgement that in large and diffuse organizations—such as the United Nations (UN) Agencies and the Consultative Group on International Agricultural Research (CGIAR) global programs—that we would not assume they

[1] Rosenberg 1994, using different terminology, has argued that the first industrial revolution was only possible because the 'institutional negative feedback' of the earlier period was removed.

were managed in any a priori unified manner. So the centralized programs of the CGIAR, for example, are individually included and coded for their identified linkages and functions. A database of 108 institutions and programs was identified and many of the roles and functions were confirmed through direct contact with the agencies.[2]

4.0 Networks and functions

The entire sample of 108 institutions and programs were included in the base analysis. On first glance, one would be inclined to conclude that the program and policy community related to ABS and TK is over-determined and that there may be a surplus of efforts. The social network analysis shows otherwise.

4.1 The global network

The total density of this population—representing all possible dyadic (1 to 1) ties present (whether they are mutually recognized or not)—was 0.0132. That is, 1.3% of all of the possible ties between any of the two institutions have been identified by the institutions. In short, this is a relatively loosely connected community. Other analyses of research and policy networks show densities of 5-25% (Ryan, 2008).

One factor limiting the density is that there are 28 isolated organizations—each of the isolates were identified in the word searches, interviews and institutional data mining exercises and were deemed to address one or more of the functions directed to ABS/TK, but neither they nor any of the other 107 entities in the database identified any relationships with others. The inclusion of isolates (i.e., totally non connected organizations) could distort the measure. We re-ran the analysis without the isolates (with a sample of 80 connected actors), learning that the density with the isolates removed is 0.0242.

We decided to leave the isolates within the analysis. Having a larger sample tends to widen the margins of error, raising the standard deviations and imposing a higher burden of proof when identifying centrally placed actors.

[2] The social network analysis was produced through Organization Risk Analysis (ORA) software developed at Computational Analysis of Social and Organizational Systems (CASOS) at Carnegie Mellon University; the runs were undertaken March 11, 2010.

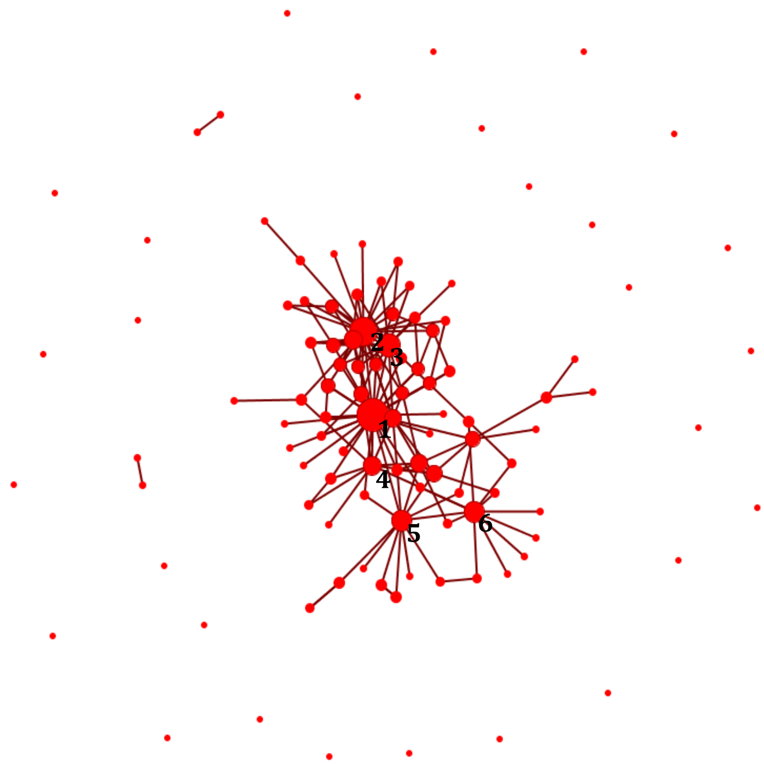
Table 1: Metrics for the 1-mode International ABS and TK community

Measure	**Value**
Row count	108
Column count	108
Link count	153
Density	0.0132
Isolate count	28
Component count	31
Reciprocity	0.0625
Characteristic path length	2.4994
Clustering coefficient	0.1025
Network levels (diameter)	5
Network fragmentation	0.5064
Degree centralization	0.1484
Betweenness centralization	0.0359
Closeness centralization	0.0103
Reciprocal?	No (6% of the links are reciprocal)
Source: Authors' results produced by ORA (developed at CASOS-Carnegie Mellon University).	

Figure 1 shows the structure of the international actors involved in ABS and TK policy and programming. As one can see, there is a form of hub and spoke system, with a dense centre, a starburst of uni-directionally linked actors and then a large number of isolated actors.

While density tells us about the potential for a network to operate, it is necessary to examine the structure of the network to get a sense of the pathways and flows. The three main centrality measures offer some insights. Total degree centrality of the 108 actor world was .1484. Nine of the 108 organizations occupy central positions in the network (based upon total degree centrality measures that are at least one standard deviation above the mean for the population). Biodiversity International (formerly IPGRI) and the CGIAR, are unambiguously the most centrally connected, with measures 6 and 4 standard deviations above the mean. The others, while statistically centrally connected, are ranked much lower.

Figure 1: The International ABS and TK Community



Source: Authors' dataset using Organizational Risk Analysis (ORA)

Figure 1 key:

1. BI/IPGRI	Bioversity International / International Plant Genetics Resource Institute
2. CGIAR	Consultative Group on International Agricultural Research
3. ACIAR	Australian Centre for International Agricultural Research
4. FAO	Food and Agriculture Organization
5. CBD	Convention on Biological Diversity
6. BioNet I	BioNet International

Table 2: Key central actors in the international ABS and TK world

	Eigenvector		Total Degree Centrality		TDC Rank In	TDC Rank Out	Betweenness	
Bioversity International/IPGRI	1.0000	***	0.1589	******	3	1	0.0366	********
CGIAR	0.9244	***	0.1250	****	1	28	0.0209	****
International Crop Information System	0.5682	*	0.0467	*	--	7		
Seed and PGR Services (FAO)	1.0000	***	--		--	--		
Seed Info System	1.0000	***	--		--	--		
BioNet International	--		0.0561	*				
World Summit on Sustainable Development	1.0000	***	--		--	--		
FAO	--		0.0467	*				
CBD	--		0.0607	**			0.0079	*
Global Environmental Facility	--		--		--	--	0.0065	*
Australian Centre for International Agricultural Research	0.6510	**	0.0748	**	--	--		
ICARDA	0.4208	*	--		--	--		
Global Citrus Germplasm Network	1.0000	***	--		--	--		
Centre for international Forestry Research	--		0.0374	*			0.0191	****
Collaborative Partnerships for Forestry	--		0.0374	*				
Mean	*0.1663*		*0.0132*				*0.0010*	
Standard Deviation	*0.2386*		*0.0220*				*0.0045*	

Each * denotes one standard deviation above the mean.
Source: Authors' results produced by ORA (developed at CASOS-Carnegie Mellon University).

The eigenvector centrality measure represents a measure of how the institutions are connected to equally or more important institutions. Biodiversity International and the CGIAR remain in the top rung. Their importance is highlighted by directional flows. CGIAR ranks first and Biodiversity International ranks third in in-degree centrality, reflecting the fact that other nodes use them as central platforms for activities. Biodiversity International's first rank in out-degree centrality reflects it role as a prime disseminator of knowledge to others. Those two institutions are joined by a number of institutions which have relatively fewer links but those links are with relatively well connected and centrally placed actors. This is clearly an effective strategy for more specialized entities (such as the ICIS, the Seed and PGR Services group of the FAO, the Seed

Information System, the Australian Centre for International Agricultural research and the pulse and citrus groups) to gain access to the global system. The betweenness centrality measure reveals the key gatekeepers in the system. Once again, Biodiversity International and the CGIAR central coordinating functions are the key actors for the overall system. Nevertheless, a few other actors (the CBD and GEF and the CIFR) offer specialized access to discrete functions in the system (policy, money and forestry information).

There are four types of ties between two organizations: not connected; mutually connected; or one directs to the other and the other does not direct back to it. Reciprocity measures the extent to which the ties are reciprocated in a relationship. As we gathered information, we recorded whether reported relationships were reciprocated, on the assumption that meaning, significant or important relationships are most likely to be reported. There is a tendency in the modern 'governance' world to want to appear to be linked to everyone who is anyone; frequently 'false' or misleading relationships may be reported. Placing a higher weight on reciprocal recognition gives us some sense of the stronger types of relationships that may exist in the global community. In this database (n=108), only 6.3% of the existing ties are mutual and reciprocal. Non-mutual relationships may not involve any effective communications or management.

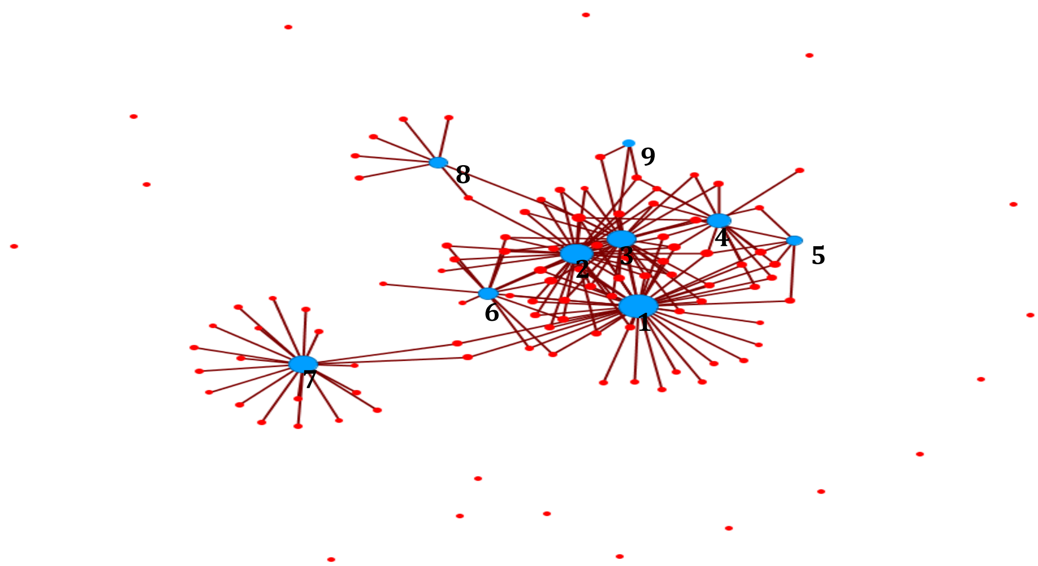
4.2 Institutions, functions and sub-networks

Each of these 108 organizations identifies their engagement with and support of one of 8 differentiated functions or activities. The network of 108 then disaggregates into 8 interlocking networks with between 3 and 46 members each. Fifty four organizations (50%) identify overlapping priorities (refer to Table 3 and Figure 2 below).

Table 3: Network-based Activities

The Network: N = 108	Sub-network Size	% of Global Network
1. Information Access, coordination or exchange	46	42.60%
2. Research, Training or Capacity Building	37	34.20%
3. Collaboration other than Research	31	28.70%
4. Conventions, Treaties, Commissions	20	18.50%
5. GR Conservation and identification	16	14.80%
6. Research Coordination	11	10.10%
7. Funding Source	7	6.40%
8. GR Handling, breeding and transfer	6	5.50%
9. Taxonomy	3	2.70%
Institutions with overlapping roles	54	50%

Figure 2: The international ABS and TK Community by Activity Involvement



Source: Authors' dataset using Organizational Risk Analysis (ORA)

Figure 2 Legend of Activities:

1. Information access and coordination of exchange
2. Research, education, Training or other capacity roles
3. Collaboration and partnerships other than research
4. Genetic resources conservation, identification or evaluation of varieties
5. Handling, breeding or transformation of genetic resources
6. Research coordination/facilitation
7. Treaties, conventions, conferences, commissions and substructures
8. Funding
9. Taxonomy

4.3 Working relationships

Given the arrangement and diversity of institutions, sub-networks and teams usually form. In this case, four 4x4 cliques and 31 3x3 cliques have formed. All of the cliques include at least one the 15 centrally placed actors identified above.

The four 4x4 cliques (i.e. all four are linked to each other, in a closed system) all involve three common actors—Biodiversity International (formerly IPGRI), the CGIAR coordinating centre and the International Crop Information System. These three core actors have created four interlocking cliques, involving four discrete actors:

- International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria;
- International Center for Tropical Agriculture (CIAT) in Columbia;
- International Maize and Wheat Improvement Center (CIMMYT) in Mexico; and
- the International Network for the Improvement of Banana and Plantain (now rolled into BI).

On the face of it, these teams four, clustered around a very tight 3x3 clique (triad) involving Biodiversity International, CGIAR and ICIS, would appear to be a powerful hub for driving forward ABC/TK policy and programming. This network-level analysis runs the risk of mis-specifying the degree of density and the central actors unless on validates the linkages by looking at the overlaps by specific priorities and functions. Table x identifies the relative important of ABC/TK related purposes and functions of these institutions by type of activity. The first point that jumps out is that two of the functions (taxonomic activities and program fund) are not priorities of any of the core triad. Moreover, the triad is not centered on any single function (no more than two of the three organizations identify their goals to any single function. When matched with the three CGIAR international centres of research (CIAT, CIMMYT and IRRI), the most significant overlap, as one might expect, is the focus on research, education, rating and other capacity building roles related to ABS and TK. At a lower but still significant level, non-research based collaborations and partnerships are a potential lower another

Table 4: Programs, priorities and functions of the six institutions involved in the core 4x4 cliques

Function	BI/ IPGRI	CGIAR *	ICIS	CIAT	CIMMYT	IRRI
GR conservation, identification and/or evaluation of varieties		2				1
Taxonomy						
Information access coordination of exchange		*	3			
Handling, breeding and/or transfer of GR		1				
Funding source						
Research, education, training or other capacity building roles	2	2		2	2	2
Research coordination/ facilitation	1	*		2		
Treaties, Conventions, Conferences, Commissions and sub-structures						
Collaboration and partnerships for other than research	1	1			2	1
(1 denotes that the institutions values but is not strongly focused on the activity; 2 denotes the activity is a main/core purpose of the institution or entity as stated in mandate or active program; 3 denotes that this is a sole activity of the institution with actual work on the subject); * denotes the CGIAR has special programs in these areas.						

4.4 Vulnerabilities and sensitivity analysis

One important concern raised about networks is that the complex structures can lead to vulnerabilities and chaos or small world effects, as small changes can be amplified (Amaral and Ottino, 2004).

To test this, we removed the two core central actors—Biodiversity International and CGIAR—from the community to see what would happen. The network changes significantly with the removal of the two. Table 5 reveals the results. In this case, reciprocity amongst actors drops over 65%, density drops 36% and the network fragments further from 31 components to 40 components. The sensitivity analysis, showing marked drops in network-level betweenness centralization, reveals how significant these two key organizations play in terms of brokering exchange in the broader network.

Table 5: Sensitivity Metrics for the 1-mode International ABS and TK community with the removal of two key organizations: CGIAR and BI/IPCRI

Measure	Value for Original Network	Value for Network sans CGIAR and BI/IPGRI	% Change
Row count	108	106	-1.9%
Column count	108	106	-1.9%
Link count	153	94	-38.6%
Density	0.0132	0.0084	-36.4%
Isolate count	28	36	28.6%
Component count	31	40	29.0%
Reciprocity	0.0625	0.0217	-65.3%
Characteristic path length	2.4994	1.4825	-40.7%
Clustering coefficient	0.1025	0.0396	-61.4%
Network levels (diameter)	5	4	-20.0%
Network fragmentation	0.5064	0.6372	25.8%
Degree centralization	0.1484	0.0642	-56.7%
Betweenness centralization	0.0359	0.0023	-93.6%
Closeness centralization	0.0103	0.0056	-45.6%
Reciprocal?	No (6% of the links are reciprocal)	No (2% of the links are reciprocal)	--
Source: Authors' results produced by ORA (developed at CASOS-Carnegie Mellon University).			

On the face of it, the system exhibits small-world effects. So we redid the analysis knocking out BI and CGIAR from the 2-mode, activity-based analysis, and discovered while the overall system looks to implode with the loss of the two core central actors, enough redundancy and interconnections exist to essentially rewire the functional sub-networks, such that while they are diminished, they largely remain functioning with their core members (table 6).

Table 6: Sensitivity Metrics on the 2-mode Activity-based Network (Organizations by Activity) with the removal of two key organizations: CGIAR and BI/IPCRI

	Centrality of Activity in the Global Network	Centrality of Activity (sans CGIAR and BI/IPGRI)	% change
Collaboration and partnerships in other than research	0.4537	0.4434	-2.3%
Funding source	0.1574	0.1604	1.9%
GR conservation, identification and/or evaluation of varieties	0.2685	0.2547	-5.2%
Handling, breeding and/or transfer of GR	0.1019	0.0943	-7.4%
Information access coordination of exchange	0.8611	0.8774	1.9%
Research coordination/facilitation	0.1944	0.1887	-2.9%
Research, education, training or other capacity building roles	0.6111	0.5849	-4.3%
Taxonomy	0.0648	0.066	1.9%
Treaties, Conventions, Conferences, Commissions and sub-structures	0.463	0.4717	1.9%
AVG	0.3529	0.3491	-1.1%
STDDEV	0.2503	0.2525	0.9%

One might conclude from this simple test that while the two key central actors (BI/IPGRI and CGIAR) are the institutional ‘glue’ that keeps the system together, the thread of common activities amongst actors could, in fact, be the binding factors.

5. Implications and extensions

The application of SNA tools to the international network of institutions and actors involved in ABS and TK policies, programs and initiatives, a contemporary example of a complex governance regime, reveals the complex nature of these systems. While on first glance, one might conclude that with 108 identifiable entities engaged at the international level (and not including more than 50 national organizations and many non-governmental organizations (NGOs) operating in the area), that the field is saturated. Examining the mode-1, organization to organization global network, we found 15 central actors, largely coordinated by two key international central actors—

Biodiversity International and the Consultative Group on International Agricultural Research (CGIAR)—which, if removed showed structural weakening. Once we moved to a mode-2 activity analysis, we discovered that a larger subset of central actors were engaged, and that when the two core actors (Biodiversity International and CGIAR) are removed, the system is weakened but not to the same extent. There would appear to be enough redundancy and interconnectivity in the system that the loss of two big-linking gatekeepers did not diminish the functionality of the system.

While this analysis is provisional, the methodology offers a new and exciting possibility of evaluating the relative strength of different governance networks, assessing the relative effectiveness of the networks, the continuities or gaps in leadership and governance and the vulnerability of the networks to changes in the mandates or resources of central actors.

While this offers a new opportunity to understand the complexity of governance, it also can be made to offer some policy prescriptions. Two further uses come to mind. First, it should be possible to use this type of analysis to assess the role of different funders—national governments, international governmental organizations, NGOs and private foundations—and the vulnerability of the international ABS effort to changing financial contributions. Second, one might be able to use the various measures of centrality and connectedness to assess and evaluate the optimal pathways for existing or new funders to contribute to the functions delivered by the eight sub-networks.

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