

Agricultural Research Networks in Sub-Saharan Africa: An Analysis of the Situation and Its Consequences

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The purpose of this article is to compare the theory and reality of agricultural research networks in sub-Saharan Africa. Networking is a mode of organization that generally suits the new environmental conditions. The analysis of the agricultural research network environment in sub-Saharan Africa shows that when institutional networks started to proliferate, human and institutional conditions were not yet ripe. This explained some of the problems. Nowadays, conditions have improved. Despite all difficulties, networks have contributed to creating a scientific community, have participated in apportioning and even harmonizing research activities, and have made it possible to maintain research activities in countries going through a crisis.

Introduction

Because of its widespread use, the concept of network organization as applied not only to research but also to businesses and political institutions quite obviously requires definition and clarification. In tropical agricultural research, work was organized through networks well before the concept was formalized (Davies, 1994). During the last ten years, donor agencies have been using the notion of networks as a mechanism for funding tropical agricultural research. This has led to a considerable increase in research networks in Africa, as well as institutions and projects of an international or regional character and consortia initiatives, as shown in the list

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Houssou (1992) drew up for Benin, and also as observed by the Special Program for African Agricultural Research (SPAAR). This phenomenon has come as a surprise to the research organizations and funding agencies that now want to make the situation more rational and that wish to evaluate network efficiency. Some wonder whether the research priorities of the national institutions are being respected. Others feel that networks tend to disturb institutions' operations and divert scientists from their main responsibilities.

The purpose of this article is to compare the theory and reality of agricultural research networks in sub-Saharan Africa. After reviewing the literature on the principles of network organization in private enterprise and in research organizations, the article considers the related consequences and, thereupon, defines the generally used concepts.

Network Enterprises: A Literature Review

There are many definitions for network organization (Snow et al., 1992; Curien, 1992; Butera, 1991; Boulanger and Perelman, 1990). Speaking about networks is often a way to connote a type of system in which the degree of interdependence varies with time. People talk about the old boys' networks, telecommunications networks, company networks, and so on. In the world of science and technology, numerous informal networks based on friendship or even on professional association have taken shape and serve as contacts for future collaboration and information sharing. This article, however, concentrates on institutional networks, in other words, the network enterprise.

The business world developed networks as a reaction to changes in competition (global markets, deregulation, breakthroughs in manufacturing processes, stronger informatics and telematics in modes of communication, etc.), and the subsequent effects on management (need to reduce costs and shorten production cycles, improve staff training, shift job sites, develop part-time and temporary employment, etc.). These changes in environment and management have reached the public service level.

Many writers have defined the word "network," or rather the idea of working in a network. For Prométhée¹ (1992), a network is a set of technical means (infrastructure), and of privately and/or publicly defined rules and norms (infostructure), that actors with rights of access can take the initiative to mobilize in order to set up and manage relationships among themselves. In the American vocabulary on strategy, a network enterprise is a "hollow corporation" composed of a set of essentially independent and autonomous sub-enterprises that develop close contacts and have a central unit to serve as a pilot and mediator. This is an alternative to vertical integration or diversification. It is a type of organizational structure that has been developed to offset the negative aspects of the more traditional forms, i.e., organization based on functions, divisions, or matrices.

One of the basic differences between a network and another mode of organization is that in a network, traditional professional relations based

on a hierarchy are replaced by forms of regulation that are based on supply/demand mechanisms. The enterprise is composed of units that are coordinated and controlled by a small core. For management, this transformation is a pledge of greater efficiency and productivity. Bonds between units can be expressed in financial terms, and enable the units to better understand the market and the techniques being used, to adapt to change more quickly, to increase staff motivation and, thus, to be more efficient. This description highlights several aspects:

- The notion of network organization is generally connected to a sense of contracts that govern flows between units for a given period of time.
- The borders of networks are permeable; contracts and environmental constraints determine access to and exit from the units. This means voluntary membership and explicit commitments by the units in the network, as if to recognize that internal bonds provide compensation for external instability and that adaptation does not seriously decrease efficiency (Miles and Snow, 1992).
- The development of networks goes hand in hand with the development of individual accountability as the number of hierarchical levels declines. This means that staff in units that belong to the network need to be appropriately trained.
- A network can only develop if information is no longer considered a source of power, if the position on the hierarchy no longer plays an overriding role in staff capacity to assess information, and if management accepts free circulation of information (de Meyer, 1993; Crozier and Friedberg, 1977).
- A network can only work effectively if the component units have confidence in each other. Good communications is one of the main conditions for success; they can be greatly facilitated by appropriate communications systems.

Last, all members do not play the same role in a network organization. A distinction can be made between:

- The pilot, who defines the limits and components of the network, establishes the communications systems, organizes flows, enables members to establish contact and has the capacity to control flow rates between units.
- The members, who contact each other through decentralized modes, and can enter, leave, and change their positions in the network since it is a constantly changing system. Not all members play the same role. Some are more active in generating ideas while others serve as gatekeepers, ensuring interface between network members and outside forces (Tushman and Katz, 1980; Allen and Cohen, 1969; Tushman and Nadler, 1986). In an efficient network, the members are usually complementary.

Prométhée adds a third category, the "supervisors," in other words, the people who create the infrastructure (i.e., communication rules and norms). The result is that the role of the pilot is restricted to defining the limits and components of the network.

The networking of enterprises, thus, is seen as a very elaborate mode for organizing work in a way which allows for quick adaptation to new

environmental constraints. The following section provides a literature review of research networks.

The Research Networks: A Literature Review

Literature on research networks distinguishes at least two trends, as presented below: the first one focuses on Michel Callon, and the second one on the networks of the International Agricultural Research Centers (IARCs).

In 1993, the French *Conseil supérieur de la recherche et de la technologie* (CRST) appointed a study group to consider research network evaluation. The group used studies by Michel Callon and his team (1989) as references. It recognized that the notion of network was very useful in describing innovation and technological creation as phenomena, and that the world of research had networked well before the network model had been conceptualized.

The group emphasized that a network relationship was useful but based on a mixture of ideas which led to ambiguity: the existence of competition did not eliminate mutual dependency and advantages in pooling resources; confidence without which cooperation (unless constantly refereed and rewarded) would be unthinkable; and access to a far larger number of contacts than those provided through the limited lists relating to bilateral contracts (hierarchical or commercial).

The network is underpinned by social actors with varying objectives and behavior patterns. The CSRT report suggests describing networks on the basis of:

- The character (homogeneous or heterogeneous) of codes, and criteria for making decisions and assessments. A network is homogeneous if it brings together only scientists or only scientists of the same discipline. It is heterogeneous if it brings together scientists, manufacturers, traders, etc.;
- The character (convergent or divergent) of the effects produced by the network. An information exchange network is convergent if all of its members can access the network's bibliographic data base. A network is divergent if all of its members are not allowed to attend all of its meetings.

Networks are essentially incentive in nature, which affects the way they are to be evaluated. The CSRT report, essentially for two reasons, recommends concentrating scientific evaluations on the basic network component. The group felt that the laboratory was, and should remain, the main place for the lengthy process of accumulating and renewing expertise and, further, hoped that, within the network, this would make it possible to prevent the good teams from veiling the bad ones, and vice versa. One indicator for the global assessment of a network could be the training opportunities it offers.

Another view of research networks has been developed by Plucknett, Ozgediz and Smith. For the last ten years, they have been studying the CGIAR (Consultative Group on International Agricultural Research) cen-

ter networks, and feel that networks contribute to institutional capacity-building by providing opportunities for meetings. Network members from the developing countries are acquainted with new methods and techniques, and the best scientists can obtain recognition.

These authors assign research networks to four categories, according to their tasks: information exchange; sharing material; scientific consultation; collaborative research. They conclude that the four types of networks mentioned above participate in creating and disseminating these three types of products, with the following exceptions:

- the information exchange network does not participate in creating knowledge and methods;
- the materials exchange network does not participate in creating knowledge.

Plucknett and his co-authors felt that the homogeneous nature of network members and the convergent character of effects produced by the network were natural; CSRT felt that this was rarely the case.

Although there are not many network evaluations available, Plucknett, Ozgediz and Smith (1991) felt that networks should have an impact on:

- their members, who can become agents of change for their home institutions, observe other ways of working, acquire and learn to convey new skills and values, shoulder responsibility, develop long-lasting relationships, and reduce redundancy in their work;
- the institution, which can benefit from new ideas and methods, as well as from opportunities for training and contacts;
- the country and the region, which strengthens its potential for conducting research and making analyses;
- science, by creating and disseminating new ideas and methods.

Pablo Eyzaguirre (1992) expanded upon the work done by Plucknett, Ozgediz and Smith, by pointing out that the explosion in scientific information available played a major role in the growth of networks. Actually, networks are efficient mechanisms for diffusing information, which is especially useful for research institutes that do not have the capacity to acquire the information that their scientists need. Networks are also efficient mechanisms for allocating specific tasks to several members at a time and then for assembling products and information.

Eyzaguirre stressed that network members were either individual scientists, research institutions or countries. He made a distinction between:

- "central-source networks" managed by IARCs which communicate their techniques through these networks;
- "regional networks" run by intergovernmental organizations with the research leaders staying in contact with the policymakers;
- "professional networks" essentially designed to enable scientists to exchange information.

Eyzaguirre pointed out that networks tend to become institutions, and in some cases turn into organizations that are superimposed on the exist-

ing ones. Despite this unfortunate aspect, they are potentially very effective tools, especially for small countries.

He also mentioned that networks are often created and supported by donor and technical assistance agencies. The former provide financial backing while the latter essentially provide technology, information and expertise.

Typologies for research networks and for network impact criteria have been suggested. The typologies put forth by Callon and by the CGIAR scientists are not very different:

- information and material exchange networks;
- "coordination" or "consultation" networks;
- "knowledge producing" or "collaborative research" networks.

The CGIAR scientists feel that nearly all networks have a role to play in creating knowledge, methods and materials. Callon is less ambitious; he stresses the role of dissemination.

Field Research: Methodology

The method that was used was inductive: from observation to a critical analysis of research networks, using information from literature on management.² The analysis of the background and operations of several agricultural research networks in sub-Saharan Africa³ was based on discussions and interviews conducted between 1992 and 1994. We met with close to a hundred scientists and administrators from national agricultural research institutes, international centres, and development assistance organizations, and with representatives of donor agencies. In view of the review of the literature, two questions were selected: Is the number of agricultural research networks in sub-Saharan Africa the result of a favorable environment? What are the consequences of the current proliferation of agricultural research networks?

The Large Number of Networks Is Actor-inspired

In Sub-Saharan Africa, the Environment is not Yet Sufficiently Hospitable for Networking Activities

Networking in the private sector was a response to new environmental conditions to which enterprises had to adapt. For agricultural research networks in Africa, the question is whether in the past or at present the physical, human, economic and institutional environmental conditions facing research institutions benefit from the development of networking. As table 1 shows, in sub-Saharan Africa, conditions are not yet ripe for creating and developing network enterprises similar to those of the private sector. In theory, this mode of organization is justified from the economic and technical vantage points (except as concerns communications systems), but not from the human and institutional vantage points. However, progress is definitively made.

*Sub-Saharan Africa, the Development of Network
Explained by the Interest of a Few Stakeholders*

The challenges facing the stakeholders, in other words, the organizations with vested interests, explain the development and prolificacy of research networks. Case studies showed that networks created during the last ten years were run mainly by research institutions working in partnership (international centres of the CGIAR, French research organizations, universities in developed countries, etc.). Launching or managing a network made it possible for them to:

- take root in a geographical area, thus parrying the installation of "competitive" institutions;
- publicize and ensure the notoriety of the founder's products, and create demand;
- train national scientists, thus influencing their way of working and ensuring their allegiance;
- use personnel and infrastructure belonging to national institutions to carry out experiments, thus avoiding having to cope with the problems that face employers and owners/tenants (role frequently played in the past);
- provide equipment for teams without having to worry about maintenance or replacements.

These few reasons explain why so many networks have been created; Oussou (1992), for instance, pointed out that Benin had four networks devoted to maize, i.e., Semi-Arid Food & Grain Research and Development, IITA, CIMMYT, and CORAF.⁴

From their side, the donor agencies, thanks to networks, have been able to finance research in several countries at the same time, without having to maintain direct contact with each country individually. Furthermore, since networks often have a tight focus (one plant, a specific cattle disease, etc.) it is easy to justify how funds are spent. Donors have also, thereby, been able to encourage the regionalization of research.

Thus, in the early 1980s in an environment that was not truly ready, networks were created thanks to, but also largely in order to satisfy donor agencies and research organizations in the developed countries. This explains their vast numbers. Since that time the environment has improved in certain cases and regressed in others.

Consequences of Current Organization

In principle, a network enterprise is composed of a steering and operating unit and independent functional units which create strong bonds amongst themselves, so that together they can produce more efficiently than they could under a different system of organization.

This concept was poorly assimilated in agricultural research circles in Sub-Saharan Africa: the funding agencies and the technical assistance agencies wanted to apply it in an environment which was not fully staged

for its development. The main consequences of this offphasing were the following.

Networks are Composed of Heterogeneous Members

Most of the agricultural research networks in Africa only bring together research scientists or institutes. Representatives of producers' organizations, extension services, NGOs, and agro-industry are seldom involved in research network activities. And yet, the character of these networks is rather heterogeneous. In the networks studied, there were two, or at most three, groups of members:

- scientists from institutes in developed countries; and
- scientists from African national and regional institutes. In some discussions, these researchers were put into two groups, i.e., scientists working in research programs deemed "strong" and scientists working in research programs deemed "weak."

This heterogeneity led to a distinction in learnership between the groups. Scientists from institutes in developed countries have been more highly trained than have a good number of their colleagues from the African institutes, and they have access to more resources. They tend to lead and run operations, something some try to avoid. Bossuyt, Laporte and van Hoek (1992) underscore the problems of a system that connects experts and counterparts. The experts tend to make themselves the leaders, who run the activities; this stifles the national counterparts' good will and prevents them from taking on responsibility. Experts are usually well qualified technicians but poor instructors.

In a system as complex as a network of operational units, collective learning, i.e., instruction for all the participants together, is the precondition to success. Mutual trust and peer judgment are also important conditions (Crozier and Friedberg, 1977). The situation can only be improved by foregoing vested interests, the power struggle, intellectual models and emotional protection. Improvement will require the members' determined, explicit commitment. At present, the decision to participate in a network is often actually a response to a solicitation from a steering body.

Furthermore, because of the heterogeneity of membership, the role of the network's pilot increases. The pilot then tends to influence the members, especially as concerns research priorities. The "weak" institutions and the least trained researchers tend to follow the pilot instead of defining their own programs. The programs they embark upon do not necessarily correspond to needs and are not educational.

Finally, because of heterogeneity, certain members benefit from the networks more than others. Scientists from the "strong" programs enjoy supplemental funding without always sharing their results with the scientists from the weaker institutes. The latter receive less funding but more knowledge and materials.

Despite these difficulties, it is important to note that networking has contributed to building up a scientific community and even, in certain instances, to meting out and harmonizing research activities. The flexibility of the existing networks is such that research activities can be maintained even in institutes going through a crisis.

The Network Tends to Become a Superstructure

In the sub-Saharan African world of agricultural research, no one speaks of network enterprises or network research teams, but rather of "networks." Networks tend to become superstructures that are superimposed on national structures. They have coordinators and committees. But a superstructure has a price. Wages are high when coordination is a full-time job. For the members there are hidden costs which are related to the time they devote to the network. Furthermore, the operating costs for a network are generally underestimated because part of the infrastructures and equipment are maintained by the home institutes.

Theoretically, the Network (with a capital N) links autonomous, independent units which are supposed to network their operations. This is especially important because of the production processes used in research institutes (Callon, 1989; de Lattre, 1990; Butera, 1991). But, as an actual matter of fact, the weakness of national units makes it difficult for them to work in a network. They are both very autonomous (survival requires them to look inward) and very subordinate (they are easily influenced). The network's steering body tends to turn into a managerial unit rather than functioning as a facilitator. The short-term efficiency goal seems to override long-term institutional development (Bossuyt et al., 1992).

The Contracts between Members are Incomplete

By becoming a member, the scientist or his institute becomes entitled to information and products disseminated by the other members and, in turn, becomes dutybound to furnish a certain amount of information and products. The framework for such exchanges is not well described, and costs have been poorly assessed. The contract, thus, is incomplete (Amigues, 1993). It is impossible to provide for all the contingencies that affect the results of the contract; there are too many. Certain actions (or lack thereof) by contracting parties cannot be checked and, hence, in the case of dispute, recourse to arbitration by a third party becomes impossible.

Most enterprises which choose this mode of working, i.e., networking, feel that the benefits outweigh the transformation costs. African research networks entail two types of costs: first, costs connected to exchange relations, i.e., transactions (postal or electronic communications, travel and meetings, time devoted to network activities); and second, costs for experiments connected to joint research.

Part of the transactions costs (telecommunications, travel, meetings) are borne by the funding agency. This biases the potential members' decision

to join, or not to join, a network. The other part (time devoted to network activities) is paid by the members' home institute and thus is not shown in the budget.

The third economic problem related to networking in the field of R&D comes from the difficulties in making a distinction between sharing ownership rights and sharing profits.

Nevertheless, emphasis should be placed on the fact that participating in a network can prevent certain duplication of work and, thus, can make it possible to reduce the cost of research. Cost reductions can also be obtained from economies of scale.

Network Activities Are Difficult to Evaluate

Sub-Saharan African agricultural research networks, on the one hand, seek to bring together individual scientists (and via them, their institutions), and, on the other, to implement collaborative research projects. In principle, a network enterprise is formed as the result of bonds between the component units. Joint production is a goal; this relationship is the means to achieving it.

The institutes that carry out collaborative research, and the funding agencies that promote networking, thought they could create bonds between research scientists (through informal networks or professional associations), facilitate the exchange of information and materials, and construct joint projects. The typology proposed by Plucknett, Ozgediz and Smith was prepared *a posteriori*. Actually, no network defined itself strictly as a network for information sharing, for exchanging materials, for scientific consultation, or for collaborative research; each one tried to do everything. Objectives were so imprecise that it was difficult to evaluate the results.

Building up relationships is an activity that is difficult to assess in quantitative terms; the criteria tend to be more qualitative. If done formally, upon precise instruction, in an environment with weak communications capacities, developing linkages becomes a costly undertaking (all the more so since budgets have specific time frames), but a necessary one in order to develop joint projects. It entails a long-term investment which is justified if it enables participants to become acquainted with each other, to identify how they are complementary, and to understand the advantages of this form of organization. A project, on the other hand, has many methods of evaluation with objective criteria.

At present, a certain number of funding agencies criticize networking because of the cost and the proliferation of networks focusing on the same subject. They want network operations to be evaluated, with an eye to eliminating some of them. This said, for future networks, the donors will have to agree to funding the contact establishment phase, and consider it as an investment, yet remember that the timing for this process has to be decided by the future network members themselves. (Table 1 summarizes the present situation of networks in sub-Saharan Africa.)

TABLE 1
Favorable and Unfavorable Elements in the Environment for
Networking in Agricultural Research in SSA

Environment	Favorable elements	Unfavorable elements
Physical		Physical boundaries are not easy to define use of geographical borders, ecological or economical criteria?
	Communication system (e-mail, fax, telephone, postal service) is still poor, though improving.	
Human	- Few scientists are bilingual (French and English). - Scientific quality of scientists is uneven and there is a lack of multi-disciplinarity. The heterogeneity of levels favors a transfer of knowledge but may hold back quality.	
Economic	- Networks might lead to economies of scale which are important considering the financial situation of the SSA countries. - Networking brings additional resources (for the research project and for the individual scientist).	The principal objective of networks might become funding.
Institutional	Many small countries in SSA are with poor resources. Networks allow the establishment of a critical mass of scientists.	- Networks imply consensual decision making: nationalistic opinions and importance of sovereignty prevent networking activities. - Tradition of centralization in national institutions. - Political instability.

Conclusion

Literature on private sector networking shows that as a mode of organization it generally suits the new environmental conditions. The analysis of the agricultural research network environment in sub-Saharan Africa shows that when institutional networks (as opposed to informal networks and professional associations) started to proliferate some fifteen years ago, human and institutional conditions were not yet ripe. This explained some of the problems. Nowadays, conditions vary from country to country. In some cases, networks have contributed to creating a scientific community, have participated in apportioning and even harmonizing research activities, or have made it possible to maintain research activities in countries going through a crisis.

A network enterprise is defined as a set of independent, quasi-autonomous, strongly interlinked sub-enterprises. One of them serves as a coordinator and a pilot and, hence, is called the "core of the network." In sub-Saharan Africa, the IARCs and research institutes from the developed countries serve as the main pilots of the networks. Because of the weakness of national institutes, networks tend to become "superstructures" wherein management becomes more important than facilitation. Since scientists in national institutions are of different levels, a network's impact on its members varies.

Finally, network organization developed within a commercial culture. The context within which exchanges take place and which determines flows between network member companies is contractual. As concerns agricultural research networks in Africa, because the context for such changes between members is not sufficiently explicit, there are problems with intellectual property rights and cost evaluations (in particular transactions on costs), problems which, moreover, limit the impact of the network. The situation is marked by "incomplete contracts." Flexibility was encouraged to facilitate the researchers' creativity but in some cases has jeopardized the discipline of management and the legal framework.

In reviewing the literature and analyzing the case of agricultural research networks in Africa, we tried to identify some of the specific characteristics of the networks. The conceptual framework used the wrong model and thus, did not lead us to the expected results.

To improve the situation, we feel that the best solution would be to continue reflecting on the economic and contractual concepts of the network. The question is: What lessons from the commercial culture can be transferred to the agricultural research networks in the developing countries?

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Notes

- Prométhée is an international group of independent scientists who work on economic globalization and regional integration.
- Especially documents of the Consultative Group on International Agricultural Research (CGIAR) and the Conférence des responsables de la recherche agronomique africains (CORAF), the Semi-Arid Food & Grain Research and Development networks evaluation, documents presented at the ISNAR (International Service for National Agricultural Research) seminar (April 1994) on choosing regional priorities. SPAAR documents on research regionalization, etc.
- A few networks were studied in greater detail: the East Africa AgroForestry Research Network (E.A. AFRENA), the Réseau de recherche sur la résistance à la sécheresse (R.R.S.) the maize network of CORAF (Conférence des responsables de la recherche agronomique africains), the networks of Semi-Arid Food & Grain Research and Development.
- SAFGRAD: Semi-Arid Food & Grain Research and Development; IITA: International Institute of Tropical Agriculture, Nigeria; CIMMYT: Centro Internacional Mejoramiento de Maíz y Trigo, Mexico; CORAF: Conférence des responsables de la recherche agronomique africains.

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S&T Indicators for Strategic Planning and Assessment of Public Research Institutions¹

Frances Anderson and Robert Dalpé

This article presents an approach we have developed for the assessment of public research institutions in the natural sciences and engineering. The method consists in the exploitation of available S&T databases and indicators, including bibliometrics (databases of scientific as well as technical literature), patents, and internal data. Results are therefore derived through multiple databases. The objective is to profile a specific national R&D community in order to assess the positioning of a public institution or program within the community to which it belongs. It involves obtaining the profile of the evolution of an R&D area, the R&D performers, the financing and support institutions, the users of R&D results, and the interactions between all these actors. A case-study of Canadian research in polymers is presented.

Introduction

As in most countries, the practice of Canadian federal R&D evaluation has gone through a number of changes since the early 1980s (Barba 1993). Prior to that, peer-review supplemented by bibliometric analysis was the predominant evaluation methodology, which focused on the quality of research and the efficiency of research management. In response to new demands placed on evaluators as to the usefulness and relevance of research institutions, the Office of the Comptroller General of Canada produced in 1986 a discussion paper entitled *Evaluation of Research and Development Programs* (Treasury Board of Canada, 1986). It placed the issue of the "quality of research" within a context common to other non-scientific program evaluations, and led evaluators to address a much wider range of questions than had previously been the case. In addition to the "quality of research," the following issues were raised:

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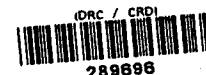
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