Partnerships for Building Science and Technology Capacity in Africa

Banji Oyelaran-Oyeyinka

United Nations University – Institute for New Technologies (UNU-INTECH), Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands

Paper prepared for the Africa–Canada–UK Exploration:
Building Science and Technology Capacity with African Partners
30 January – 1 February 2005
Canada House, London, UK

Executive Summary

This paper discusses North–South partnerships to build capacity for science and technology (S&T) in Southern countries. Partnerships for S&T capacity building in Africa are not new and vary in scale, scope, and character. The contexts for these partnerships differ, and the institutional and policy environments are evolving.

Defining Partnerships

Much of the literature deals with partnerships, or cooperative arrangements, in the North (North–North collaboration). One dimension has attracted great attention — research partnerships. These partnerships are defined as an innovation-based relationship that involves, at least partly, a significant effort in research and development (R&D).

Three key observations emerge from a review of the literature:

- Research partnerships are simply part of a broader set of collaborative relationships created to enhance innovation.
- The process of joint innovation is not only confined to formal arrangements; it involves significant elements of informal collaboration, learning, and exchange of knowledge between individuals in different organizations.
- The motivating force behind the creation of these collaborative relationships is the compelling need to innovate jointly.

New Thinking on Partnerships

The innovation system concept as a useful framework for analyzing partnerships because it provides the scope for:

- exploring patterns of partnerships;
- revealing and managing the institutional context that governs these relationships and processes;
- understanding research and innovation as a social process of learning; and
- thinking about capacity development in a systems sense.

The notion of capacity development in a systems sense entails "building up the collective capacity of networks or systems of actors interactively linked with a view to innovate." This contrasts with the conventional sense in which capacity development is often understood as the "building up stocks of research infrastructure and trained scientists." Therefore, a shift from a conventional to a systems conceptualization of capacity building requires a reorientation in the objectives of North–South partnerships. Stimulating changes in the behaviour of the system and the institutions that govern the system must become the primary objective. Institutional learning and change must be included in the partnership agenda

Insights from the Review

Partnerships are key but are often narrowly conceptualized

Partnerships for development in the South are commonly perceived as North–South or South–South research collaboration, or private–public partnerships. Some partnerships are not even focused on innovation for development, and when they are, research institutes and universities are erroneously regarded as the sole source of innovation. Insufficient attention is paid to in-country partnerships and the need for these partners to partner with other actors outside the country. The innovation-systems framework provides a way of thinking about partnerships and innovation in a holistic way — where research centres and education institutes are only part of much broader dynamic system and where research institutes and universities, farmers, firms,

NGO, industry associations, and policy bodies all need to exchange ideas, information, and knowledge to generate and apply socially and economic useful knowledge.

Getting the institutional context right for partnerships is much more demanding than is generally assumed

For partnerships to succeed, the skills, habits, and practices that allow individuals and organizations to interact with each other are critical. They need soft skills in team building, competing while cooperating, debating and resolving competing priorities, and mobilizing resources. Skills are required to build relationships based on trust and in which partners all have a sense of working toward a common goal. Barriers to partnerships must be lowered by building of "social capital." In some cases, work ethics [including accountability] will have to be rebuilt, especially when these have been interrupted by the opportunistic behaviour that often accompanies economic and political mismanagement. Building a culture of innovation among all actors in the system is a long, multi-faceted, and context-specific process.

Coordination matters

Partnerships that are designed to strengthen learning networks and coalitions tend to make better contributions to development. Partnerships that recognize the need to enhance the exchange of formal and informal knowledge by partnering African and foreign specialists are more effective in generating technical and non-technical solutions. These partnerships will not emerge automatically and must be stimulated and supported. Coordination is the key.

Strong governance is important

In the contemporary partnership approach, diversification of funding mechanisms is essential. Local and regional partners, international development agencies, and government and private funders will only be attracted to networks and organizations whose governance structures are clear and solid enough to ensure built-in monitoring of results and financial accountability. The strengthening of governance systems will allow organizations to redirect funders from "cherry picking" of specific projects to providing "basket funds," which encourage stronger intra-linkages in programming.

Capacity development is about building local systems for producing and using knowledge not just building stocks of infrastructure, trained scientists, or trained users

One of the most pressing needs in Africa is to build local systems that enhance the capacity to innovate: local systems to generate and apply knowledge and information are necessary to build absorptive capacity, accelerate poverty reduction, manage natural resources better, boost productivity, compete in local and export markets, and improve well-being. The strengthening of key organizations (public and private) is vital.

Stimulating demand is as important as generating the science and technology

Making the supply of agricultural research more demand driven may yield only very modest dividends if, at the same time, we do not try to stimulate and organize the demand for agricultural research from the farmers themselves.

S&T partnerships for capacity building in Africa need to move away from a narrowly defined agenda of strengthening research infrastructure, enhancing access to technologies, and developing core skills toward the building of local systems — technical and institutional — for producing and using knowledge.

S&T capacity initiatives in Africa need to recognize and accept that building effective S&T partnerships has as much to do with strengthening the ability of individuals and society to learn how to change as it does with creating science and technology, core skills, and physical facilities. Individuals and society must learn to change their historically determined routines, build coalitions, compete and cooperate at the same time, debate priorities, respect each others views and rights, resolve conflicting ideas, mobilize and account for resources transparently,

and work in participatory ways within interdisciplinary and multi-organizational teams toward a common goal —innovation and development in a continually changing setting.

Some Policy Challenges

From a policy perspective, the strength of an innovation system approach lies in the attention it draws to policy dynamics and the way these emerge from the interaction between policies and the habits and practices of the actors whose behaviour is targeted by policy. The impact of policies will thus vary across different institutional contexts. Besides, the right kinds of policy are, all too often, not present or fail to connect in a way that stimulates a process of innovation.

Question: *How and what role can policy research networks and their partners play in ensuring policy coherence and relevance?*

We know that the creation of effective partnerships involves a wide array of linkages. Of critical importance is a better understanding of the factors that must be addressed to get the "institutional" setting right for more effective partnerships. These partnerships must not only be sensitive to the needs of the poor but also to "institutions" that often impose gender-based constraints that effectively restrict both participation and access to the benefit of activities in the broad innovation and development arena.

Questions: *What factors are likely to stimulate or constrain institutional development — including social capital development? What are the implications of adding an institutional development agenda to existing agendas of partnerships for S&T capacity building in Africa?*

If capacity development is about building local systems for producing and using knowledge, and not only about building stocks of infrastructure, trained scientists, or trained users, there is an empirical question of how to reform the nature and structure of partnerships (for S&T capacity building in Africa) to effectively contribute to the development of innovation systems.

Question: *How and under what circumstances can this result be achieved?*

Introduction

This paper discusses North–South partnerships to build capacity for science and technology (S&T) in Southern countries. Partnerships for S&T capacity building in Africa are not new and vary in scale, scope, and character. The contexts for these partnerships differ, and the institutional and policy environments have are evolving. More importantly, our ideas about the role that S&T plays in development, and the ways in which knowledge is transferred, are increasingly challenged.

Four sets of issues are critical to capacity development and partnership for knowledge generation:

- All agents in the economy are involved in a continuous process of learning and the notion of knowledge "producer" and "user" has limited conceptual and policy relevance.
- Organizations do not innovate in isolation; they do so within a network of other actors in a supportive environment.
- Learning is a process of trial and error that takes place over a long time and possesses a systemic and incremental character. Therefore, S&T policy design for development must be re-conceptualized in "systems terms" and take historical forces into account.
- The role of knowledge has become increasingly central to the analysis of both economic progress and institutions. Institutions define the complexity and sophistication of the knowledge that is generated, and are at the same time they are shaped by this knowledge.

The efficiency with which knowledge is created and diffused depends on the variety of institutions promoting innovation. In terms of S&T partnerships, it is clear that technological knowledge is crucial to development. However, designing the right social institutions to absorb, retain, advance, and sustain knowledge has turned out to be much more challenging. The failures to reap the promises of partnerships are often due to failed institutions and to our assumptions that institutions are neutral.

The case studies discussed in this paper show that S&T partnerships have often been shaped by a common view of science and technology and the role both play in development. Knowledge was seen as scientific knowledge generated in a laboratory. No account was paid to the modes and mechanisms of diffusion. This view, which influenced the design and implementation of many S&T projects, was unable to tackle the question of how new knowledge and skills would fit into existing systems. It was totally ill-equipped to address the scope of parallel organizational and institutional changes that were required to facilitate the commercial use of the resulting scientific and technological knowledge.

By examining existing research and analysis of S&T partnerships for capacity building in Africa, this paper shows that partnerships that are designed to work as self-contained activities are insulated from the very system they seek to influence. This gap between science generation and its "market" is rooted in old thinking that equates science and technology generation (through formal research) with innovation. This conventional view promoted the mistaken notion that scientists and technology specialists, through their research organizations, were the innovators and producers of new knowledge. Furthermore, this knowledge would then have to be transferred to

users in a linear process from basic research, to applied research and development, to the market.

In reality, to transfer knowledge, producers and users must be connected through a layer of agents working to diffuse this knowledge. In many S&T capacity building initiatives in Africa, the role of other services and actors outside the sphere of research and education has received little emphasis. This is particularly true for the role of the private enterprises that make commercial use of new technologies. This linear technology-transfer model has failed, and a systems conception of the process is advocated.

This paper reviews the broader literature on technology-related partnerships to provide a conceptual basis for examining several S&T partnerships aimed at building capacity in Africa. Short case studies are also presented of both successful and less successful S&T partnerships to examine the nature of partnership, the organizational and institutional context, the policy environment, the contributions made to development, and the difficulties encountered.

The Literature

Much of the literature deals with partnerships, or cooperative agreements, in the North (North–North collaboration). One dimension has attracted great attention — research partnerships. Hagedoorn et al. (2001) define a research partnership as an innovation-based relationship that involves, at least partly, a significant effort in research and development (R&D). Research collaboration is as old as modern science itself, and collaborative efforts involving researchers from more than one country date to the nineteenth century. More recently, inter-country collaboration, including North–South research collaboration, has been growing at about 7–8% per year. Partnerships have expanded among both new and traditional technologies and between academia and industry.

Okamura and Vonortas (2004, page 1) use the term "innovation networks" to capture the impetus behind the immense web of collaborative relationships created between business and non-business entities:

> *Networks involve a wide range of collaborative activities including joint ventures, research corporations, joint research and development (R&D), technology research agreements such as technology sharing, cross-licensing, mutual second-sourcing), direct investment, customer-supplier relations, R&D contracts, one-directional technology flow agreements (e.g. licensing, second-sourcing), manufacturing agreements, and so forth …Innovation networks also often involve informal collaboration and knowledge exchanges across individuals in different organizations and systemic learning …*

Three key observations emerge from these works:

- Research partnerships are simply part of a broader set of collaborative relationships created to enhance innovation.
- The process of joint innovation is not only confined to formal arrangements only; it involves significant elements of informal collaboration, learning and exchange of knowledge between individuals in different organizations.
- The motivating force behind the creation of these collaborative relationships is the compelling need to innovate jointly.

Okamura and Vonortas (2004) provide a helpful overview of the theoretical and empirical literature on the factors that inspire collaborative innovation in the Northern context. They discuss theories that range from pragmatic motives that necessitate a neoclassical cost–benefit analysis of investment (including the risk factor of investing in uncertain and expensive research activities) to transaction-cost theories and strategic-management theories that view these alliances as processes that enable firms to create, develop, and realign the capabilities of its resources. Citing the complexity and multidisciplinary nature of partnerships, Okamura and Vonortas (2004, page 10) conclude that:

> *The theoretical foundations of the studies on [technological] alliances has been shifting from a mainstream industrial organization perspective (De Bondt et al., 1992; Suzumura, 1992; Vonortas, 1994) and a transaction cost economics perspective (Williamson, 1985, 1991; Menard, 1996a, 1996b) that viewed each alliance as an island, towards a systems view leaning heavily on the concepts of the resource based view of the firm (Teece, 1992; Eisenhardt and Schoonhoven, 1996) and of learning networks (Gulati, 1995, 1998; Powell et al., 1996; Walker, 1998; Oliver, 2001).*

Two important observations can be derived from this analysis:

- The shift in thinking toward a resource-based view emphasizes that collaborators attach great importance to organizational learning and the need to build new capabilities to develop sustained competitive advantages. Consequently, there is the need to improve old, and build new, capabilities on a continuous basis. When existing routines, practices, and policies constrain capacity-development efforts, the focus must be on stimulating the demand for learning and aligning technical and social capabilities.
- Much of the analysis implicitly assumes that the creation of new relationships will lead to innovation. In other words, the ultimate goal of the collaborators is to generate new knowledge that can be translated, by other collaborators within the system, into new products and processes that result in social and economic benefits. In reality, S&T partnerships involving North–South collaboration are not necessarily configured in ways that permit or encourage the translation of knowledge into marketable products and services.

There are striking differences between the underlying motivations and the nature of the partnerships in North–North and North–South collaborations. North–South collaboration is characterized by asymmetric power relations (Narvaez Berthelemot et al. 2002). The partners are often unequal in terms of scientific resources, access to funding, and networks of research resources. The partnerships also tend to be driven by geopolitical and linguistic considerations and by the opportunity to access specific population groups, unique facilities, or indigenous knowledge in the South. The motivations include the need to address global problems, such as climate change, and to identify development needs and programs that can be supported through development aid. Although multinational corporations and other private entities are major actors in research funding in the North, their subsidiaries rarely invest in research in the South. Similarly, they tend not to invest in North–South partnerships. Consequently, local research and technology organizations often suffer acute funding shortages. In this respect, development organizations tend to fill the gap, albeit partially.

Three broad types of North–South relationships were identified:

- The principal actor controls resources, makes decisions, assigns tasks, identifies information needs, assesses performance, and uses sanctions. In this scenario, subordinate actors are assigned tasks, carry out instructions, comply with the decisions of the principal actor, have no independent access to resources, and respond to information requirements.
- A consultative relationship is established to allow the leader to obtain information from the stakeholders, define actions, and control resources and decision-making. The stakeholders supply information, agree to, and carry out, identified tasks, and give opinions on resource use and priorities.
- A coalition relationship in which there is a managing partner and partners. The managing partner facilitates relationships among all actors through a process of negotiation and consensus building, and ensures that the process is iterative and responsive to change. The partners recognize that the focus of the coalition is a shared agenda of overlapping interests, accept collective responsibility for strengthening the capacity of the coalition, and are committed to joint ownership of the processes and products.

Elements of each of these relationships are found in different models of partnerships. The main hypothesis of this paper is that enhanced consultation and participation by all actors in the design and implementation of programs and projects is associated with success. Both a focus on local needs defined by national actors and a partnership designed to strengthen local capabilities were clearly evident in a recent study supported by IDRC (see Table 1).

New Thinking on Partnerships

Since the late 1980s, a more systemic and holistic view of the innovation process has gained currency. The innovation systems concept is now widely used for policy in OECD countries (Hall 2002; Chema et al. 2003). This contemporary approach draws inspiration from a number of fields in economics and has produced the much-cited conceptual framework "national systems of innovation" (NSI). NSI has been defined in a variety of ways. Freeman (1987, page 1) defines it as "…the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify an diffuse new technologies." Lundvall (1988) believes that learning, which he considers to be an interactive process, and institutions are the critical components of NSI. In a narrow sense, institutions are conceived to be organizations such as universities and technology institutes; whereas, in broad terms, institutions include the political context, habits, practices, norms, and rules regulating relations and interactions among people. His conceptualization of NSI (Lundvall 1992, page12) emphasizes the diffusion of "economically useful knowledge." Metcalfe (1995) defines NSI as "…that set of institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store, and transfer the knowledge, skills, and artifacts, which define new technologies. The element of nationality follows not only from the domain of technology policy but from elements of shared language and culture which bind the system together, and from the national focus of other policies, laws and regulations which condition the innovative environment."

Table 1: Biopharmaceutical Innovation System in Nigeria: Focus on Local Needs (Oyeleran Oyeyinka 2004).

This study shows that Nigeria has established a number of public research institutions (PRIs) and university faculties that were critical to the development of a biotechnology system of innovation. The country has a large domestic market for drugs and over the years has invested in science education that has produced scientific and technological human resources including doctors, pharmacists, and technicians. Some of the PRIs have made commendable progress within a very hostile scientific environment and developed notable drugs and vaccines. The hallmark of the centres that have been relatively successful is their focus on local needs and problems, which seems to be a major trigger for innovation, and their sustained efforts to bring their research to a successful conclusion. The notable examples include:

- The Malaria group at the University of Ibadan. Although the group has yet to come up with an innovative drug, its existence demonstrates how support for institutional capacity building can create a critical mass for research on a local disease problem. The pitfall of a focus on a disease that affects wide areas of the globe is likely duplication of research effort because Malaria research is widespread and WHO — the main supporter of the Ibadan program — is very active in this field. They have tried to alleviate this problem by linking the project to wider initiatives of the WHO, but they are less linked with other local groups.
- The Federal University of Technology, Minna. The development of a typhoid vaccine was an important response to a severe and endemic outbreak of typhoid fever. The effort to develop this vaccine may seem redundant because typhoid vaccines exist. However, different typhoid vaccines used successfully in one situation may not work in others. Going beyond vaccines to treatment required further research and innovative. However, the process has not been institutionalized, and attempts to use the typhoid-vaccine experiment to create future research platforms have been unsuccessful due to severe limitations of infrastructure, finance, and good laboratory facilities.
- NIPRID. This work to develop a sickle-cell drug has been the most successful judging by the fact that it has reached the commercial stage and is being produced on a limited scale. Sickle-cell anaemia is common among black people, and therefore there is a large market in countries such as the United States. The significance of the research is that Nigeria has succeeded in creating a drug that is licensed to a producer in the United States based on *indigenous knowledge*.
- National Veterinary Research Institute (NVRI). Of the PRIs, the most successful in terms of volume of biological vaccines and rate of inventive activities is the NVRI. The institute has made a sustained and lasting impact on combating livestock diseases not only in Nigeria but in West Africa. NVRI has consistently focused on local disease and relied to a considerable extent on the capability of its own scientists. The institute has always emphasized staff training and has a policy that every scientist should undertake foreign training every year in other laboratories to remain current.

Triggers for Innovation:

Based on these examples, the major triggers for innovation are:

- Local crises — epidemics (e.g., typhoid).
- Interaction among users and producers of knowledge for innovation and problem solving — for example, a local healer whose family signed an agreement with NIPRID on the plants that were traditionally used to treat sickle-cell anaemia.
- Research institutions looking to solve local problems such as livestock disease, malaria, and sickle-cell anaemia.

But why has success at commercializing inventions been so rare? One drawback has been that rewards for researchers — such as promotion and travel to work with overseas laboratories — come less from focusing on local problems than on publishing in foreign journals and working on problems of "universal" importance, where the universe is most often defined in terms of major world markets (e.g., cardiovascular drugs). HIV is not the exception but the rule. Not until it was evident as a pandemic in the United States did it become a major focus of drug research in the American pharmaceutical industry.

So how does one explain the different orientations in these cases? One explanation is that the behaviour and norms of the actors were shaped historically to centre on local needs. There is some evidence for this in cases where the impetus for the most significant changes came from the desire to solve local disease problems rather than to fulfil academic requirements for publication.* The work on malaria at the University of Ibadan has the support of former colleagues who have moved to international organizations such as the WHO. With this knowledge to connect them to other networks, the Ibadan team could avoid duplicating the work going on elsewhere and create synergies with others within a network that is growing in Africa. The work of NVRI scientists bears out this orientation most poignantly. The institute has a tradition of solving local animal-disease problems. This focus over the last eight decades could explain, to a great extent, its considerable success in developing vaccines.

* Professor Sofowora founded research on traditional medicine at Obafemi Awolowo University, Ile Ife. His students have continued as leaders in focusing on local problems and needs. Professors Okogun and Wambebe have inspired their students to continue work on phytomedicine and there is evidence of this in the work at the University of Ibadan and NIPRID. The knowledge of Professor Adamu (who had spent a large part of his life in NVRI) on animal vaccine was critical to the development of the typhoid vaccine. His skill and leadership were pivotal to the whole effort.

The overview by Edquist (1997, page 10) is instructive in emphasizing institutions and innovation: "…all authors working within the systems of innovation approach [have been] centrally focused on technological innovation and, in addition, all are interested in organizational and institutional change." Innovations are new creations of economic significance. They relate to the production of new knowledge, or to new combinations of existing knowledge. The crucial point is that this knowledge cannot be regarded as innovation unless it is transformed into products and processes that have social and economic use (Edquist 1997). The processes through which technical innovations emerge are complex. These processes include the emergence and diffusion of different knowledge elements, i.e., scientific and technological possibilities and the "translation" of these knowledge elements into new products and production processes. This translation does not follow a "linear" path from basic research to applied research to the development and implementation of new process and new products. Instead, it is characterized by complicated feedback mechanisms and interactive relations involving science, technology, learning, production policy and demand. Interactions and interdependence are two of the most important characteristics of the innovation systems approach (Edquist 2001).

Research is not the sole source of innovation. Innovation grows from a network of private- and public-sector actors whose interactions produce, diffuse and use knowledge that is economically useful (Lundvall 1992). The system includes both the actors (components) and the interactions that define their engagement. The components are generally taken to be institutions and organizations (Oyelaran-Oyeyinka 2004, page 2). Interaction is critical because organizations do not innovate alone. The system is dynamic and evolving and can stimulate change in complex relationships. The framework places emphasis on interactive learning between producers and their suppliers, buyers, and organizations that support them. It acknowledges the influence of routines and historical habits and the importance of the local and international policy environment that sets the parameters within which all actors can learn and innovate (Lundvall 1992; Nelson 1993; Nelson and Winter 1982).

Habits and practices influence innovative behaviour and may inhibit efforts to diffuse and use knowledge. Therefore, the approach recognizes the influence of actors and markets — networks of firms and farmers, knowledge-generating and training institutions, financial institutions, government policies, and the macro-economic climate.

The innovation system concept is useful because it provides a framework for:

- exploring patterns of partnerships;
- revealing and managing the institutional context that governs these relationships and processes;
- understanding research and innovation as a social process of learning; and
- thinking about capacity development in a systems sense (Hall 2002).

The notion of capacity development in a systems sense entails "building up the collective capacity of networks or systems of actors interactively linked with a view to innovate." This contrasts with the conventional sense in which capacity development is often understood as the "building up stocks of research infrastructure and trained scientists" (Hall and Sulaiman 2002, page 193).

Therefore, a shift from a conventional to a systems conceptualization of capacity building requires a reorientation in objectives of North–South partnerships.

Table 2: Key Features of Conventional Agricultural Research System and Agricultural Innovation System (for further details see Hall 2004).

Institutional Feature	Agricultural Research System	Agricultural Innovation System
Guiding agenda	Scientific	Developmental
Relationships involved	Narrow, hierarchical	Diverse, consultative
Partners	Scientists in other public agencies	Scientist, entrepreneurs, and development workers from the public and private sectors
Selection of partners	Predetermined by institutional roles defined by the arrangement of the research system	Coalitions of interest. Determined by the nature of task, national institutional context and skills, and resources available
Role of partners	Fixed. Predetermined by institutional roles defined by the arrangement of the research system	Flexible. Determined by the nature of task, national institutional context and skills, and resources available
Research priority setting	Fixed. By scientists	Consensual. By regional stakeholders and by needs of task network
Work plans and activities	Fixed at beginning of project	Flexible, iterative
Mandate for research/task approach adopted	Fixed by institutional norms of the research system	Negotiated through coalitions of interest
Knowledge produced	Technical/scientific	Technical/scientific and institutional
Indicators of performance	In scientific terms to other scientists	In development terms to donors. In terms of fulfilling role in task network to other partners
Responsibility for achieving impact	Other agencies dedicated to extension and technology promotion	Sorghum Millet Improvement Programme (SMIP) scientists and their partners in task networks
Capacity building	Trained scientists and research infrastructure	Collective capacity of task networks, social capital, and partnership skills

Stimulating changes in the behaviour of the system and the institutions that govern the system must become the primary objective. Institutional learning and change must be included in the partnership agenda (Mosse 2001; Hall and Sulaiman 2002).

Summary

The innovation systems concept provides a useful framework for improving the design of S&T partnerships for capacity building in Africa. Instead of focusing explicitly on strengthening the research and education sectors, or forging links between these sectors and producers, recent thinking urges the need to strengthen context-specific coalitions among diverse partners to allow them to learn and work together for innovation. In other words, the new thinking urges S&T capacity building in Africa not to focus on the parts but on the systems. A more holistic capacity-building approach

would help to bridge the gaps between the research sector, the education and training sector, and the other sectors in the national system with which actors in research and education need to interact to bring about innovation.

The next section presents some case studies of S&T partnerships in Africa to provide a better understanding of: the range and nature of actors involved in the partnerships; the extent of interactions; the flows of knowledge; what might have been learned and by whom; and the institutional and policy context of the partnership and how this may have provided opportunities and constraints for learning. To the extent possible, the contribution of the partnership to development is identified. Table 2 highlights the differences between research-based and innovation-based partnerships.

S&T Partnerships for Capacity Building in Africa: An Analysis

Case Study One: The Uganda Integrated Programme

Following Uganda's impressive reforms at the macro-economic level, a number of initiatives were developed and supported through international development assistance to address pressing development needs. One of these was the Uganda Integrated Programme (UIP) of the United Nations Industrial Development Organization (UNIDO), Vienna, Austria.

Origins and Nature of Partnership

UIP was designed as an integrated capacity-development program and executed through a cooperative agreement between UNIDO and the Ministry of Tourism, Trade and Industry on behalf of the Government of Uganda. The project emerged from a visit by the Director-General of UNIDO to Uganda in July 1998. He promised UNIDO support to develop a comprehensive strategy for the industrial sector using UNIDO's new program and integrated service packages. Uganda became one of the first testing grounds for this new integrated approach. Subsequently, phase I of UIP was implemented in Uganda in March 1999 and has since been renewed. The first phase was supported through a conglomeration of international development assistance (USD6.26 million) from the following sources: Italy (USD1.55 million); Norway (USD1.38 million); UNIDO (USD1.06 million); Japan (USD0.88 million); Austria (USD0.71 million); and Denmark (USD0.67 million).

The stated objective of UIP was to:

> *…support poverty eradication and faster economic growth through promotion of micro and small scale enterprises and improved competitiveness and sustainability of agro-related industries* (UNIDO 2002, page 6).

The program aligned itself with three key principles that shaped its strategies. First, it embraced participatory principles because its second principle, sustaining results, depended very much on how well it involved and built capacities of a number of relevant organizations. Its third principle was integration:

> *…very strong emphasis was placed on the building of synergies within and among the different components of UIP …UIP has [built] synergies with other programmes with similar objectives …including the Deregulatory Project of DFID on trade licensing, FAO and WHO in the fisheries sector, JICA on skills upgrading and entrepreneurship development through Nakawa Vocational Training Institute,*

UNDP, the District Promotion Center in the implementation of the Master Craftsman Programme at district levels, and Enterprise Uganda collaboration through investment promotion" (UNIDO 2002, page 6).

In Vienna, the project was overseen by the Agro-Industries and Sectoral Support Branch of UNIDO and directed by a team of specialists who catered to the technical requirements of the agro-subsectors and the related institutional development imperatives. The arrangements for program execution were unique and remarkably different from many other development assistance programs in Uganda. For example, the program executed its objectives through several clusters of foreign and national subject-matter specialists who worked together and learning from each other (Table 3).

The coalitions included specialists from research institutes, policy-development agencies of government, universities, private business, consulting companies, private-sector organizations, local and international development agencies, and support and service organizations. Table 3 also reveals that this program was designed to coordinate interactions between local and foreign experts and between these experts and private-sector organizations, government agencies, and funding agencies.

Contribution to Capacity Development

Many contributions were made by this program:

- creation of a coordination framework for food inspection and quality control activities;
- strengthening the regulatory framework for food inspection;
- strengthening laboratories concerned with food safety;
- enhancing the capacity of organizations in charge of food inspection and standardization, organizations dealing with investment promotion, and networks involved with information and communication technology;
- strengthening R&D and support organizations dealing with agro-processing technologies and cleaner production by building capability in postharvest and small-scale food processing technologies and introducing Hazard Analysis and Critical Control Point (HACCP) and Good Manufacturing Principles (GMPs) to the fish-processing industry; and
- introducing these same principles (HACCP and GMPs) to other food processing industries (fruits and vegetables, meat, and diary).

Arguably, this list of achievements could also be assigned to other successful development assistance programs in Uganda or many other African countries. This is not the point. The key feature that distinguishes UIP from many other capacity-development initiatives is that it succeeded in linking actors with varying levels of expertise and in building the collective capacity of these networks to develop solutions to technological constraints.

For example, after the imposition of European Union (EU) restrictions on imports of Ugandan fish, UIP swiftly assisted the government to prepare quick and effective correspondence with the EU Commission regarding guarantees put in place by Uganda. It supported the publication and dissemination of a fish-inspection manual written by local fisheries scientists within the Department of Fisheries Research (DFR). It also financed the upgrading of in-country laboratories and thus reduced the transaction costs associated with overseas laboratory analysis. The microbiology

Table 3: Cluster of Expertise under UNIDO's Uganda Integrated Programme (UNIDO, 2002, Annex).

UIP Components and Implementation	Executing Coalition
Overall Direction, UNIDO, Vienna	Project managers (technical specialists and nationals of various countries) each directing different aspects of the integrated program: food (team leader); textile; leather; micro, small and medium enterprise; investment promotion; investment promotion unit; information; quality; Uganda National Bureau of Standards; cleaner production
Coordination Unit, Uganda	Overall national coordinator (local Ugandan) and Food component coordinator and national expert (NE) in food inspection and legislation supported by 2 secretaries and 2 drivers
Food-industry Sub-Component	National experts (NE) covering fish inspection; food technology; food safety(fish); sanitary food inspection; postharvest technology; honey production and marketing; veterinary inspection; food safety (other food sub-sectors); quality systems; quality management systems; boat design and building International experts (IE) covering: fishing technology and handling; food safety assurance; good manufacturing principles and HACCP; fruits and vegetable processing; agro-machinery; honey production and marketing; postharvest and small-scale processing technologies; fish inspection management system; quality management systems; assessing US/RAF/95/171 (a specific technical standard)
Textile Sub-Component	NE in garment and new product development; basic and surface design; business management, marketing, and promotion; business plan training, production and implementation; weaving and funds mobilization; management and marketing; dyeing, surface design, and cleaner production Chief technical advisor (foreign specialist) Technical expert in machine maintenance and repair (local) Two technical assistants in product development; surface design and colour (local) IE in weaving
Leather Sub-Component	Two national experts in tannery effluent treatment Three international experts
Micro and Small-Scale (MSE) Component	NE covering engineering; entrepreneurship development; MSE development; master craftsmanship; MSE policy; accounting systems; microfinance; lease financing; MSE support systems Two international experts in economics and MSE development
Investment Promotion Unit	Head (foreign) supported by Two local officers and 2 secretaries and 1 driver
Uganda Investment Authority (institutional development)	Four NE: foreign investors survey NE: telecommunication technologies NE and IE : training consultants in customer care
Uganda Business Information Network	Two NE in information systems & networking software Four IE One secretary and one driver
Coffee Sector	Two NE: strategic plan for development and promotion of coffee Three IE: technical aspects and marketing
Uganda Cleaner Production Centre	Director and deputy (both local) Two IE
Multi-Purpose Village Workshops	Three NE in agro-economics, economics; women entrepreneurship development One IE in agricultural machinery and engineering

laboratory of the Uganda National Bureau of Standards was not only fully equipped, but an internationally acceptable quality-management system was introduced. UIP also provided support to a private laboratory owned by a locally incorporated Belgian firm, which was later approved by the EU to conduct in-country pesticide residue analysis. The "government chemist" analytical laboratory was also upgraded. Most critical, UIP identified and paid consulting firms (based in Europe) to strengthen HACCP audit systems at the government department responsible for fisheries (DFR) and to train fisheries inspectors and quality-assurance managers across all fish processing and exporting firms. The interactions between these foreign specialists and the fish-processing firms were a vital source of learning and key ingredients to the introduction of the process-related technical changes necessary to re-enter the European market (Kiggundu 2005).

Case Study Two: Partnerships to Enhance ICT Use for Innovation and Development in Africa

The number of initiatives dealing with enhancement of ICT diffusion and use in Africa is large. The International Development Research Centre (IDRC) was a pioneer and early believer in the transformative power of ICTs for development in Africa. It has been a lead supporter of ICT-related policy-development initiatives in Africa since the late 1990s, and has combined this with support for research projects on ICT access and use by under-served communities. Some of its initiatives include Acacia, ARISE (African Research for Information Society Emergence), and Research ICT Africa!, which is housed at the LINK Centre at Witwatersrand University in Johannesburg, South Africa.[1]

Conceived and led by IDRC, Acacia supports Canada's contribution to the African Information Society Initiative (AISI) — a framework for using ICTs in Africa to accelerate economic and social development. AISI was endorsed by African governments in 1996 as an action framework to build Africa's information and communication infrastructure.

> *At the time, considerable skepticism prevailed about the development potential of ICTs. Few donor and development agencies were investing in ICTs for development, and even private-sector interest was limited. Few African countries were connected to the Internet, and new policies on ICTs and liberalization of the telecommunications sector had only begun to surface in a few countries. That was the context in which the International Development Research Council launched the Acacia I program in 1997 … The first-generation Acacia program focused on four countries: Mozambique, Uganda, South Africa and Senegal … The Acacia program included social investments in pilot multi-purpose community telecenters, school networking activities and accelerated ICT policy development*

[1] Among other objectives, this initiative set out to develop a "network web site with a range of online tools and features to support research, providing access to research materials, promoting communication exchanges among the various centres in support of the research, and facilitating dissemination of research results." It also set to "improve interaction between African centres and a range of leading research centres and networks in other continents, specifically through the inclusion of LINK into the international network of universities doing research for thee *info*Dev initiated, and ITU supported World Dialogue on Regulation for Network Economies project." In addition, the objectives of Research ICT Africa! include the development of Africa's first Masters and PhD programs in this field at LINK Centre, as a foundation for similar developments at other universities (http://www.acacia.org.za/WEBTIMES/launch_of_research_ict_africa!.htm).

> *initiatives in each Acacia country, as well as considerable investments in evaluation and related research.* (IDRC, 2004).

The ICT environment in Africa has changed dramatically since Acacia was first launched:

> *Many new technologies have emerged, especially in the area of wireless communications. At the same time, telephone and Internet access in Africa has increased, largely due to private-sector intervention. All 53 African countries are now online, and there is at least one private-sector telecommunications provider in every country. Many monopolistic policy regimes have been liberalized to create more market competition, better access and lower prices. There have also been renewed efforts, both global and regional, to bridge the digital divide - notably, the New Africa Initiative, which calls for a new partnership between Africa and the international community in order to address the continent's development problems. Awareness of the relationship between ICTs and development has grown.* (Acacia II Prospectus at http://web.idrc.ca/en/ev-6559-201-1-DO_TOPIC.html)

IDRC conducted a number of studies and used the lessons that were learned to build on results achieved through Acacia I. More fundamentally, Acacia I was organized as a pilot and semi-autonomous program. Acacia II will function more as an integrated program, maintaining close links with similar IDRC initiatives, such as PAN Americas, PAN Asia, and Bellanet. All of these initiatives have adopted common research themes to enhance learning and reinforce programming. The new Acacia was designed to accommodate changes in the ICT environment in Africa and to engage more in inter-agency, public–private, and North–South partnerships.

In Acacia II, emphasis was placed on:

- *ICT policy research to support applied research that fosters pro-poor policies and promotes equitable access to ICTs and information;*
- *Technology research and development to support research into practical models for affordable and functionally relevant technical solutions, among under-served communities for meeting their basic needs in terms of health, education, employment and sustainable economic exploitation of the environment; and*
- *Knowledge generation for enhanced ICT appropriation to increase African content in ICTs by supporting research into the development of Internet tools that focus on information pertinent to the South* (Acacia II Prospectus at http://web.idrc.ca/en/ev-6559-201-1-DO_TOPIC.html)

Although policies tend to focus on physical artefacts, in-country linkages between researchers, educators, processing and manufacturing industries, farmers and their organizations, traders, and NGOs tend to be weak. This situation tends to vitiate the strength of the networks that ICTs seek to create. Consequently, knowledge and information tend to be confined to small subsystems, and their flow to the rest of the system is often problematic. Therefore, under-served communities supported by IDRC's ICT program will likely acquire and gradually master the operational skills of these technologies, but they will find it difficult to access services and additional knowledge required to transform their production practices, processes, and products. "Practical models for affordable and functionally relevant technical solutions" will

assist, but their adoption is likely to be hampered by other difficulties such as poor access to markets, financial services, and complementary knowledge inputs.

No single organization can solve these problems alone. Research organizations generate knowledge and information that communities supported by IDRC could use to make progress. Technology faculties at universities, food technology departments, veterinary faculties, and non-university institutes can all help find scientific and technical solutions to the difficulties faced by producers (farmers and firms). The link with industry is vital. Innovative change grows out of multi-organizational efforts, and it is the interactive relationship between these actors that stimulates flows of knowledge and enables ICT users to improve their production practices, processes, products, and general standard of living.

It is conceivable that IDRC may have to reconfigure its networks of partners to embrace all players in the target communities, from production to markets, from ICT research to formal agricultural and industrial research, and from educators and business-development service providers to private agents involved with the use of new technology. For this reconfiguration to take root, deliberate efforts must be made to support the emergence of amenable "institutions." Nevertheless, it is unreasonable to be deterministic about the scale and scope of the partnerships and institutional changes that will be necessary to enhance the building of local capacities in a systems sense. A quick review of the IDRC website indicates that a number of useful features for systems capacity building have already been embraced by some of its newer ICT-related initiatives.

The evaluation (and monitoring) studies planned under Acacia II and Research ICT Africa provide a good opportunity to explore the arrangements and activities that lead to, or contribute to, innovation. These studies may identify the institutional settings and partnership arrangements that are necessary to use ICTs and ICT research more effectively for poverty reduction and innovative change. The effectiveness of ICT-led approaches to innovation and development in local settings in which complementary policies and services (local systems in general) are so fragmented will have to be examined in details. Under what circumstances can ICT-led partnerships contribute to the more effective use of science, technology, and other forms of knowledge for innovation and development? There is little understanding of these circumstances and few empirical examples of what has succeeded or been less successful and why. IDRC can help fill this void by using an innovation systems framework to conduct its planned evaluation and monitoring studies of the ICT program in Africa. It may be useful to partner with other ICT programs on the continent in this effort.

Case Study Three: Partnerships in S&T Policy Research and Development

Some of the best-known examples of partnerships concerning S&T policy research in Africa are the African Technology Policy Studies (ATPS) and the African Economic Research Consortium (AERC), which are both based in Nairobi, Kenya. Each has succeeded in creating a strong research network — one to support economic policy processes and the other science and technology policy. Another IDRC activity that has had considerable success in promoting local design and a focus on local needs is Research on Knowledge Systems (RoKs). This case study focuses on AERC and ATPS.

The Africa Economic Research Consortium (AERC)

The following quote from the AERC website (www.aercafrica.org/about/network.asp) explains its mission:

> *…[Established in 1988], the objective of AERC is to strengthen local capacity for conducting independent, rigorous inquiry into problems pertinent to the management of economies in sub-Saharan Africa …Hence, the mandate is threefold: enhancing the capacity of locally based researchers to conduct policy-relevant economic inquiry; promoting retention of such capacity; and encouraging its application in the policy context …the linking of individuals and institutions in a knowledge sharing, experience sharing framework — is the key strategic instrument for implementing AERC's activities. The consortium is itself a network of 12 funders who support a commonly agreed programme of research activities, its dissemination and the training of future potential researchers. The research programme networks individual researchers in the region — supported by eminent resource persons — to carry out research on selected themes. This alleviates professional isolation, encourages exchange of experiences and creates peer pressure for enhancing quality. The emphasis of the programme is on the quality and policy relevance of the research. Quality is achieved through a dynamic support system that features peer review and technical and literature backup …A comprehensive communications and outreach strategy encourages the application of AERC products to economic policy making …Through its website the consortium is linked to other resource centres worldwide, while resource persons from around the world enrich the technical base and the variety of research experiences. Methodology workshops sharpen research skills and expose the network to relevant developments.*

The list of universities, research institutes, individuals, and organizations that constitute the AERC network is indicative of how vast and important this network is as a resource for economic policy development and analysis on the continent. The research program is a collaborative effort of 15 economic research organizations from 12 African countries. The training program manages a Collaborative Master's Programme (CMAP) (for Anglophone Africa except Nigeria and South Africa) in Economics in partnership with 21 universities in 17 sub-Saharan Africa countries.

The linking of African and international scholars through research-methodology workshops and the process of peer review has promoted the exchange of formal and informal knowledge and contributed to learning and knowledge acquisition. One factor that may explain the success achieved by AERC in publishing policy-relevant, internationally published research is its ability to create and manage such linkages. A closer look at the way AERC manages its programs and network indicates that this ability must partly derive from the very strong standards of governance AERC has set for itself. In a general sense, strong governance systems permit organizations to stay on track, ensure the relevance of its activities, form relationships of trust with funders and partners, and permit transparent accountability of results and finances. In the case of AERC, a strong system of governance must have contributed to its ability to successfully persuade donors and other partners to support AERC's budget by contributing to a basket of funds instead of "cherry picking" the best research. AERC is therefore able to create connectivity in its program by retaining the freedom to allocate pooled funds in the best way possible:

> *Since AERC's inception, its donors have pooled their funding for the Research and Training programmes. In approving the Consortium's annual work programme, the Board of Directors endorses the proposed allocation of funds to the set of activities proposed by the Executive Director as a whole, not to particular themes, proposals or grantees.* (http://www.aercafrica.org/about/governance.asp)

Curiously, there is no formal connection between AERC and ATPS. For example, the current focus on "enhancing the capacity of locally based researchers to conduct policy-relevant economic inquiry" by the AERC might be jointly carried out by the two networks in specific subjects. This could produce several benefits including building the capacity of economists and non-economists to produce knowledge and analysis that could be applied by policymakers.

The African Technology Policy Studies (ATPS) Network

The ATPS has its roots in a meeting in Monrovia, Liberia, in 1982 and the subsequent launching of the East African and West African Technology Policy Studies Networks (EATPS and WATPS, respectively). These networks were merged into a regional network 10 years ago for greater impact and better coordination. The work of ATPS is focused on innovation for development. Its approach and work program is also more interdisciplinary, and the Network is engaged in a number of collaborative arrangements such as the S&T program of the New Partnership for Africa's Development (NEPAD). Although other donors have participated in funding its programs, IDRC has been critical to the founding and sustenance of the network.

According to the network website (www.atpsnet.org):

> *ATPS is a multi-disciplinary network of researchers, policy makers and other end-users interested in the generation, promotion and strengthening of innovative technology/industrial policies in Africa. With a regional secretariat in Nairobi, it operates through national chapters in 17 countries to, among others:*
>
> - *Enhance capacity for technology policy formulation, implementation and research. Its conception of capacity includes both human and institutional capacity;*
> - *foster networking and collaborative research between researchers and policy experts and to facilitate inter-disciplinary, cross-sectoral and cross-national efforts for comparative and complementary research and exchange of information, experience and skills.*

Given the way it operates, some of the challenges faced by AERC may not apply to ATPS. However, ATPS will also have to strengthen its collaborative research agenda by engaging in innovation-focused research partnerships whose research priorities have been influenced by a more diverse set of actors — industry associations, enterprise-support organizations, and relevant professional organizations. For example, some program committees could benefit from industrial chairs. Notably, the list of partners — at least the one accessible off the ATPS website — does not include AERC as a partner or collaborator.[2] ATPS is also not mentioned as a collaborator in the research program of AERC although this does not necessarily mean that the two organizations do not collaborate. However, the promotion of innovation-focused research partnerships among various organizations and actors on and outside the African continent would help both organizations to have a positive influence on each other's

[2] The list of partners includes Common Market for Eastern and Southern Africa (COMESA), African Centre for Technology Studies (ACTS), United Nations Economic Commission for Africa (UNECA), Africa Development Bank (ADB), and African Institute for Economic Development and Planning (IDEP) and the list of collaborators includes UNU-INTECH in the Netherlands, scholars at Cambridge University, Aalborg University in Denmark, and Stanford University in USA.

research priorities. Moreover, research has shown there is often a disconnect between economic policies and S&T policies in a number of African countries. This suggests that both AERC and ATPS should work more closely to blur this demarcation.

ATPS has achieved significant success on several fronts:

- Raising awareness among policymakers and policy analysts of the role of S&T in development;
- Building up a community of researchers and core capabilities in S&T analysis across African countries;
- Bridging the gap between public officials trained in traditional economic analyses and scholars in the social sciences, natural sciences, and engineering in a number of African countries;
- Building up an important body of research outputs through funded projects defined and undertaken by African scholars themselves; and
- Disseminating these outputs through yearly regional conferences and the publication of national policy briefs and a series of research and discussion papers.

Case Study Four: Capacity Development for Health System

The Tanzanian Essential Health Interventions Project (TEHIP) started in 1996 as a four-year research and development project. TEHIP was designed to test the feasibility and measure the impact of an evidence-based approach to health planning at the district level. It was a partnership between the IDRC and the Tanzania Ministry of Health. From its inception, through to the development and implementation of the tools, TEHIP was designed to influence health policies at the local and national levels (Neilson and Smutylo 2004).

The idea was to support two pilot districts in Tanzania (Morogoro and Rufiji) to generate locally researched information on the burden of disease, cost-effectiveness, health-system capacity, and community preferences and to turn this evidence into effective and innovative tools for health planning, priority setting, and resource allocation. TEHIP developed and implemented several tools for district-level health planning including: a method for calculating and presenting both Burden of Disease data (the BoD tool) and district health accounting to help policymakers better understand the effects of the burden of disease in their respective districts, allocate resources based on the burden of disease, and manage and track those allocations. Another tool, the Cascade System, evolved after the project was started to organize and integrate health-service delivery at the district level more efficiently and economically (Neilson and Smutylo 2004, page 2). On cost-effectiveness, the tools included the District Cost Information Tool, District Health Expenditure Mapping Tool, and a District Intervention Coverage Tool. For health-system capacity, a number of innovations and new tools and strategies have evolved including the District Integrated Management Tool, District Health Mapping Tool, the Community Ownership Management Strategy, and Strengthening Health Management and Administration. Together, these tools and strategies can be seen as major interventions into the capacities of the TEHIP-supported districts and must be understood in that sense when making comparisons with conventional approaches to planning and resource allocation.

In the two districts where TEHIP helped to improve local health-care planning, the mortality of children under the age of five dropped by 43% in Morogoro District

between 1997 and 2003 and by 46% in Rufiji District between 2000 and 2003. This has been attributed to significant improvements in local health care.

In terms of its contribution to capacity for policy development, Neilson and Smutylo (2004) concluded that:

- *TEHIP influenced health policies by expanding policy capacities, broadening policy horizons, and affecting policy regimes.*
- *It influenced the thinking and actions affecting how research data and other kinds of evidence can be used to make decisions about health policies, programs, and priorities. This influence occurred both in terms of: the processes of policy formulation, implementation, and reform; and the content of the policies, programs, and reforms.*
- *Some of the factors explaining TEHIP's ability to influence policy were: political commitment from senior-level officials at both the national and district levels; the collaborative efforts between IDRC and the Government of Tanzania; additional resources TEHIP provided to the districts; TEHIP's design with the intent to work within the existing health planning and management systems rather than creating a parallel system; and the commitment, dedication, and expertise supplied by the TEHIP personnel. Factors inhibiting TEHIP's influence included: the "experimental" nature of TEHIP; the existing capacity in the remaining 112 districts to implement the tools on a national scale; limited dissemination of the tools and the results; and strained relations between TEHIP and the AMMP [Adult Morbidity and Mortality Project supported by the UK Department for International Development and the University of Newcastle on Tyne].*

Overall, Neilson and Smutylo observe that despite the significant contributions made by TEHIP to both the processes and changes to policies, programs, and priorities, considerable challenges to sustaining this influence remain. There is the unresolved question of "successful projects: then what"? They also suggest that a key question is how to expand externally funded, district-level support projects to a national scale.

The TEHIP case provides a very good example of how a "project" can succeed but fail in its attempt to successfully influence deep-going systemic policy change. Although TEHIP implemented some of its capacity-building activities in a systems sense (research activities were conducted by inter-organizational, inter-disciplinary networks for example), no mechanism was put in place to build the capacity of the system, particularly the relevant policy-development agencies needed to replicate activities beyond TEHIP's short life. Under these circumstances, it might have been useful to sustain a parallel effort aimed at building the capacity of the local system to take over beyond the pilot project. Admittedly, this step would require a longer planning horizon and much more complex processes of interaction.

Case Study Five: Partnership at the Regional Level

The S&T program of NEPAD (New Partnership for Africa's Development) is another key regional initiative supported by IDRC. A systematic evaluation of the impact of NEPAD is premature given its relatively short life. However, it deserves close attention due to its potential far-reaching impact on policy thinking. The S&T ministerial council governing NEPAD recently approved the use of the systems of innovation framework. Subsequently, the first NEPAD Ministerial Conference on Science and Technology called on the NEPAD Secretariat to initiate activities that would generate an African

Table 4: Framework for Science and Technology in NEPAD (NEPAD 2003).

Science and technology and research and development are most effectively developed in the national and regional setting, through the overarching approach of a "system of innovation." A system of innovation can be defined as a network of institutions in the public and private sectors whose activities and actions initiate, import, modify, and diffuse new technologies, based on research and development, to achieve enhanced economic growth and quality of life. The Ministerial Conference endorses the use of a system of innovation approach, a common set of indicators, and an annual African innovation network. To give effect to these, the Conference recommends that the system of innovation approach be introduced by actions of the NEPAD Secretariat by:

- Holding NEPAD sub-regional workshops to elaborate the use of the system of innovation processes;
- Developing country processes involving senior national teams, assisted by consortia of experts experienced in the approach;
- Securing the budget requirements funded by national budgets and supplemented with ODA to be mediated through the NEPAD secretariat (or another designated agency); based on country policy processes at USD500,000 per country and USD500,000 for NEPAD integrative work; and
- Involving the African Development Bank, UNESCO, and UNECA, Regional Centres of Excellence (RECs) in formally receiving the outcomes of such national NSI studies to facilitate mainstreaming of S&T in national programs, using appropriate financing.

Annual African Innovation Outlook

We propose as a key output an annual report on the developments in science, technology, and innovation in Africa at the national, sub-regional, and regional level produced by the NEPAD S&T implementation secretariat under the mandate of the Steering Committee and transmitted to the Ministers Council when they meet, for their consideration.

Centres of Excellence

Recognizing the need and urgency to establish efficient and effective R&D institutions and networks for Africa's sustainable development, and taking note of the commitment by African leaders to establish networks of centres of excellence in areas such as biosciences, geosciences, environmental sciences, and ICTs, this Ministerial conference endorses the established initiatives to create NEPAD centres of excellence, including, but not limited to, the Africa Bioscience Initiative, The Square-Kilometre Array Radio Telescope, The African Institute of Space Science, the African Laser Centre, and the African Virtual University.

International S&T Cooperation

Recognizing the importance of international cooperation in science and technology we are committed to improving the quality of bilateral and multilateral S&T cooperation. We call on the NEPAD Secretariat to:

- Gather relevant information and facilitate sharing of experiences on implementation and management of bilateral and multilateral agreements;
- Develop a program of activities to build and strengthen the capacity of African nations to negotiate, implement and monitor international agreements;
- Establish good-practice guidelines and undertake to transmit these through the mechanisms described above; and
- Identify and institute ways and means to facilitate increased mobility of scientists and engineers within Africa to ensure more effective research and development outcomes, knowledge sharing and networking.

Capacity Building

Given the critical importance of capacity building in S&T and its linkage to short, medium, and long-term outcomes, we propose that an integrated approach be adopted and that the NEPAD S&T implementing secretariat undertake the following actions:

- use all available means to promote the adoption by countries of training programs on the interaction of science and technology with public policy. Emphasis should be placed on how national and international policies influence the evolution of technology; how rapid development and growth of technology is shaping public policies; institutional forms to respond to technological opportunities and challenges; and how developments in technology can be influenced or shaped to contribute to Africa's economic recovery and growth.

Innovation Outlook (AIO), that is, a comprehensive profile or survey of the innovation landscape. It further agreed to promote the application of a national system of innovation (NSI) framework and methodology to guide and inform policy-making (Oyelaran-Oyeyinka et al. 2004, page 8). As a result, NEPAD requested UNU-INTECH to prepare a document for conducting innovation surveys.

Recently, UNU-INTECH completed a study that designed the innovation survey for NEPAD. The study explains the innovation system approach, reviews the associated concepts, details a number of design features for the survey, and suggests a number of capacity-development activities. The study also emphasizes that the survey should be policy-relevant and focus on the core elements in an innovation process: linkages; learning; and investment. This process is expected to serve as a catalyst for other initiatives aimed at assisting African countries and their partners to build networks and local systems for S&T capacity development. Table 4 explains, in part, the focus of NEPAD.

Case Study Six: S&T Partnerships for Capacity Building of Agriculture

This case is based on a collection of findings and conclusions generated by several reviewers of agricultural science and technology (S&T) partnerships for capacity building in Africa. In contrast to the Uganda Integrated Programme (UIP) approach of building local coalitions and networks of learning and knowledge flows, these reviews of agricultural S&T capacity building show an entirely different experience. The focus has been on producing good science and technology and organizing its transfer to the users (farmers). Research organizations are perceived as the innovators, and technologies are understood to involve radical changes. This view does not take into account cases in which technologies are incrementally upgraded and adapted by users. If this view is correct, then the process-related technical improvements introduced by Uganda's fish-processing firms did not depend on the learning networks and coalitions that UIP supported. On the contrary, the innovations came from the transfer of technology from the research sector (Kiggundu 2005).

The following summary presents a broad overview of the experiences emerging from analyses of agricultural S&T partnerships in Africa.

> *… when whiteflies and the viruses they carry threatened the profitability of vegetable growers in the Southern United States, a massive research and control effort was mounted. When tropical whiteflies threatened glass-house-grown vegetables in Europe, consumers clamored for alternatives to pesticides. And when the same pests wiped out bean-growers in Central America and threatened cassava farmers in Africa with famine, the world tried to look the other way. But now a more complete response is organized.* (Lukas Brader, IITA Director General, CGIAR 2000, page 18)

Local, regional, and international agricultural research organizations often play an important role in generating agricultural S&T. In particular, collaborative efforts between the 16 international agricultural research centres of the Consultative Group on International Agricultural Research (CGIAR) and the National Agricultural Research Systems (NARS) in the various African countries have been pivotal to the development of agricultural science and technologies in Africa. The research centres of the CGIAR and their national partners represent an important international scientific resource (Watts et al. 2003, page 5).

> *… thanks to the Integrated Pest Management program (IPM) and collaboration among [CGIAR] centers like CIAT, ICIPE, AVRDC, CIP and IITA and many other partners, research on a new strain of cassava mosaic disease in Africa brought substantial benefits to farmers in … [they] are now growing healthy cassava crops that give them at least a 50 per cent increase in yield without extra cost and inputs, an increase worth about USD1 billion a year …CIMMYT, ICIPE, ICRISAT, and IITA are collaborating on the stemborer taskforce …Several centers and partner institutes have also developed a strategy for integrated management of soil-borne pathogens of food crops. New options for controlling parasitic flowering plants have evolved through well focused research. Because of the success of these and other initiatives, CGIAR is now the recognized leader of research on Integrated Pest Management (IPM) and plant health matters in the tropics that are critical to the rural poor.* (Lukas Brader, IITA Director General, CGIAR 2000, page 19)

However, Chema et al. (2003, page ix) argued that:

> *The potential of agricultural science and technology (S&T) to bring greater prosperity has, to date, not materialized for the large majority of the African farmers and consumers. This is not because of a lack of effort to exploit the potential of agricultural S&T (investments in agricultural research have, on average, been relatively higher in sub-Saharan Africa than in Asia), but because the institutional setting within which agricultural innovation has to take place is so much weaker in sub-Saharan Africa than in Asia or Latin America. Lack of markets, poor infrastructure, and political instability are just some of the factors that are placing significant constraints on the impact of agricultural S&T in sub-Saharan Africa. Moreover, the agricultural innovation system itself seems to function rather poorly.*

This view is shared by many other analysts. For example, Watts et al. (2003, page 5) observe that:

> *…there is a current perception among donors and other stakeholders that insufficient progress is being made, and that consequently the CGIAR centers and their partners, are not contributing as effectively as they could to the achievement of development goals. As a result of this crisis of confidence, funding has declined and calls to restructure and reorient the work of CGIAR centers and national research organizations have intensified; in some circles the very notion that agricultural science is a useful tool for improving the livelihoods of the world's poor has been questioned.*

There is growing consensus among reviewers of agricultural research systems (and their reforms) that these systems were premised on an underlying conceptual framework that is unable to deal with the more complex development challenges that have emerged in the past 20–25 years. For example, Watts et al. (2003, page 5) note that:

> *When the CGIAR system was formed in the early 1970s, its main goal was relatively simple: to assure food supplies in the developing world using agricultural science to increase the productivity of major food crops. The institutional model involved the creation of international centers of excellence to develop technologies to be transferred to national programs and onwards to farmers. Implicit in this design was the assumption that scientists could both identify research priorities and act as the central source of innovation …[The*

> *authors observe that the research agenda of the Centers has been broadened to accommodate environmental sustainability, and a more explicit focus on poverty reduction] … but the Centers are struggling to address this expanded agenda with an institutional design intended for a narrower and simpler task.*

Similarly, the International Centre for Development Oriented Research in Agriculture (ICRA 2004) states:

> *While new technologies will be needed, the overriding demand is for a change of approach, which requires new policies, new institutions and new ways of working…organizations and professionals engaged in rural development need highly specialized skills. But because they are being asked to tackle broader issues, they can no longer work in isolation. They need to interact with each other and with stakeholder groups such as farmers, extensionists, policy makers, private businesses, traders, non-government organizations and donors …*

For Chema et al. (2003, page 51):

> *The new NARS reforms will probably improve the efficiency and relevance of agricultural research (particularly for market-oriented farmers), but they will not solve the problem of how to reach the millions of African subsistence farmers, unlock their potential, integrate them into the market, and set them on a path of self-perpetuating innovation. Agricultural research cannot solve this problem on its own: it will require a concerted effort by many different agencies …*

These studies have a number of things in common. They show that agricultural S&T has not succeeded in increasing agricultural productivity in Africa to its full potential. They assert that one of the problems is a reliance on an underlying model of organizing agricultural S&T that ignores a large part of the sources of innovation and production. Producing good science is simply not enough. The science and technologies generated by agricultural R&D institutes must be translated into economically useful applications. For this to happen, agricultural research organizations must collaborate with other organizations to make better contributions to the process of innovation. This process requires huge investments in institutional change: methods of work must change, new partners and relationships must be developed and sustained, and flows of knowledge must occur and be sustained. To be more effective, these analysts suggest that instead of placing emphasis on strengthening agricultural research systems, *the focus should be on strengthening agricultural innovation systems.*

Conclusion

S&T partnerships in Africa have produced either researched technologies whose adoption is low, or highly educated and trained scientists able to execute specialized tasks within their respective disciplines but unable to increase adoption rates or accelerate development by creating productive relationships with other agents of change (e.g., traders, farmers, industrialists, development practitioners in the NGO sector, or even scientists from other disciplines). The technologies are either not relevant to potential users, the majority of whom are trapped in subsistence or informal routines of production and basic survival, or the core skills that are being imparted are too removed from the problems faced by existing systems. Generally, the picture of S&T capacity building in Africa is one of a weak but growing supply of technologies and human resources and, strikingly, a low demand for, and therefore limited or even unproductive deployment of, these resources. By and large,

partnerships for S&T capacity building have made only a modest contribution to the development challenge in Africa. They have largely not succeeded in resolving old and new problems such as low agricultural productivity, weak technological capabilities in manufacturing and processing, poverty, food security, and environmental degradation.

Insights from the Review

Partnerships are key but are often narrowly conceptualized

Partnerships for development in the South are commonly perceived as North–South or South–South research collaboration, or private–public partnerships. The language used by scientists, educators, and government representatives from nine African nations and several industrial countries at the 1998 International Conference on the Development of Science and Technology in Africa (University of Natal, Durban South Africa, 27–31 July 1998) was Science and Technology Research and Development Partnerships in Africa. Some partnerships are not even focused on innovation for development, and when they are, research institutes and universities are erroneously regarded as the sole source of innovation. Insufficient attention is paid to in-country partnerships and the need for these partners to partner with other actors outside the country. The innovation-systems framework provides a way of thinking about partnerships and innovation in a holistic way — where research centres and education institutes are only part of much broader dynamic system and where research institutes and universities, farmers, firms, NGO, industry associations, and policy bodies all need to exchange ideas, information, and knowledge to generate and apply socially and economic useful knowledge.

Getting the institutional context right for partnerships is much more demanding than is generally assumed

For partnerships to succeed, the skills, habits, and practices that allow individuals and organizations to interact with each other are critical. They need soft skills in team building, competing while cooperating, debating and resolving competing priorities, and mobilizing resources. Skills are required to build relationships based on trust and in which partners all have a sense of working toward a common goal. Barriers to partnerships must be lowered by building of “social capital.” In some cases, work ethics [including accountability] will have to be rebuilt, especially when these have been interrupted by the opportunistic behaviour that often accompanies economic and political mismanagement. Building a culture of innovation among all actors in the system is a long, multi-faceted, and context-specific process.

Coordination matters

Partnerships that are designed to strengthen learning networks and coalitions tend to make better contributions to development. Partnerships that recognize the need to enhance the exchange of formal and informal knowledge by partnering African and foreign specialists are more effective in generating technical and non-technical solutions. These partnerships will not emerge automatically and must be stimulated and supported. Coordination is the key.

Strong governance is important

In the contemporary partnership approach, diversification of funding mechanisms is essential. Local and regional partners, international development agencies, and government and private funders will only be attracted to networks and organizations

whose governance structures are clear and solid enough to ensure built-in monitoring of results and financial accountability. The strengthening of governance systems will allow organizations to redirect funders from "cherry picking" of specific projects to providing "basket funds," which encourage stronger intra-linkages in programming.

Capacity development is about building local systems for producing and using knowledge not just building stocks of infrastructure, trained scientists, or trained users

One of the most pressing needs in Africa is to build local systems that enhance the capacity to innovate: local systems to generate and apply knowledge and information are necessary to build absorptive capacity, accelerate poverty reduction, manage natural resources better, boost productivity, compete in local and export markets, and improve well-being. The strengthening of key organizations (public and private) is vital.

Stimulating demand is as important as generating the science and technology

Making the supply of agricultural research more demand driven may yield only very modest dividends if, at the same time, we do not try to stimulate and organize the demand for agricultural research from the farmers themselves.

S&T partnerships for capacity building in Africa need to move away from a narrowly defined agenda of strengthening research infrastructure, enhancing access to technologies, and developing core skills toward the building of local systems — technical and institutional — for producing and using knowledge.

S&T capacity initiatives in Africa need to recognize and accept that building effective S&T partnerships has as much to do with strengthening the ability of individuals and society to learn how to change as it does with creating science and technology, core skills, and physical facilities. Individuals and society must learn to change their historically determined routines, build coalitions, compete and cooperate at the same time, debate priorities, respect each others views and rights, resolve conflicting ideas, mobilize and account for resources transparently, and work in participatory ways within interdisciplinary and multi-organizational teams toward a common goal — innovation and development in a continually changing setting. In addition to the set of hard-core skills held by scientists and bureaucrats and other professionals, these actors must be supported to acquire (and continuously improve) soft skills critical to their ability to create and sustain innovation coalitions.

Markets and social conventions in the North already place strong enough pressures on private enterprise to invest in innovation activities. To survive in such markets, enterprises must respond to these sophisticated demands. As societies in the industrialized world have evolved and advanced their production practices, education systems, and other social policy areas, so have their social capital soft skills (e.g., human abilities to form and sustain productive coalitions, debate priorities, respect each others views and rights, and resolve conflicting ideas). Reinforced by the social and economic policies and the competitive environment prevalent in these economies, the social capital that has accumulated in these industrialized societies seems to have contributed to a *positive culture of innovation*. In contrast, S&T partnerships in the South tend to be executed in an environment in which this culture of innovation is less suitable. The habits and practices within which an enterprise operates is a key factor that conditions the behavior of collaborators in innovation coalitions. It is therefore plausible that the habits and practices of farmers (such as subsistence agricultural activities) and firms (informal activities for survival) and of organizations

and society in general impede the emergence of a culture of innovation and therefore the effectiveness of S&T coalitions in Africa. Investments to build this culture must be included in the expanded agenda of S&T partnerships for capacity building in Africa. Table 5, a summary of a recent conference and a collection of journal papers, provides further thoughts on partnerships.

Table 5: New Agenda for North–South Research Collaboration? (Hall 2004).

The overall impression (from the case studies) is that a significant shift does need to take place in the way North–South research collaboration is conceived. Already, the beginnings of this shift can be detected. This is not to suggest that many of the existing forms of collaboration — fellowship programs, scientific networks, and disciplinary research — will not continue to play a role. These will undoubtedly remain important. The change that is detected, however, is an increasing emphasis on the building of networks and systems of partners and institutions that can respond to the contemporary demands of sustainable development. This new focus is consistent with emerging trends in development assistance, in general, where the importance of relationships is one aspect of the agenda for collaboration that is less concerned with creating deliverable products, and more concerned with introducing behavioural change.

There is still, however, a long way to go. This is particularly so for development-assistance agencies responsible for science and technology. Professional norms seem to perpetuate the myth of the linear transfer of technology as a model of innovation. The innovation-system framework at least offers a tangible alternative to deal with many of the problems that those working in the sector know only too well. Examples include: shelves of unwanted technologies and unread policy briefs; partnerships that are both inequitable and unaccountable; unresolved contentions between science and society such as those seen in the polarized debates associated with biotechnology or the environment; and questionable impacts on developmental goals. It is acknowledged that the innovation-system framework presents some significant challenges for both scientists and bureaucrats, but these simply have to be faced.

There are important implications for three aspects of development assistance that support North–South research collaboration. First, capacity development needs to be thought of in evolutionary systems terms where the emphasis is on creating socially embedded systems of learning and innovation. In practical terms, this means supporting the development of networks of partners from across the research and research-user divide and developing institutional mechanisms that ensure priorities and procedures are socially relevant. Ways of achieving this will always be country-specific and experimental, but the innovation-system framework does highlight what some of the fundamental properties of these systems should be. For example, attention will specifically need to be given to the nature of partnership and the influence of institutional arrangements, particularly if pro-poor development is to be promoted. Another example is the need to build in processes of institutional learning and change. Although this mainly concerns the roles of Southern partners and relationships in Southern innovation arenas, further thought will also have to be given to the most appropriate role of Northern research partners in developing these new systems competencies.

The second implication is that development-assistance agencies will also have to change the way they are organized to accommodate this new thinking. For example, the sharp distinction that usually exists between programs responsible for research and those responsible for capacity development will have to be blurred. Similarly, the distinction between research and general development assistance becomes less relevant as learning and capacity development assume an integral role in innovation and change. This also has implications for how development-assistance bureaucracies deal with accountability and monitoring and evaluation (M&E). This systems perspective on North–South collaboration suggests that it is behavioural and institutional changes that are going to be the key measures of achievement. M&E systems are often poorly adapted to deal with the qualitative nature of such indicators. Also, the preoccupation of many agencies with measuring the impact of programs as a way of justifying past decisions, needs to be expanded to a more learning-orientated focus that helps address deficiencies and design better approaches (Horton and Mackay 1999).

The third implication is that even formal capacity development (in the training sense) will need to go beyond its current focus on predominantly disciplinary expertise. Although such expertise is clearly still important, what Southern innovation systems also require are broad-based professionals who can apply their disciplinary expertise in ways that recognise the systems nature of innovation and change and its relationship to the needs of society. Clark (2002), for example, argues that there is a desperate shortage of such human capital, particularly in the policy arena.

Some Policy Challenges

"From a policy perspective, the strength of an innovation system approach lies in the attention it draws to policy dynamics and the way these emerge from the interaction between policies and the habits and practices of the actors whose behaviour is targeted by policy. The impact of policies will thus vary across different institutional contexts." (UNU-INTECH 2004, page 9). Besides, the right kinds of policy are, all too often, not present or fail to connect in a way that stimulates a process of innovation.

Question: *How and what role can policy research networks and their partners play in ensuring policy coherence and relevance?*

We know that the creation of effective partnerships involves a wide array of linkages. Of critical importance is a better understanding of the factors that must be addressed to get the "institutional" setting right for more effective partnerships. These partnerships must not only be sensitive to the needs of the poor but also to "institutions" that often impose gender-based constraints that effectively restrict both participation and access to the benefit of activities in the broad innovation and development arena.

Questions: *What factors are likely to stimulate or constrain institutional development — including social capital development? What are the implications of adding an institutional development agenda to existing agendas of partnerships for S&T capacity building in Africa?*

If capacity development is about building local systems for producing and using knowledge, and not only about building stocks of infrastructure, trained scientists, or trained users, there is an empirical question of how to reform the nature and structure of partnerships (for S&T capacity building in Africa) to effectively contribute to the development of innovation systems.

Question: *How and under what circumstances can this result be achieved?*

References

Chema, S., Gilbert, E., and Roseboom, J. 2003. A Review of Key Issues and Recent Experiences in Reforming Agricultural Research. ISNAR Research Report 24. International Service for National Agricultural Research, The Hague, The Netherlands. (www.isnar.cgiar.org/publications/catalog/rr.htm)

CGIAR, 2000. Synergies in Science. Intercenter Collaboration to Eradicate Hunger and Poverty. Consultative Group on International Agricultural Research (CGIAR), Washington, DC, USA. (http://www.cgiar.org/publications/pub_secretariat.html)

Clark, N.G. 2002. Innovation systems, technology assessment and the new knowledge market: implication for the third World Development. Journal of the Economics of Innovation and New Technology, 11(4-5), 353–368.

Edquist, C. (ed.). 1997. Systems of Innovation, Technologies, Institutions and Organizations. Pinter Publishers, London, UK.

Edquist, C. 2001. The Systems of Innovation Approach and Innovation Policy: An Account of the State of the Art. Lead paper presented at the DRUID Conference, Aalborg, 12–15 June 2001. (unpublished).

Freeman, C. 1987. Technology Policy and Economic Performance: Lessons from Japan. Pinter Publishers, London, UK.

Hagedoorn, J., Carayannis, E., and Alexander, J. 2001. Strange Bedfellows in the Personal Computer Industry: Technology Alliances Between IBM and Apple. Research Policy, 30, 837–849.

Hall, A.J., Sivamohan, M.V.K., Clark, N.G., Taylor, S., and Bockett, G. 2001. Why Research Partnerships Really Matter: Innovation Theory, Institutional Arrangements and Implications for Developing New Technology for the Poor. World Development, 29(5), 783–797.

Hall, A. and Sulaiman, R.V. 2002. Application of the Innovation Systems Framework in North–South Research. The International Journal of Technology Management and Sustainable Development, 1(3), 182–195.

Hall A. 2002. Innovation Systems and Capacity Development: An Agenda for North–South Research Collaboration? The International Journal of Technology Management and Sustainable Development, 1(3), 146–152.

Hall, A., Mytelka, L. and Oyelaran-Oyeyinka, B. 2004. Agricultural Innovation Systems: Concepts and a Methodology for Diagnostic Assessments. United Nations University – Institute for New Technologies (UNU-INTECH), Maastricht, The Netherlands (unpublished).

Horton, D., Mackay, R., Andersen, A., and Dupleich, L. 2000. Evaluating Capacity Development in Planning, Monitoring, and Evaluation: A Case from Agricultural Research. International Service for National Agricultural Research, The Hague, The Netherlands, Research Report No. 17.

ICRA. 2004. New Demands Call for New Thinking. Flyer 1, July 2004. International Centre for Development Oriented Research in Agriculture, Wageningen, The Netherlands.

IDRC. 2004. Acacia II Prospectus, International Development Research Centre, Ottawa, Canada. (http://web.idrc.ca/en/ev-6559-201-1-DO_TOPIC.html)

Kiggundu, R. 2005. Technological Upgrading in Developing Country Firms: The Fish Processing and Export Industry in Uganda. PhD Dissertation, United Nations University – Institute for New Technologies (UNU-INTECH), Maastricht, The Netherlands (forthcoming).

Lundvall, B.A. 1988. Innovation as an Interactive Process: From User-Producer Interaction to the National System of Innovation. In: Giovanni Dosi, Christopher Freeman, Richard R. Nelson, Gerald Silverberg, and Luc Soete (eds.), Technical Change and Economic Theory. Pinter Publishers, London, UK.

Lundvall, B.A. (ed.) 1992. National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. Pinter Publishers, London, UK.

Metcalfe, S. 1995. The Economic Foundations of Technology Policy: Equilibrium and Evolutionary Perspectives. In: Stoneman. P. (ed.), Handbook of the Economics of Innovation and Technological Change. Blackwell, Oxford, UK.

Narvaez Berthelemot, N., Russel, J.M., Velho, L., 1999. The Scientific Collaboration of the Mercosur Countries as an Indicator of Latin American Regional Activity. Research Evaluation, 8(2), 83–90.

Neilson, S. and Smutylo, T. 2004. The TEHIP Spark: Planning and Managing Heath Resources at the District Level. A Report on TEHIP — Its Influence on Public Policy. Final Report. Evaluation Unit, International Development Research Centre (IDRC), Ottawa, Canada.

Nelson, R. and Winter, S. 1982. An Evolutionary Theory of Economic Change. Harvard University Press, Cambridge, USA.

Nelson, R. (ed.) 1993. National Innovation Systems: A Comparative Analysis. Oxford University Press, Oxford, UK.

NEPAD. 2003. S&T Ministerial Conference, Draft Outline of an Action Plan. Johannesburg, South Africa, 6–7 November 2003.

Okamura, K., Vonortas, N.S. 2004. Choosing a Partner. The George Washington University, Washington D.C. (also available at The Center for International Science and Technology Policy: http://www2.gwu.edu/~cistp/PAGES/research2.html)

Oyeleran-Oyeyinka B., Mytelka, L., and Gehl Sampath, P. 2004. Nigeria (Bio) Pharmaceutical System of Innovation. United Nations University – Institute for New Technologies (UNU-INTECH), Maastricht, The Netherlands. Draft Report.

UNIDO. 2002. Uganda Integrated Programme (UIP) Phase I Report, United Nations Industrial Development Organization, UIP Uganda (unpublished).

UNU-INTECH. 2004. Designing Innovation — Relevant Innovation Survey for NEPAD. United Nations University – Institute for New Technologies (UNU-INTECH), Maastricht, The Netherlands.

Watts, J., Mackay, R., Horton, D., Hall, A., Douthwaite, B., Chambers, R., and Acosta, A. 2003. Institutional Learning and Change: An Introduction. ISNAR Discussion Paper No. 03-10. International Service for National Agricultural Research, The Hague, The Netherlands.