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Agricultural Research in Sudan: The Perspective of INTSORMIL Social Scientists

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The International Sorghum/Millet Collaborative Research Support Program (INTSORMIL) is devoted to improving the production, distribution, and consumption of these two cereals among small producers in less-developed countries. In addition, the program seeks to improve the institutional capacity of its host countries to generate and adapt new knowledge through training and collaboration with local scientists. The sociologists and anthropologists in this multidisciplinary project have focused on sociocultural constraints to production, distribution, and consumption of sorghum and millet in low-rainfall areas, such as the Sahel of Africa, where these crops are particularly important. INTSORMIL has addressed these constraints in the context of the various social structures involved in sorghum and millet production and distribution. Consequently, the research has focused on farming, marketing, extension, and research systems. This chapter highlights one such interrelated social system: the agricultural research system in Sudan.

Among the major constraints faced by agricultural development projects in sub-Saharan Africa is the basic infrastructure to support their efforts. The agricultural research system is an important and often essential part of that infrastructure and of the process of economic development. Indeed, Mellor (1986) states that "first and foremost" in a strategy for broad foreign assistance policy "is the investment in agricultural research and its support services." Furthermore, the agricultural research system is vital to the success of any program of collaborative research between scientists in developing and developed nations.

Despite these facts, the agriculture research system is either ignored in the work of natural and social scientists or taken as given. When attention is directed to the research system, it usually takes the form of briefly summarizing budgets, human resources, and organizational structures or of identifying research products to be disseminated to farmers. In contrast, our work in Sudan and elsewhere sought to place INTSORMIL's research in a broader

sociology of agricultural science perspective (DeWalt this volume). The research reported here addressed the internal dynamics of Sudan's Agricultural Research Corporation (ARC), including its organization and practices, as well as the social, economic, and political situation in which it is embedded.

SUB-SAHARAN AFRICA AND SUDAN

Sub-Saharan Africa is a vast region encompassing 41 countries that are considered the poorest in the world's economy. While these nations' economies are dominated by the agricultural sector, in only 11 of 31 countries for which data are available did the average annual growth rate of agricul ure exceed the population growth rate between 1973 and 1974. In addition, sub-Saharan Africa as a whole is the only area of the world where per capita food production has declined over the past two decades. In 1985, approximately 170 million of its 540 million people were fed entirely with imported grain. Africa is losing its ability to feed itself (Brown and Wolf 1986).

While there is no such thing as a typical African economy, Sudan exemplifies all the conditions described above. In the late 1970s, the UN identified it as one of the least developed countries in the world. Approximately 65% of Sudan's population works in the agricultural sector; agricultural products, especially cotton, made up over 70% of the country's exports in 1983 (Bank of Sudan 1983).

During the postcolonial period, agricultural development in Sudan has emphasized large-scale irrigation projects (such as the Gezira and Kenana schemes or the Rahad Project), which require substantial capital and often heavy commitments of public funds. But, the bulk of agricultural land and labor, particularly for food, is still devoted to small-scale farming and pastoral systems of livestock production. In addition, approximately 80% of all crops are grown in rainfed areas. In the 1970s, many policymakers, planners, and foreign donors shifted their attention to small-scale farming and small-scale projects. However, because of population increases caused by a growth rate of 2.8%, augmented by over a million recent refugees (Gurdon 1986), agricultural and food production per capita both declined considerably between 1973 and 1984(FAO 1985). This decline has been worsened by drought in the 1980s. Finally, a prolonged colonial experience and the current long and bloody civil war have made it extremely difficult to achieve political stability and economic development.

THE AGRICULTURAL RESEARCH CORPORATION

Despite the difficult social, economic, and political environment, the Sudan's agricultural research system has grown substantially since its modest

beginning in 1902. Initially, research stations and laboratories were staffed by British scientists and were established to meet the demand of the Lancashire cotton industry. They focused almost exclusively on cotton, particularly in the proposed irrigation area between the two Niles that eventually became the Gezira Scheme. By the late 1940s, concern for nutritional deficiencies forced attention to food crops. Research in this area began in 1952, but the system included only about 50 scientists to conduct research on both export and food crops.

Fifteen years later, the semiautonomous Agriculture Research Corporation was created. In 1977, preexisting research functions in the areas of food processing, forestry, fisheries, range management, and wildlife were incorporated into the ARC. More recently, with the establishment of the Western Sudan Agriculture Research Project, progress has been made toward improving rainfed agriculture and livestock production in the west and integrating economic scientists into the organization.

Today, with approximately 175 scientists and 140 assistant scientists (including a large number who are abroad for training), the ARC accounts for approximately two-thirds of Sudan's agricultural research. Foreign scientists are a very small minority on the staff. In addition, there are roughly 600 technical assistants, 400 clerical and support staff, and nearly 4,000 laborers (ARC 1980). The ARC has achieved a critical mass of well-trained scientists, but it faces other human resource problems and serious economic constraints arising from deteriorating economic conditions in the Sudan generally.

Little information had been collected on this key agricultural research system. Indeed, we were unable to find any in-depth study of any African research system. Consequently, our research involved a variety of information sources, including reviews of historical materials; project reports and government documents; a series of 1982 on-site interviews of about two hours each with 62 ARC scientists; nine questionnaires returned from ARC scientists whose work sites were not visited; and approximately 20 interviews with research administrators and government officials. The number of respondents (n = 71) represented approximately 55% of the ARC on-site scientific staff in Sudan. Additionally, questionnaires were sent to approximately 50 Sudanese students enrolled in U.S. universities between September 1982 and May 1983. Twenty-five of these students were supported by the ARC, with the remainder being supported by other government or private organizations. Their response rate was approximately 50% (n = 25).

Human Resources

Since the rate of development of science, technology, and social institutions is determined in large part by human resources (e.g., scientists and staff), the backgrounds, professional training, and capacity of ARC scientists were

examined. Although Sudan's agricultural scientific community has increased significantly during the last two decades, its size and growth are about average for developing countries in Africa. For example, the annual growth rate between 1970 and 1980 for selected nations was Nigeria 17.3%, Zambia 3.4%, Madagascar −.6% (Oram and Bindlish 1981). The ARC scientific community is well-trained; 65% hold PhDs, a figure that far exceeds the World Bank target of 20%. Among ARC scientists, most master's-level and nearly all PhD-level education was received at universities in Great Britain and the United States.

Despite this relatively large and well-trained scientific community, there are a number of human resource-related problems. During the early to mid-1980s, the research staff continued to be augmented by significant numbers of newly trained scientists returning from overseas. This has put pressure on an already overextended research system and has exacerbated the erosion of operating budgets. Furthermore, declining budgets threatened the system's ability to retain its scientists. At the same time, the increasing scale and complexity of the ARC and the intense competition for funds in the national budget have illustrated the need for personnel trained in research management. Inadequate budgets also made it extraordinarily difficult for the ARC to compete for farm labor during peak planting and harvesting periods. Many scientists reported that experimental plots were not harvested on time or at all, thereby wasting the work of trained scientific personnel. Finally, the development of human resources should be congruent with Sudan's overall needs and priorities. This requires a closer examination of the balance between scientists devoted to export and/or cash crops as opposed to those concentrating on food crops for national consumption, and to their disciplinary, institutional, and geographical distribution.

Research Resources

ARC scientists are strongly oriented toward applied research. They categorized their research over the last five years as 83% applied, 13% basic, and 4% development. Most of this work takes place in experiment-station fields (56%), and about a third is conducted in the laboratory. The low percentage of research in farmers' fields (3%) reflects the lack of adequate transportation and the relative weakness of institutional ties that would permit on-farm experiments.

Various resources are necessary to the research process. ARC scientists rated the adequacy and importance of the resources for their work on a scale of 1 (very adequate, very important) to 5 (very inadequate, very unimportant). Availability of experimental land was seen as the most adequate resource, followed by personal freedom to determine research problems. On the other hand, equipment and financial support were seen as the most inadequate.

Transportation, availability and quality of trained technical help, and opportunities for advanced education were also seen as inadequate (Table 4.1). While the perceived adequacy of resources differed significantly, scientists viewed most of these inputs as very important to their work. They saw financial support and operating supplies and materials as the two most critical, but they ranked all resources as important. Furthermore, the discrepancy between adequacy and importance is quite large for many of the resources.

Sudanese students enrolled in PhD programs in the United States likewise rated the resources available to them at their host institutions (Table 4.1). Scientific literature, personal freedom to incorporate new materials and techniques and to determine research problems, and transportation were the most adequate resources. While these four factors received the highest adequacy ratings, there was virtually no difference between this group of variables and the remaining resources. The range was 1.4–2.2; thus, all were considered adequate to very adequate. The only inadequate rating was given for availability and quality of labor. With regard to importance: scientific literature, equipment and tools, opportunities for advanced education, and personal freedom to incorporate new materials and techniques into research were considered the most important. While these were rated slightly higher, all resources were considered to be very important.

Not surprisingly, the Sudanese students (all of whom were enrolled in major U.S. land grant and agricultural schools) considered their institutional resources to be significantly more adequate than did the ARC scientists on site in Sudan. The students rated every resource, except for experimental land, the students rated every resource as more adequate than did the Sudanese scientists.

These findings were generally consistent with those for Asian rice breeders (Hargrove 1978), U.S. scientists (Busch and Lacy 1983), and the international community of sorghum scientists (Marcotte, Busch, and Lacy 1983). Sudanese and other scientists from less developed countries agree with scientists from developed countries as to what is important with respect to resources, but the former labor under much less adequate research conditions. It is to the credit of ARC scientists that they have not used current fiscal problems as an excuse to abandon a meaningful research program. However, about a third of the Sudanese scientists expressed their intent to seek work in other countries with more adequate resources, support, and salaries if research conditions in Sudan did not improve.

Career Advancement

All organizations should have a reward system that provides a career ladder, offers employee incentives, and encourages support for the organization's

TABLE 4.1. RATINGS OF ADEQUACY AND IMPORTANCE OF RESOURCE FACILITIES

Resource Facilities	Scientists[a]		Students[b]	
	Adequacy	Importance	Adequacy	Importance
Operating supplies and materials	3.6	1.2	2.1	1.9
Experimental land	1.7	1.5	2.2	2.6
Research equipment and tools	4.0	1.3	1.8	1.7
Transportation	3.8	1.3	1.6	2.4
Trained help	3.7	1.4	2.2	1.9
Freedom to incorporate new materials and techniques into research	2.1	1.6	1.5	1.7
Freedom to determine research problems	1.9	1.6	1.6	1.9
Contact with other scientists	2.7	1.4	2.0	1.8
Opportunities for advanced education	3.7	1.5	1.9	1.7
Opportunities to gain scientific recognition	3.2	1.4	2.1	1.8
Opportunities for professional advancement	3.2	1.5	1.8	1.9
Training opportunities for people who work under you	3.7	1.5	2.2	2.3
Average Mean Score	3.3	1.4	2.0	1.9

[a]Mean ratings of 71 scientists in Sudan -- 1 = very adequate/important; 5 = very inadequate/unimportant.

[b]Mean Ratings of 25 Sudanese students in the U.S. -- 1 = very adequate/important; 5 = very inadequate/unimportant.

goals. In research institutions, this system must also take into account the enormous diversity of research products, as well as the differing pace of production across disciplines. Finally, the reward system should consider the relevance of research products to the institution's clientele.

Scientists were asked what criteria they felt were important for advancement within the ARC. Publications were seen as the single most important criterion. Primarily, this meant writing annual reports, although several scientists also published in British and U.S. journals. Number of years of service was seen as the second most important criterion, while actual evaluation of research projects ranked third. Only one out of six scientists identified problem-solving or meaningful research as a criterion for promotion.

These responses indicate discontinuity between the goals of the ARC and the system used to reward its scientists. As with most scientists, there is little assurance that publications will benefit clients. Likewise, length of service with the ARC is likely to be unrelated to any client needs. Few ARC scientists viewed fieldwork or problem-solving as important in career advancement. Consequently, although the ARC does use objective criteria for promoting its scientists, such criteria may not encourage them to generate results useful to potential client groups. However, with little additional expenditure, it may be possible to change the reward system to better direct research toward the needs of farmers and other clients.

Scientific Communication

Because production of scientific knowledge is intimately bound to the ability to exchange information, systems of scientific communication in the ARC were assessed. With respect to formal communications, the major means by which ARC scientists (56%) keep abreast of current literature is regular scanning of journals. ARC scientists read approximately 2.5 journals regularly, e.g., *Agronomy Journal*, *Experimental Agriculture*, *Crop Science*, or *Food Science and Technology*. Travel (11% of scientists) and publications other than journals (5%) were considered to be of little importance. Unfortunately, relatively few scientific journals are available to ARC scientists because of budgetary constraints and foreign currency restrictions. Likewise, travel—which agricultural scientists from developed countries consider a major source of information—is not a principal channel of communication for ARC scientists because of insufficient funds for travel both within and outside Sudan. To compensate for this relatively weak formal communication network, ARC scientists have developed a strong informal network. Forty-five percent report that they converse daily with colleagues in their departments. This compares quite favorably to scientists in other countries. For example, U.S. agricultural scientists report that they talk about research with their departmental colleagues somewhat less than weekly (Lacy and Busch 1983).

In sum, scientific communication in the ARC is restricted in several significant ways. Access to journals is limited by the small numbers of titles in libraries and the lack of transportation to libraries. Access to fellow colleagues at other stations, institutions, or nations is also limited by restricted travel opportunities and minimal telephone services. Effective agricultural research policy must address the scientific communication system, its integral relationship with the goals and products of agriculture and agricultural R&D, and potential conflicts in the present system.

Research Goals and Beneficiaries

By definition, agricultural research is a goal-oriented activity. This is implicit in its strong mission orientation. However, the particular goals of research may differ markedly from program to program, discipline to discipline, and scientist to scientist. In addition, scientists' perceptions of research goals may differ significantly from those of administrators.

To assess the relative importance of various research goals to ARC scientists, a list of 10 common goals was utilized. Scientists ranked each of these 10 on a scale of 1 (no importance) › 5 (highest importance) in terms of their own research. Mean scores ranged from a high of 4.5 for increasing agricultural productivity and 4.3 for developing new knowledge, to a low of 2.6 for improving marketing efficiency. Significantly, only one goal ranked below the midpoint of 3 on the 5-point scale (Table 4.2). This suggests that, unlike their U.S. counterparts, ARC scientists take a broad view of research goals in their work. In fact, these scores may understate the differences, given the narrower range of disciplines in the ARC. The principal goal of ARC scientists is to increase agricultural productivity. It seems apparent that in order to pursue this mission, scientists must understand the circumstances of their clients. Moreover, one of the most important and difficult roles for the scientist as a change agent is to diagnose the needs of clients (Rogers and Shoemaker 1971). Perhaps even more difficult is to incorporate that perception into an ongoing applied program.

Given this requisite for understanding and diagnosing client needs, researchers were asked whom they perceived as the main audience for their research (Table 4.3). The largest group of perceived beneficiaries was farmers (50% of responses), followed by industry (24%) and extension/government (16%). This identification of farmers as the principal audience appears consistent with the goal of ARC scientists to increase agricultural productivity. However, it deviates somewhat from previous studies. For example, the most important perceived beneficiaries for U.S. agricultural scientists were large farmers and the general public, followed by other scientific disciplines, small farmers, and agribusiness, but with minimal differentiation among beneficiaries (Busch and Lacy 1983:167-168).

The data on perceived research goals and beneficiaries in Sudan suggest some potential and fundamental anomalies in the role of agricultural research there. First, although scientists see farmers as their research audience, they have limited or nonexistent communication links with these potential clients. When scientists were asked how their audiences received information about ARC research, the most popular answers were reports and publications. Ironically, however, adult literacy in Sudan is only 20% (World Bank 1980). Therefore, most farmers could not use such reports. ARC scientists' next most frequent answer to this query was information dissemination through extension. However, because of the country's serious economic difficulties,

TABLE 4.2. GOALS OF AGRICULTURAL RESEARCH AMONG SUDANESE AGRICULTURAL SCIENTISTS AND STUDENTS

Goals	Total (n=71)	Scientists[a] 1 (n=30)	2 (n=16)	3 (n=25)	Students (n=25)
Increase agricultural productivity	4.5[b]	4.6	5.0	3.9	4.7
Develop new knowledge or improved methodology	4.3	4.2	4.1	4.6	4.6
Decrease production costs of farm products	3.9	4.0	4.1	3.7	3.8
Improve level of rural living	3.6	3.3	3.1	4.2	4.6
Protection from insects, disease, and other hazards	3.6	3.4	3.7	3.8	4.3
Protect consumer health and improve nutrition	3.6	3.2	2.9	4.7	4.2
Promote community improvement	3.4	3.2	2.5	4.2	4.2
Expand demand by developing new products or enhancing product quality	3.4	3.0	2.9	4.3	3.9
Expand export markets	3.2	3.1	2.9	3.6	3.5
Improve marketing efficiency	2.6	2.4	2.2	3.2	3.5

[a]Group 1 agricultural scientists at Gezira and Shambat, Group 2 scientists at remote regional stations (Hudeiba, Kadugli, Kenaana, New Halfa, Rahad, Sennar, and Yambio), Group 3 scientists at the commodity stations and specialized centers (Food Research Center, Forestry Research Center, Gum Arabic Research Station, Fisheries Research Center, and Wildlife Research Section).

[b]Scale 1 to 5 -- 1 = of no importance; 5 = of highest importance.

the Sudanese extension service lacks both the staff and resources to disseminate information.

Another anomaly centers on research goals. Scientists see certain goals as significantly more important than others in the conduct of their research. In contrast to their counterparts in developed countries, Sudanese scientists view a wider range of goals as important. However, various subgroups differ in their perception of the most important goals. This would be relatively unproblematic if there were no link between the maximization of particular research goals and the flow of research benefits to certain groups; but this is not the case. For example, successful research to increase agricultural productivity is most likely to benefit literate farmers near experiment

TABLE 4.3. SCIENTISTS' PERCEIVED BENEFICIARIES OF AGRICULTURAL RESEARCH

Beneficiaries	Scientists' Responses	
	N	%[a]
Farmers	29	46.8
Industry	15	24.
Extension/government	10	16.1
General public	4	6.5
Students/universities	3	4.8
Projects	1	1.6
Total	62	99.8

[a]Does not sum to 100 due to rounding.

stations, processing and marketing firms able to purchase agricultural commodities at lower prices, and perhaps consumers—although if food quality and nutritional goals are generally neglected, little or no benefit may accrue to consumers. Similarly, emphasis on research to expand export markets may benefit certain export-crop farmers while also raising consumer prices for food crops. The promotion of community improvement may also cost some groups and benefit others. For example, crops and livestock can be protected through the use of chemical sprays, but such chemicals may increase health hazards to farm workers, rural residents, and ultimately the general public.

Finally, the pursuit of any goal involves costs and benefits. It may appear that the solution is to develop a system that maximizes benefits and minimizes costs. However, this approach addresses only the issue of outcomes; it ignores questions concerning beneficiaries and those likely to incur costs. No simple economic cost/benefit analysis can resolve this fundamental problem. These complex issues highlight the need for a more informed, comprehensive agricultural research policy.

CONCLUSIONS AND SIGNIFICANCE OF THE STUDY

The current situation in the ARC combines opportunity with the frustration of inadequate resources. The staff, soon to be augmented by additional colleagues, is generally well-trained and highly committed to applied research in agriculture. However, the facilities, supplies, and other research resources

are inadequate for even the present staff. Without adequate funding, the available human resource potentials will be underutilized and possibly even lost to the system.

In summary, it is not enough just to provide funds for training new scientists and technicians. Budgetary support for operational costs other than salaries is essential, yet it is often neglected. Training and staff development should be matched with the provision of recurrent funds and capital investment to support their research. Infusion of adequate funding and resources for current operations, as well as for institutional development in the ARC, should be a high priority of the Sudanese government and other agencies interested in agricultural development in Sudan.

In addition to analyzing the ARC research system and offering recommendations to ARC administrators and scientists, INTSORMIL sociologists' "research of research" provided an important and possibly unique social science contribution to agricultural development work in Sudan. First, it treated the ARC in more than the cursory style of many external reviews of research systems. The study included in-depth interviews with junior scientists as well as department heads and station directors, surveys of scientists in training, and site visits to over half the research stations in the system. This provided multiple perspectives from a representative sample, plus observations useful to both Sudanese policymakers and foreign assistance agencies interested in strengthening the research capacity.

Second, this investigation complemented the work of other INTSORMIL social scientists regarding farming systems, extension structures, and marketing networks. The study represented one of the few occasions in which all these essential social systems in the food chain were examined in the same project.

Third, analysis of the ARC system furnished U.S. biological scientists in INTSORMIL with insights into the research milieu of their potential Sudanese collaborators. As with the CRSP structure, international agricultural development increasingly stresses collaboration between scientists in developed and developing countries. Understanding agricultural research organizations is important for the success of collaborative efforts.

Fourth, international development analysts increasingly emphasize the role of national agricultural research for development. Investment in agricultural R&D and its support services is currently a major focus of foreign assistance policies. Therefore, well-designed studies of the research system take on added significance for guiding these investments.

Finally, studying the research system provides new insights into the interrelationships among research, extension, and producer clients. The focus on research requires the reformulation of traditional views of information flow between research and extension. In this model, the research system is no longer taken as a given that provides value-free knowledge. Instead, it is

viewed in terms of its internal and external dynamics and its broader technical, social, economic, and political context.

NOTES

Portions of this chapter appeared in Lacy, Busch, and Marcotte 1983.

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