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Strengthening Innovation Capacity of Nigerian Agricultural Research Organizations

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Contents

List of Tables

List of Tables

List of Figures

ABSTRACT

The Nigerian agriculture sector has grown by an annual average of 7 percent over the past 10 years. However, this growth has been mainly due to land expansion rather than productivity increase. Yield gaps remain very high, ranging from 80 t0 250 percent of the current yield in major crops. Significant changes are needed to revitalize Nigeria's agriculture research systems; these changes require new relationships and new capacities to bring forth innovations that will produce greater productivity and increased incomes for agricultural producers.

This paper provides a descriptive analysis of a survey conducted among 43 organizations and 366 staff involved in agricultural research in Nigeria. The purpose of this analysis is to understand the status of capacity and performance of these organizations and staff within the innovation system perspective. This paper develops a conceptual framework to help analyze the innovation capacity and performance of some of Nigeria's agricultural research organizations. Findings from this paper suggest that the status of innovation capacity indicates an overall weakness in the level of collaboration and in monitoring the use, influence, and impact of available technologies and publications. Results also indicate that organizations vary significantly, with some organizations being more productive, well-connected, and aware of the adoption and impact of their research outputs than others. Mean comparison tests were used to understand the variation of innovation capacity and performance given the same broader policy and enabling environment throughout Nigeria. The comparison tests show that an organization's culture and work environment matter in inducing good performance and innovation capacity. Statistical tests confirm significant differences in the indicators of organizational culture and work environment between "good" and "bad" performing organizations. In addition to suggestions for strengthening organizational and management capacities for research, this paper provides suggestions for strengthening the researchers' scientific and technical competencies, which are both important within the innovation system perspective.

Keywords: research system; innovation system, capacity development, organizational culture

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ABBREVIATIONS AND ACRONYMS

ABU	Ahmadu Bello University
AfDB	African Development Bank
ARCN	Agricultural Research Council of Nigeria
ASTI	Agricultural Science and Technology Indicators
AUC	Africa Union Commission
BSc	Bachelor's degree
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CRIN	Cocoa Research Institute of Nigeria
CTA	Technical Centre for Agricultural and Rural Cooperation
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation)
FA	faculty of agriculture
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FCA	federal college of agriculture
FCAHPT	Federal College of Animal Health and Production Technology
FCC	federal cooperative college
FCFFT	Federal College of Freshwater Fisheries Technology
FCVMLT	Federal College of Veterinary and Medical Laboratory Technology
FMARD	Federal Ministry of Agriculture and Rural Development
FMAWR	Federal Ministry of Agriculture and Water Resources
FTE	full-time equivalent
FUTA	Federal University of Technology, Akure
FVM	faculty of veterinary medicine
GDP	gross domestic product
GIS	geographic information system
HND	higher national diploma
IAR	Institute for Agricultural Research
IAR&T	Institute of Agricultural Research and Training
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	information and communications technology
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IPM	integrated pest management
IPR	intellectual property rights
IT	information technology

ABBREVIATIONS AND ACRONYMS

KARI	Kenya Agricultural Research Institute
LCRI	Lake Chad Research Institute
M&E	monitoring and evaluation
MOU	memorandum of understanding
MOUAU	Michael Okpara University of Agriculture, Umudike
MSc	Master's degree
NAERLS	National Agricultural Extension and Research Liaison Services
NAPRI	National Animal Production Research Institute
NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NBS	National Bureau of Statistics
NCRI	National Cereals Research Institute
NEPAD	New Partnership for Agricultural Development
NGO	nongovernmental organization
NIFFR	National Institute for Freshwater Fisheries Research
NIFOR	Nigeria Institute for Oil Palm Research
NIHORT	National Institute for Horticultural Research
NIOMR	Nigerian Institute of Oceanography
NRCRI	National Root Crops Research Institute
NSPRI	Nigerian Stored Products Research Institute
NVRI	National Veterinary Research Institute
OAU	Obafemi Awolowo University
R&D	research and development
ReSAKSS	Regional Strategic Analysis and Knowledge Support System
RI	research institute
RRIN	Rubber Research Institute of Nigeria
UAM	University of Agriculture, Makurdi
UNAAB	University of Agriculture, Abeokuta
USAID	United States Agency for International Development
WARDA	Africa Rice Center

1. INTRODUCTION

Strong agricultural research and development (R&D) is crucial for improving agricultural productivity and efficiency, which in turn both lead to agricultural development, food security, and poverty reduction. However, several studies have shown that in many developing countries, in particular in sub-Saharan Africa, there is persistent underinvestment in R&D and weak research capacity, both of which continue to undermine agricultural productivity and growth in these countries.

In an attempt to address this issue, several efforts have been implemented over the decades to strengthen national agricultural research systems (NARS) in numerous developing countries. These efforts have led to a series of reforms, including expansion, contraction, restructuring, downsizing, privatization, and decentralization (Byerlee and Echeverria 2002), though with mixed results. Overall, the capacity of many NARS, especially in sub-Saharan Africa, remains weak. The Food and Agriculture Organization of the United Nations ([FAO] 2002) summarized some positive impacts of past interventions, as well as some remaining major challenges:

- Agricultural research management has been improved at all levels (policy formulation, planning, organizing, evaluation, and so on) globally.
- Strategic planning processes, priority setting, and program budgeting and management are now routinely performed by many NARS; however, the effectiveness of the implementation has not been assessed.
- Adequate bodies have been established, though their proper functioning is uncertain.
- Human resources have improved in quality and quantity, though staff attrition is still very high in many NARS.
- Although there has been a focus on commodity-oriented research, there is limited attention to problem-focused multidisciplinary research.
- Institutes remain fragile, and financial sustainability continues to be a major challenge.
- Links among research, education, extension, and the markets remain weak.

In recent years, a new paradigm, called the agricultural innovation system, has been promoted to bring out innovations that better respond to the needs of farmers and other clients (World Bank 2006). The agricultural innovation systems approach emphasizes a stronger link of knowledge systems (research, extension, education) with markets and other actors in the supply chains, as well as with those in the broader policy environment. This system changes how research is done, with a shift in focus from research outputs and productivity to the use and adoption of technologies being generated by research, as well as to how those technologies are helping to solve the problems of farmers and to alleviate the constraints of supply chain actors. The focus is now on creating social or economic value from technologies generated by research. This system highlights the importance of creating better partnerships with other researchers, knowledge brokers, innovation networks, and clients in all stages of R&D, from research prioritization and planning to implementation, monitoring, and evaluation. This new perspective has implications for capacity building for research; for measuring performance, outputs, and impacts; and for looking at incentive systems to promote interactions and innovativeness. Within the innovation system perspective, however, limited empirical analyses have looked at these issues except for several case studies. Although these studies are insightful, they are limited in their applicability to other contexts due to a lack of broader contextual considerations, as well as a lack of information on different typologies of where specific interventions might work or do not work.

Another related research gap is in understanding the institutional context and incentive structures, as well as the organizational changes and restructuring, of agricultural research systems. Raina (2003) emphasized the important distinction between institutional reforms and changes in organization and management when analyzing reforms and performance. Often, organizational and management changes are not enough to foster innovation processes. In the 1980s and 1990s, organizational and management changes were made in India's NARS, including efforts to encourage private–public interaction in agricultural research, priority-setting methods in research organizations, introduction of management

solutions to improve the morale of personnel, communication within and between research institutes, modernization of research infrastructure, provision of resources for operating expenses, efforts to improve client focus, and upgrades of training and skills in frontier research and management issues (Raina 2003). Although these changes did solve some of the organizational problems, they did not solve the underlying institutional problems, such as issues with hierarchies, values, ideologies, professional norms or attitudes, incentives, and motivations. In fact, India has since shown evidence of declining crop productivity and an apparent inability and weaknesses of its NARS to reverse this trend (Raina 2003). As Raina (2003) stressed, the analytical issue of distinguishing between organizational change and institutional reform is critical for the effectiveness both of policy and of the innovation process. The former does not imply the latter; when the latter is ignored, institutional constraints often block the innovation process (Raina 2003). Thus, there is a scope for research that looks at incentives among individual researchers and organizations.

1.1. Objectives and Innovation of this Study

This paper aims to fill some of the knowledge gaps and to contribute to an understanding of the functioning of agricultural research systems, in particular in developing countries. The paper begins with an empirical analysis and measurement of innovation capacity and performance at the individual and organizational levels. Within the innovation system perspective, performance is not only limited to research productivity (or research output as a ratio of input) but also extends to the linkages and interactions among stakeholders, as well as to the uptake of technology and the social and economic use of these technologies. The past 20 years have seen increased attention in scholarly research to innovation and linkages. Relevant themes, such as innovative work behavior (de Jong and den Hartog 2010), research collaboration and linkages (Ponomariov and Boardman 2010; Manjarres-Henriquez et al. 2009; Boseman and Corley 2004), and organizational culture (Moynihan and Pandey 2007; Willem and Buelens 2007; Stone et al. 2007; Henri 2006), are increasingly addressed in the literature. However, research on these themes in the agriculture sector is scant. Thus, this paper reviews the literature on other sectors in order to gain insights and to borrow techniques, methods, and tools for analysis. Studies available on agriculture sectors are mainly case studies (Spielman et al. 2008; Hall 2005; Hall et al. 2001), as well as a few quantitative studies in the context of developed countries (Murovec and Prodan 2009). The innovation system approach has been criticized for not being able to produce more rigorous types of research other than case studies. Therefore, this study aims to provide a first step toward benchmarking and hypothesis testing for the innovation system by focusing on the innovative capacity and performance of organizations and individuals as parts of an innovation system, rather than focusing on the national level.

This study then deviates from the usual measurement and assessment of capacity, which focus on training needs. Instead, it systematically looks at the constraints of achieving better performance—that is, innovation—in order to understand the feasible change process and what learning and capacity-building activities can do to facilitate the change process. This paper focuses on the relationship between performance and the practices and strategies being adopted by looking at factors that affect "good" and "bad" performance at the individual and organizational levels. These factors are critical for understanding the strategies and approaches that work and do not work in a particular context.

This study also integrates incentive and institutional problems, in addition to organizational and management issues. In the literature, research productivity has been measured in terms of publications expressed as a ratio of the level of resources. This study aims to add the institutional dimension to explain the performance of research organizations and individuals. According to Raina (2003), although the organizational and management changes made to India's NARS did lead to some progress, underlying incentive and institutional issues (hierarchies, values, ideologies, beliefs, leadership, professional norms or attitudes, incentives, and motivations) remained, causing serious fragility in the entire system. Therefore, this study addresses this critical area of research in order to address not just organizational weaknesses but also institutional bottlenecks and incentive issues.

Finally, there has been a lack of empirical analysis on the nature and type of capacity in research organizations. IFPRI's Agricultural Science and Technology Indicators (ASTIs) have focused on data collection and analysis of trends and number of researchers (such as full-time equivalent staff) by gender, educational background, and field of specialization. However, there is no available documentation and analysis of skill sets, knowledge, motivations, results orientation, mission orientation, level and type of linkages, priorities, and constraints by individual scientists and managers, all of which help explain variations in performance and innovation. This study hopes to complement the data and analysis provided by ASTI.

1.2. Nigerian Context

Nigeria was chosen as the country of focus because of the government's demand, through the Agricultural Research Council of Nigeria (ARCN), for such analysis in order to inform their organizational strategies and programming. Moreover, Nigeria has arguably the largest and most complex NARS in sub-Saharan Africa, with the largest network of agricultural universities and faculties of agriculture and veterinary medicine in general universities, as well as CGIAR (Consultative Group on International Agricultural Research) facilities. Given the complexity and diversity of Nigeria's agricultural research institutes, the country is an appropriate case for looking at variations across organizations in terms of performance, innovation capacity, and impacts. However, Nigeria's NARS is also relatively unstable and is beset by numerous unique challenges that warrant special attention. These challenges include:

- *Institutional instability:* The frequent changes in ministries supervising agricultural research since independence (1960) have left Nigeria with no national agricultural policy or strategic plan, as well as weak advocacy at the highest levels of government on behalf of the Nigerian NARS.
- *Funding instability:* Although Nigeria's NARS is largely funded by the federal government, the Nigerian budgeting process has been described as complex and lacking transparency. Idachaba (1998) and Beintema and Ayoola (2004) described long delays and shortfalls in the disbursement of funds, as well as excessive delays of capital funds to virtually all research institutes. As a result, communication systems and facilities in the country's agricultural research institutes are entirely inadequate. Several institutes are still not connected to the Internet, and none of their staff were directly connected to email. Political instability and seed policies have also discouraged private-sector investment in research and seed sectors, while bureaucratic and lengthy approval processes for new varieties are further prohibiting private-sector research activities.
- *Research staff instability:* The research staff instability index (or the ratio of the number of staff who have left NARS to the total number of staff) indicates high staff turnover in most institutes over short periods, contributing to unsustainable research programs (Idachaba 1998). According to Idachaba (1998), the human resources management of NARS must go beyond traditional concerns with scale and staffing level adequacy to the analysis of staff instability and turnover.
- *Governance instability:* The governance instability index (or the ratio of the number of members of the governing board who have been removed or who have retired over a given period) shows high board turnover. Most institutes show little or no institutional memory in their governing bodies. Board members are appointed not so much for their sustained professional input over time but more as political patronage. Institute governance is thus severely affected, because board members are unable to provide the critical mass professional advice, integrity, and transparency required to guide institute management.
- *Democratic polity:* Civil society has, after many years of military rule, developed a military dependency syndrome, meaning researchers, farmers, and beneficiaries of agricultural research have come to depend on the military and its narrow band of advisers for all initiatives in agricultural research policy and programs. Development of civil society capacity is critical for it to play the required advocacy roles on behalf of agricultural research.

- *University–institute linkages:* There are currently weak linkages among the approximately 81 government and higher-education institutes engaged in agricultural research. The weak capacity of higher-education agencies conducting agricultural research in terms of full-time employees (FTEs) is often cited (Idachaba 1998; Beintema and Ayoola 2004). The newly established Universities of Agriculture were designed to play a vanguard role in developing linkages, but anecdotal evidence suggests that weak research–university and interuniversity collaboration persists. The functional integration of the Institute of Agricultural Research (IAR), one of the researcher institutes, and Ahmadu Bello University (ABU) is considered a potential success story of institute–university integration schemes. However, lessons learned and experiences of what elements work and do not work have not been assessed. Likewise, the scalability of such an integration scheme is still not well understood.

Several attempts have been made, and others are underway, to strengthen the system (such as the World Bank–funded National Agricultural Research Project [NARP], 1994–1999), but all have met with limited success. In 2006, ARCN was established and assigned the statutory function of coordinating, supervising, and regulating all agricultural research, training, and extension in Nigeria. This council signifies an opportunity to create the necessary reforms that will move agricultural research and production forward for the benefits of Nigeria's resource-poor farmers.

As ARCN undertakes its strategic planning and research priority-setting processes, this study aims to guide and inform those processes by providing evidence-based empirical analyses on the status of the innovation capacities of ARCN, its affiliated research institutes and federal colleges, and other higher-education institutes involved in agricultural innovation. This study also aims to suggest strategies and approaches for strengthening these capacities and incentives. To do this, the study looks at different levels of capacity (including individual, organizational, and institutional) and the several dimensions of capacity (including skills and competencies, financial and physical assets, organizational structures, formal rules, informal norms, incentives, networks and linkages, and policy context). Although this study covers only public-sector research and higher-education institutes, it does focus on linkages, interactions, and partnerships between these organizations and other players in the system and on their interplay with the larger policy environment within the innovation system perspective.

1.3. Research Questions

This paper is structured around the following two research questions:

- What is the level of innovation capacity and performance of individual researchers and research organizations in Nigeria?
- What capacity gaps and incentive issues are keeping researchers and research organizations in Nigeria from achieving greater innovation capacity and performance?

First, the conceptual framework that guides data collection and analysis is presented. Second, the methodology used for data collection and analysis is described. Third, the results are presented based on the key elements in the conceptual framework. The results section is structured as follows: (1) performance of the agriculture sector; (2) organizational landscape of agricultural research and the broader enabling environment; (3) research and innovation performance; and (4) elements of innovation capacity, including organizational capacity, organizational culture, individual capacity and incentives, and gaps and constraints. Fourth, the discussion section expands on the implications for capacity building and strategies for strengthening research organizations. Finally, the paper summarizes the main messages and concludes with policy implications.

2. CONCEPTUAL FRAMEWORK

The framework starts with the basic principle that organizations and individuals with strong capacity and motivations are needed to bring forth innovations to achieve improved productivity, incomes and food security. Within the innovation systems perspective, the performance of research organizations can be measured by the quantity and quality of research outputs (e.g., publications and technologies); efficiency of resource use; linkages and interaction with other organizations; and actual adoption, use, and impact of research outputs. In other words, performance is measured by innovation. Innovation performance is affected by individual and organizational capacity and incentives to produce innovations. Hall (2005) described three types of capacity: (1) research capacity, which involves the resources needed to conduct scientific research; (2) technological or scientific capacity, which concerns the resources needed to manage technical change, including scientific skills and knowledge, institutions, and networks that connect science, the market, policy, and other actors; and (3) innovation capacity, which involves these same broad skills, linkages, and structures but which focuses on using these skills to produce knowledge and putting that knowledge to social and economic use. Innovation capacity is not only concerned with systems and linkages but also with the ability to learn and change and to reconfigure these arrangements in response to changing demands and circumstances. Innovation capacity and incentives are engrained in the context in which organizations work and in which individuals perform. To determine the sources of the innovation capacity and incentive issues, it is important to look at the various elements at both the organizational and individual levels, including the organizational landscape, capacity, and culture, as well as the individual capacity and incentives. These elements are, in turn, conditioned by their interaction with the agricultural extension and education systems, which are a critical part of the agricultural innovation systems; by their linkage with farmers and other actors in the value chain; and by the broader enabling environment. Figure 1 presents a visual presentation of the nexus between capacity and incentive and the linkages of both to performance, the broader enabling environment, and development goals.

Within this framework, the capacity development perspective is used, focusing on the following questions:

- What constraints present in these elements hinder the production of useful innovations and the achievement of development goals?
- What feasible change processes will ease these constraints?
- What can be facilitated by learning processes and capacity development activities?
- What effective methods and approaches are there for learning and capacity development?

Due to the complexity of NARS and the sources of the weaknesses and instability of NARS, this study employs a number of disciplines and approaches to understand the underlying factors affecting research institutes' innovation capacity and performance.

First, as already mentioned, this study adopts the innovation systems approach, which looks at the nexus of research, extension, and education and their linkages and interactions with actors in the supply chain and in the broader enabling environment. The innovation systems approach views innovation in a systemic, interactive, evolutionary way, whereby networks of organizations, together with the institutions and policies that affect their innovative behavior and performance, bring new products and processes into economic and social use (World Bank 2006). The first implication of this system perceptive is that we cannot study one component on its own; instead, we must look at all the components and the interaction between each component, because the performance of one component depends on that of the others. As a result, it is crucial to look at the linkages and interactions of NARS with agricultural extension and education systems and with the broader enabling environment. The second implication is that we must look at performance not only in terms of produced research outputs but also in terms of the application and adoption of the use of these outputs, as well as the innovation processes behind them. This highlights the importance of strengthening individual and collective capabilities to innovate; of improving organizational cultures in support of such capabilities; and of fostering linkages and partnerships with farmers and other actors in the innovation systems (CTA 2009; Spielman et al. 2008; Hall et al. 2000;

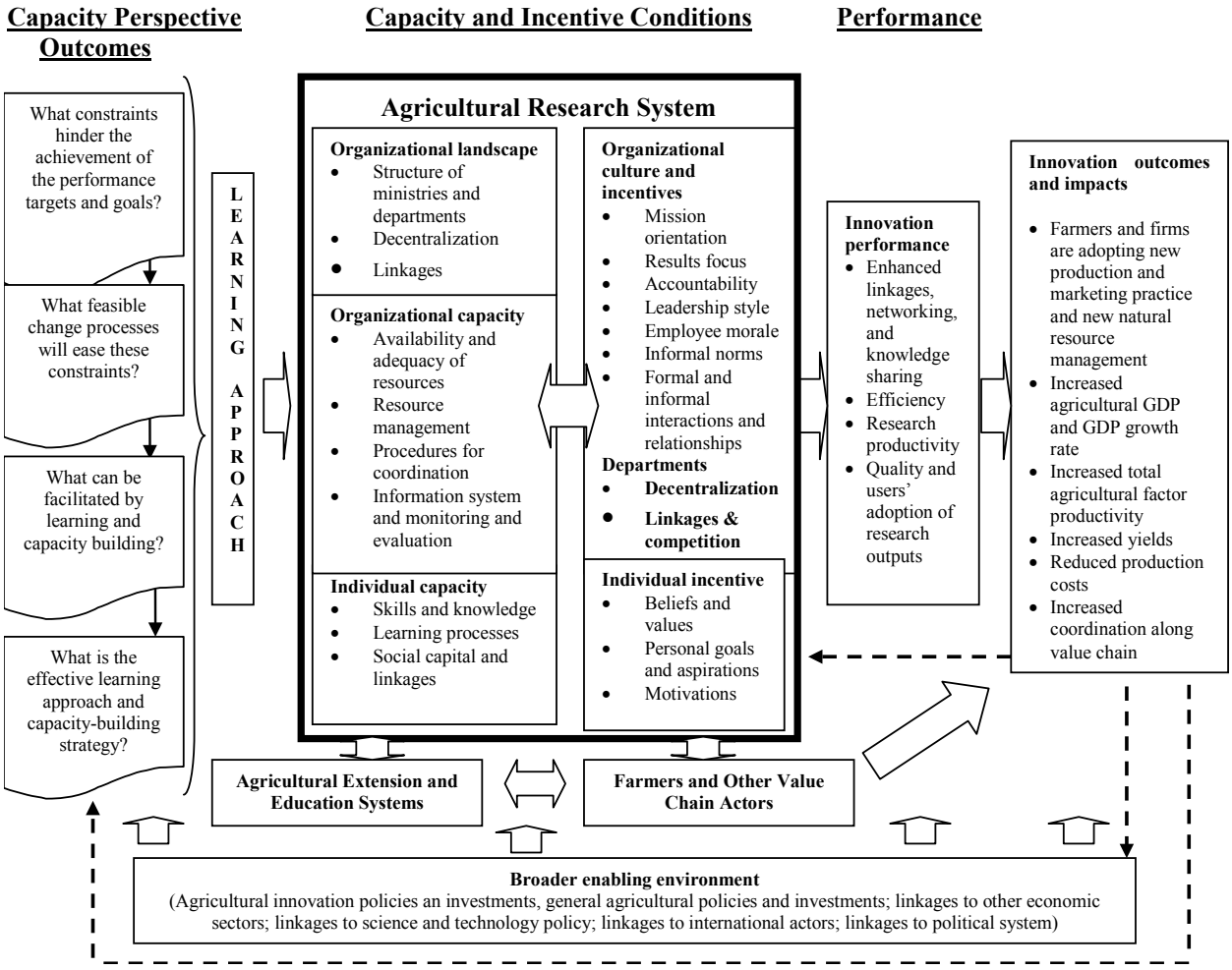
Cohen and Levinthal 1990). Measures are combined from public-sector performance indicators (World Bank 2001; Manning, Mukherjee, and Gokcekus 2000), as well as from indicators within the innovation systems perspective (CTA 2009; Spielman and Kelemework 2009; Spielman et al. 2008; Spielman and Birner 2008; Hall, Mytleka, and Oyeyinka 2006, 2005; Hall et al. 2000).

Second, this study performs capacity gap assessment to look at the skills and competency needs of, as well as the gaps in, organizational and management procedures, systems, and instruments. At the individual level, technical and functional skills and competencies are assessed, and training and learning needs are identified. At the organizational level, the status of organizational procedures and systems are assessed, constraints and gaps are identified, and suggestions for future training and learning investments are provided. In identifying gaps, this paper also looks at the goals and priorities set forth in the ARCN strategic and operational plan (2010–2020) to better understand how best to channel efforts and investments in achieving them (see ARCN 2010b).

Third, the institutional economics approach complements the capacity gap assessment in focusing on the incentive structures and bottlenecks of enforcing the rules, regulations, and schemes that have been established to manage the organization, thus achieving behavior changes and institutional reforms. According to organizational design literature, four structural elements are needed for this to occur: formal incentives (salary, promotion, training, international conferences, and so on), external checks and balances, availability of timely information, and informal structures and organizational culture (Manning, Mukherjee, and Gokcekus 2000; World Bank 2001; Raina 2003). Within institutional economics, attention is given to different institutional arrangements and incentive structures that worked in some organizations in Nigeria and to deriving lessons learned from organizations where certain arrangements did not work.

Fourth, instead of looking at or measuring how innovative a national innovation system is, we look at the components and actors within a national innovation system—in particular, agricultural research organizations—with the assumption that a system's innovativeness depends on the innovativeness of organizations and the actors within them. It is also the assumption that there are innovative, or "good performing," organizations and not innovative, or "bad performing," organizations within an innovation system. The purpose of this study is to capture the factors that affect "good" or "bad" performance within a national innovation system.

Figure 1. Conceptual framework for analyzing an agricultural research system's performance within the innovation systems perspective



Source: Authors.
Note: Thick arrows represent the direction of impact; thin solid arrows represent the chronological step and flow of analysis; and thin broken arrows represent the feedback process.

3. METHODOLOGY

This study uses a survey method, which was conducted in May to July 2010, to understand the innovative capacity and performance of agricultural researchers and organizations. It focuses on public-sector agricultural organizations, including research institutes (RIs); federal colleges of agriculture (FCAs), under the aegis of ARCN; faculties of agriculture or veterinary medicine at federal universities; three universities of agriculture; and ARCN. Based on the 2010 ARCN records, there are 15 RIs, 11 FCAs, about 40 faculties of agriculture (FAs), and 8 faculties of veterinary medicine (FVMs) located across Nigeria's six agroecological zones (including the South-South political zone). The study team covered all 15 RIs, 11 FCAs, 3 universities of agriculture, and ARCN. Due to the far distances of some organizations and a limited time allowed for survey data collection, the team focused on 25 faculties of agriculture and veterinary medicine based on the organizations' geographic proximity. This gave a total sample of 54 organizations. The distribution of the organizations included in the survey is presented in Figure 2.

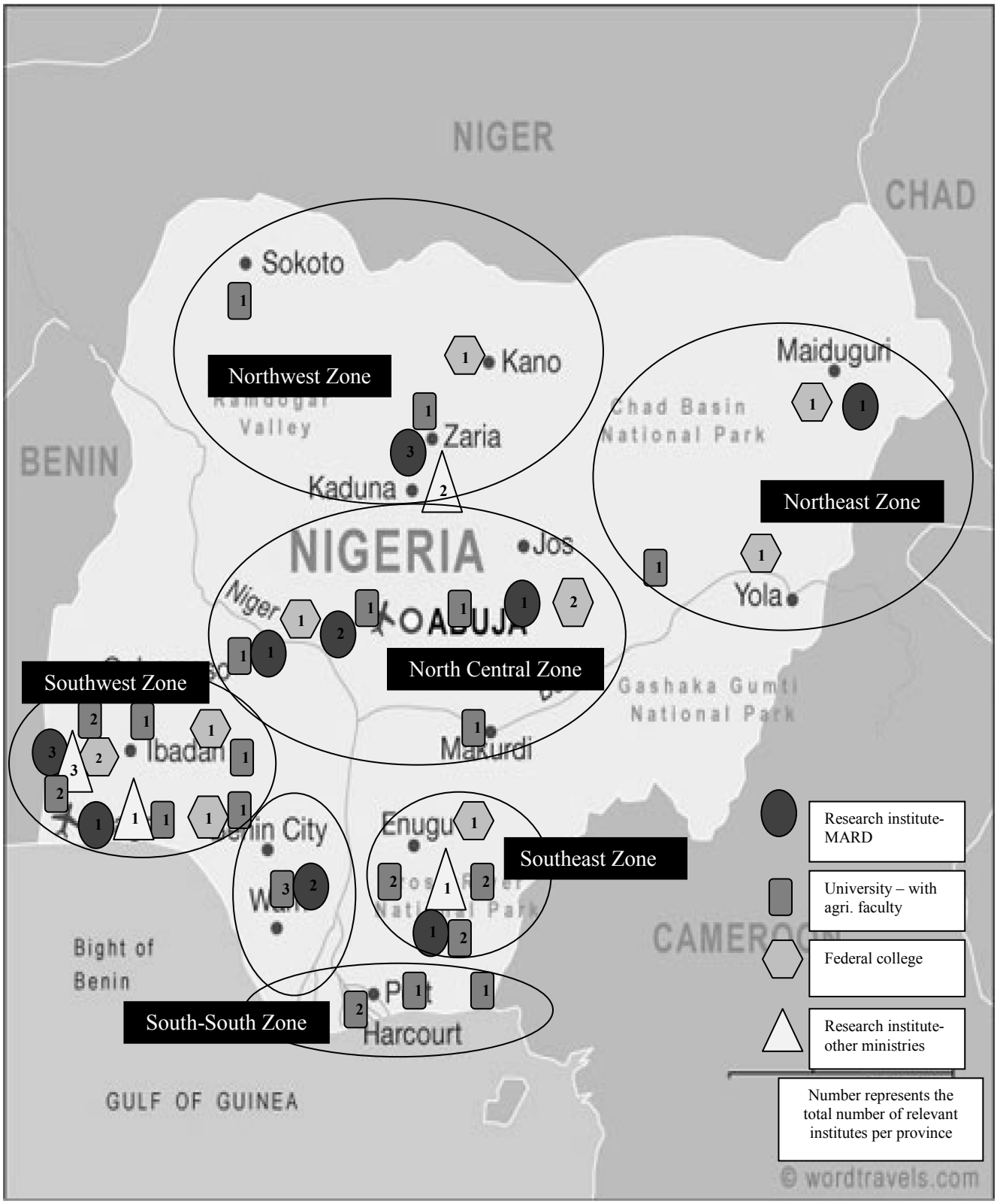
3.1. Sampling Approach

The target number of respondents for each organization was 10 staff. Research staff were selected from each organization's nominal roll, stratified into top management, middle management, and junior research staff. Due to a lack of explicit attention to and marginalization of female respondents in many of the past agricultural research systems surveys, the study team ensured that female respondents were included in the survey. First, the team selected three or four female research staff from the list across the different strata. Second, the team selected the remaining six or seven respondents to represent the three strata (one or two from top management, two from middle management, and three junior research staff). The actual number of respondents was based on respondents who were willing to be interviewed or to answer the questionnaire. The actual number of respondents per organization ranged from 2 to 9, averaging 6 respondents and totaling 366 respondents in 43 organizations.

3.2. Questionnaire

Two sets of questionnaires were used—one questionnaire for organizations, to be answered by organization heads or a designated representative, and another for individual researchers. The questionnaire for organizations included questions on the organization's mission; research management issues and training needs; scientific and technical training needs; the availability of physical and human resources; research outputs; management systems and procedures; partnerships and linkages; accountability and motivations; and funding sources. The questionnaires were answered either through face-to-face interviews or by written or filled-out responses, depending on circumstances in the organizations or preferences of respondents. The average time taken to answer the organization questionnaire was 2.5 hours. The questionnaire for individual researchers covered demographic and individual characteristics; research outputs; workload; linkages; research issues and training needs; motivation and incentives; and perception of the organization's culture. The average time taken to answer the individual questionnaire was 2.5 hours.

Figure 2. Distribution of sample research organizations across six zones in Nigeria



Source: Worldtravels.com..

3.3. Characteristics of Respondents

The survey covered 43 organizations involved in agricultural research in Nigeria: 14 RIs, 12 FCAs (including a federal cooperative college), and 17 faculties of agriculture and veterinary medicine (see list in Table A.1). Responses were also collected from ARCN. Within these 43 organizations, the survey was able to get responses from 366 individual researchers, including 10 ARCN staff.

The study summarizes the survey results from the 366 research staff, with 35 percent of results from RIs, 28 percent from FCAs (including veterinary medicine and fisheries), 35 percent from faculties of agriculture and veterinary medicine in relevant universities, and 3 percent from ARCN (Table 1). Because of the purposive clustering and explicit inclusion of women in the sample, about 30 percent of the total respondents were women. Compared with the ASTI dataset, which is a larger sample survey, the proportion of women in RIs is 27 percent, while in faculties of agriculture, it is 10 percent. This difference means that the sample overrepresents female researchers as compared with the population. This purposive clustering is important for identifying any systematic differences between women and men researchers in terms of their resources, opportunities, conditions, and productivity. In the analysis, gender is used as a control variable.

Table 1. Distribution of respondents by organization type and gender (N = 366 researchers)

		Gender	
Type of Organization	**Total**	**Male**	**Female**
Research institute	**127***	86 *	41*
	(35) **	*(68)** **	*(32)** **
Federal college	**102**	74	28
	(28)	*(73)*	*(27)*
University	**127**	88	39
	(35)	*(69)*	*(31)*
ARCN	**10**	7	3
	(3)	*(70)*	*(30)*
Total	**366**	**255**	**111**
	(100)	*(70)*	*(30)*

Source: IFPRI-ARCN survey (2010).
Notes: * Frequency. ** Figures in parentheses and italics are percentages to the total per organization type.

Across all survey respondents, 46 percent hold PhD degrees, 41 percent hold master's degrees (MSc), and 13 percent hold bachelor's degrees (BSc), (Table 2). There are fewer PhD holders in federal colleges (18 percent) as compared with those in research institutes (54 percent) and universities (65 percent). ARCN also has more BSc and MSc degree holders (90 percent) than PhD holders (10 percent). As a suggested future research area, there may be a need to look at the needs of federal colleges and ARCN in terms of either acquiring new PhD holders or providing long-term training for existing staff to cover the identified needs. Based on key informants, even in some research institutes, hiring PhDs holders or providing PhD training for existing staff in order to fill out staffing requirements has been difficult due to a lack of funding.

Table 2. Distribution of respondents by highest degree and organization type (N = 366 researchers)

	Organization Type				
Highest Degree	**Total**	**Research Institute**	**Federal College**	**University**	**ARCN**
Bachelor of Science (BSc)	48*	7	35	2	4
	*(13)***	*(6)*	*(34)*	*(2)*	*(40)*
Master of Science (MSc)	149	52	49	43	5
	(41)	*(41)*	*(48)*	*(34)*	*(50)*
PhD	169	68	18	82	1
	(46)	*(54)*	*(18)*	*(65)*	*(10)*
Total	**366**	**127**	**102**	**127**	**10**

Source: IFPRI-ARCN survey (2010).
Note: * Frequency; ** Figures in parentheses and italics are percentages to the total per organization type.

Across all respondents, 74 percent are between 31 and 50 years of age, while 18 percent are more than 50 years old, indicating a relatively young human stock for agriculture research (Table 3). However, the averages hide some differences across organization type. For example, there is a relatively greater percentage of older researchers in research institutes (30 percent) than in federal colleges (7 percent) and universities (19 percent). Comparing these figures with the highest degree in Table 2 indicates that there are quite a few young PhD holders across organization types, particularly in research institutes and universities. A relatively limited number of more senior and PhD holders in federal colleges may pose constraints in terms of availability of supervision and mentorship to younger research staff.

Table 3. Distribution of respondents by age group and organization type (N = 366 researchers)

Age Group	**Total**	**Research Institute**	**Federal College**	**University**	**ARCN**
Younger than 20 years old	11*	3	8	0	0
	*(3)***	*(2)*	*(8)*	*0*	*0*
21–30 years old	19	8	5	5	1
	(5)	*(6)*	*(5)*	*(4)*	*(10)*
31–40 years old	138	45	38	48	7
	(38)	*(35)*	*(37)*	*(38)*	*(70)*
41–50 years old	133	39	40	52	2
	(36)	*(31)*	*(39)*	*(41)*	*(20)*
51 years old and older	65	32	11	22	0
	(18)	*(25)*	*(11)*	*(17)*	*0*
Total	**366**	**127**	**102**	**127**	**10**

Source: IFPRI-ARCN survey (2010).
Notes: * Frequency; ** Figures in parentheses and italics are percentages to the total per organization type.

These characteristics are compared with available larger-sample surveys. For example, ASTI maintains a database of the number of researchers (both head count and FTE) in organizations involved in agricultural research in Nigeria. Due to this study's purposive clustering approach, we expect overall differences across the clusters, but we do not anticipate differences within clusters. Tables 4 and 5 present the comparison of the IFPRI-ARCN survey used in this study (2010) and the ASTI dataset (2009) in terms of education background and age group, disaggregated between gender and organization type. Available ASTI data allow comparisons among RIs and universities, but not FCAs.

Table 4. Distribution of respondents by age group, comparing IFPRI-ARCN and ASTI surveys (N = 356 researchers)*

Gender and Age	Total		Research Institute (RI)				University				FCA	
			IFPRI-ARCN (14 RIs)		ASTI-AWARD (15 RIs)		IFPRI-ARCN (17 faculties)		ASTI-AWARD (6 faculties)		IFPRI-ARCN (12 FCAs)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Male												
Younger than 20 years old	7**	(3)***	3	(3)							4	(5)
21–30 years old	12	(5)	5	(6)	24	(3)	4	(5)	24	(6)	3	(4)
31–40 years old	71	(29)	21	(24)	251	(33)	26	(30)	90	(22)	24	(32)
41–50 years old	105	(42)	32	(37)	263	(35)	40	(45)	149	(36)	33	(45)
51 years old and older	53	(21)	25	(29)	217	(29)	18	(20)	146	(36)	10	(14)
Total Male	**248**	**(100)**	**86**	**(100)**	**755**	**(100)**	**88**	**(100)**	**409**	**(100)**	**74**	**(100)**
Female												
Younger than 20 years old	4	(4)									4	(14)
21–30 years old	6	(6)	3	(7)	22	(9)	1	(3)	16	(12)	2	(7)
31–40 years old	60	(56)	24	(59)	106	(43)	22	(56)	43	(32)	14	(50)
41–50 years old	26	(24)	7	(17)	78	(32)	12	(31)	42	(31)	7	(25)
51 years old and older	12	(11)	7	(17)	41	(17)	4	(10)	35	(26)	1	(4)
Total Female	**108**	**(100)**	**41**	**(100)**	**247**	**(100)**	**39**	**(100)**	**136**	**(100)**	**28**	**(100)**

Source: IFPRI-ARCN survey (2010). Note: * Excluding 10 ARCN respondents; ** Frequency; *** Figures in parentheses and italics are percentages.

Table 5. Distribution of respondents by education, comparing IFPRI-ARCN and ASTI surveys (N = 356 researchers)*

Gender and Education	Total		RI				University				FCA	
			IFPRI-ARCN (14 RIs)		ASTI (15 RIs)		IFPRI-ARCN (17 faculties)		ASTI (28 faculties)		IFPRI-ARCN (12 FCAs)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Male												
BSc	30**	(12)***	3	(3)	192	(28)	2	(2)	386	(18)	25	(34)
MSc	84	(34)	29	(34)	270	(39)	22	(25)	619	(29)	33	(45)
PhD	134	(54)	54	(63)	226	(33)	64	(73)	1148	(53)	16	(22)
Total Male	**248**	**(100)**	**86**	**(100)**	**688**	**(100)**	**88**	**(100)**	**2153**	**(100)**	**74**	**(100)**
Female												
BSc	14	(13)	4	(10)	91	(35)	0	0	34	(14)	10	(36)
MSc	60	(56)	23	(56)	120	(46)	21	(54)	102	(43)	16	(57)
PhD	34	(31)	14	(34)	48	(19)	18	(46)	99	(42)	2	(7)
Total Female	**108**	**(100)**	**41**	**(100)**	**259**	**(100)**	**39**	**(100)**	**235**	**(100)**	**28**	**(100)**

Source: IFPRI-ARCN survey (2010). Note: * Excluding 10 ARCN respondents; ** Frequency; *** Figures in parentheses and italics are percentages.

Among RIs, the IFPRI-ARCN survey sample includes fewer male researchers 31–40 years old and more male researchers 41–50 years old as compared with the ASTI dataset (Table 4). Among university faculties, the IFPRI-ARCN survey sample includes fewer male and female researchers 51 years old and older, more male and female researchers 31–40 years old, and more female researchers 41–50 years old. For universities, male and female researchers 51 years old and older are underrepresented in the IFPRI-ARCN survey; female and male researchers 31–40 years old are overrepresented; and male researchers 41–50 years old are overrepresented. For RIs, female researchers 31–40 are overrepresented in the sample, whereas female researchers 41–50 years old are underrepresented.

For both RIs and universities, the IFPRI-ARCN survey includes more female and male researchers with PhDs and fewer researchers with BSc degrees only (Table 5). For researchers with MSc degrees, the sample includes slightly more male researchers and fewer female researchers. This means that the sample is likely to overrepresent researchers with PhD degrees and to underrepresent researchers with BSc degrees. Female researchers with MSc degrees are also overrepresented, whereas male researchers with MSc degrees are underrepresented. The results are controlled for in the analysis in terms of age group, gender, and education background.

4. RESULTS

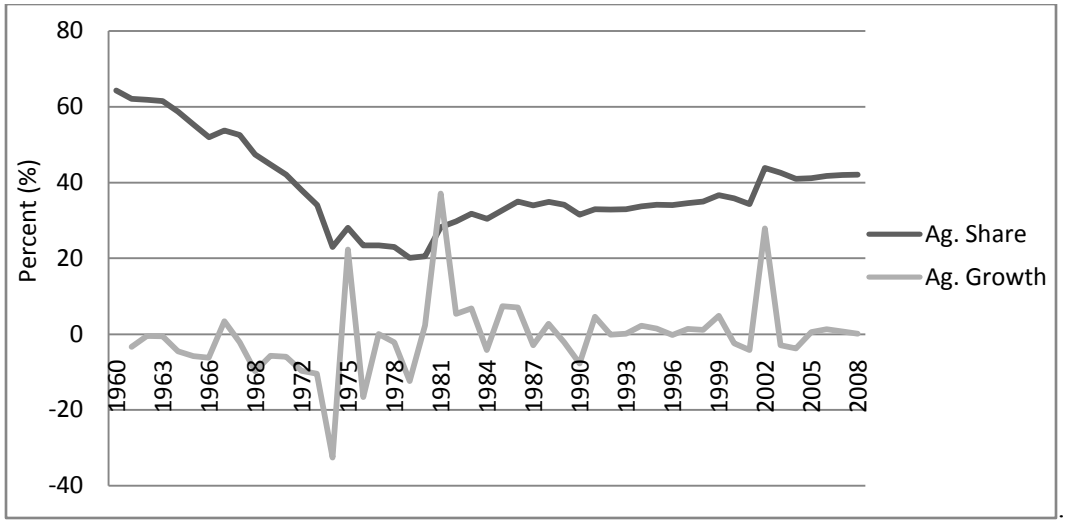
This paper provides a qualitative analysis and exploratory approach of the survey data following the conceptual framework. First, the performance of the agriculture sector is presented, followed by the organizational landscape of agricultural research in Nigeria. Then, research performance, as reported by organizations and by individual researchers, is presented, followed by the organizational capacity and organizational culture and individual capacity and incentives. The results of a simple correlation analysis between performance and organizational and individual characteristics are then presented. Training needs are presented, followed by discussions and policy implications.

4.1. Performance of the Agriculture Sector

Nigeria's agricultural development can be classified into three phases—namely, pre-1970, 1971–1985, and from 1986 to date. Figure 3 presents the agricultural GDP share and growth rate from 1960 to 2008. In the pre-1970 phase, private operators dominated production activities in the agriculture sector. The 1971–1985 period saw a pronounced decline in the share of agriculture value-added in GDP, in part because of the rising dominance of the oil sector, but also because of the extreme uncertainty in policy direction brought about by increased government intervention in the sector. Public-sector efforts during that time focused on importing massive quantities of fertilizers, chemicals, machinery, and seeds, as well as on developing infrastructure, such as dams, feeder roads, farm service centers, fertilizer distribution centers, and tractor hiring units. Yet growth performance during this period was highly erratic and associated with wide swings.

The post-1985 period saw a reduced direct intervention by the federal government, thereby allowing markets to function, which led to the return to growth in the sector. The share of agriculture value in GDP gradually increased, and growth performance was, on average, much better than in the previous two phases. The average annual sector growth rate from 2001 to 2008 was about 7 percent. The current growth of agriculture has, nonetheless, come from increasing the use of land rather than from gains in productivity.

Figure 3. Agriculture share of GDP and growth rates in real terms, 1960–2008 (percent)



Source: FMAWR (2010).

Overall, crops remain the dominant agricultural activity in Nigeria. The crop subsector contributes about 85 percent to the agriculture GDP, whereas livestock contributes about 10 percent, fisheries about 4 percent, and forestry about 1 percent. Of the crops subsector, roots (in particular, cassava and yam) dominate in tonnage, though cereals (maize, sorghum, rice, and millet) are becoming important for the domestic demand for food. The roots group accounts for 9 percent of GDP, whereas cereals account for 8 percent. The major problem with these crucial subsectors is that their current yields observed in farmers' fields are substantially below their potential yields, which are often predicted based on growth under idealized conditions of controlled field trials or maximum yields of comparable agroecological zones (Table 6). Based on official national yield data of major crops from the Nigerian government and estimates of potential yields by IFPRI, yield gaps range from 80 to 250 percent the current yield in major crops (Table 6). Thus, a key focus should be to facilitate yield enhancement.

Table 6. Estimated current and potential yield of selected major crops in Nigeria, 2009 (metric tons per hectare)

Crop	Current Yield	Potential Yield
Cassava	12.3	28.4
Yam	12.3	18.0
Rice	1.9	7.0
Maize	1.4	4.0
Sorghum	1.1	3.2
Millet	1.1	2.4

Source: The current yields come from FMARD (2007) and NBS (2005); the potential yields come from ReSAKSS WA (2009).

4.2. Organizational Landscape of Agriculture Research

ARCN, which is responsible for the oversight and management of Nigeria's agricultural research system, is under the Federal Ministry of Agriculture and Water Resources (FMAWR). Within the oversight of ARCN are 15 RIs, which focus on specific commodity or thematic areas, and 11 FCAs, which are linked to the RIs for research, training, and outreach. Federal cooperative colleges (FCCs) are also linked with ARCN and research organizations for training and outreach activities. A high degree of decentralization exists among research institutes. Each RI has about 5–20 substations or experimental stations situated in strategic areas across the country.

In addition, there are three universities of agriculture (University of Agriculture, Abeokuta [UNAAB]; Michael Okpara University of Agriculture, Umudike [MOUAU]; and University of Agriculture, Makurdi [UAM]) and several faculties of agriculture and veterinary medicine (and other agriculture-related faculties) under federal and state universities. These other universities and faculties educate and train researchers and players in the agricultural sector; they also perform research to some extent. These universities and faculties are all under the Ministry of Education.

The Ministry of Environment is linked to ARCN and other research organizations related to biotechnology and biosafety issues. The Ministry of Science and Technology and its research institutes are linked to FMAWR and ARCN. The Ministry of Commerce is linked to the ARCN and FMAWR in terms of the working of commodity markets.

Several international and regional organizations are working with FMAWR and ARCN on agricultural and research policy issues. These include CGIAR (including the International Institute of Tropical Agriculture (IITA), International Livestock Research Institute [ILRI], IFPRI, International Center of Tropical Agriculture or Centro Interamericano de Administraciones Tributarias [CIAT], International Crops Research Institute for the Semi-arid Tropics [ICRISAT], and Africa Rice Center [WARDA]), Africa Union Commission / New Partnership for Agricultural Development (AUC/NEPAD), Forum for Agricultural Research in Africa (FARA), FAO, U.S. Agency for International Development (USAID), World Bank, African Development Bank (AfDB), Brazilian Agricultural Research Corporation

(EMBRAPA), Kenya Agricultural Research Institute (KARI), and Indian Council of Agricultural Research (ICAR).

Producer associations also play a major role in Nigeria's agricultural and research policy process. The Rice Farmers Association, Poultry Association, Cocoa Processors Association, National Rubber Association, Catfish Farmers Association, and Cassava Growers Association are among the influential associations in terms of agricultural and research policy agenda.

4.3. Research Performance

The measures of performance at the organization level are presented first, followed by measures of performance at the individual researcher level.

4.3.1 Organization Level

All organizations reported having formal, written statements describing the main purpose of their organizations. Each organization was asked whether they have formal monitoring and evaluation (M&E) systems that trace their outputs and performance over time. Across all organizations, about half reported having M&E systems. Among those that reported the presence of M&E systems, the majority (76 percent) said that they were either very satisfied or satisfied with the implementation of those systems, whereas 24 percent said that they had limited satisfaction or were not satisfied with the implementation. Of those with M&E systems, the common research outputs that those organizations monitor included the number of publications and technologies produced. Table A.2 presents the other research performance measures suggested by respondents.

4.3.1.1 Technologies

Most of the technologies reported were produced in research institutes. Since 1997, 205 technologies have been produced, including 58 biological and technological technologies (with LCRI and NRCRI contributing 9 biological technologies each); 56 mechanical technologies (with IAR&T contributing 30 of these); 19 chemical technologies (with Nigeria Institute For Oil Palm Research (NIFOR) and Rubber Research Institute of Nigeria (RRIN) contributing 5 each of these technologies); and 72 management technologies (with National Animal Production Research Institute (NAPRI) contributing 13 and Cocoa Research Institute of Nigeria (CRIN) contributing 11). Table 7 presents the key technologies produced by the research institutes. Although the number of technologies produced seems substantial, ARCN or the institutes do not monitor the adoption or impact of these technologies. As discussed below, 40 percent of individual researchers did not have any knowledge about the adoption or impact of new varieties or breeds that they have been produced, and 20 percent did not have information about the adoption or use of new management practices or technologies developed (see Table 13).

Table 7. Number of technologies produced by research institutes, 1997–2008

Organization	Biological Technologies	Mechanical Technologies	Chemical Technologies	Management Technologies
Cocoa Research Institute of Nigeria (CRIN)	2	0	0	11
Institute for Agricultural Research (IAR)	5	30	0	7
Institute of Agricultural Research and Training (IAR&T)	4	1	2	4
Lake Chad Research Institute (LCRI)	9	0	0	0
National Agricultural Extension and Research Liaison Services (NAERLS)	0	0	0	0
National Animal Production Research Institute (NAPRI)	6	4	0	13
National Cereals Research Institute (NCRI)	4	0	0	6
National Institute for Fresh Water Fisheries (NIFFR)	4	4	0	2
National Institute for Oil Palm Research (NIFOR)	3	6	5	5
National Institute for Horticultural Research (NIHORT)	4	0	1	0
Nigerian Institute of Oceanography and Marine Research (NIOMR)	0	0	0	4
National Root Crops Research Institute (NRCRI)	9	4	3	7
National Stored Products Research Insitute (NSPRI)	0	2	0	5
National Veterniary Research Institute (NVRI)	4	1	3	0
Rubber Research Institute of Nigiera (RRIN)	4	4	5	8
Total	**58**	**56**	**19**	**72**

Source: ARCN (2010a).

Among the 12 FCAs, FCA-Ibadan (8 technologies), Federal College of Veterinary and Medical Laboratory Technology (FCVMLT), Vom (2 technologies), and Federal College of Animal Health and Production Technology (FCAHPT), Ibadan (3 technologies) reported some technologies generated since 2005, while other FCAs reported no technologies generated.

Of the 18 faculties of agriculture that responded, only the College of Agronomy at the University of Makurdi (6 technologies), the Faculty of Agriculture at Obafemi Awolowo (OAU) in Ile-Ife (5 technologies), the Faculty of Agriculture at the University of Nigeria (2 technologies), and the Federal University of Technology (FUTA) in Akure (1 technology) reported having technologies that had been produced since 2005. In all technologies produced, these faculties reported at least one international collaborator and at least one regional or national collaborator.

4.3.1.2 Publications

The organizational level had limited responses about the number of publications. The completed responses covered only 21 organizations (10 RIs, 7 FCAs, and 4 FAs). Among those that responded, the number and publications varied significantly across organizations. Overall, about 30 percent had international research collaboration; 50 percent had regional or national research collaboration; and only 30 percent of the organizations had knowledge of the use, influence, or impact of publications produced.

Of the 10 RIs questioned, the number of books and journal articles published since 2007 varied significantly: Books published ranged from 0 to 50; articles in international and regional journals both ranged from 0 to 150 ; and articles in national journals ranged from 0 to 200 (Table 8). Most organizations did not have co-authors from other international, regional, or national research organizations, except National Veterinary Research Institute (NVRI), Vom, NCRI-Badeggi, and LCRI-Maiduguri for journals and NIHORT and Institute of Agricultural Research and Training (IAR&T) for books. Most organizations (about 60 percent) did not have any information about the use and impact of these publications.

Of the seven FCAs, the number of books and journal articles published since 2007 varied significantly: Books published ranged from 0 to 15; articles in international journals ranged from 0 to 36; articles in regional journals ranged from 0 to 40; and articles in national journals ranged from 0 to 165. Most of these articles did not have international co-authors, though most had regional or national co-authors. Most organizations (70 percent) did not have any information regarding the use and impact of these publications.

Of the four faculties, the number of books and journal articles published since 2007 varied significantly: Books published ranged from 0 to 20; articles in international journals ranged from 20 to 100; articles in regional journals ranged from 15 to 150; and articles in national journals ranged from 0 to 400. Most articles had regional or national co-authors. Most organizations (75 percent) did not have any information on the use and impact of these publications.

4.3.1.3 Patents, Awards, Networks, and Formal Collaboration

In terms of patents, of the 43 organizations that responded, only 4 reported any patent produced: National Cereals Research Institute (NCRI), Badeggi (1 patent), Lake Chad Research Institute (LCRI), Maiduguri (4 patents), CRIN-Ibadan (5 patents), and Federal College of Freshwater Fisheries Technology (FCFFT), New Bussa (1 patent). No faculty of agriculture or veterinary medicine reported any patent produced.

In terms of awards, of the 43 organizations that responded, only 7 reported receiving at least one award since 2007. No FCA reported any award received. Among RIs, NRCRI, NCRI, National Institute for Freshwater Fisheries Research (NIFFR), and RRIN each reported at least one award received since 2007. Among faculties, FUTA, University of Abeokuta, and FA-University of Ilorin each received at least one award since 2007.

In terms of networks, all organizations reported membership in at least one professional network or association.

Table 8. Number of publications by organization, type of publication, collaboration, and perception of use and impact (N = 21 organizations)

Organization	Book				International Journal				Regional Journal				National Journal			
	No.*	Intl.	Regl.	Use	No.	Intl.	Regl.	Use	No.	Intl.	Regl.	Use	No.	Intl.	Regl.	Use
Research Institute (10)																
NRCRI-Umudike	8	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0
NVRI-Vom	1	DK	DK	1	38	29	41	0	10	40	40	0	33	16	21	0
NIHORT-Ibadan	50	17	0	0	28	0	0	0	106	0	0	0	0	0	0	0
NCRI-Badeggi	2	0	0	0	14	25	25	0	3	33	100	0	25	0	25	0
NIFFR-New Bussa	2	0	100	0	15	0	100	0	19	0	100	0	31	0	100	0
IAR-Zaria	DK	DK	DK	1	25	DK	DK	1	1	DK	DK	1	20	DK	DK	1
LCRI-Maiduguri	0	0	0	0	5	0	100	1	8	0	100	1	21	0	100	1
IAR&T-Ibadan	30	5	0	0	150	0	0	0	150	0	0	0	200	0	0	0
CRIN-Ibadan	7	0	0	0	65	0	0	0	85	0	0	0	156	0	0	0
NIOMR-Lagos	0	0	0	0	30	0	0	1	28	0	0	0	48	0	0	0
FCA (7)																
FCA-Akure	15	0	10	1	30	0	90	1	40	0	80	1	60	0	95	1
FCA-Ibadan	15	67	33	0	9	0	28	0	3	0	9	0	3	0	10	0
FCVMLT-Vom	3	0	67	0	35	0	100	0	25	0	70	0	40	0	100	0
FCAHPT-Ibadan	15	0	0	1	36	10	12	1	14	15	8	1	165	20	10	1
FCFFT-New Bussa	3	0	20	1	9	DK	DK	0	3	DK	DK	0	14	DK	DK	0
FCMFT-Lagos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FCFFT-Baga	0	0	0	0	0	0	0	0	0	0	0	0	6	0	10	0
Universities (4)																
FA-FUTA-Minna	0	0	0	0	30	0	100	0	78	0	100	0	160	0	100	0
FA-OAU-Ile Ife	0	0	0	0	20	0	0	0	15	0	0	0	13	0	0	0
FA-UNN	10	40	60	0	>20	10	90	0	>50	10	90	0	0	0	0	0
FA-UNICAL	20	10	20	0	100	10	20	1	150	15	18	1	400	5	10	1

Source: IFPRI-ARCN survey (2010).

Notes: No. = Number of publications; Intl. = Percentage of publications with at least one international co-author; Regl. = Percentage of publications with at least one regional or national co-author (outside own organization); Use = dummy (1 = if organization had information on the use, impact, or influence of publication; DK = don't know.

In terms of collaboration, only limited formal linkages were reported to exist between organizations and external partners (Table 9). Although organizations reported some linkages with farmers' organizations, only 27 percent had institutional mechanisms for formal collaboration. Among the challenges for strengthening collaboration that were consistently identified by organization heads are (1) inadequate funding to facilitate interaction among farmers; (2) lack of project vehicles and mobility; (3) no forum for interaction; (4) weak leadership and coordination within research organizations; (5) weak implementation of some parts of the memorandum of understanding (MOU); (6) lack of interest on the part of farmers' organizations; and (7) weak farmers' organizations, associated with low literacy and a lack of mobilization and capacity building. Only 17 percent of organizations reported having formal collaborations with agro-industries, while 24 percent of organizations had formal collaborations with nongovernmental organizations (NGOs). A better trend is seen in research organizations' formal collaboration with international partners (48 percent of respondents), training institutes (54 percent), research institutes (58 percent), higher-education institutes (53 percent), and ministry of agriculture staff (52 percent).

Table 9. Distribution of organizations based on level of formal collaboration (N = 43 organizations)

Type of Organization	With Informal Interaction (% total respondents)	With Formal Collaboration (% of total respondents)	Challenges in Collaboration
Farmers' organization	100	27	Inadequate funding to facilitate interaction; lack of project vehicle; no forum for interaction and poor leadership structure; weak implementation of some part of the MOU; lack of interest on the part of the farmers; very weak farmers' organization; lack of farmers' mobilization and group formation; lack of sustainability of collaborative efforts; illiteracy of some farmers
NGOs	69	24	Inadequate funding; lack of interest on the part of NGOs; bureaucracy and delay in signing the MOU; weak mobilization; lack of sustainability of collaborative effort; lack of project vehicle
International partners	66	48	Problem of fulfilling counterpart funding; funding limitation; communication gap; lack of sustainability of collaborative efforts; competition among researchers; inadequate research facilities; lack of mobility
Training institutes	73	54	Inadequate funding; stress sometimes affects program; few physical spaces for interaction; difficult to find interested partners; lack of sustainability of collaboration; limited mobility
Research institutes	77	58	Inadequate funding; stress sometimes affects program; competition among researchers; communication gap; lack of sustainability of collaborative effort; program overlap; bureaucracy
Higher-education institutes	78	53	Inadequate funding; competition; difficulties in getting response; inadequate space; divergent areas of focus
Private sector	46	17	Strict term of agreement; competition; limited funds; lack of sustainability of collaborative efforts
Ministry of agriculture	81	52	Inadequate funding; bureaucracy; no responsiveness on proposal; difficulty in obtaining required data; delay in release of funds; administrative bottlenecks; late transfer of information to the institutes; limited training of human resources

Source: IFPRI-ARCN survey (2010).

There are differences in terms of formal linkages by organization type (Table 10). More than half of the RIs reported having formal linkages with other RIs, colleges, and universities; half had formal linkages with training institutes and international and regional development partners; and fewer than 30 percent had formal linkages with the private sector, farmers' organizations, and NGOs. The linkages among FCAs are even more limited, with less than half of all FCAs having formal linkages to any stakeholder group. Only 43 percent of FCAs reported having formal linkages with research institutes, while 36 percent had formal collaboration with farmers' organizations. Among faculties, more than half had formal linkages with training institutes, half had formal collaboration with research institutes, and 43 percent had formal partnerships with international and regional development organizations and other universities and colleges.

Table 10. Distribution of organizations based on formal collaboration, 2010 (N = 43 organizations)

Organization Type	Farmers' Organizations	NGOs	International and Regional Development Partners	Training Institutes	Research Institutes	Higher-Education Institutes	Private Sector
Research institute (out of 14 institutes)	4	2	7	7	10	9	4
	(29)	*(14)*	*(50)*	*(50)*	*(71)*	*(64)*	*(29)*
FCA (out of 12 colleges)	5	2	2	3	6	4	1
	(36)	*(14)*	*(14)*	*(21)*	*(43)*	*(29)*	*(7)*
Universities (out of 17 faculties)	3	4	6	8	7	6	3
	(21)	*(29)*	*(43)*	*(57)*	*(50)*	*(43)*	*(21)*

Source: IFPRI-ARCN survey (2010).

The status of the research performance presented thus far indicates an overall weakness in the level of collaboration and in monitoring the use, influence, and impact of technologies and publications being produced. Results also indicate that organizations vary significantly, with some organizations more productive, well-connected, and aware of the adoption and impact of their research outputs than others. To give a quick indication of which organizations are good or bad performers, the survey also asked organization heads to name the top three best-performing organizations in each organization type, excluding their own organization (Table 11). NVRI tops the list for RIs, with 15 respondents; FCA-Akure leads the FCAs, with 15 counts; and University of Ibadan and ABU-Zaria lead among FAs, with 13 and 12 counts, respectively, and among FVMs, with 17 and 15 counts, respectively. These indications of good or bad performance will be used in subsequent sections to identify potential factors that explain variations in performance.

Table 11. Frequency of organizations considered good performers, 2010

Organization	Frequency of Mention
Research Institutes	
National Veterinary Research Institute (NVRI)	15
National Root Crops Research Institute (NRCRI)	8
Nigerian Institute for Palm Oil Research (NIFOR)	7
National Institute for Horticultural Research (NIHORT)	7
Institute of Agricultural Research and Training (IAR&T)	7
National Cereals Research Institute (NCRI)	6
Institute for Agricultural Research (IAR)	6
Cocoa Research Institute of Nigeria (CRIN)	5
National Agricultural Extension and Research Liaison Services (NAERLS)	4
National Animal Production and Research (NAPRI) (only individual researchers)	3
Nigerian Institute of Oceanography (NIOMR)	2
Lake Chad Research Institute (LCRI)	2
National Institute for Fresh Water Fisheries Research (NIFFR)	2
Nigerian Stored Products Research Institute (NSPRI)	2
Rubber Research Institute of Nigeria (RRIN)	1
Federal Colleges of Agriculture (FCA)	
FCA-Akure	15
FCA-Ibadan	7
FCAHPT-Ibadan	6
FCA-Ishiagu	5
FCAH&PT-Vom	4
FCMFT-Lagos	3
FCVMLT Vom	3
FCFFT-New Bussa	3
FCFFT-Baga	1
FCH-Dadin Kowa	1
FCPI&SPT-Kano	1
Faculties of Agriculture (FA)	
UI-FA-Ibadan	13
ABU-FA-Zaria	12
OAU-FA-Ile Ife	8
UNAAB-FA-Abeokuta	9
FUTA-Akure	6
MOUA-Umudike	5
UAM-Col. of Agronomy-Makurdi	4
UNN-FA-Nsukka	3
UNILORIN-FA	2
ATBU-FA-Bauchi	2
Univ. of Uyo-FA	0
UNIPORT-FA	0
Unical-FA	0
Univ of Benin-FA	0
UA-FA-Abuja	0
FUTA-FA-Minna	0
FCC-Kaduna	0
Faculties of Veterinary Medicine (FVM)	
UI-FVM-Ibadan	17
ABU-FVM-Zaria	15
UNIMAID-FVM-Maiduguri	7
UNN-FVM-Nsukka	6
UNAAB-FVM-Abeokuta	4
UAM-CVM-Makurdi	0
UA-FVM-Abuja	0
MOUA-Umudike-FVM	0

Source: IFPRI-ARCN survey (2010).

4.3.2 Individual Researcher's Level

Research outputs by individual researchers include number of research projects led since 2005, technologies produced since 2005, publications produced since 2007, and number of linkages.

4.3.2.1 Research Projects

Organization types varied in terms of the number of research projects led by individual researchers (Table 12). Across all organization types, the number of research projects led by researchers since 2005 ranged from 0 to 32. The majority of these research projects had no international, regional, or national collaborators. For RIs, 74 percent had no international collaborators, and 61 had no regional or national collaborators; for FCAs, 97 percent had no international collaborators, and 88 percent had no regional or national collaborators; and for faculties, 85 percent had no international collaborators, and 79 percent had no regional or national collaborators.

Among RIs, 21 percent of researchers did not lead any research project, while 66 percent were leading 1 to 6 research projects. Among FCAs, 66 percent of respondents were not leading any research project, and 17 percent had 1 or 2 research projects that they were leading. Among faculties, 28 percent were not leading any researcher projects, while 28 percent were leading1 or 2 research projects.

4.3.2.2 Technologies

In terms of technologies generated since 2005, more than 95 percent of research staff in federal colleges and universities did not produce new breeds or varieties, compared with 77 percent of staff from research institutes who did not produce any of these new varieties (Table 13). More than 83 percent of research staff in federal colleges and universities had not produced any management technologies since 2005, while 53 percent in research institutes did not generate any of these technologies. Within RI, each researcher produced an average of one new varieties and one new management technology since 2005, although the range of technologies produced by each research can be from zero to 15 new varieties and from zero to 10 new management technologies.

In RIs, about 45 percent of researchers reported having international, regional, or national collaborators in developing their new varieties. Of the 5 researchers in FCAs and universities who had produced new varieties, only one respondent had at least one national or regional collaborator but no international collaborator.

In terms of management technologies, about 50 percent of RI researchers reported having regional or national collaborators, while 28 percent reported having international collaborators in developing their new management technologies. In FCAs, 62 percent of researchers had a national collaborator. In universities, 33 percent had an international collaborator, while 47 percent had national or regional collaborators.

In terms of knowledge of the adoption of new varieties of technology, 38 percent of the 26 RI researchers who reported producing at least one new variety had no knowledge of the adoption; 8 percent said their technologies had limited adoption (less than 20 percent); 35 percent said their technologies had moderate adoption (21–40 percent); and 19 percent said their technologies had wide adoption (41 percent or more). Of the five researchers in FCAs and universities that reported new breeds, one had no knowledge of adoption; one reported limited adoption; two had moderate adoption; and one reported wide adoption.

Table 12. Distribution of individual respondents based on number of research projects they are leading, 2010 (N = 366 researchers)

Number of Projects the Individual Researcher Is Leading	RI	FCA	University	Number of Projects with International Research Collaborators	RI	FCA	University	Number of Projects with Regional and National Research Collaborators	RI	FCA	University
0	27*	67	36	0	95	99	108	0	78	90	100
1	6	10	18	1	17	3	17	1	13	6	16
2	20	7	18	2	9			2	21	1	3
3	22	3	12	3	3		1	3	3	2	
4	14	4	7	4	2			4	3		2
5	10	1	8	5			1	5	3		
6	12	2	5	10	1			6	2	3	1
7	3	1	2					8			1
8	3	2	4					9	1		
9	2	1						10	2		4
10	3	1	6					12	1		
12	1	1	3								
13		1									
14	1										
15	1		2								
16			1								
17			1								
18			1								
20		1	2								
25	1										
30			1								
32	1										

Source: IFPRI-ARCN survey (2010).
Note: * Frequency.

In terms of knowledge of management technologies produced, out of 47 RI researchers who reported having at least one management technology produced, 21 percent had no knowledge of adoption, whereas almost 30 percent knew of at least limited, moderate, or wide adoption of their technologies. In FCAs, almost half did not have knowledge of adoption. In universities, 73 percent did not have knowledge of adoption of their technologies.

Table 13. Distribution of respondents based on technologies produced, 2005–2009 (N = 366 researchers)

Number of Variety or Breed of Technology Produced	RI	FCA	Univ.	Number of Management Technologies Produced	RI	FCA	Univ.
0	101*	98	126	0	80*	89	112
1	13	3	1	1	19	9	7
2	5	1		2	13	2	3
3	1			3	6	1	2
4	1			4	3		1
5	1			5	3		2
8	1			6	1	1	
12	2			8	1		
15	2			10	1		
Total respondents with nonzero technologies produced	26	4	1	Total respondents with nonzero technologies produced	47	13	15
Number of respondents with international collaborator	11	0	0	Number of respondents with international collaborator	13		5
Number of respondents with regional or national collaborator	12	1	0	Number of respondents with regional or national collaborator	24	8	7
Distribution of respondents based on knowledge of adoption of technology produced				**Distribution of respondents based on knowledge of adoption of technology produced**			
1 = No knowledge	10*		1	1 = No knowledge	10*	6	11
2 = No adoption				2 = No adoption	1		1
3 = Limited adoption	2	1		3 = Limited adoption	11	3	2
4 = Moderate adoption	9	2		4 = Moderate adoption	12	3	1
5 = Wide adoption	5	1		5 = Wide adoption	13	1	

Source: IFPRI-ARCN survey (2010).
Note: * Frequency.

4.3.2.3 Publication

Publications considered in the survey are books and journal articles in international, regional, and national journals. Overall, researchers in universities had the most publications, followed by researchers in RIs; staff in FCAs had fewer publications (Table 14). Across all organization types, 30 percent of researchers in RIs, 56 percent of researchers in FCAs, and 13 percent of those in universities were not first authors on any publications since 2007. For those who reported some publications, there was a wide range in the total number reported. In RIs, 57 percent of researchers reported 1 to 10 publications as first author, though the number of publications as first author reached as high as 46 publications. In FCAs, 41 percent of staff reported 1 to 10 publications as first author, though that number reached as high as 24 publications. In universities, 64 percent of staff reported 1 to 10 publications as first author; the maximum reported was 35 publications as first author. In addition, 79 percent of researchers in RIs, 50 percent in

FCAs, and 85 percent in universities had more publications as second author, with the number of publications per researcher ranging from 1 to 40 publications.

Table 14. Distribution of respondents based on publications produced, 2007–2009 (N = 366 researchers)

	First Authorship				Second Authorship			
	RI	FCA	University	ARCN	RI	FCA	University	ARCN
Number of Publications								
0	30*	56	13	80	21	50	15	80
1–10	57	41	64	20	66	43	70	20
11–20	6	2	17	0	8	7	13	0
21–30	6	1	5	0	4	0	1	0
31–40	0	0	2	0	1	0	0	0
41–50	1	0	0	0	0	0	0	0
Collaboration**								
With international co-authors	34**	22	29	0	31	12	28	-
With regional and national co-authors	79	82	67	50	74	80	61	-
Number of dissemination events for publications**								
0	24**	33	25	0	35	35	42	50
1–10	64	67	70	100	60	63	56	50
11–20	10	0	3	0	4	2	2	0
21–30	0	0	1	0	1	0	0	0
31–40	1	0	0	0	0	0	0	0
41–50	1	0	1	0	0	0	0	0

Source: IFPRI-ARCN survey (2010).
Notes: * Percentage to total number of organizations; ** Percentage to total number of organizations with nonzero publications.

For those researchers who were the first author on publications, a majority (66 percent in RIs, 78 percent in FCAs, and 71 percent in universities) had international co-authors (Table 14). However, the majority of researchers (79 percent in RIs, 82 percent in FCAs, and 67 percent in universities) reported having at least one regional or national co-author. A similar pattern exists for researchers who were second authors on their publications.

For those researchers with publications, a majority (76 percent in RIs, 67 percent in FCAs, and 75 percent in universities) had disseminated the research findings in at least one event. A similar pattern exists for researchers who were second authors on their publications. The number of dissemination events for publications per researcher reached as high as 42 events for publications as first author and 30 events for publications as second author.

Table 15. Distribution of respondents based on level of interaction with stakeholders (percent) (N = 366 researchers)

Stakeholders	Research Institutes				Federal Colleges				Universities				ARCN				Total			
	1*	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Farmers	14**	44	17	25	34	32	13	22	26	54	11	10	33	56	-	11	25	44	13	18
2. Extension agents	29	39	17	15	68	22	4	6	55	36	3	6	67	33	-	-	51	33	8	9
3. Private sector	39	52	5	3	51	39	4	5	42	54	2	2	83	17	-	-	45	48	4	3
4. NGOs	56	38	6	1	75	24	1	-	78	19	2	1	83	17	-	-	69	27	3	1
5. Staff of other research and higher-education institutes	6	55	11	28	5	51	15	28	8	59	11	22	-	83	-	17	6	56	12	26
6. International research organizations	45	47	3	5	81	16	3	-	52	40	5	3	33	50	17	-	58	36	4	3
7. Regional research organizations	60	38	-	2	86	14	-	-	84	13	3	-	33	50	-	17	75	22	1	1
8. Ministry of Agriculture staff	39	46	6	9	54	40	3	3	48	43	7	2	17	50	-	33	46	43	5	5

Source: IFPRI-ARCN survey (2010).
Notes: * 1 = Never; 2 = a few times a year; 3 = about once a month; 4 = several times a month; ** Figures are in percent to total respondents per organization type.

4.3.2.4 Level of Interaction

In terms of the degree of interaction with relevant stakeholders in developing these new technologies, a large proportion of all respondents had no interaction with relevant stakeholders—25 percent had no interaction with farmers, 51 percent never interacted with extension agents, 44 percent never interacted with the private sector, 69 percent had no interaction with NGOs, 58 percent had not spoken with international research organizations, 76 percent had not interacted with regional research organizations, and 46 percent had never spoken with Ministry of Agriculture staff (Table 15). Of all respondents, 6 percent never interacted with staff in other research institutes or higher-education institutes. The degree of collaboration for research was much better for research institutes and worst for federal colleges. About 34 percent of researchers in federal colleges had no interaction with farmers, 68 percent had no interaction with extension agents, 51 percent had no interaction with the private sector, 75 percent had not interacted with NGOs, and at least 80 percent had not spoken with any international or regional research organizations.

Analysis at the individual level confirms limited research collaboration or interaction with farmers and other actors in the innovation system. It also confirms limited knowledge about the use and impact of technologies and publications developed. Moreover, it echoes the findings at the organizational level that individual researchers' innovative performance vary widely. It will be important to look at potential factors that explain the variations in innovative performance across individual researchers.

4.4. Organizational Capacity

This section is structured as follows: (1) adequacy of human resources, (2) adequacy of physical resources, and (3) nature of procedures and systems in place.

4.4.1 Adequacy of Human Resources

Respondents were asked to rate the adequacy of human resources in their organization. Across all organizations, a majority said that they were either somewhat satisfied (43 percent of organizations) or satisfied (33 percent) with the adequacy of personnel in the main station or headquarters in performing the organization's mission (Table 16). The remaining 23 percent of organizations were either not satisfied (13 percent) or had little satisfaction (10 percent) the adequacy of their personnel to perform the organization's mission. The picture is less encouraging for substations (including zonal stations and experimental stations). Across all organizations, 61 percent were either not satisfied (26 percent) or had little satisfaction (35 percent) with their substation's human resource adequacy to perform the organization's mission. About 26 percent were somewhat satisfied, while the remaining 13 percent were either satisfied or very satisfied.

The level of satisfaction pertains to both the quantity and quality of human resources. A total of 19 respondents specifically mentioned the need for training and retraining of staff on both technical knowledge and soft skills. Two respondents specifically highlighted the need for training staff on specialized technical knowledge on the organization's priority research areas. Two respondents mentioned the need for sensitization and mind-set reorientation for researchers to focus on effects on the ground and useful innovations. Two respondents even mentioned that research facilities and equipment had been donated to and made available to the organizations but that none of the staff knew how to use them. Respondents remarked on the need to carry out a better matching of human resources with facilities and equipment for more efficient use of resources. A total of 16 respondents mentioned the need to hire more staff, especially well-qualified and skilled labor, to fill vacancies. Outposting senior officers to substations was highlighted by two respondents.

Table 16. Distribution of organizations based on adequacy of human resources (N = 43 organizations)

S tations	Percentage of Respondents Based on Level of Satisfaction (%)					Suggestions for Improvement	
	1*	2	3	4	5	Specific suggestions	Number of respondents
Headquarters (N = 43)	**13**	**10**	**43**	**33**	**0**		
						Training and retraining of staff	19
						Employment of well-qualified, skilled laborers	16
						Training in priority specialized areas	2
						Post senior research officers to outstations	2
						Match personnel resources with research and laboratory facilities	2
						Mind-set reorientation for researchers toward impacts and innovations	2
Substations (N = 23)**	**26**	**35**	**26**	**9**	**4**		
						Exposure to international research organizations and international meetings and conferences	2

Source: IFPRI-ARCN survey (2010).
Notes: * 1 = Not satisfied; 2 = little satisfied; 3 = somewhat satisfied; 4 = satisfied; 5 = very satisfied; ** For each organization, the figure is the average score for all substations.

A closer look at existing human resources reveals that a majority of organizations have a significant number of staff vacancies, including research staff and research technicians. These vacancies make up a significant share of the number of established positions required to perform each organization's mission. Table 17 presents a sample staff profile, including the number of established positions and vacancies of a research institute. This sample institute has many similarities with existing organizations. First, the level of vacancies is about half of the currently employed research staff. Second, more BSc and MSc degree holders are employed than what is needed, while a large number of positions requiring PhD holders are left vacant. Key informants indicate that the main reasons for this second issue include (1) a freeze in hiring in 2007, (2) a current lack of PhD holders who can be hired to fill the positions, (3) a lack of funding to hire, and (4) limited opportunities for existing MSc degree holders to enroll in a PhD program. Third, only a small proportion of female staff are employed, especially in research. In the sample, only 12 percent of those currently employed as researcher scientists are female; 28 percent of research technicians are female; and 30 percent of administration and finance staff are female.

Table 17. Staff profile for a sample research institute (May 2010)

Category	Number of Established Positions Needed to Achieve Organization's Mission	Number of Staff Currently Employed			What Is the Current Vacancy?	If There Is Vacancy, Since When?	If There Is Vacancy, Why?
		Total	Male	Female			
1. Research scientist	71	49	43	6	22	2007	Embargo on employment
PhD	49	16	14	2	33		
MPhil	0	0	0	0	0		
MSc	15	33	29	4	-18		
BSc/BA	8	0	0	0	8		
2. Research technologist	45	39	28	11	6	2007	Embargo on employment
PhD	5	0	0	0	5		
MPhil	0	0	0	0	0		
MSc	20	5	2	3	15		
BSc/HND*	20	34	26	9	-14		
3. Finance and administrative staff	193	172	121	51	21	2007	Embargo on employment

Source: IFPRI-ARCN survey (2010)
Note: *Higher National Diploma.

Compared with the situation described by Idachaba (1998), staff turnover appears to be a lesser concern in the Nigerian NARs. Still, 16 percent of organizations reported that staff turnover is a problem, which is a greater source of concern in federal colleges and research institutes than in universities (Table 18). Staff turnover occurs at all levels (from junior staff to top management staff). Low salary, better salary elsewhere, and lack of prospects for career development were the more consistently mentioned causes of staff turnover.

Table 18. Distribution of organizations based on degree of staff turnover (N = 43 organizations)

	All	Research Institutes	Federal Colleges	Universities	ARCN
Organizations that said staff turnover is a problem (%)	16*	20	29	8	0
Causes					
Low salary	4**	2	1	1	0
Better salary elsewhere	3	2	0	1	0
Lack of prospects for career development	2	2	0	0	0
Frequent changes of the leadership	1	0	0	1	0
Levels of staff turnover					
Junior research staff	2	2	0	0	0
Senior research staff	2	1	0	1	0
Research technologist	1	1	0	0	0
Top management	1	1	0	0	0

Source: IFPRI-ARCN survey (2010). Notes: * Percentage; ** Frequency.

In terms of years that research staff have stayed with an organization, 43 percent have been with their current organization for at least 10 years, while 42 percent have been with their current organization for more than 2 years (Table 19). These findings are consistent with information in Table 18, which demonstrates a lesser degree of staff turnover as had been depicted in the 1990s. More staff members in research institutes have stayed with their current organization for more than 10 years than have those in federal colleges and universities. More research staff with one to two years in their current organization are in federal colleges than in research institutes and universities; more research staff with 2 to 5 years in their current organization are in universities than in research institutes and federal colleges.

Table 19. Distribution of respondents by years in an organization and organization type (N = 366 staff)

Years in the Organization	Total	Research Institute	Federal College	University	ARCN
Less than 6 months	10*	0	6	4	0
	*(3)***	*0*	*(6)*	*(3)*	*0*
6–11 months	6	0	2	4	0
	(2)	*0*	*(2)*	*(3)*	*0*
1–2 years	39	7	18	12	2
	(11)	*(6)*	*(18)*	*(9)*	*(20)*
2–5 years	70	21	12	31	6
	(19)	*(17)*	*(12)*	*(24)*	*(60)*
6–10 years	80	24	25	29	2
	(22)	*(19)*	*(25)*	*(23)*	*(20)*
More than 10 years	161	75	39	47	0
	(44)	*(59)*	*(38)*	*(37)*	*0*
Total	**366**	**127**	**102**	**127**	**10**

Source: IFPRI-ARCN survey (2010).
Notes: * Frequency; ** Figures in parentheses and italics are percentages to the total per organization type.

4.4.2 Adequacy of Physical Resources

Heads of organizations were asked to rate the adequacy of laboratory facilities and communication systems in their organizations. A majority either were not satisfied (24 percent of organizations) or rated their headquarter laboratory facilities with little satisfaction (31 percent) (Table 20). Forty-two percent were either somewhat satisfied (21 percent) or satisfied (21 percent). Only 3 reported being very satisfied.

Respondents consistently highlighted the need for modern, up-to-date research facilities and equipment (24 respondents); rehabilitation of laboratories, including adding additional laboratory space (8 respondents); improved power supply (2 respondents); and the provision of training and retraining for staff who operate modern laboratory facilities (2 respondents) for both headquarters and substations. One respondent mentioned the urgent need to hasten the establishment of planned substations and the furnishing of these stations with adequate infrastructure for better outreach and better linkage of research with what farmers in different localities really need.

Table 20. Distribution of organizations based on satisfaction with the adequacy of resources (N = 43 organizations)

Facilities and Materials	Headquarters (N = 43)							Substation*** (N = 23)						
	Percentage of respondents based on level of satisfaction					Suggestions for improvement		Percentage of respondents based on level of satisfaction					Suggestions for improvement	
	1	2	3	4	5	Specific suggestion	Number of respondents	1	2	3	4	5	Specific suggestion	Number of respondents
Laboratory and other research facilities	24 *	31	21	21	3			57	35	4	4	0		
						Modern research facility and equipment	24**						More funds for infrastructure	5
						Rehabilitate laboratories, increase laboratory space, add laboratories	8						Transportation facilities	2
						Improve power supply	2						Laboratory reagents	2
						Provide training and retraining of laboratory technicians	2						Employment of qualified technologists	1
						Establish and maintain long-term agreement with the suppliers	1						Need for urgent establishment for the planned stations	1
													Maintenance and storage facilities	1
Communication and information systems	24	41	14	17	3			65	30	0	0	4		
						Improve Internet facility	21						Access to international journal	1
						Improve the information and communications technology (ICT) facility	8						Well-equipped field vehicles	1
						Provide computers	6						Provision of infrastructure	1
						Provide regular power supply	3						Employment of competent IT staff for zonal offices	1
						Train and retrain IT and research staff on ICT	2							
						Provide website management and dissemination	1							

Source: IFPRI-ARCN survey (2010). Notes: * Percentage; ** Frequency; *** For each organization, the figure is the average score for all substations.

Table 21 presents the perception of adequacy of other physical resources. A majority of organizations reported not being satisfied with the adequacy of facilities or equipment. More than 80 percent of organizations were not satisfied at all or had little satisfaction with the adequacy and quality of gene banks, germplasm storage, biological materials, Internet facilities, computer facilities, journals, and training facilities. A relevantly more favorable rating was given to library facilities, with the percentage of nonsatisfaction going down to 31 percent among RIs and universities and to 67 percent among FCAs. This result indicates serious weakness in the ability of these essential facilities to do research. A systematic assessment of optimal investments in these facilities and equipment is warranted. Investment in human resources or training will not be effective without complementary investments in filling the physical resources gaps.

Table 21. Distribution of organizations based on the adequacy of facilities (percent)

Adequacy of Resources	RI	FCA	Univ.
Gene banks, germplasm storage, access to biological materials			
1*	69**	67	63
2	31	25	25
3		8	13
4			
5			
Internet facilities			
1	46	83	44
2	54	17	44
3			13
4			
5			
Computer facilities			
1	38	58	44
2	54	42	31
3	8		19
4			6
5			
Library facilities			
1	31	67	31
2	31	33	44
3	38		19
4			6
5			
Access to journals			
1	54	92	81
2	46	8	6
3			6
4			
5			
Training equipment and facilities			
1	38	83	69
2	54	8	13
3	8	8	19
4			
5			

Source: IFPRI-ARCN survey (2010).
Notes: * 1 = Not satisfied; 2 = little satisfied; 3 = somewhat satisfied; 4 = satisfied; 5 = very satisfied; ** Percentage.

4.4.3 Organizational Procedures and Systems

A number of organizations do not have organizational procedures, strategies, or plans in place. Among RIs, 57 percent do not have an M&E system, 43 percent do not have a training strategy, 86 percent do not have an intellectual property rights (IPR) strategy, and 29 percent do not have a personnel management plan (Table 22). Among FCAs, 50 percent do not have an M&E system, 25 percent do not have a training strategy, 83 percent do not have an IPR strategy, and 50 percent do not have a personnel management plan. Among faculties, 53 percent do not have an M&E system, 35 percent do not have a training strategy, 76 percent do not have an IPR strategy, and 51 percent do not have a personnel management plan.

Table 22. Distribution of organizations based on presence of strategies or plans (N = 43 organizations)

	Strategic Plan		Training Strategy		IPR Strategy		Personnel Mgt. Plan	
Organization Type	**%**	**Satisfaction**	**%**	**Satisfaction**	**%**	**Satisfaction**	**%**	**Satisfaction**
Research institute	50	4 are satisfied; 1 is somewhat satisfied	57	1 is very satisfied; 6 are satisfied; 1 is not satisfied at all	14	2 are satisfied	71	1 is very satisfied; 7 are satisfied; 1 is somewhat satisfied; and 1 are little satisfied
FCA	42	1 is very satisfied; 4 are satisfied; 1 are little satisfied	75	4 are very satisfied; 5 are satisfied	17	2 are satisfied	50	5 are satisfied; and 1 are little satisfied
Universities	59	5 are very satisfied; 3 are satisfied; 1 is somewhat satisfied; 1 is not satisfied at all	65	3 are very satisfied; 5 are satisfied; 2 are somewhat satisfied; 1 is little satisfied	24	1 is very satisfied; 2 are satisfied; 1 is little satisfied	59	2 are very satisfied; 5 are satisfied; 1 is somewhat satisfied; and 1 is little satisfied

Source: IFPRI-ARCN survey (2010).

4.4.4 Organizational Culture

The organizational cultural or work environment is an important enabler for increased research productivity. For this study, we made a list of 26 indicators of organizational culture based on literature review and questionnaire pretesting. This list includes performance appraisal, open and transparent recruitment system, satisfaction with compensation, leadership, political interference, equality between male and female staff, and so forth. Respondents were asked to rate whether they strongly agree, agree, disagree, or strongly disagree with these 26 indicators. Table 23 presents the distribution of respondents based on their perception of their organization's work environment and culture.

Across all organizations types, 95 percent of respondents agreed or strongly agreed that they feel recognition from colleagues, and 87 percent either agreed or strongly disagreed that they feel satisfaction with their job. This indicates high self-value and signifies the role of peer recognition as a source of motivation among researchers. Ninety-three percent of respondents either agreed or strongly agreed that there is equal opportunity for men and women staff in promotion, which indicates a low degree of gender

inequality in employment and opportunities in research organizations. About 88 percent of respondents either agreed or strongly agreed that there are good opportunities for promotion within the organization. More than 65 percent of respondents either agreed or strongly agreed with the majority of the indicators of organizational culture, except for the following, in which more than 35 percent of respondents either disagreed or strongly disagreed:

- Enough resources to carry out work as required by professional norms (80 percent)
- Fear of losing job in the near future (77 percent)
- Corruption or misuse of funds is not a problem (52 percent)
- Hardly any political interference in the work (47 percent)
- Clients or partners never complain about the organization's performance (42 percent)
- Organization hires purely on the basis of merit (41 percent)
- Staff are paid equally as compared with staff in other organizations who do comparable tasks (39 percent)
- Organization has an open and transparent system of staff recruitment (37 percent)
- Mobility to operational area is easy (37 percent)

Results indicate an enormous inadequacy of resources to carry out the organization's mission, which is consistent with the analyses above. Results also indicate serious job insecurity among researchers, as identified by 77 percent of respondents. Corruption and misuse of funds and political interference appeared to be serious concerns, as being mentioned by 52 percent and 47 percent of respondents, respectively. A high proportion of researchers also showed dissatisfaction with the organization's performance based on the frequency and degree of complaints by clients and partners (42 percent), staff recruitment (41 percent), staff remuneration (39 percent), and easy mobility in their operational areas (37 percent).

Respondents were also disaggregated by organization and organization type, though there is no apparent difference in trends and results. Given the hypothesis that innovation capacity and performance are affected by organizational culture, among other variables, we tested the potential heterogeneity of organizations within organization types according to their culture, innovation capacity, performance, and effectiveness. This section uses the results from Table 11, on perceptions of good- and bad-performing organizations, as given by organization heads. Heads of organizations and other relevant experts were asked to name three research institutes—three FCAs, three FAs, and three FVMs—that they consider the top three good-performing organizations in each organization type. The top half of the organizations per organization type that were mentioned as good performing were coded as "good performer," while the bottom half of the organizations in each organization type were coded as "bad performers."

The next step was to determine the significant elements of organizational culture or work environment between good performers and bad performances. For each measure of the organization's culture, we computed the average score (four-point Likert scale) for good and bad performers. We then tested for any differences in means between the two groups within each organization type. The means and p-values are reported in Table 24.

Table 23. Distribution of respondents based on their perception of the organizational culture (N = 366 staff)

Characteristics	All Respondents (in percent)			
	SA*	A	D	SD
Feeling of recognition as hard worker /1	**37**	**58**	**4**	**1**
Organization has an open and transparent system of staff recruitment /2	11	51	28	9
Staff are paid the same as staff in other organizations who do comparable tasks /2	13	47	26	13
Organization hires purely on the basis of merit /2	11	47	33	8
Organization promotes staff purely on the basis of merit	16	64	16	4
Good opportunities for promotion within the organization /1	**23**	**66**	**9**	**2**
Performance appraisals are carried out in a fair way	14	69	15	2
Male and female staff have equal opportunities in getting promoted /1	**38**	**54**	**6**	**2**
Fear of losing job in the near future /2	1	22	51	26
Enough resources to carry out work as required by professional norms /2	2	18	59	21
Corruption and misuse of funds are not a problem /2	9	40	40	12
Hardly any political interference in the work /2	8	44	37	10
Most staff are well qualified to do their jobs	17	60	19	4
Majority of staff work expected hours	13	61	22	4
Clients or partners never complain about the organization's performance /2	7	51	38	4
Complaints from clients are taken very seriously by the organization	20	54	23	3
Majority of staff have a clear understanding of tasks and functions	11	65	21	3
Organization is effective in budget	10	60	26	3
Supervisor or manager is always around when needed	15	66	18	1
Supervisor or manager consults staff regarding important changes or decisions	11	61	23	5
Supervisor or manager gives staff freedom	14	68	17	2
Mobility to operational area is easy /2	11	53	31	6
Satisfied with job /1	**22**	**65**	**12**	**1**
The organization shares information on its performance to key stakeholders and clients	12	68	16	4
The organization works with media to share information, disseminate research findings, and make the organization accountable	14	55	27	4
Other staff within the organization are satisfied with their work and have stayed in the organization for several years.	15	62	20	3

Source: IFPRI-ARCN survey (2010).
Notes: * SA = Strongly agree; A = Agree; D = Disagree; SD = Strongly disagree; /1 = More than 85 percent of respondents either agree or disagree; /2 = more than 35 percent of respondents either disagree or strongly disagree.

Overall, out of the 26 measures we adopted, we found significant differences between good and bad performers in terms of 15 indicators of organizational culture. By organization type, we found differences between good and bad performers in RIs using 10 indicators; in federal colleges, 3 significant indicators; in university faculties of agriculture, 11 significant indicators; and in university faculties of veterinary medicine, a single significant indicator (Table 24). We drew the following inferences from our results:

1. **Good-performing organizations have good hiring procedure.** This is a very obvious, but important, finding of this study. To perform better, an organization should have a good, qualified staff; this is only possible when the hiring system is open and transparent and is based on merit. Our study supports this statement. We found a significant difference between

good and bad organizations (5 percent level of significance) in mean responses to whether their organization has an open and transparent system of staff recruitment. The mean response for good performers was closer to 1 than the mean for bad performers, indicating that better performers have better hiring procedure. In addition, we found a significant difference between the good- and bad-performing organizations in the mean response to whether their organization hires purely on the basis of merit.

2. **Good-performing organizations have good performance evaluation and reward systems.** The mean differences in responses to the following measures are significant in our study:
   - Merit as the basis of promotion
   - Good opportunities for promotion in the organization
   - Fair performance appraisals

   In all of these responses, the lower mean for good performers than for bad performers suggests that good-performing organizations have good evaluation and reward systems. (Note that scales of measure range from 1 to 4, with 1 being "strongly agree" and 4 being "strongly disagree.") Promotion is also a way of rewarding employees and could thus be an incentive for the staff to excel in their career positions.
3. **Good-performing organizations offer job security.** Better job security will help staff to focus on their jobs rather than wasting time looking for other jobs or searching for other activities to supplement their incomes. Job security allows the staff to be more efficient at their jobs, thus enhancing the organization's performance. We found a significant difference between good-performing institutions and bad-performing institutions in staff's mean responses to whether they fear losing their jobs in the near future. The higher mean response (3.13) for good-performing organizations than for bad-performing organization (2.96) suggests that better job security adds to better performance of the organization.
4. **Good-performing organizations share information.** We found a significant difference between good- and bad-performing organizations in the mean response to whether the organization shares its performance information with key stakeholders and clients. Likewise, there is a significant difference in the mean response to whether the organization works with media to share information and disseminate research findings. Again the lower mean for good-performing organizations leads us to infer that they share information with stakeholders and disseminate findings through media.
5. **The staff of good-performing organizations perform their duties.** We found a significant difference in the mean responses to whether the majority of staff work expected hours and to whether the majority of staff has a clear understanding of tasks and functions. The lower mean response to these concerns leads us to conclude that the staff of good-performing organizations understand and perform their duties.
6. **Good-performing organizations take complaints from clients very seriously.** A significant mean difference exists in the responses from good- and bad-performing organizations to whether complaints from clients are taken very seriously by the organization. The lower mean (1.97) of good-performing organizations as compared with bad-performing organizations (2.19) suggests that the former takes complaints from clients very seriously and acts on them accordingly to improve the organization's operations and performance.
7. **Good-performing organizations offer freedom in the performance of duties and easy mobility to operational areas.** The lower value of the mean response among good-performing organizations to whether supervisors or managers give freedom and to whether mobility to operational areas is easy indicates greater freedom to do work and easier mobility to operational areas, as compared bad-performing organizations.

Similarly, the distinction between good and bad organizations based on the organization's culture depends on the type of organization. For example, only one measure—mobility to operational areas is easy—was significantly different between good- and bad-performing faculties of veterinary medicine. This implies that there is not much difference in other traits of organizational culture in these institutes. In university faculty of veterinary medicine, other factors that are not captured in the organization's culture could be attributed to good performance.

Good- and bad-performing research institutes, however, differ significantly in terms of several measures of organizational culture. Based on our results, we deduced that good-performing RIs have the following organizational culture:

- Equal opportunities for promotion for both male and female staff
- Staff qualified to do their jobs
- Staff satisfied and have stayed with organization a long time
- Organization takes clients complaints seriously
- Organization shares information
- Good performance evaluation and reward systems
- Freedom in performance of duties

However, we also found a significant difference between good- and bad-performing research institutes in terms of the mean response to whether the staff are paid equally compared with staff in other organizations who do comparable tasks. The mean response (2.39) is higher for the good-performing research institute, which implies that the majority of respondents disagrees on this concern. This further leads us to infer that the salary level of good-performing research institute staff doing the same job is different from what it is in other organizations. However, there is not enough evidence or data to suggest that their salary is higher or lower than others doing the comparable job. Similarly, the significant indicators for federal colleges are counterintuitive. It may be that factors other than organizational culture explain the difference between good and bad performers.

In terms of university faculty of agriculture, good performers are distinct from bad-performing counterparts in terms of the following indicators:

- Good hiring procedures
- Corruption and misuse of fund are not a problem
- Effective budget management
- Share performance information to stakeholders
- Good opportunities for promotion
- Staff works expected hours
- Clients do not complain about the organization's performance
- Organization takes client complaints very seriously
- Supervisor always consults subordinates regarding important changes or decisions

It is only in the university faculty of agriculture that we found the significant difference between good- and bad-performing organizations in the mean response to whether corruption and misuse of funds are a problem. The mean response of good-performing organizations is lower than that of bad-performing organizations, which implies that there is no (or less) corruption and misuse of funds in good-performing organizations.

Table 24. Average score on indicators of organizational culture by organization type and perceived performance level (N = 366 researchers)

Indicators of Organizational Culture	All				Research Institute			Federal College			Faculty of Agriculture			Faculty of Veterinary Medicine		
	All	Good	Bad	p-value	Good	Bad	p-value	Good	Bad	p-value	Good	Bad	p-value	Good	Bad	p-value
1. Feeling of recognition as hard worker	1.70	1.71	1.69	.802	1.58	1.71	.210	**1.81**	**1.48**	**.021***	1.97	1.85	.425	1.44	1.6	0.44
2. Organization has an open and transparent system of staff recruitment	2.34	**2.23**	**2.43**	**.030***	2.25	2.33	.557	2.09	2.29	.304	**2.13**	**2.63**	**.003***	2.63	2.18	0.272
3. Staff are paid equally compared with staff in other organizations who do comparable tasks	2.36	2.43	2.31	.232	**2.39**	**2.11**	**.090****	**2.72**	**2.16**	**.005***	2.39	2.54	.383	2.06	2.36	0.486
4. Organization hires purely on the basis of merit	2.38	**2.25**	**2.48**	**.012***	2.27	2.34	.667	2.13	2.29	.320	**2.19**	**2.77**	**.001***	2.5	2.09	0.341
5. Organization promotes staff purely on the basis of merit	2.08	**1.97**	**2.16**	**.017***	1.92	2.06	.230	1.91	2.10	.188	2.00	2.28	.118	2.19	2.18	0.987
6. Good opportunities for promotion in the organization	1.90	**1.76**	**1.99**	**.001***	**1.65**	**1.91**	**.017***	1.94	1.82	.429	**1.88**	**2.20**	**.014***	1.56	1.82	0.247
7. Performance appraisals are carried out fairly	2.03	**1.94**	**2.10**	**.018***	**1.89**	**2.08**	**.071****	1.93	2.00	.642	2.00	2.20	.117	2	2	1
8. Male and female staff have equal opportunities for getting promoted	1.72	1.65	1.77	.140	**1.46**	**1.75**	**.023***	1.71	1.56	.226	1.77	1.93	.307	1.94	1.73	0.496
9. Fear of losing job in the near future	3.03	**3.13**	**2.96**	**.084****	3.20	3.03	.334	2.97	2.77	.380	3.19	2.93	.110	3.2	3.18	0.969
10. Enough resources to carry out work as required by professional norms	2.99	2.98	3.01	.712	3.00	2.94	.617	**3.13**	**2.80**	**.030***	2.94	3.17	.102	2.69	3.18	0.117
11. Corruption and misuse of funds are not a problem	2.53	2.49	2.56	.459	2.40	2.38	.918	2.52	2.31	.206	**2.53**	**2.90**	**.038***	2.63	2.36	0.466
12. Hardly any political interference in the work	2.48	2.46	2.49	.793	2.37	2.32	.764	2.58	2.32	.106	2.48	2.76	.137	2.5	2.27	0.448
13. Most of the staff is well qualified to do their jobs	2.07	2.01	2.12	.162	**1.96**	**2.17**	**.052***	2.00	2.02	.910	1.97	2.19	.180	2.25	2	0.529
14. Majority of staff work expected hours	2.15	**2.05**	**2.22**	**.024***	2.04	2.17	.309	1.90	2.10	.188	**2.03**	**2.29**	**.086****	2.38	2.64	0.443
15. Clients or partners never complain about the organization's performance	2.40	2.34	2.44	.213	2.38	2.27	.403	2.13	2.26	.406	**2.38**	**2.67**	**.048***	2.56	2.55	0.952
16. Complaints from clients are taken very seriously by the organization	2.10	**1.97**	**2.19**	**.011***	1.84	2.04	.128	1.94	1.83	.510	**2.00**	**2.53**	**.001***	2.4	2.18	0.523
17. Majority of staff has a clear understanding of tasks and functions	2.13	**2.05**	**2.19**	**.065****	1.94	2.17	.030*	1.90	1.98	.603	2.16	2.36	.197	2.5	2.18	0.282
18. Organization is effective in budget	2.22	**2.11**	**2.29**	**.019***	2.08	2.21	.285	2.03	2.04	.953	**2.13**	**2.49**	**.016***	2.31	2.55	0.492
19. Supervisor or manager is always around when needed	2.04	1.98	2.08	.156	1.92	2.09	.160	1.94	1.84	.474	2.13	2.21	.483	2	2.36	0.235
20. Supervisor or manager consults staff regarding important changes or decision	2.19	2.12	2.25	.109	2.00	2.13	.320	2.16	2.02	.412	**2.22**	**2.49**	**.071****	2.19	2.18	0.98
21. Supervisor or manager gives staff freedom	2.05	**1.96**	**2.12**	**.025***	**1.88**	**2.15**	**.015***	1.97	1.88	.523	2.10	2.29	.160	1.94	2	0.811
22. Mobility to operational area is easy	2.32	**2.24**	**2.39**	**.086****	2.13	2.29	.289	2.45	2.24	.233	2.39	2.53	.362	**1.88**	**2.55**	**.023***

Table 24. Continued

Indicators of Organizational Culture	All				Research Institute			Federal College			Faculty of Agriculture			Faculty of Veterinary Medicine		
	All	Good	Bad	p-value	Good	Bad	p-value	Good	Bad	p-value	Good	Bad	p-value	Good	Bad	p-value
23. You are satisfied with your job	1.90	1.84	1.94	.143	1.89	1.98	.411	1.87	1.88	.915	1.84	2.00	.232	1.63	1.64	0.967
24. The organization shares performance information with key stakeholders and clients	2.12	**2.01**	**2.20**	**.011***	**1.79**	**2.09**	**.003***	2.16	2.00	.234	**2.11**	**2.44**	**.048***	2.25	2	0.369
25. The organization works with media to share information, disseminate research findings, and make the organization accountable	2.20	**2.03**	**2.33**	**.000***	**1.77**	**2.15**	**.001***	2.13	2.14	.956	**2.10**	**2.56**	**.006***	2.6	2.45	0.582
26. Staff in your organization are satisfied with their work and have stayed in the organization for several years.	2.10	2.03	2.15	.145	**2.00**	**2.23**	**.068****	2.00	1.88	.391	2.07	2.30	.155	2.13	2.09	0.884

Source: IFPRI-ARCN survey (2010).
Note: Good = "Good"-performing organizations; Bad = "Bad"-performing organizations; p = p-value;
* Significant at 5 percent level; ** Significant at 10 percent level.

4.5. Individual Capacity and Incentives

In addition to educational background, discussed earlier, an individual researcher's capacity can also be measured in terms of work experience, workload devoted to research and dissemination activities, and field of specialization, all of which contribute to the organization's goals and priorities. Across the different types of organizations, the majority of staff (around 80 percent) has more than two years of work experience since their last degree (Table 25). About 60 percent have more than five years of work experience since their last degree. Although these findings indicate seniority and maturity of researchers in their field, they also show a lack of follow-up in long-term training for non-PhD holders, considering that they make up more than 50 percent of the sample researchers. There is no difference in trends across organization types.

Table 25. Distribution of respondents by years of work experience and organization type (N = 366 staff)

		Organization Type			
Work Experience	**Total**	**Research Institute**	**Federal College**	**University**	**ARCN**
Fewer than 6 months	13 *	4	2	7	0
	*(4)***	*(3)*	*(2)*	*(6)*	*0*
6–11 months	9	2	2	4	1
	(2)	*(2)*	*(2)*	*(3)*	*(10)*
1–2 years	47	18	15	14	0
	(13)	*(14)*	*(15)*	*(11)*	*0*
2–4 years	78	28	19	28	3
	(21)	*(22)*	*(19)*	*(22)*	*(30)*
5–7 years	80	22	27	27	4
	(22)	*(17)*	*(26)*	*(21)*	*(40)*
8–10 years	40	16	10	14	0
	(11)	*(13)*	*(10)*	*(11)*	*0*
More than 10 years	99	37	27	33	2
	(27)	*(29)*	*(26)*	*(26)*	*(20)*
Total	**366**	**127**	**102**	**127**	**10**

Source: IFPRI-ARCN survey (2010).
Notes: * Frequency; ** Figures in parentheses and italics are percentages to the total per organization type.

On average, RI staff allocate 60 percent of their eight-hour workday to research, 11 percent to training, 7 percent to administration and research management, 6 percent each to teaching and to dissemination and communication of technologies generated, and the remaining 3 percent to public service (Table 26). Federal colleges and university faculties of agriculture spend most of their workday teaching (54 percent and 46 percent, respectively); and they spend less time for research (23 percent and 32 percent, respectively). There is less time for research among federal colleges than among university faculties of agriculture. ARCN staff spends 74 percent of their time doing research management and only 12 percent doing research. About 19 percent of the ARCN staff's working day is spent on training, extension, and dissemination and communication of research findings.

Table 26. Average time allocation of research staff by type of organization (N = 366 staff)

Workload	Research Institute	Federal College	University	ARCN	Total
Research	60*	23	32	12	38
Teaching	6	54	46	1	34
Training	11	8	6	2	8
Extension	8	5	4	4	6
Dissemination and communication	6	4	4	8	5
Administration and management	7	—	—	74	8
Public Service	3	6	8	—	3
Total	**100**	**100**	**100**	**100**	**100**

Source: IFPRI-ARCN survey (2010).
Note: * Figures are percentages to total per organization type.

In RIs, fields of specialization seem to be varied, and the number of respondents seems to be evenly distributed across fields (Table 27). For example, 14 percent of respondents specialize in biotechnology, breeding, or genetics; 12 percent in veterinary medicine and animal science; 11 percent in plant health; 9 percent in agronomy; 9 percent in soil science; and 8 percent in economics. In FCAs and universities, a high proportion of researchers specialize in veterinary medicine and animal science. A very small proportion of RI staff have rural sociology or agricultural extension. All the ARCN respondents are technical staff, and there seems to be none that do policy and economic research.

Table 27. Distribution of respondents by field of specialization (percent) (N = 366 staff)

Specialization	RI	FCA	Universities	ARCN
Biotechnology, breeding, or genetics	14*	1	6	0
Veterinary medicine or animal science	12	24	36	20
Plant health	11	4	6	0
Agronomy	9	10	6	0
Soil science	9	5	11	10
Economics	8	5	9	0
Food science or postharvest technologies	7	5	1	30
Fisheries or aquaculture	6	14	6	10
Chemistry	6	0	1	20
Biology	5	12	2	10
Rural sociology or agricultural extension	5	9	10	0
Agricultural engineering	4	3	0	0
Environmental management	2	1	0	0
Statistics or biometrics	1	1	1	0
Forestry	0	0	3	0
Irrigation management	0	3	1	0
Others	2	5	0	0

Source: IFPRI-ARCN survey (2010).
Note: * Figures are percentages to total per organization.

In terms of membership in professional associations and networks, 60 percent of research staff are not members at the international level, whereas 69 percent are not members at the continental level (Table 28). However, a majority (84 percent) of respondents are members of between one and three national professional associations or networks. A similar pattern exists for participation in professional conferences and consultations. Across all respondents, 67 percent had not attended any international conferences; 72 percent had not participated in any continental conferences or consultations; 20 percent had not joined any national professional conference; and 75 percent had been to between one and four national professional conferences since 2007 (Table 29). Federal colleges have weaker linkages with professional associations (international, continental, and national) and less frequent participation in professional conferences and consultations at all levels (Tables 28 and 29).

Table 28. Distribution of respondents based on membership in professional associations (N = 366 staff)

Number of Professional Associations	Total	Research Institutes	Federal Colleges	Universities	ARCN
Number of international associations or networks related to field					
0	60*	48	83	54	70
1	25	27	17	27	30
2	12	17	0	16	0
3	3	7	0	1	0
4	0	0	0	1	0
6	0	0	0	1	0
11	0	1	0	0	0
Number of regional associations or networks related to field					
0	69	70	83	57	90
1	19	16	12	29	10
2	9	12	5	10	0
3	2	3	0	3	0
4	1	0	0	2	0
Number of national associations or networks related to field					
0	13	10	19	12	10
1	29	27	32	28	40
2	37	39	27	43	40
3	17	21	20	12	10
4	2	1	2	4	0
5	1	2	0	1	0
7	0	0	0	1	0

Source: IFPRI-ARCN survey (2010).
Note :* Figures are in percent to total respondents per organization type.

Table 29. Distribution of respondents based on participation in conferences (N = 366 staff)

Number of Professional Conferences	Total	Research Institutes	Federal Colleges	Universities	ARCN
Number of international consultation and conferences related to field					
0	67*	61	77	64	90
1	18	17	18	19	10
2	11	16	4	13	0
3	2	3	0	3	0
4	2	3	1	1	0
5	0	0	0	1	0
6	0	1	0	0	0
Number of regional consultation and conferences related to field					
0	72	67	81	70	60
1	18	25	10	17	20
2	7	7	5	8	10
3	2	0	3	3	10
4	1	1	1	2	0
Number of national consultation and conferences related to field					
0	20	15	27	20	30
1	20	26	17	20	0
2	35	34	31	40	20
3	11	9	13	12	0
4	7	10	7	4	20
5	3	3	5	2	10
6	1	1	0	1	20
7	0	1	0	0	0
8	1	1	0	1	0
9	0	1	0	0	0
10	0	0	1	0	0

Source: IFPRI-ARCN Survey (2010).
Note: * Figures are in percent to total respondents per organization type.

In terms of individual motivation, respondents were asked to provide their top three motivations for increasing research productivity. Across all 307 who answered this question, the highest proportion of respondents (43 percent) mentioned promotions as one of the top three important sources of motivation for increasing research productivity (Table 30); 39 percent mentioned high salary; and 32 percent mentioned skills development and training. However these sources of motivation differ across different types of organization. The top three important sources of motivations for staff in research institutes are:

- More timely release of funds (43 percent of respondents)
- Promotion (38 percent)
- More research funds (37 percent)

In federal colleges, the top three important sources of motivations for researchers are:

- High salary (58 percent of respondents)
- Promotion (53 percent)
- Skills development and training (49 percent)

The top three important sources of motivation for university staff and faculty are:

- Promotion (40 percent of respondents)
- High salary (33 percent)
- More timely release of funds (33 percent)

The three important sources of motivation for the 10 respondents in ARCN are:

- Skills development and training (50 percent of respondents)
- Peer recognition (50 percent)
- Promotion (40 percent)

In addition to these motivation sources, at least 50 respondents mentioned better laboratory facilities, more research support, and more time to do research among their top three important sources of motivation. In addition, 41 respondents identified a more conducive work environment, 34 respondents mentioned more international contacts, 21 mentioned better leadership or management, and another 21 identified more guidance from supervisors among their top three important motivation factors.

Table 30. Distribution of respondents by motivations in improving their productivity (N = 307 staff)

Motivations	All	Research Institute	Federal Colleges	Universities	ARCN
Promotion	132*	38	45	45	4
	*(43)***	*(38)*	*(53)*	*(40)*	*(40)*
High salary	120	33	49	37	1
	(39)	*(33)*	*(58)*	*(33)*	*(10)*
Skills development and training	97	23	42	26	5
	(32)	*(23)*	*(49)*	*(23)*	*(50)*
More timely release of funds	95	43	11	37	3
	(31)	*(43)*	*(13)*	*(33)*	*(30)*
More research funds	80	37	14	27	0
	(26)	*(37)*	*(16)*	*(24)*	*0*
Better lab and research facilities	71	28	17	26	0
	(23)	*(28)*	*(20)*	*(23)*	*0*
More research support	58	16	18	23	1
	(19)	*(16)*	*(21)*	*(21)*	*(10)*
More time for research	55	13	14	27	2
	(18)	*(13)*	*(16)*	*(24)*	*(20)*
More conducive work environment	41	12	11	17	1
	(13)	*(12)*	*(13)*	*(15)*	*(10)*
More international contacts	34	11	3	18	2
	(11)	*(11)*	*(4)*	*(16)*	*(20)*
Better leadership or management	21	8	6	6	1
	(7)	*(8)*	*(7)*	*(5)*	*(10)*
More guidance from supervisor	21	7	2	9	3
	(7)	*(7)*	*(2)*	*(8)*	*(30)*
Better communication facilities and systems	19	7	4	7	0
	(6)	*(7)*	*(5)*	*(6)*	*0*
International travel	17	1	5	11	0
	(6)	*(1)*	*(6)*	*(10)*	*0*
Peer recognition	14	5	3	4	5
	(5)	*(5)*	*(4)*	*(4)*	*(50)*
More administrative support	7	3	1	3	0
	(2)	*(3)*	*(1)*	*(3)*	*0*
Appreciation by farmers	6	3	1	2	0
	(2)	*(3)*	*(1)*	*(2)*	*0*
Total	**307**	**100**	**85**	**112**	**10**

Source: IFPRI-ARCN survey (2010).
Notes: * Frequency; ** In percent to total per organization type.

4.6. Gaps in Organization and Management

This section summarizes the constraints and gaps from the previous discussion about the current status of performance, organization, management, and individual capacity and incentives. Heads of organizations were asked to identify their top five issues or constraints in terms of managing research (Table 31). Across all organization types, inadequate funding for research was at the top of the list for 32 respondents and was identified as the top issue among universities (identified by 16 respondents), the second top issue among federal colleges (8 respondents), and the second top issue among research institutes (7 respondents).

The second major issue, as identified by 25 respondents, is inadequate and decaying research infrastructure. A related issue is the lack of modern research equipment, mentioned by 17 respondents. These two issues combined are the top major management issue in both federal colleges and universities, which is consistent with the alarming picture described in Section 4.4.2 and in Tables 20 and 21. Two respondents also mentioned the need for staff accommodation and student hostels.

The third major issue across all organization types is insufficient human capacity (20 respondents). This is also related to lack of technical expertise for research mentioned 11 respondents. These issues are rated as the top research management issue among research institutes, which is consistent with the human capacity condition described in Section 4.4.1. This third major issue essentially boils down to lack of funding to hire qualified staff to fill vacancies, as well as lack of funding and opportunities for long-term training of existing staff. Two respondents also mentioned brain drain and staff turnover as issues, which have implications on the motivations and incentives for staying in current organizations.

The fourth major issue—insufficient power supply (11 respondents)—is highlighted as a major constraining factor for staff to do laboratory research. Although staff realize that it may be difficult to change the country's energy policy, short-term and medium-term solutions include sufficient funding to purchase and operate adequate generators.

The fifth major issue is improving the relevance and impact of research results. Strategies to effectively disseminate research results were mentioned by seven respondents. Four respondents mentioned the relevance of research, policy communication, and farmers' empowerment. Five respondents mentioned the lack of collaboration and interaction with stakeholders. All of these issues boil down to the need for a mind-set reorientation among researchers toward the innovation systems perspective, with emphasis on partnership, linkages, and impacts on the ground. This mind-set reorientation remains a big challenge among heads of organizations.

The sixth major management issue is the lack of access to relevant publications and international exposure. Heads of organizations emphasized the need to update researcher knowledge and to widen the exposure of researchers to good practices and innovative approaches worldwide.

At least two respondents also mentioned the following research management issues:

- Inconsistent or lack of government policy
- Poor Internet connectivity; poor Internet communications technology and data management
- Planning; strategic direction; resource use planning and management
- Lack of commitment to research by government
- Lack of capacity for economic analysis
- Lack of accountability; no performance monitoring and evaluation

Table 31. Distribution of organizations based on top five research management issues identified (N = 43 organizations)

Research Management Issues	Number of Respondents*				
	All	Research Institutes	Federal Colleges	Universities	ARCN
Inadequate funds for research	32**	7	8	16	1
Inadequate/decaying infrastructure, facility, materials	25	5	11	8	1
Insufficient human capacity	20	8	4	7	1
Lack of modern research equipment	17	2	3	12	0
Lack of technical expertise for research	11	3	7	1	0
Insufficient power supply	11	3	2	6	0
Dissemination of research results	7	2	2	3	0
Lack of collaboration	5	0	0	5	0
Lack of access to recent relevant publications and exposure	5	1	0	2	0
Relevance of research/technology adoption, policy, communication, empowerment of farmers	4	3	0	1	0
Brain drain and staff turnover	3	1	0	1	1
Inconsistent or lack of government policy	3	0	0	3	0
Poor Internet connectivity; poor ICT and data management	3	1	0	2	0
Planning; strategic direction; resource use planning and management	3	2	0	1	0
Lack of commitment to research by government	2	0	0	2	0
Lack of capacity for economic analysis	2	0	0	2	0
Accountability; performance monitoring and evaluation	2	1	1	0	0
Staff accommodation; student hostel	2	0	2	0	0
Timeline adherence	1	0	0	1	0
Research integrity	1	0	0	1	0
Poor staff emolument	1	1	0	0	0
Technology generation	1	1	0	0	0
Project implementation	1	1	0	0	0
Attraction of external funding	1	1	0	0	0
IPR policy	1	1	0	0	0
Mobility for field trip	1	1	0	0	0

Source: IFPRI-ARCN survey (2010).
Notes: * Respondents mentioned this specific research management issue in any order when asked about their top five major research management issues. ** Frequency.

Although many research management issues were identified by heads of organizations, several of those issues can be addressed through support for learning and training. First, strategies for fundraising and diversifying funding sources can be helpful to ease the enormous financial constraints in research organizations. Second, advocacy and negotiation skills for research policy changes and increased funding for agriculture and research can be enhanced. Third, training and learning events on innovation systems, including sharing of good practices and experiences from other countries, can be intensified. Fourth, facilitation of exchange programs, South-South collaboration, and international learning events can be intensified to increase researcher exposure to other country's experiences. Fifth, capacity strengthening can be implemented for strategic planning, resource use planning and management, economic analysis, data and knowledge management, performance monitoring and evaluation systems, and resource use planning and management

A set of predetermined activities, based on literature review and questionnaire pretesting, were asked of heads of organizations to gain a better understanding of the specific external support needed by research organizations (Table 32). The major areas in which external support is mostly needed are as follows:

- Conducting evidence-based policy analysis (64 percent of respondents)
- Designing policy options that favor the development and adoption of productivity-enhancing, poverty-reducing agricultural technologies (57 percent)
- Designing approaches and mechanisms for diversifying funding sources (55 percent)
- Designing necessary and optimal infrastructure required for the different activities (53 percent)

The second major areas in which external support is mostly needed are:

- Designing an institutional capacity development plan to review and modify the reigning paradigms, as need arises (47 percent of respondents)
- Developing a mechanism for co-investing in and co-utilizing key physical resources for a common purpose (47 percent)
- Planning and managing human resources to build capacity to implement, monitor, and evaluate programs (46 percent)
- Mobilizing financial resources and developing accountability (46 percent)
- Developing methodologies to make the organization client- and market-oriented (43 percent)
- Doing advocacy and lobbying for policy change and implementation (42 percent)
- Conceptualizing research ideas and applying up-to-date research methods and design techniques (37 percent)
- Designing the framework of and monitoring programs or projects (37 percent)
- Designing the framework of and evaluating programs, projects, and actions (36 percent)

Table 32. Distribution of respondents based on external support needed* (N = 43 organizations)

	Area of Activity	Full Support	Some Support	No Support
Area of policy analysis and development				
1	**Conducting evidence-based policy analysis****	**64**	**28**	**8**
2	**Designing policy options that favor development through the broad-based adoption and diffusion of productivity-enhancing, poverty-reducing agricultural technologies****	**57**	**41**	**3**
3	Designing an institutional capacity development plan to review and modify the reigning paradigms, as need arises***	47	50	3
4	Developing a mechanism for co-investing in and co-utilizing key physical resources for common purpose***	47	42	11
5	Doing advocacy and lobbying for policy change and implementation***	42	39	19
Area of research design and research management				
6	Conceptualizing research ideas and application of up-to-date research methods and design techniques***	37	58	5
7	Setting priorities for the organization's programs, projects, and actions	17	63	20
8	Planning programs, projects, and actions	25	61	14
9	Developing and motivating effective multidisciplinary and multi-institutional initiatives in the organization	34	58	8
10	Designing the framework of and monitoring programs or projects***	37	58	5
11	Designing the framework of and evaluating programs, projects, and actions***	36	58	6
12	Developing methodologies to make the organization client- and market-oriented***	43	51	5

Table 32. Continued

	Area of Activity	Full Support	Some Support	No Support
Area of human resources				
13	Planning and management of human resources to build capacity to implement, monitor, and evaluate programs***	46	43	11
14	Assessing capacity of staff to meet the needs of the job	29	58	13
16	Planning, implementing, and evaluating staff development	24	57	19
17	Negotiating effectively and managing conflicts	18	44	38
18	Managing and communicating effectively among staff, partners, and investors	25	47	28
19	Developing systems of staff motivation and performance evaluation	27	51	22
20	Effectively organizing and conducting meetings	17	31	53
Area of financial management				
21	Mobilizing financial resources and develop accountability***	46	41	14
22	Designing and planning cost-efficient budget to optimize scarce resources	27	54	19
Area of physical resources				
23	**Designing necessary and optimal infrastructure required for different activities****	**53**	**36**	**11**
24	**Designing approaches and mechanisms for diversifying funding sources****	**55**	**39**	**5**
25	Managing facilities and equipment	34	45	21
General areas				
26	Effectively handling information and communication technology	32	61	8
27	Developing an effective system of outreach and public relations	34	63	3

Source: IFPRI-ARCN survey (2010).
Notes: * Figures are in percent. ** Top major activity where external support is mostly needed (at least percent of respondents identified full support needed); ***Second major activity where external support is mostly needed (35–50 percent of respondents identified full support needed).

The above analysis, which was based on responses from heads of organizations, is complemented by responses from 366 research staff across 43 organizations. A set of predetermined1 "soft skills," particularly on policy analysis, research design and methods, research management, and organization and communication, were asked of respondents. Using a five-point Likert scale, respondents were asked to rate the importance of these soft skills in performing their work as researchers in their organization. Table 33 indicates a high level of importance of the predetermined soft skills as perceived by 347 researchers. All skills have been rated by at least 80 percent of the respondents as being somewhat important, important, or very important. Given the consistent rating across respondents (with at least 80 percent of respondents rating them as very important), the following soft skills were rated as the top priority areas:

- Research monitoring and evaluation (100 percent of respondents)
- Research planning and priority setting (87 percent)
- Convincing proposal writing (86 percent)
- Statistical analysis and proficiency in statistical software (84 percent)

The following soft skills were rated as the second top priority area (with 60–80 percent of the respondents rating them as very important):

- Environment analysis (66 percent of respondents)
- Research cost-benefit analysis (60 percent)

[1] Based on a review of recent training needs assessment studies on the agriculture sector; modified and validated during the questionnaire pretesting.

- Technical and scientific writing (78 percent)
- Research project management (77 percent)
- Research methods and design (76 percent)
- Effective communication (76 percent)
- Quality management for research (75 percent)
- Research impact assessment (73 percent)
- Leadership and decisionmaking (72 percent)
- Participatory research methods (71 percent)
- Advanced statistical analysis (70 percent)
- Human capacity assessment (70 percent)
- Stress management (67 percent)
- Innovation system perspective (66 percent)
- Advocacy and lobbying (65 percent)
- Fundraising (64 percent)
- Partnership and network building (60 percent)

Respondents were also asked about their competency level in those skills for which the rating was at least "somewhat important," using a five-point Likert scale. In all the skills, at least 84 percent of the respondents identified some competency gap (that is, a difference between the importance level and their competency level). Priority areas for training (with at least 40 percent of respondents identifying a big competency gap or at least a two-point difference between importance level and competency level) include the following:

- Advocacy and lobbying (65 percent)
- Patent procedure for technology (62 percent)
- Geographic information system (GIS) and resource mapping (62 percent)
- Advanced statistical analysis (60 percent)
- Intellectual property rights (57 percent)
- Fundraising (50 percent)
- Stress management (49 percent)
- Climate change analysis (48 percent)
- Market and trade policy analysis (48 percent)
- Partnership and network building (48 percent)
- Quality management for research (46 percent)
- Statistical software for data analysis (45 percent)
- Multimedia design and production (45 percent)

Table 33. Perceived importance of selected "soft skills" to research staff's work and their perceived competency gap (N = 366 staff)

Soft Skills	Perceived Importance					Perceived Competency Gap		
	VI*	I	SI	LI	NI	BG*	SG	NG
Policy analysis								
Climate change analysis	76**	21	2	—	—	48	43	9
Food security and nutrition policy analysis	74	23	1	1	1	31	65	4
Environment analysis	66	32	2	—	—	34	59	8
Research cost-benefit analysis	60	26	5	7	2	33	61	5
Poverty vulnerability analysis	53	32	9	2	5	36	60	5
SWOT (strengths, weaknesses, opportunities, and threats) and constraints analysis	52	41	4	1	1	31	64	5
Commodity value chain analysis	43	30	6	11	9	41	54	5
Market and trade policy analysis	39	36	6	13	6	48	50	2
Stakeholder analysis	37	41	11	9	3	34	60	6
Gender analysis	37	42	13	7	11	24	66	10
Research design and methods								
Statistical analysis	84	14	1	1	—	24	69	7
Statistical software for data analysis	84	14	1	1	—	45	51	4
Technical and scientific writing	78	19	2	1	1	22	62	16
Research methods and design	76	21	2	2	—	18	74	8
Participatory research methods	71	28	1	—	1	30	62	9
Advanced statistical analysis	70	22	7	1	—	60	36	4
Geographic information system (GIS)	54	31	6	6	3	62	37	1
Research management								
Research monitoring and evaluation	100	84	16	—	—	26	68	6
Research planning and priority settings	87	11	2	—	1	27	68	5
Convincing proposal writing	86	12	2	—	—	37	55	8
Research project management	77	23	—	—	1	37	58	5
Quality management for research	75	24	1	—	—	46	51	3
Research impact assessment	73	26	2	—	—	28	62	10
Leadership and decision making	72	27	1	—	—	33	62	5
Innovation systems perspective	66	30	3	1	—	29	67	4
Fundraising	64	32	2	2	—	50	47	3
Partnership and network building	60	37	3	—	—	48	50	2
Intellectual property rights	57	34	6	2	2	57	39	4
Patent procedure for technology	55	35	6	2	3	62	37	1
Organization and communication								
Negotiation and conflict resolution	24	29	11	24	13	38	50	12
Advocacy and lobbying for research policy and funds	65	31	4	—	1	65	33	2
Effective communication	76	20	2	1	—	11	71	18
Stress management	67	27	3	2	1	49	47	4
Human capacity and competency need assessment	70	27	2	—	—	37	61	2
Multimedia design and production	50	32	9	5	4	46	50	3
Entrepreneurship development	49	41	7	2	2	39	60	1
Alternative extension approaches	53	38	8	—	1	35	63	2

Source: IFPRI-ARCN survey (2010).
Notes: * VI = Very important; I = Important; SI = Somewhat important; LI = Of little importance; NI = Not important; BG = Big gap; SM = Small gap; NG = No gap. ** In percent across each competency.

4.7. Gaps in Scientific and Technical Competency

The innovation systems perspective requires a fresh look at science policy analysis for agriculture, and this implies a new type of relationship with other stakeholders, as well as new types of capacity on the part of scientific institutions and organizations. These changes do not require any reduction in the quality of the science; instead, they require an improvement of their ability to undertake quality science. This section focuses on gaps in scientific and technical competencies among researchers. The following sections present the key research issues in the areas of crops, livestock, fisheries, natural resources management, and policy and institutions. Instead of directly asking about their training needs, we first asked about the priority research issues that their organizations are mandated to do. By doing so, we could prime respondents for deeper reflection about the specific training requirements needed at their organizations. Results indicate that staff retraining on technical and scientific skills and knowledge is needed for organizations to become up-to-date with the latest advanced techniques and methods.

4.7.1 Crop Research Issues and Training Needs

The main research issue in crops is improvement of breeding and varietals, with 89 respondents mentioning it as a priority research area (Table 34). Within breeding, three respondents specifically mentioned biotechnology as being important. Both breeding and management practices for Striga control were also singled out as important research topics. A majority of respondents emphasized yield improvement as the main consideration for breeding. Three respondents specifically mentioned breeding early-bearing fruits and pest- and disease-free crop varieties. Drought resistance was also specifically mentioned by five respondents as an important consideration for breeding. One respondent singled out the control of tomato bacteria wilt disease as an important consideration for research. Respondents highlighted the need for retraining staff on the latest techniques for breeding and genetic modification, molecular biology, genetic mapping, clonal and hybrid trials, preventive breeding, genetic engineering, GIS, biometrics, and plant tissue culture technologies.

The second grouping of major crop research areas includes processing, value addition, and crop utilization, as identified by 46 respondents. Within agroprocessing, oil quality was specifically mentioned, and the related topics of storage, postharvest, and packaging were also considered priority research areas by 20 respondents. Another related topic, mentioned by 5 respondents, is food safety, product quality, and health. Respondents highlighted priority training needs for agroprocessing, food safety, storage science, and product quality management.

The third grouping of major research areas includes improved crop management and crop husbandry, mentioned by 38 respondents. Within improved crop management, the following issues were specifically mentioned as important research areas: farm mechanization, improved cultural crop production practices, low-cost crop management, development of ecologically adoptable crops, and Fadama food plains farming. Integrated farming systems were specifically mentioned by 10 respondents as important research areas. Respondents then highlighted the following crop issues as areas with priority training needs: crop husbandry, farm mechanization, procurement of laboratory equipment and chemicals, and training for research technologists. In addition, respondents mentioned the need for participation in learning events and conferences to gain increased exposure to the latest crop management techniques and methods.

The fourth major area, mentioned by 36 respondents, is plant health. Twenty respondents mentioned crop protection and weed control as being important, and 16 respondents highlighted pest and disease diagnosis, control, and management. Two respondents specifically mentioned identification of indigenous plants for pest and insect control, and nine respondents singled out integrated pest management (IPM) as important research topics. Respondents also highlighted priority training needs in pathology, entomology, integrated weed management, GIS, IPM, and organic farming.

The fifth major crop research area is extension research and the analysis of farmers' adoption or nonadoption of technologies. This research area was identified as important by 28 respondents. A related topic, identified by 16 respondents, was crop economics and markets research. Two respondents

specifically singled out resource efficiency management as an important consideration. Respondents then highlighted priority training needs in agricultural economics, statistics, GIS, and extension research.

The next significant grouping of crop research areas of importance, as identified by 22 respondents, was soil and water management. Soil fertility management was singled out as an important research area by 16 respondents; soil and water management combined were highlighted by 5 respondents; and irrigation management was mentioned by 1 respondent. Respondents highlighted priority training needs in soil analysis and survey, GIS and resource mapping, water management, and irrigation management.

Fourteen respondents identified various aspects of horticultural and high-value crops as important crop research areas. The various responses that make up this grouping include domestication of wild tree crops and indigenous fruits; increased production of high-quality cocoa, rubber, and gum arabic; control of fruit flies; improvement of industrial crops for local industries; pathogens related to the decay of fruits; and analysis of the socioeconomic value of tree crops as important research areas. Respondents highlighted priority training needs in the improved production of horticultural and high-value crops, as well as improved marketing and processing techniques for these crops. Other research areas mentioned by respondents are shown in Table 34.

Table 34. Distribution of respondents based on key crop research issues identified (N = 206 staff)

Key Crop Research Issues	All	Research Institutes	Federal Colleges	Universities	ARCN
Breeding, genetic improvement, varietal improvement	89	50	5	28	3
Processing, value addition, crop utilization	46	38	4	2	2
Crop management, crop husbandry	38	19	3	15	1
Extension; farmers' technology adoption	28	21	2	4	1
Crop protection and weed control	20	10	3	6	1
Storage, postharvest, packaging	20	15	4	1	0
Pest and disease diagnosis, control, and management	16	8	0	7	1
Soil fertility and management	16	7	4	5	0
Crop economics and markets research	16	10	0	6	0
Integrated farming system	10	9	0	1	0
Integrated pest management	9	5	2	2	0
Natural resource management; ecology; environmental safety; environmental impact assessment	9	7	0	2	0
Farm mechanization	8	6	2	0	0
Availability of planting materials; seed production	7	5	0	2	0
Effective nutrient management; fertilizer application and management	6	4	0	2	0
Improved soil, land, and water management technology	6	3	1	2	0
Agroclimatology, including climate change	6	2	1	2	0
Food security and nutrition	5	3	1	1	0
Food safety; quality standard; health	5	3	0	1	1
Improved cultivation of horticultural crops	4	2	0	2	0

Source: IFPRI-ARCN survey (2010).

4.7.2 Livestock Research Issues and Training Needs

Table 35 shows the key research issues in livestock as identified by respondents. Animal breeding and genetic improvement were the top priority research areas identified by 33 respondents. Of these respondents, four specifically mentioned trypanotolerance in cattle breeds as an important research issue. Priority training needs identified by respondents include animal physiology and reproduction, modern techniques in genetics and breeding, biotechnology, and new enzyme development.

The second major livestock research area is animal disease diagnosis, treatment, and control, as specified by 28 respondents. Within this research area, five respondents specifically mentioned vaccination, pharmacology, and parasitological studies as being important. Priority training needs include the use of polynorase chain reaction (PCR) in diagnosis; modern techniques of disease control; vaccination development techniques; diagnostic tools and kits; infection; exposure to new equipment; techniques for drug research; disease diagnosis, such as molecular and immunohistochemical techniques; virology; and ethnoveterinary techniques. Respondents emphasized the need for improvement in research equipment to accompany staff training and retraining in order to improve research productivity.

The third major research area, identified by 25 respondents, is animal nutrition, health, and hygiene. Priority training needs include forage conservation and animal nutrition.

The fourth and fifth major livestock research areas, each identified by 24 respondents, are feed production and management and livestock production and animal husbandry. Priority training needs for feed production and management include low-cost feed development, the amelioration of the feed restriction effect, feed resources evaluation, monogastric animal feeding, feed formulation, and amino acid supplements. Priority training needs for livestock production and animal husbandry include exposure to modern husbandry techniques.

The sixth major livestock research area identified by 16 respondents is processing, handling, and packaging. In addition, 13 respondents singled out food safety and product quality as important research topics. Priority training needs for these research areas include animal product processing technology, drying behavior of processed animal product, design and construction of primary processing, preservation equipment, knowledge of canning as a means of preservation, and food safety.

Six respondents identified the seventh major livestock research area as artificial insemination, with required training on modern techniques in artificial insemination. Other research areas mentioned by five respondents or fewer include dairy production (5 respondents), livestock extension research (4 respondents), livestock mechanization and facilities (4 respondents), the incorporation of exotic and indigenous animals for local breeds (4 respondents), and drug production (3 respondents). Training on modern techniques in these areas was considered vital to the improvement of respondents' work in their organizations. Other research areas mentioned by respondents are shown in Table 35.

Table 35. Distribution of respondents based on identified key research issues on livestock (N = 210)

Key Livestock Research Issues	Total	Research Institute	Federal College	University	ARCN
Animal breeding, genetics	33	6	10	15	2
Animal disease, diagnosis, treatment, and control	28	6	2	18	2
Animal nutrition, health, and hygiene	25	3	9	13	—
Feed production and management	24	6	8	10	—
Livestock production; animal husbandry	22	2	8	11	1
Processing, handling, packaging	16	4	4	7	1
Food safety, hygiene, product quality	13	4	—	8	1
Artificial insemination	6	3	1	2	—
Dairy production	5	2	—	3	—
Livestock extension research	4	2	2	—	—
Livestock mechanization, diagnostic facilities, and processing facilities	4	—	2	2	—

Table 35. Continued

Key Livestock Research Issues	Total	Research Institute	Federal College	University	ARCN
Incorporating exotic and indigenous animals for local breeds; genotype of wild animals	4	2	—	2	—
Alternative sources of drugs; drug production; drug antagonism effects	3	—	—	3	—
Livestock physiology	2	—	—	2	—
Organic food production	2	—	—	2	—
Economic analysis of livestock	2	—	1	—	1
Animal behavioral studies	2	—	—	2	—
Environmental sustainability	2	—	—	2	—

Source: IFPRI-ARCN survey (2010).

4.7.3 Fisheries Research Issues and Training Needs

Similar to crops and livestock, breeding and genetic improvements were also identified as the top research issues for fisheries by the largest consensus of respondents (Table 36). Five respondents specifically mentioned fish biotechnology as an important research topic under fish breeding; in addition, stagnant fish growth was singled out as an important topic. Training on modern techniques in breeding and genetic manipulation, species identification, shrimp breeding, modern cytogenetics, and biotechnology were all identified as important. However, several respondents mentioned that although training of existing staff is necessary, more technical staff must be hired to do fisheries research, especially in relevant organizations with abundant vacancies.

The second major group of research is fish feeds, nutrition, and health, as identified by 21 respondents. Priority training needs include production of floating feeds, fish nutrition, feed extrusion technology, feed management, alternatives to fish meal and soybean meal, and least-cost formulated diets.

The third major research area, mentioned by 21 respondents, is spoilage, processing, and quality control. Two respondents specifically mentioned the need to look at women's participation in fish processing and marketing. Priority training needs include improved processing technologies; training on how to operate modern equipment, such as the atomic absorption spectrophotometer; proximate composition and shelf life of different species; retort pouch processing; new processing and packaging techniques; marketing strategies; food safety; and storage science.

The fourth major fisheries research area is aquaculture production. A related topic is fishpond management and fish farm mechanization techniques, which were mentioned by five respondents. Another related topic is an integrated poultry-fish-crop system, which was mentioned by three respondents. In addition, homestead fishing in rubber farms was singled out. Priority training needs include fish culture systems, culture of marine fish species, stocking techniques, fish farm engineering, mariculture, shrimp culture, and integrated fish-poultry-crop farming.

A consensus of 14 respondents identified fish disease surveillance and control as the subsequent major fisheries research area. Training needs include diagnoses and treatment of fish diseases, fish parasitology, fish biology, fish pathogen culturing, identification of fish pathogens, and treatment control measures.

Other research areas consistently identified include water pollution and environmental issues, sustainability of fisheries production, advanced fisheries management practices, hatchery management, limnology, extension research, and fishing gear and craft technologies. Priority training needs include water quality management, fishing gear and crafts, new water kit equipment, new hatchery equipment, brookstock management, production of high-quality fish seeds, and oil spill in aquatic environments. Other research topics mentioned by respondents are shown in Table 36. In addition to training required, respondents highlighted the importance of access to international journals and publications and participation in international conferences on fisheries, because it is through increased exposure to new

practices that respondents may be better informed on modern techniques and may receive up-to-date information on these important research issues.

Table 36. Distribution of respondents based on identified key research issues on fisheries (N = 215)

Key Fisheries Research Issues	Total	Research Institute	Federal College	University	ARCN
Fish breeding; genetic improvements	25	9	14	2	0
Fish feeds, nutrition, health	21	7	7	6	1
Spoilage, postharvest, processing, marketing, storage	21	10	8	2	1
Aquaculture (shrimp, catfish, mariculture, stocking)	19	4	10	5	0
Fish disease; fish parasitological studies	14	6	3	5	0
Water pollution; environmental pollution; environmental impact assessment	10	3	2	5	0
Sustainability of fisheries production	10	4	1	4	0
Fisheries management and fisheries development	8	0	7	1	0
Hatcheries management; breeder fish development; fingerling production	6	1	3	0	1
Fish pond management and farm engineering techniques	5	1	2	2	0
Extension; impact assessment of technologies; poverty reduction	5	2	2	0	0
Limnology	4	2	2	0	0
Fishing gear and craft technologies	3	0	3	0	0
Integrated poultry-fish-crop farming	3	3	0	0	0

Source: IFPRI-ARCN survey (2010).

4.7.4 Natural Resources Management Research Issues and Training Needs

Soil and water management are rated as the top natural resources management research priority, as mentioned by 35 respondents (Table 37). Under soil fertility, alley farming was specifically mentioned. Another related topic is sustainable land use and management and erosion control, which was mentioned by seven respondents. Another related topic, identified by three respondents, is irrigation management. Priority training needs include soil analytical technique, land survey, water management, soil erosion control, biometrics, irrigation management, land evaluation through remote sensing, and design of low-cost irrigation technologies.

Strategies for sustainable resource use and management are the second major research priority area, identified by 11 respondents. Related topics to sustainable resource use and management that were mentioned by respondents include environmental management, environmentally friendly technologies, and waste management. Priority training needs include environmental impact assessment, GIS, geographic positioning system, biometrics, strategies for sustainable resource use and management, and waste management.

The third major natural resources management research priority (identified by nine respondents) is forest conservation. This research priority includes agroforestry, which was mentioned by nine respondents. Other related topics include conservation of endangered species (mentioned by 8 respondents), germplasm conservation (5 respondents), and biodiversity and wildlife conservation (6 respondents). Priority training needs identified by respondents include forest conservation, GIS, stock assessment, germplasm, ecology, biodiversity management, and germplasm conservation.

The next group of research priorities is pollution control and prevention. Priority training needs include pollution monitoring and control, the use of crop products to reduce oil-polluted soils, and the prevention of chemical spillage. Six respondents identified sustainable fisheries management as another natural resources management research priority. Further topics related to this research issue include overfishing, chemical deposits in water bodies, endangered sea turtles, characterization of bodies of water, and aquatic weed control. Priority training needs include oceanography of deep water, marine conservation, analysis of chemical deposits in water bodies, stock assessment, and GIS.

Other research priorities range from climate change and agriculture and livestock (identified by seven respondents) to organic farming (mentioned by six respondents). Priority training needs include satellite observations for sea surface temperature, use of organic manure, and composting. See Table 37 for a complete list of all research priorities mentioned by survey respondents.

In addition to training required, respondents highlighted the importance of access to international journals and publications and participation in international conferences on natural resources management. Again, respondents acknowledged that access to such sources and events is crucial for them to be better informed of modern techniques and to acquire up-to-date knowledge on these research issues. They emphasized the need to procure more books and publications on sanitation and environ management. Some respondents stressed that the lack of skills and training are not the problem; rather, it is the lack of facilities and materials to do the research—soil testing and land survey equipment were given as prime examples.

Table 37. Distribution of respondents based on identified key natural resource management issues (N = 366)

Key Natural Resource Management Issues	Total	Research Institute	Federal College	University	ARCN
Soil fertility and water management	35	21	9	4	1
Strategies for sustainable resource use and management	11	3	3	5	0
Forest conservation	9	2	1	6	0
Pollution control, prevention, management	8	4	2	2	0
Conservation of endangered species	8	3	0	5	0
Agroforestry	9	4	0	5	0
Biodiversity and wildlife conservation	6	1	1	4	0
Sustainable fisheries resource management	6	1	3	2	0
Climate change and agriculture/livestock	7	2	0	2	3
Sustainable land use and management	6	2	0	3	1
Germplasm conservation	5	4	0	1	0
Organic farming	5	1	1	3	0
Irrigation	3	3	0	0	0
Waste management	3	2	0	1	0
Integrated pest management	3	2	0	1	0

Source: IFPRI-ARCN survey (2010).

4.7.5 Policy and Institutional Research Issues and Training Needs

Only a few respondents answered the question on policy and institutions, because they perceived these issues as not relevant to their mandate. Fewer than 10 staff from federal colleges and universities responded; most responses were from research institutes. Strategies for poverty reduction, extension research, impact assessment, monitoring and evaluation of policies, and fisheries regulation were the most consistently cited research areas. Other research topics are shown in Table 38. Priority training needs include training in policy analysis and impact assessment, collaborative research, private-public partnerships, strategic planning, and policy communication.

Table 38. Distribution of respondents based on identified key research issues on policy research (N = 70 staff)

Key Policy Research Issues	Total	Research Institute	Federal College	University	ARCN
Strategies for poverty reduction	6	5	1	0	0
Extension	6	4	0	2	0
Impact assessment; policy implementation, monitoring, and evaluation	6	2	1	1	2
Fisheries regulation	5	5	0	0	0
Program/project development and management	4	0	1	1	2
Job creation	3	3	0	0	0
Collaborative research; partnership	3	2	0	1	0
Private-sector participation in agricultural research and policy process	3	1	0	2	0
Rural finance	2	0	0	2	0
Strategic planning	2	0	0	2	0
Food safety and public health	2	1	0	1	0
Policy awareness and communication	2	1	0	0	1
Agricultural policy analysis	2	2	0	0	0
Infrastructure development and policies	2	2	0	0	0
Food security	2	1	1	0	0
Participatory approaches; participatory research	2	2	0	0	0
Policies on agricultural productivity	2	2	0	0	0
Training policies; human resources development	2	1	1	0	0
Inconsistent project and program funding	2	1	0	0	1
Improved livelihoods	2	0	0	0	2
Agricultural economics and marketing	1	1	0	0	0
Self-sufficiency in fish production	1	1	0	0	0
Horticulture	1	1	0	0	0
Nonavailability of raw materials	1	0	1	0	0
Reduction of the importation of seed stocks	1	1	0	0	0
Competitiveness	1	0	0	0	1
Women empowerment	1	1	0	0	0

Source: IFPRI-ARCN survey (2010).

4.8. Lessons Learned from Past Training

Respondents were asked whether they had received any technical training related to their field. Of the respondents, 59 said they had received at least one technical training course in the past five years (Table 39). Although responses were not significantly different across gender and highest degree, there is a significant difference across organization type, in that more staff in research institutes received past training than did those in federal colleges, faculties of agriculture, and ARCN.

Table 39. Distribution of respondents who have received training since 2007 (N = 347 staff)

Organization Type	Distribution of respondents who received training (%)
Research institute	71
Federal college	51
University	54
ARCN	50
Total	59
Highest degree	
BSc	57
MSc	53
PhD	63
Total	59
Gender	
Male	59
Female	59
Total	59

Source: IFPRI-ARCN survey (2010).

A majority of respondents found the trainings useful. More than 60 percent found that the training was very useful, while 30 percent found it useful and 7 percent found it somewhat useful (Table 40). Some respondents indicated that some past trainings lacked needs assessment or were not relevant to the trainees' field or areas of work. Some respondents indicated a lack of software, equipment, or modern facilities to work with (for example, feed production and laboratory analysis); unreliable power supply; and lack of funds to implement and practice the training lessons. Others mentioned the short time for training or a lack of follow-up training. Many respondents, including the organization heads, indicated that trainings were provided to only one or two staff and that more people needed to be trained. A majority of organizations, including federal colleges and universities, have no system of institutionalizing training within their organizations. Many respondents indicated that for trained staff to be able to train other organization staff, training should have more depth, more practical or hands-on sessions, and longer class periods.

Table 40. Distribution of respondents based on usefulness of past training (N = 366 staff)

Usefulness of Training	Research Institute	Federal College	University	ARCN	Total
Not useful	1*	—	—	—	1
Somewhat useful	10	2	7	—	7
Useful	25	36	31	40	30
Very useful	64	62	62	60	63

Source: IFPRI-ARCN Survey (2010).
Note: * In percent to total per organization type.

Respondents were also asked, using a five-point Likert scale, about their satisfaction with the transparency of the selection of training participants. The highest proportion of respondents said they were satisfied with the selection of participants in past trainings, whereas 21 percent said they were not satisfied (Table 41). Thirteen percent said they had little satisfaction, while 18 percent said they were somewhat satisfied with the selection of participants in past trainings.

When asked about the most important criteria used in the selection of trainees, 43 percent rated seniority as the most important (Table 41). The second most used criterion is professional merit, which was rated by 26 percent of respondents as the most important and by 47 percent as the second most important. The third most commonly used criterion was is gaps in the organization, which was rated by 21 percent of respondents as the most important, by 15 percent as the second most important, and by 29 percent as the third most important. Eleven percent rated favoritism as the most important criteria being used in the selection of training participants. These findings indicate the need for more careful selection of training participants that is based on identified skill gaps, usefulness in the organization, professional merit, and qualifications of the potential trainees.

Table 41. Distribution of respondents based on satisfaction with trainee selection (N = 366 staff)

Perceptions on Past Training	Total	Research Institutes	Federal Colleges	Universities	ARCN
Satisfaction with training participants' selection					
Not satisfied	21*	21	17	27	11
Little satisfied	13	14	10	14	11
Somewhat satisfied	18	26	18	10	33
Satisfied	42	35	47	44	44
Very satisfied	6	3	8	6	0
First criteria for choosing trainees					
Seniority	43	45	43	43	13
Professional merit	26	22	20	34	25
Favoritism	11	8	11	13	13
Depending on the identified skill gap in the organization	21	25	26	10	50
Second criteria for choosing trainees					
Seniority	23	20	17	27	63
Professional merit	47	58	51	33	25
Favoritism	16	11	14	24	0
Depending on the identified skill gap in the organization	15	11	18	16	13
Third criteria for choosing trainees					
Seniority	25	29	28	20	13
Professional merit	16	12	17	16	50
Favoritism	30	30	29	30	25
Depending on the identified skill gap in the organization	29	29	27	34	13

Source: IFPRI-ARCN survey (2010).
Note: * Figures are in percent to total per organization type.

5. DISCUSSION AND POLICY IMPLICATIONS

This paper provides a descriptive analysis to assess the level of innovation capacity of Nigerian agricultural research system and provide strategies and entry points of strengthening this capacity. Data and information analyzed here is based on a survey conducted with 43 public-sector organizations and 366 individual researchers involved in agricultural research in Nigeria in May and July 2010. The following major findings and key messages emerged:

Weak innovation capacity: The status of research performance presented so far indicates an overall weak innovation capacity of Nigeria's researchers and research organizations. Of particular importance are the overall low level of collaboration and the lack of monitoring and evaluating the use, influence, and impact of technologies and publications being produced by organizations and individual researchers. Although research productivity seems high (205 technologies were produced by research institutes from 1997 to 2008, and the number of publications from 2007–2009 could go as high as 1 book and 14 journal articles per full-time researcher), about 70 percent of these organizations do not have international research collaboration; 50 percent have only regional or national research collaboration; and 70 percent do not have knowledge in terms of use. At the individual researcher's level, about 40 percent of individual researchers do not have any knowledge regarding the adoption or impact of new varieties or breeds that they produced, and 20 percent do not have information on the adoption or use of new management practices or technologies that they developed.

Weak overall organizational capacity: Substantive capacity and incentive gaps are present at the agricultural research organizations. Across all organization types, inadequate and decaying infrastructure and widespread staff vacancies are the two most critical issues constraining the innovation capacity. Both are products of lack of funding and too much dependence on federal allocation. Support is urgently needed to strengthen the abilities for fundraising, diversifying fund sources, and the advocacy and negotiation for agricultural policy change and increased investment in agriculture and research. Some of these issues cannot be solved simply by training. There must also be a greater advocacy to stop freezes in hiring so that critical positions can be filled. A lack of motivation to perform better or to produce more can constrain any capacity development investments or efforts made related to training and hiring new staff. Training for scientific skills should be coupled with a better work environment and organizational culture, both of which have been proven to be important motivating factors for researchers and their organizations to perform better. Among research institutes, the timely release of funds is the top motivating factor identified by researchers in order for them to produce more and be more innovative.

Limited linkages with other organizations: There are very weak linkages and interactions with farmers, the private sector, extension agents, and other actors within the innovation system. About 77 percent of respondents had no international collaboration, while more than 54 percent had no regional or national collaboration in their research projects. In terms of the degree of interaction with relevant stakeholders in developing these new technologies, a large proportion had no interaction with relevant stakeholders; 25 percent of respondents had no interaction with farmers; 51 percent had never interacted with extension agents; 44 percent had never interacted with the private sector; 69 percent had no interaction with NGOs; 58 percent had not spoken with international research organizations; 76 percent had not interacted with regional research organizations; and 46 percent had never spoken with staff from the Ministry of Agriculture. Although a lack of funding is the main cited reason for these weak interactions and collaborations, other challenges consistently cited include lack of leadership; lack of a forum, platform, or opportunity for such interaction; lack of mobility; and tight competition among researchers and between private-sector and public-sector organizations. Greater awareness and sensitization, as well as exposure to practical knowledge, good practices, and experiences on innovation systems in other countries, are urgently needed. ARCN can play a role in facilitating a platform or forum for greater interaction and collaboration.

Organizational culture matters: Organizations and individual researchers vary significantly—some seem to be more productive, well-connected, and more aware of the adoption and impact of their

research outputs than others. It is important to understand factors for why some organizations are doing better than others, given the same broader policy and enabling environment. An organization's culture and work environment seem to make a difference in inducing good performance and innovation capacity. Statistical tests confirm the significant differences in the indicators of organizational culture between good- and bad-performing organizations. Based on the survey, good performance and innovation capacity are associated with the presence of fair and transparent hiring procedures; effective performance evaluation and reward systems; systems of career development and job security; systems of information sharing and knowledge management; clearly defined and communicated division of roles and responsibilities; systems of feedback from stakeholders; and provision of flexibility, freedom to do work, and mobility among researchers. These elements should be adopted by other organizations to increase innovation capacity and improve performance.

Continued skills development training is needed: There is an obvious need for more training and learning support for enhancing both technical knowledge and organizational and management skills. Modern techniques in breeding; genetics; biotechnology; disease control; plant, animal, and fish nutrition and health; aquaculture; processing, packaging, marketing, and storage techniques; biometrics and statistical analysis; GIS; analysis of climate change; and soil and water management appear to be the most widely cited technical training requirements. There needs to be a strong emphasis on improved ability for agriculture economics, policy analysis, impact assessment, and extension research. In addition to fund-sourcing skills, support is required for new approaches in research design and methods, performance monitoring and evaluation, strategic planning, data and knowledge management, IPR policy, patent procedures for technologies, stress management, effective communication, and quality management for research.

More effective ways of delivering training will be needed: A majority of researchers have received some form of training in the past. However, there is some degree of dissatisfaction regarding the usefulness of the training and the selection of participants (21 percent were not satisfied and 13 percent said they had little satisfaction). The most widely used criteria for trainee selection was seniority, according to a majority of respondents, whereas 11 percent rated favoritism as the most important criteria being used in the selection of training participants. These findings indicate the need for more careful selection of training participants based on identified skill gaps, usefulness in the organization, goals and priorities set forth by the organizations, and professional merit and qualifications of potential trainees.

In addition to training, other innovative learning approaches need to be adopted. Respondents highlighted the importance of access to international journals and publications, as well as wider international exposure among researchers. These approaches can be achieved through exchange programs, South-South collaboration, and other innovative learning events to widen the exposure of researchers to good practices and experiences in other countries.

Holistic and integrated approach of innovation capacity development: Although priority trainings are needed, respondents emphasized that training alone will not produce effects if the other, more constraining, problems are not addressed. These problems include inadequate facilities and lack of personnel. Supporting capacity strengthening for research organizations should be viewed more holistically and more broadly; it should look beyond training to include institutional and political considerations, as well as multiple dimensions for innovation capacity. Transforming the agricultural research systems in general, and in Nigeria in particular, will require a comprehensive package that addresses multiple causes of the problem and sources of rigidities, not just patches of short-term remedies.

APPENDIX: SUPPLEMENTARY TABLES

Table A.1. Recommended additional research performance measure, 2010 (N = 43 organizations)

Organization Type	Recommended Additional Research Performance Measure
Research institute	1. Number of bulletins, manuals, and pamphlets produced
	2. Number of farmers, companies, and other stakeholders requiring information from research findings
	3. Participation and presentation in conference and workshops
	4. Trainings and workshops organized
	5. Radio and television programs produced and aired
	6. Extension methodologies developed
	7. Dissemination of technologies produced
	8. Adoption of technologies produced
	9. Impact on farmers, community, production, and food security
Federal colleges of agriculture	1. Number of field experiments established
	2. Number of studies ongoing
	3. Number of farmers, companies, and other stakeholders requiring information from research findings
	4. Field services delivered
	5. Stakeholder assessment and acceptability of organization's outputs and performance
	6. Trainings and workshops organized
	7. Radio and television programs produced and aired
	8. Extension methodologies developed
	9. Dissemination of technologies produced
Universities (out of 17 faculties)	1. Number of farmers, companies, and other stakeholders requiring information from research findings
	2. Dissemination of technologies produced
	3. Participation and presentation in conferences and workshops
	4. Dissemination of technologies produced
	5. Adoption of technologies produced
	6. Impact on farmers, community, production, and food security

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