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MEASURING R&D PERFORMANCE FROM AN INNOVATION SYSTEMS PERSPECTIVE

An Illustration from the Nigeria and Ghana Agricultural Research Systems

Catherine R. Ragasa, Aliyu Sabi Abdullahi, and George Owusu Essegbey

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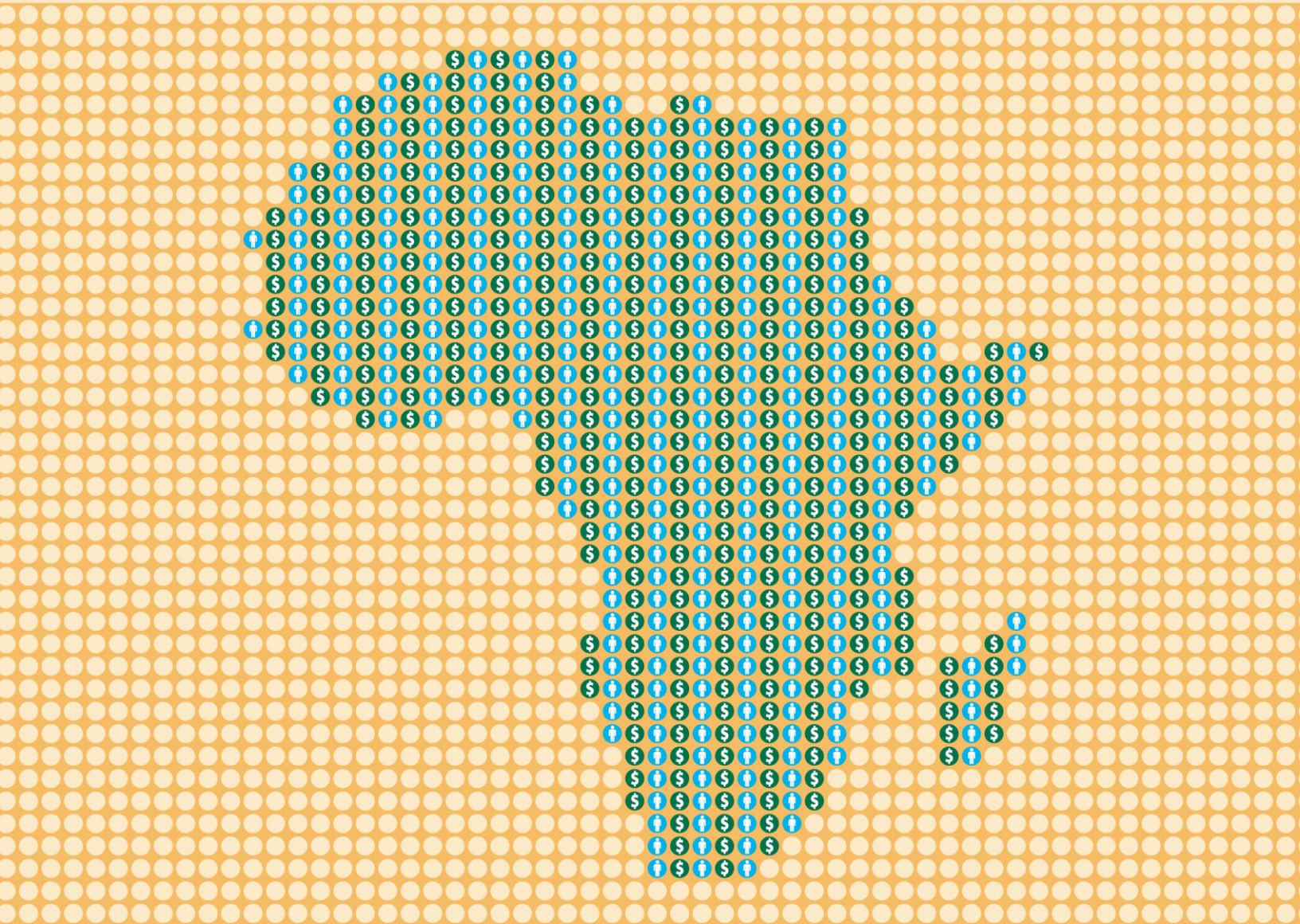
AGRICULTURAL R&D: INVESTING IN AFRICA'S FUTURE
Analyzing Trends, Challenges, and Opportunities



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About the Authors

Catherine R. Ragasa (c.ragasa@cgiar.org) is a postdoctoral fellow within the Development Strategy and Governance Division of the International Food Policy Research Institute; **Aliyu Sabi Abdullahi** (aliyu.abdullahi@arcnigeria.org) is the special assistant to the executive secretary, and program manager of Planning and Institutional Development, at the Agricultural Research Council of Nigeria; and **George Owusu Essegbey** (goessegbey@stepri.csir.org.gh) is the director of the Science and Technology Policy Research Institute.

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Acronyms and Abbreviations

agGDP	agricultural gross domestic product
ARCN	Agricultural Research Council of Nigeria
CAADP	Comprehensive Africa Agriculture Development Program
CORMA	Client-Oriented Research Management Approach
CRIG	Cocoa Research Institute of Ghana
CSIR	Council for Scientific and Industrial Research (Ghana)
FTE(s)	full-time equivalent(s)
GDP	gross domestic product
GIMPA	Ghana Institute of Management and Public Administration
IAD	institutional analysis and development
IFPRI	International Food Policy Research Institute
M&E	monitoring and evaluation
MDGs	Millennium Development Goals
MOA	Ministry of Agriculture
NARO(s)	national agricultural research organization(s)
NARS(s)	national agricultural research system(s)
NGO(s)	nongovernmental organization(s)
OPAS	Organizational Performance Assessment System
REFILS(s)	Research–Extension–Farmers–Input-Supplier Linkage System Committees
RELC(s)	Research–Extension Linkage Committee(s)
R&D	research and development
STEPRI	Science and Technology Policy Research Institute
WAAPP	West Africa Agricultural Productivity Program

Abstract

This paper combines elements of organizational design, institutional analysis, and innovation systems literature to empirically measure organizational performance of agricultural research agencies in Nigeria and Ghana. Results presented in this paper are limited to researchers' perceptions and measures at the national agricultural research organization (NARO) level, and are part of a larger ongoing research program that assesses the effectiveness of R&D investment in these countries.

Findings suggest a very weak to nonexistent farmer or impact orientation in NAROs in these countries, given that large shares of researchers in the samples interviewed had not interacted with farmers or extension agents in the previous year, nor had they any knowledge of the adoption or impact of the technologies they had contributed to generating. Results suggest that NAROs in Nigeria are more productive than those in Ghana based on the number of publications produced, their dissemination, and the perceived adoption and impact of technologies and publications produced. These factors are correlated with reports of greater emphasis on the part of their organizations on the number of publications produced, and greater research linkages in most organizations in Nigeria compared with those in Ghana.

Researchers in Ghana, however, reported more interaction with other innovation actors (other than researchers), which may be a reflection of a reported greater emphasis on internally generated (nongovernment) funding, which in turn requires greater collaboration with the private sector, nongovernmental organizations, and other innovation actors. Researchers in Ghana reportedly have higher staff morale, which translates into higher job satisfaction, satisfaction with the effectiveness of their organizations, and satisfaction with their own work environment compared with researchers in Nigeria. Interestingly, this does not seem to be correlated with most performance measures other than linkages with other innovation actors.

Within Nigeria and Ghana, there seems to be variability across organizations, suggesting that there are both well- and poorly performing organizations within, not just across, countries. Consistent indicators that are all correlated with increased research productivity include the ratio of PhD- to MSc-qualified researchers, the ratio of the operating budget to FTE researcher, researchers' satisfaction with their work environment and with the physical resources available in their organizations, and the presence of international research collaboration and linkages with other innovation actors. Since this is an ongoing pilot study, continuous revision of the definitions and measures used is necessary, but the information gained can be applied to other countries for benchmarking purposes, to extract lessons from past implementation experiences, and to identify realistic indicators of well-performing researchers and organizations that can be usefully measured across a variety of countries and contexts.

1. INTRODUCTION

Numerous research and policy documents highlight the importance of agricultural productivity to food security and poverty reduction (World Bank 2007). Many studies also emphasize that increasing agricultural productivity requires investment in research and development (R&D) and extension, usually coupled with infrastructure (Gabre-Madhin and Haggblade 2003; Diao et al. 2006; World Bank 2007). Various studies have illustrated the high (although widely differing) rates of return to investment in agricultural research in developed and developing countries measured in tangible outputs, often in the form of varietal improvement (Alston et al. 2000; Fan, Fang, and Zhang 2001; Fan 2002; Thirtle, Lin, and Piesse 2003; Byerlee 2004; Heisey and Fuglie 2007; Walker et al. 2008; Hazell 2010; Maredia, Bernsten, and Ragasa 2010). These findings are the primary justification underlying the advocation of increased investment in R&D and extension.

Another set of the literature, however, points to the limited effectiveness of R&D and extension, attributing continually high yield gaps to the inability of these systems to respond to producer demands and new sectoral challenges (Eicher 2001, 2004; Byerlee 2004; IAC 2004; Clark 2005). Funding for agricultural R&D in developing countries increased in the 1980s and 1990s, but issues of financial sustainability and over-reliance on donor funding ultimately emerged as major problems (Pardey, Roseboom, and Beintema 1997; Eicher 2001, 2003, 2004; Beintema and Stads 2011). Much of the literature on agricultural research capacity has focused on Africa, mainly because of a general perception of weak and heavily fragmented research capacity there compared with other regions (Lynam and Blackie 1994; Pardey, Roseboom, and Beintema 1997; Eicher 2001, 2003, 2004; Beintema and Stads 2004; Daane 2008; Jones 2009; Beintema and Stads 2011).

While the need for increased funding and investment in R&D has been emphasized, understanding is limited when it comes to the effectiveness and functioning of the R&D organizations and systems that will receive the intended investment. Several attempts at reform and reorganization have been implemented, and new arrangements have been adopted over the years (Echeverría, Trigo, and Byerlee 1996; Byerlee and Alex 1998; FAO 2002; Byerlee and Echeverría 2002; Raina 2003), but these developments are rarely analyzed in terms of implementation experiences, outcomes, and impacts. No single study could be found that focuses on the perceptions, values, attitudes, and motivations of agricultural scientists and how these relate to their activities and the outputs and outcomes generated. With increasing scarcity of resources, it is vital to understand how R&D organizations and scientists can be more effective and efficient.

A major knowledge gap in understanding and strengthening R&D systems stems from the lack of empirical application of framework, metrics, and benchmarks to measure organizational performance and institutional impact in the context of agricultural research (Goldsmith 1993; Horton et al. 2000; IAEG 2001; Mackay and Horton 2003a, 2003b; Henry and Mark 2003; Walker et al. 2008; Yawson and Sutherland 2010). Frameworks for organizational performance assessment have been articulated by Smith and Sutherland (2002),Yawson et al. (2006), and Yawson and Sutherland (2010) on the use of balanced scorecards for institutional capacity diagnosis; by Peterson, Gijsbers, and Wilks (2003) on Organizational Performance Assessment System (OPAS),which uses a select group to rate the organization's research output, such as technologies, publications, and organizational management systems; and more recently on the Client-Oriented Research Management Approach (CORMA), which also diagnoses internal management practices and procedures, but broadens the coverage of stakeholders providing the ratings (Heemskerk et al. 2003).Still, no single study shares experiences of the implementation process or compares and contrasts the experiences of various organizations or countries. Moreover, while these tools and metrics exist, their use has been limited or unsustained, which boils down to looking at incentives for or bottlenecks in institutionalizing impact orientation and organizational performance assessment. For example, while OPAS has been implemented within the institutes of Ghana's Council for Scientific and Industrial Research (CSIR), very few organizations have

done any organizational performance assessment in recent years or used performance indicators beyond quantifying numbers of publications and trainings provided.

This paper combines elements of existing frameworks, metrics, and benchmarks for organizational performance assessment, having pilot-tested them in Nigeria and Ghana to compare and contrast levels of organizational performance and identify possible elements that explain variations in these measures. The paper neither invents nor reinvents frameworks, perspectives, and approaches for analysis. Rather, it combines existing measures of organizational performance evaluation to illustrate that amore comprehensive look at organizational issues can yield useful insights and add value to current data collection and analysis by the Agricultural Science and Technology Indicators (ASTI) initiative, which focuses on trends in research expenditure and human capacity. More specifically, this paper answers the following research questions:

1. Are agricultural research organizations within Nigeria and Ghana performing differently, and what are the factors that account for these differences?
2. Are there patterns of differences between the agricultural research performance measures in Ghana and Nigeria that are explained by differences in their policies, emphasis, and practices?

Comparing countries in terms of their organizations' structure and operations allows for possible explanations of why weaker or stronger indicators of organizational and individual researcher performance are observed (Box 1, Table 1).[1]

Box 1. Background on Nigeria and Ghana

In terms of policy environment, both Nigeria and Ghana have had similar significant periods of agricultural policy change and structural adjustment over the years, and yet they still have issues with low productivity and high yield gaps in their major crops. Ghana, however, is performing better than Nigeria on many fronts. In 2008, Ghana was close to achieving the 6-percent target growth rate for agriculture set by the Comprehensive Africa Agriculture Development Program (CAADP), whereas Nigeria's growth rate was –0.3 percent. Both countries have a low ratio of agricultural spending to agricultural GDP(less than 5 percent), which is much lower, for example, than Asian countries, which average 10 percent (Fan, Omilola, and Lambert 2009). Ghana also reached the CAADP target of investing 10 percent of total public expenditures in agriculture as of 2009, whereas Nigeria only achieved a share of 4.5 percent that year. In terms of economywide growth, the 2009 GDP growth rate was 4.5 percent in Ghana and only 2.9 percent in Nigeria. The same year, malnutrition rates were 13.9 percent in Ghana (on track with Target 1 of the Millennium Development Goals [MDGs]) and 28.7 percent in Nigeria (well short of the target), and the poverty rate was 35.5 percent in Ghana (on track with Target 1 of MDGs) and 64.4 percent in Nigeria (once again, considerably outside Target 1 of the MDGs; Omilola and Lambert 2010).On a positive note, after decades of decline, agricultural research spending in Nigeria began to rise from 1998 and continued to climb until 2008, the last year for which data are available(in constant prices).

In terms of their national agricultural research systems (NARSs), Nigeria has the largest and most complex system in Sub-Saharan Africa, operating against a historical backdrop of unstable governance, institutions, and funding. Ghana has a relatively small system operating within a more stable environment, yet it is hampered by financial, human resource, and infrastructural constraints. In absolute terms, Nigeria's system is much larger and has higher agricultural research expenditures and staffing. It also has a higher ratio of research expenditures to full-time equivalent (FTE) researchers, as well as more researchers per million farmers, than Ghana. However, Ghana's percentage of agricultural research spending to agricultural GDP is higher (0.94 percent compared with 0.42 percent for Nigeria (Flaherty, Essegbey, and Asare 2010; Flaherty et al. 2010). Both countries have instituted a series of NARS reforms, but they have limited documentation and evidence of their effectiveness or the responsiveness of their research institutions to the needs of poor farmers.

Source: Authors.

[1] Note that this paper is part of a larger, ongoing research initiative that looks at the cost-effectiveness and impact of technologies in Nigeria and Ghana; the paper should be taken as a work in progress, given that continuous revision is needed to refine measurements and definitions.

Table 1. Socioeconomic indicators for Nigeria and Ghana

Socioeconomic indicator	Nigeria	Ghana
Population, 2010 (millions)	158	24
Poverty headcount ratio at national poverty line, 2009(share of population [%])	64.4	35.5
Gross national income per capita,2008–10(U.S. dollars)	1,180	1,173
Life expectancy, 2007–09 (years)	51	64
Literacy rate, 2009(share of population [%])	61	67
Growth rate of gross domestic product, 2009 (%)	2.9	4.5
Malnutrition rates, 2009(%)	28.7	13.9
Agriculture's a share of gross domestic product (%)[a]	33	31
Agricultural investment as a share of total public expenditure, 2009(%)	4.5	10
Ratio of agricultural investments to agricultural gross domestic product, 2009(%)	<5	<2
Growth rate of agricultural gross domestic product, 2009 (%)	–0.3	4.5
Agricultural research expenditure, 2008 (million PPP dollars)	392	95
Number of agricultural researchers, 2008 (FTEs)	2,062	537
Ratio of agricultural spending to FTE, 2008 (millions)	0.20	0.18
Researchers per million farmers, 2008 (FTEs)	168	90
Agricultural research expenditure, 2008(share of AgGDP [%])	0.40	0.94

Source: Compiled by authors from World Bank, Omilola and Lambert 2010; and ASTI database.
Notes: PPP indicates purchasing power parity; FTE, full-time equivalent.
a. Data for Nigeria are a two-year average for 2006–07; data for Ghana are a four year average for 2006–09.

2. FRAMEWORK, MEASUREMENTS, AND DATA

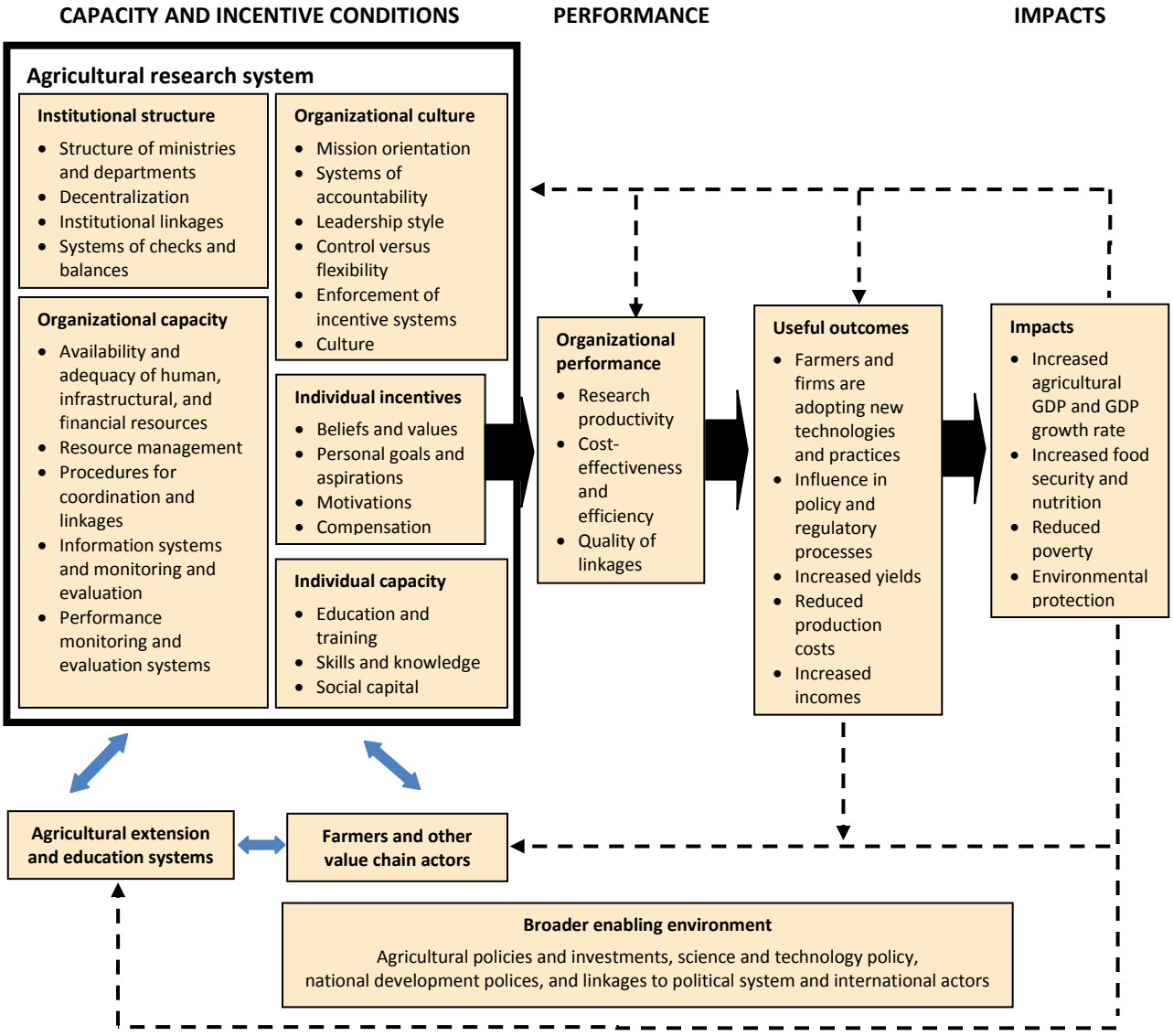
This paper combines elements of institutional theory, organizational design, public-sector motivation literature, and an innovation systems perspective to measure and explain variations in performance. Institutional analysis and development (IAD) highlights the importance of institutional structures and governance in influencing behavior and performance. Structures looked at are formal monitoring and evaluation (M&E) systems, an organization's mission orientation and culture, and financial incentives potentially affecting performance.[2] Organizational design theory emphasizes management systems and procedures for coordination and communication, which can affect performance. Systems and procedures looked at include the existence and implementation of an M&E system for performance, staff's satisfaction with the M&E system, staff recruitment policy, the performance appraisal system, strategic and operational planning, intellectual property rights planning, and staff training and development planning. Public-sector motivation literature emphasizes staff morale as an important link in the effectiveness, efficiency, and sustainability of public-sector organizations. Staff morale is measured as a staff rating of their satisfaction with their job and work environment. The innovation systems perspective focuses on (1) recognition of a wider, differentiated set of innovation suppliers; (2) demand responsiveness and better connectivity of agricultural research with a wider range of innovation actors beyond extension agents and farmers; and (3) an expanded definition of the innovations being developed to include both economic and social applications (World Bank 2007, 2011). These elements are captured by looking at the other innovation actors with whom researchers are

[2]Raina (2003) stresses the need to distinguish between organizational management systems and institutional reform, which is critical for the effectiveness of both policy and of innovation processes. Organizational management often includes formal structures, such as recruitment policies, staff appraisal systems, and other plans, whereas institutional reform emphasizes organizational values, culture, motivations, and staff accountability. In addition to organizational management constraints, Raina (2003) emphasizes the need to look at institutional constraints that can block the innovation process, as well as sources of motivation that can improve performance.

interacting and the level of those interactions. Higher education institutes are included as innovation suppliers, and some indicators are used to assess the use and impact of research outputs.

In bringing these elements together, a clear distinction is made between performance on the one hand, and factors that potentially affect performance on the other. Figure 1 presents a pathway from influencing factors, to organizational performance, to the outcomes and impacts of NARSs within a wider innovation system and broader policy and institutional context. Associated factors explaining variations in performance are grouped as either capacity-or incentive-based. *Capacity* is defined both in terms of the individual (skills, knowledge, education, training, and social capital) and the organization (physical and financial resources, and human resource and management systems). *Incentives* are inherent to an individual's preferences, values, and needs, and are influenced by the nature of institutions and both formal and informal structures/norms. These can manifest themselves as formal incentives(salaries, position classifications, security, and tenure),checks and balances, the availability of timely information on performance or progress in achieving specific objectives, the quality of reward systems, the degree of mission-orientation, and informal structures (such as organizational culture) (Hall et al. 2000, 2001, 2003; Raina 2003). *Organizational culture* represents "the collection of traditions, values, policies, beliefs and attitudes that constitute a pervasive context for everything we do and think in an organization" (Marshall and McLean 1988, 32); several studies have concluded that organizational culture affects an individual's incentive to perform in various contexts. Quinn and Rohrbaugh 1983, Quinn 1988,Quinn and Spreitzer 1991,Yeung et al. 1991,Ramanujam and Rousseau (2006), and Gregory et al. 2009 have done empirical work on organizational culture using a "competing values model" that incorporates two sets of competing values within the organizations: (1) the *control* versus *flexibility* dilemma, which refers to preferences about structure, stability, and change, and (2) the *people* versus *organization* dilemma, which refers to differences in organizational focus. The combination of two sets of competing values gives rise to four different dominant types of culture: (1) group culture, (2) development culture, (3) rational culture, and (4) hierarchical culture (Henri 2006; Gregory et al. 2009). A balanced culture occurs when no one type of culture dominates. Specific measures and survey questions on organizational culture, as used in the aforementioned studies, were adopted in this paper.

Figure 1.A conceptual framework: Analyzing an agricultural research system's performance and impact pathway within an innovation systems perspective



Source: Devised by authors.
Notes: Solid (thick) arrows represent the direction of impact; solid (thinner) arrows represent important linkages and connectivity; and broken arrows represent the feedback process.

In terms of *organizational performance*, three sets of indicators were drawn from the literature: (1) conventional measures of productivity, including quantification of technology developed and publications (such as Peterson, Gijsbers, and Wilks 2003 and Bantilan et al. 2004); (2) public-sector motivation and performance, emphasizing staff morale (for example, Manning, Mukherjee, and Gokcekus 2000; World Bank 2001; and Yawson and Sutherland 2010); and (3) agricultural innovation systems indicators emphasizing connectivity and linkages among various innovation actors, and measures of use and impact of innovations generated by the system (based on Hall et al. 2001, 2002; Hall, Mytleka, and Oyeyinka 2006; Spielman and Birner 2008; Spielman and Kelemework 2009; and CTA 2009).

Technology involves all technologies developed, including biological, chemical, and mechanical technologies and improved production, management, conservation, and marketing practices.

Publications include books, book chapters, and peer-reviewed publications (particularly articles in international and national scientific journals), published as first author or coauthor. Additional measures are included, such as patents and professional awards received by the organization or any of its staff. Staff morale is measured as the respondents' ratings on their job satisfaction, their satisfaction regarding the effectiveness of their organization given its budget, their satisfaction of their own output in comparison to the input of other staff of similar qualifications in similar positions, and their satisfaction in terms of their work environment. The third set of innovation system indicators used includes the frequency of interactions with other innovation actors and end-users, the quality of these linkages, research collaboration, dissemination of research outputs, and the perceived rate of adoption of technologies generated and the perceived use of publications produced by research organizations. Perceptions of scientists were triangulated with information from the heads of organizations as a proxy for adoption because actual adoption rates are currently being collected and validated. Data collection at the farm level is ongoing. The specific indicators for both individuals and organizations are detailed in Appendix Tables A1 and A2; the profile and characterization of responding researchers and organizations based on these indicators are presented in the next section of this paper. See Box 2 for more information on the methodology employed.

Box 2. Data and methodology

The data and information used in this paper were collected through multiple sources. A face-to-face survey using computer-assisted and mobile-based personal interviews was jointly conducted by the International Food Policy Research Institute (IFPRI) and the Agricultural Research Council of Nigeria (ARCN) in Nigeria between May and July 2010, and a similar survey was jointly conducted by IFPRI and the Science and Technology Policy Research Institute (STEPRI) in Ghana between May and July 2011. Two sets of questionnaires were used. The first targeted organizations, to be answered by the head or designated representative; the second targeted individual researchers. The survey was complemented by interviews with key informants and relevant literature reviews.

In Nigeria, a total of 47 relevant public-sector organizations involved in agricultural research were interviewed, including all 15 of ARCN's agricultural research institutes, all 11 federal colleges of agriculture(FCA), and 21 of 48 faculties of agriculture and veterinary medicine in federal universities (based on the willingness of organizations to participate and respond to the survey). In Ghana, a total of 16 public-sector organizations involved in agricultural research were interviewed, including all 9 agriculture-related research institutes under CSIR; 1 of 3 relevant non–CSIR research centers, the Cocoa Research Institute of Ghana (CRIG), based on the willingness of organizations to participate in and respond to the survey; and 6 of 15 faculties of agriculture in public universities identified by STEPRI and ASTI (Flaherty et al. 2010).

Face-to-face surveys of 3–20 randomly selected staff per organization were then conducted by the IFPRI–ARCN–STEPRI teams. Actual sample sizes depended on the total number of research staff at each organization: in Nigeria, sample sizes ranged from 26 to 140 research staff in research institutes and from 5 to 214 staff conducting research in universities, and in Ghana sample sizes ranged from 10 to 77 research staff in research institutes and from 5 to 29 staff working on research in universities. In Nigeria, of a total of 3,920 researchers (individuals, not FTEs), a random sample of 344 were interviewed (9 percent); in Ghana, of a total of 706 researchers, a random sample of 237 were interviewed (33 percent).

Source: Authors.

3. RESULTS AND DISCUSSION

The discussion that follows focuses on the differences between average observed and perceived performance measures in Nigeria and Ghana, and how they relate to the different policies or priorities of organizations in these countries.[3] Specific indicators reflecting capacity, peer effects, and incentive systems are examined to determine which of them explain the variations in performance measures.

Indicators of Observed Research Productivity

Low Number of Technologies Produced Based on Budget and Staffing Levels

In 2009, ARCN in Nigeria began collecting and taking inventory of all the technologies developed by its research institutes since 1997.Between1997and2008, 205 technologies were reported in total, including 58 biological technologies (new breeds and varieties); 56 mechanical technologies; 19 chemical technologies; and 72 improved production and management practices (Table 2). The resulting ratio of available researchers to the number of technologies produced is 2:1, suggesting that it took four to six researchers (the common number of researchers in a team to develop a technology) to develop two to three technologies in 12 years.[4] The ratio of the research expenditures to the number of technologies produced is 3.5:1, suggesting that total research expenditure is about $3.5 million in 2005 purchasing power parity (PPP)[5] prices per technology produced.[6] While no international standards or estimates for optimal research expenditure per technology exists (mainly due to differences in the nature and production of technologies and in cost structures and local contexts), revisiting some of the cost–benefit analyses in existing literature indicates that the total research expenditure per new variety on common beans developed by Michigan State University was around $0.28 million (Maredia, Bernsten, and Ragasa 2010). This suggests that research expenditure per technology in Nigeria is higher than indicated by Maredia, Bernsten, and Ragasa (2010).

In Ghana, Obirih-Opareh, Essegbey, and Frempong (2008) compiled 38 technologies cutting across crops, livestock, fisheries, and others released in 2008. IFPRI and STEPRI are currently compiling data on the wider range of agricultural technologies produced, but a preliminary estimate indicates that CSIR and other research organizations had developed 109 improved technologies since their establishment (38 biological technologies or new varieties, 2 chemical technologies, 7 mechanical technologies, and 52 improved management practices from CSIR agricultural-based research institutes, and 10 improved management practices from universities). Nevertheless, these preliminary estimates have yet to be validated and hence cannot be used for comparison purposes at this stage.

That being the case, a survey of individual researchers is currently more informative. About 75 percent of MSc- and PhD-qualified scientists in Nigeria and 52 percent of MSc- and PhD-qualified researchers in Ghana indicated that they had not contributed to the production of any technologies in the past five years. Almost 20 percent of both MSc- and PhD-qualified researchers in Nigeria produced neither a technology in the previous five years nor a publication in the previous three years. Twelve percent of PhD-qualified researchers and 37 percent of MSc-qualified researchers in Ghana reported not being involved in producing any technology (in the previous five years) or any publication (in the previous three years).

[3] More in-depth discussions can be found on Nigeria in Ragasa et al. 2010, on Ghana in Ragasa and Essegbey 2011, and on factors affecting research productivity at the scientist level in Ragasa 2011a.

[4] Based on ASTI data, the average number of researchers employed at ARCN during 1990–2001 was roughly 500 FTEs, which would correspond to the researcher capacity contributing to producing new breeds released between 1997 and 2008.

[5] PPP indexes are the preferred method for converting relative economic data because they measure the purchasing power of currencies across countries by eliminating national differences in pricing levels in a wide range of goods and services, and are relatively stable over time compared with traditional exchange rates (Beintema and Stads 2011).

[6] Based on ASTI data, the average research expenditure at ARCN during 1990–2001 was roughly $60 million per year or $720 million in total for 12-year period).

Table 2. Productivity indicators employed in the study

Indicators	Nigeria	Ghana
Total technologies produced, 1997–2008	207[a]	109[b]
New breeds/varieties	58	38
Improved production and management practices	72	68
Mechanical/processing technologies	56	7
Chemical technologies	19	2
Ratio of total FTE researchers to total technologies generated	2	4
Ratio of total FTE researchers to total new varieties/breeds generated	9	11
Distribution of researchers reporting not having contributed to technologies generated (% of respondents)	75	52
Distribution of researchers reporting having produced at least one publication (% of respondents)disaggregated by		
BSc qualification	79	25
MSc qualification	82	63
PhD qualification	88	88
Total number of publications produced[c] (mean) disaggregated by	6.28	3.37
BSc qualification	4.79	0.33
MSc qualification	6.47	2.19
PhD qualification	6.47	5.40
Distribution of researchers reporting having disseminated their publications (% of respondents), disaggregated by		
BSc qualification	67	100
MSc qualification	77	62
PhD qualification	79	61
Number of dissemination events (mean), disaggregated by	4.13	1.73
BSc qualification	3.16	0.33
MSc qualification	4.50	1.14
PhD qualification	4.05	2.73
Distribution of researchers reporting having no knowledge of the use or impact of their publications (% of respondents)	70	85
Number of organizations reporting having registered patents	4	0
Number of organizations reporting having received awards	15	4

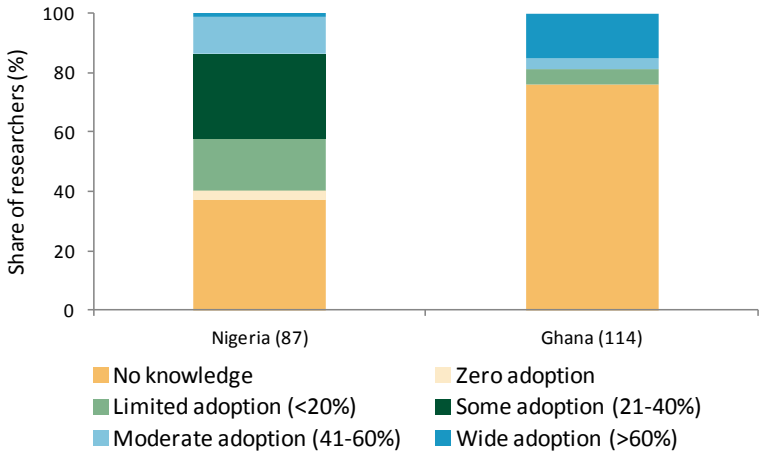
Source: IFPRI–ARCN survey (May–July 2010); IFPRI–STEPRI survey (May–July 2011).
a. These data are for the period 1997–2008.
b. These are preliminary estimates of technologies produced and released since the establishment of the organizations; they have yet to be validated.
c. Publications are defined as books, book chapters, and peer-reviewed publications (particularly articles in international and national scientific journals), authored or coauthored in the previous three years.
d. Dissemination events are defined as presentations by any of the authors at conferences, workshops, trainings, or organized or informal meetings in which research results were shared and presented to other researchers, policymakers, farmers, or extension agents.

Limited Adoption and Impact Based on Researchers' Perceptions and Field Visits

The picture is even more discouraging when looking at the reported adoption of technologies generated in Nigeria and Ghana. More than 90 percent of the heads of the organization sand scientists interviewed reported that they were not aware of any evaluation or impact assessment studies of the technologies they produced. Of the 87 scientists interviewed in Nigeria who reported having contributed to the development of at least one technology, 63 percent were aware of the adoption level of technologies produced due to interactions with and feedback from farmers or extension agents (conversely, 37 percent were not aware of adoption levels; Figure 2). When the researchers were asked about their awareness of the extent of adoption, 20 percent reported either no adoption or limited adoption of

their technologies; 29 percent reported some adoption; 13 percent reported moderate adoption; and 1 percent reported wide adoption.[7]

Figure 2. Distribution of researchers based on their knowledge of the adoption of technologies they produced



Source: IFPRI–ARCN survey (May–July 2010); IFPRI–STEPRI survey (May–July 2011).
Note: Units in parenthesis on the x axis indicate the number of researchers who reported having contributed to at least one technology produced and released by their organization in the previous five years.

The situation in Ghana is even more alarming in terms of the reported adoption of technologies. Of the 114 researchers who reported having contributed to the development of a technology, only 24 percent were aware of their adoption rates (conversely, a huge 76 percent were unaware of adoption rates). These high percentages of researchers without knowledge or feedback on the adoption or impact of their technologies is consistent across research institutes, CRIG, and the faculties of agriculture. Of those that reported being aware of the adoption of technologies produced, 5 percent reported limited adoption of their technologies; 4 percent reported some adoption; and 15 percent reported wide adoption. In early 2011, CSIR and IFPRI also began to look at the adoption rate of a few technologies (using a sample of 10 technologies reported by scientists and the heads of organizations as having high adoption rates). Preliminary results suggest that, based on focus group interviews and field visits, only 4 of the 10 technologies had been well adopted; 1 technology had been adopted at a medium level, and the remaining 5 technologies had been adopted at low levels or not at all (van Rheenen et al. 2011). This indicates that adoption may in fact be lower than reported by scientists.

In terms of technology commercialization and patent registration, four research institutes reported having patents for their technologies (patents per organization ranged from 1 to 5), while there were no reported patents developed by any organization in Ghana. This is another indication of low transfer and uptake of technologies developed in research institutes to farmers and other end-users in both countries.

Lower Publication Rate in Ghana than in Nigeria

Researchers in Nigeria reported producing more publications[8] than those in Ghana across all qualification levels. In terms of the average number of publications, BSc-qualified researchers in Nigeria had published four to five publications in the previous three years, or one to two publications per year. MSc-

[7] Scientists were given the choice of 1 = no adoption in areas where it is expected to benefit; 2 = limited adoption (less than 10 percent); 3 = some adoption (21–40 percent); 4 = moderate adoption (41–60 percent); and 5 = wide adoption (more than 61 percent).

[8] Publications include peer-reviewed publications, particularly articles in national and international scientific journals, books, and book chapters published as first author or coauthor.

and PhD-qualified researchers had published six to seven publicationson average in the previousthree years, or two to three publications per year. In contrast, BSc-qualified researchers in Ghana had hardly published anything in the previous three years; MSc-qualified researchers had published about two publications in the past three years; while PhD-qualified researchers had published five to six publications in the previous three years.

More Dissemination in Nigeria, But Limited Knowledge of Impact of Publications in Both Countries

A large proportion of researchers reported never having disseminated their publications[9] (21–23 percent in Nigeria and 38–39 percent in Ghana), and a higher percentage of researchers in Nigeria than in Ghana reported having disseminated their publications. Researchers employed at research institutes in Nigeria tend to disseminate more publications than their colleagues at federal colleges of agriculture or at universities (which makes sense, given that the primary teaching mandate in the higher education sector). PhD-qualified researchers employed at CRIG tend to disseminate more of their publications than do their colleagues at research institutes or universities in Ghana.

In terms of the average number of events where publications were disseminated, the averages were four events in Nigeria and one to two events in Ghana. To capture the effectiveness of publications, researchers were asked about any feedback they received, or their knowledge of the use of their publications and by whom. The vast majority had received no feedback (70 percent in Nigeria and 85 percent in Ghana); of those who said they received feedback, most reported that their books and papers were used by students or as textbooks in schools, while others mentioned that readers had contacted them to ask for more information on their research. There seems to be no feedback mechanism in the organizations, and lack of interest among researchers to know who uses their publications and to what extent.

Variability across Organizations within a Country Context

Results of analyses of variance indicate wide variation across organizations in terms of measures of research output and perceptions on adoption, suggesting scope for differentiating well- and poorly performing organizations and identifying possible explanations. Building on this, the survey questionnaire asked heads of organizations to list their recommendations of the top three well-performing organizations (1) in terms of technologies generated and publications produced, and (2)in terms of impact on farmers and the community; they could also choose their own criteria and name the top three well-performing organizations that fit them. Among the criteria chosen were funding/revenues generated and level and advancement of facilities/physical infrastructure. Results suggest that the organizations chosen for the first and third sets of rankings tended to be the same, indicating a strong correlation between funding/physical resources and research output. The majority of respondents indicated no awareness of the impact of their own organization or others; hence, they were unable to answer the question about impact on farmers and the community. For those that did answer that question, responses were consistent with organizations/rankings given for the other questions.

Limited Correlation among Conventional Performance Measures

The consistency of performance measures was explored through correlation analyses, the results of which indicate that only a few of the measures were positively correlated, whereas many were either not statistically correlated or were negatively linked (Appendix Table A3). The perceived adoption of technologies produced was positively correlated with peer rating in Nigeria, but the opposite was the case in Ghana. In Nigeria, perceived adoption was also positively correlated with the number of awards received and the total number of technologies generated and publications produced, but in both Nigeria

[9]Dissemination events are defined as presentations by any of the authors at conferences, workshops, trainings, or organized or informal meetings in which research results were shared and presented to other researchers, policymakers, farmers, or extension agents.

and Ghana it was negatively correlated with research productivity—that is, the number of technologies generated and publications produced per staff member. Seemingly, the total output produced and the size of organizations are seen as measures of performance, but not necessarily of effectiveness and productivity. The total number of technologies generated per staff member was positively correlated with the number of publications produced per staff member.

The number of awards received was negatively correlated with research productivity in both Nigeria and Ghana, but positively correlated with perceived adoption of technologies in Nigeria. In Ghana, the number of publications per PhD- and MSc-qualified staff member, the number of dissemination events held, and the perceived use of publications and technologies were positively correlated with peer rating.

There seems to be limited complementarity and consistency across the different measures of performance used, suggesting multiple objectives and perceptions both of performance and of performance measures. In addition, observed research outputs may not provide researchers or organizations with better awareness of adoption or impact. This diversity of perceptions and objectives suggests the need for some tradeoffs in choosing and prioritizing realistic sets of indicators and targets based on the various mandates of the organizations in question. With this in mind, instead of creating an index of performance measures, in this paper, each was correlated with capacity and incentive measures.

Connectivity and Linkages with Other Innovation Actors

Linkages with other innovation actors are analyzed at the individual researcher level by directly asking them about the frequency of their interactions with other innovation actors. The responses were then averaged out at the organization level.

Linkages with Other Researchers

Higher shares of MSc- and PhD-qualified researchers in both Nigeria and Ghana reported interacting with national and international researchers as coauthors of publications. About 63 and 76 percent of PhD-qualified researchers in Ghana reported international collaboration and coauthorship, respectively, compared with only24 and 23 percent, respectively, in Nigeria. Of the MSc-qualified researchers, 78 percent of those in Ghana and 48 percent of those in Nigeria reported national collaboration.

For those researchers who reported having generated technologies, the majority in both countries reported not having collaborated either nationally or internationally. For those that had collaborated, national collaboration was more common for both MSc- and PhD-qualified researchers in Nigeria than it was for those in Ghana. International collaboration was more prevalent among MSc-qualified researchers in Ghana than MSc-qualified researchers in Nigeria, but it was more common among PhD-qualified researchers in Nigeria than PhD-qualified researchers in Ghana. It is also interesting to note that BSc-qualified researchers in Ghana were collaborating both nationally and internationally.

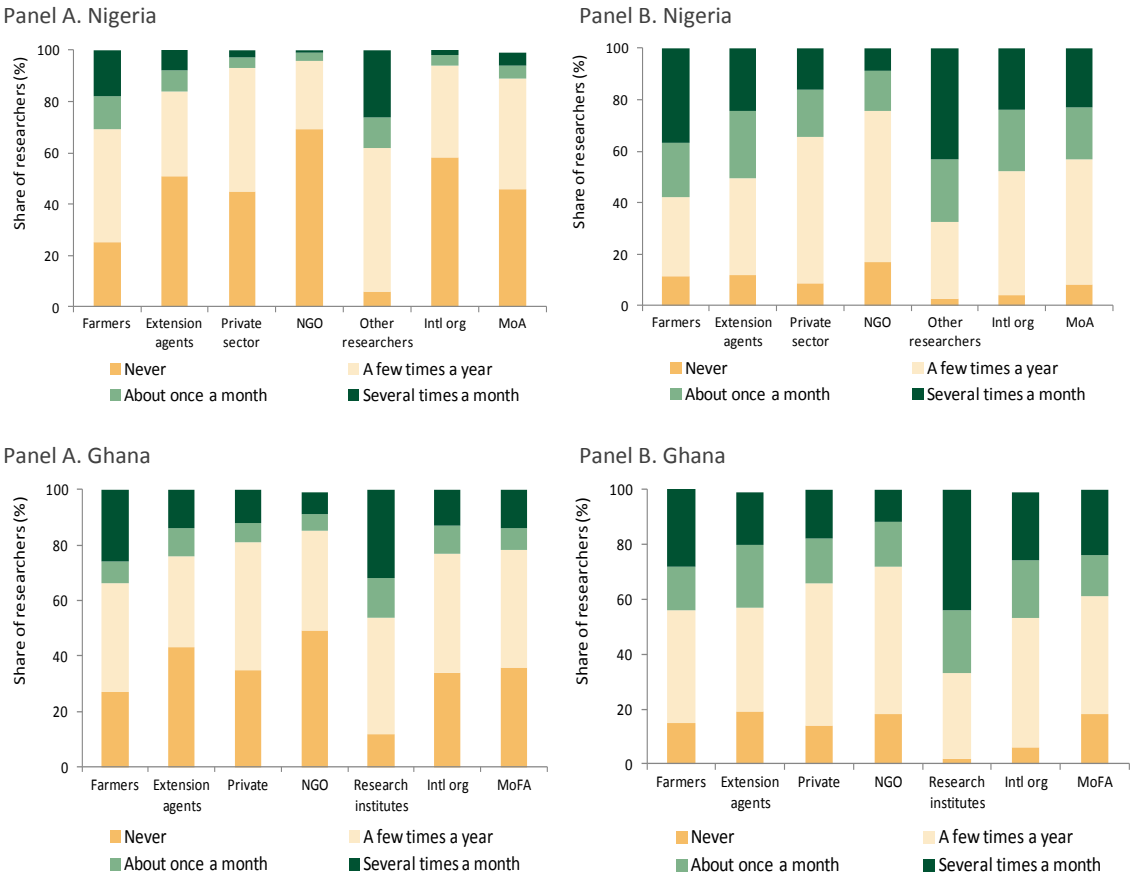
Researchers in Nigeria reported higher levels of interaction with researchers in other organizations: 6 percent of those in Nigeria reported not having interacted with other researchers in the previous year, compared with 12 percent in Ghana (Figure 3). Researchers employed at CRIG appear to have been less connected: 39 percent reported not having interacted with researchers outside their organizations in the previous year.

Limited Linkages with Farmers and Extension Services

Many researchers in both Ghana and Nigeria had not interacted with farmers or extension agents in the previous year, but there was no statistical significance between the two countries in terms of the reported frequency of interactions. About 25 and 27percent of researchers in Nigeria and Ghana, respectively, reported not having interacted with farmers in the previous year (Figure 3); 51 and

43percent of researchers in Nigeria and Ghana, respectively, had also not interacted with extension agents in the previous year.

Figure 3. Distribution of researchers based on frequency of interaction with innovation actors



Source: IFPRI–ARCN survey (May–July 2010); IFPRI–STEPRI survey (May–July 2011).

One institutional arrangement promoted mainly through World Bank–funded projects to foster greater interaction among innovation actors is research–extension linkage committees (RELCs) in Ghana and research–extension–farmer–input-supplier linkage system committees (REFILS) in Nigeria. These committees were established as platforms for joint priority-setting, information sharing, and demand articulation, but with only limited success. In Ghana, RELCs operate at the regional and district level; each RELC has 15 members, including two representatives of farmer organizations, one representative from a nongovernmental organization (NGO), one representative from agribusiness, and representatives from research and extension services. Several reports have concluded that the approach is useful in demand-driven priority-setting (Bekure and Annor-Frempong 1998; FAO–DFID–ODI 2002), but a number of studies have highlighted some limitations in fostering sustained interaction and linkages among innovation actors (Doamekpor 2005; Spielman, Ragasa, and Rajalahti 2011; Ragasa 2011b).

Survey data suggest that in Ghana, half of the faculties of agriculture and 40 percent of agricultural research institutes had never participated in RELCs. Moreover, less than 30 percent of researchers in these institutes and faculties reported being involved in RELC activities. Half of these organizations said that less than 10 percent of their researchers were involved in RELCs. A survey of 237 agricultural researchers suggests that 87 percent were not involved in RELCs. About 70 percent of researchers reported producing at least one new technology in the previous five years or producing at least one publication in the previous three years, but they had never used RELCs as a platform for identifying problems and disseminating their new innovations. This is alarmingly low participation.

Of the 70 extension agents interviewed in an IFPRI and World Bank survey in 2008, 51 percent were not aware of RELCs (Ragasa 2011b), and 70 percent had not sourced any information, improved management practices, or technology in any RELC–related activities. Across all 600 technologies or management practices/packages promoted by the 70 extension agents in 2007, agents reported that only 6 percent had been derived from RELC–related activities. Nevertheless, the majority of topics and technologies promoted by extension agents (82 percent) had been sourced from or learned through colleges and training centers or through in-service training.

In Nigeria, REFILS operate at the zonal level. All 13 of the country's agricultural research institutes were involved in REFILS activities because the institutes coordinate those activities in each zone. However, the number of staff within each organization who reported being involved in REFILS activities ranged from 2 to 100 percent of all research staff. About half of organizations reported that the majority of their researchers were involved, but the other half reported that less than 10 percent of their researchers were involved. This suggests that a majority of researchers is not tapping into REFILS as a platform for obtaining feedback from farmers and disseminating their research and new technologies. A number of the heads of organizations interviewed noted that REFILS was unable to promote collaboration between researchers and other innovation system actors. Among colleges and universities, engagement in REFILS was even weaker. No faculties of agriculture in major universities were involved in REFILS despite their roles in agricultural research and innovation. Only 55 percent of federal colleges of agriculture were involved in REFILS, and for those colleges that were involved, the percentage of staff involved was less than 10 percent.

Beyond problems of participation, the responses of heads of organizations suggest the presence of greater institutional and systemwide issues. Lack of follow-up in response to the identified needs and problems of farmers is a major problem identified in both Ghana and Nigeria. Heads of organizations attributed this to the lack of resources and funding available for innovation processes, especially extension service provision. Multistakeholder platforms only make sense when they are linked to research and innovation processes.

Limited Linkages with Other Innovation Actors

Interactions with the private sector, NGOs, ministries of agriculture, international organizations, political authorities, and policymakers are limited for researchers in both countries. Despite REFILS and RELCs having an explicit focus on the private sector and other stakeholders, private participation is limited. About 35 percent of researchers in Ghana and 45 percent of those in Nigeria reported not having met with a private firm in the previous year. In Ghana, partnerships with private firms and NGOs were being promoted, but only in a limited way. In 1996, the Government of Ghana passed new policies and changed CSIR's mandate to address private-sector concerns. One of the new policies makes commercializing technologies a key function of CSIR; to date, however, according to the survey no patented technologies exist.

About 34 percent of researchers in Ghana and 58 percent of those in Nigeria reported having never met with international organizations. About 36 and 46 percent of researchers in Ghana and Nigeria, respectively, reported not having met with Ministry of Agriculture (MOA) staff either at local or national levels (excluding MOA extension agents). About 50 and 69 percent of researchers in Ghana and Nigeria, respectively, said they had not met with an NGO in the previous year.

There were no differences in the frequency of interactions across qualification levels, but some distinct variations were reported across types of organizations. For example, the frequency of interactions of researchers from the research and higher education institutes were similar in Ghana, but researchers at CRIG reported having more frequent interactions with the private sector, and much less interaction with NGOs. In Nigeria, fewer researchers employed at research institutes reported lack ofinteractions with innovation actors compared with those at the universities and federal colleges of agriculture. The federal colleges of agriculture reported the highest share of researchers who had not

interacted with innovation actors. In Ghana, fewer researchers employed at CRIG reported lack of interaction with farmers or private sector in the previous year; however, more researchers reported not having interacted with other innovation actors (especially NGOs, researchers at other organizations, and international organizations). Fewer researchers at universities than at research institutes reported not having interacted with all types of innovation actors. Researches within the research institutes in Nigeria reported more linkages with innovation actors than those at Nigerian universities, but the opposite was the case in Ghana. Federal colleges of agriculture were the least connected of the three groups across all types of innovation actors, including farmers and extension agents.

The Gap between the Actual and Perceived Importance of Interactions

When researchers were asked what they thought the frequency of interactions should be in order for them to perform their work well and to increase their productivity, the majority indicated that more frequent interactions were needed than were currently practiced. Results suggest differences between the actual and perceived importance of the various frequency levels of interaction with various actors. Overall, 22–24 percent of researchers reported less frequent actual interactions with farmers than was perceived necessary;similarly,32–34 percent of researchers reported less frequent actual interactions with extension agents, 34–37 percent reported less frequent interaction with the private sector, and 40–44 percent reported less frequent interaction with NGOs than was perceived necessary. Hence, an examination of the factors hindering greater interaction would appear necessary. Among the factors cited as hindering interaction with farmers in both Nigeria and Ghana were lack of vehicles or transportation, remoteness of farmers, lack of interest among farmers and researchers, lack of funding to organized meetings with farmers, time constraints, and lack of existing contacts with farmers. Heads of organizations in Nigeria and Ghana cited inadequate funding to facilitate interaction, lack of project vehicles, lack of a forum for interaction, poor leadership structures, weak implementation of some part of the memorandum of understanding (of a project), lack of interest on the part of the farmers, weak farmer organizations, lack of group formation/farmer mobilization, lack of sustainability of collaborative efforts, and farmer illiteracy in some cases. For those who did report interacting with farmers or extension agents, interactions were rated as either “useful” or “very useful” to the researchers’ work, and the majority said that they were able to share ideas; learn about farmers’ problems; and disseminate information, technology, and research findings to farmers or extension agents. This indicates the presence of fundamental and structural constraints to greater interaction that need to be minimized.

In contrast, however, about 10 and 15 percent of researchers in Nigeria and Ghana, respectively, did not believe that interactions with farmers were required in order for them to perform their work well. Similarly, 10 and 19 percent in Nigeria and Ghana, respectively, did not believe that interactions with extension agents were required, and a further 10 percent of researchers in both countries, approximately, did not believe that interacting with other innovation actors was important for their work. This indicates the need to raise awareness among researchers of the importance of these kinds of collaborations in order to shift the mindset of researchers regarding the importance of being connected to the wider innovation system.

Two strategies would be useful for fostering greater connectivity among researchers: (1) addressing the obvious lack of information on the importance and relevance of collaboration and linkages across the innovation system and (2) addressing the constraints to more frequent interaction as described by researchers and heads of organizations, particularly in terms of the funding needed. Many studies focus on the vital need for greater linkages and collaboration, but few look at the constraints and disincentives that prevent this from happening.

Strong Correlations with Other Performance Measures

Positive correlations exist between the frequency of interactions between researchers and various types of innovation actors. In Nigeria, for example, more frequent interaction with farmers is correlated with

more frequent interaction with MOA staff, NGOs, and researchers at other organizations; interaction with the private sector is positively correlated with interactions with NGOs, researchers at other organizations, and MOA staff; and more frequent interaction with extension agents is positively correlated with more frequent interaction with NGOs, international organizations, and MOA staff. In Ghana, greater interaction between researchers and international organizations is positively correlated with all other sets of innovation actors, with the exception of farmers. More frequent interaction with MOA staff is positively correlated with all other types of innovation actors with the exception of researchers at other organizations. The frequencies of interactions with farmers and extension agents are positively correlated. Interaction with NGOs is positively correlated with frequency of interaction with the private sector and extension agents. The analysis reveals two common themes in terms of the factors that hinder interaction among various innovation actors. First, there is general lack of interest in and motivation toward interacting, particularly because it does not effect promotional advancement, salary increases, or recognition. Second, lack of funding is often the major constraint to collaboration and interaction between researchers and other innovation system actors.

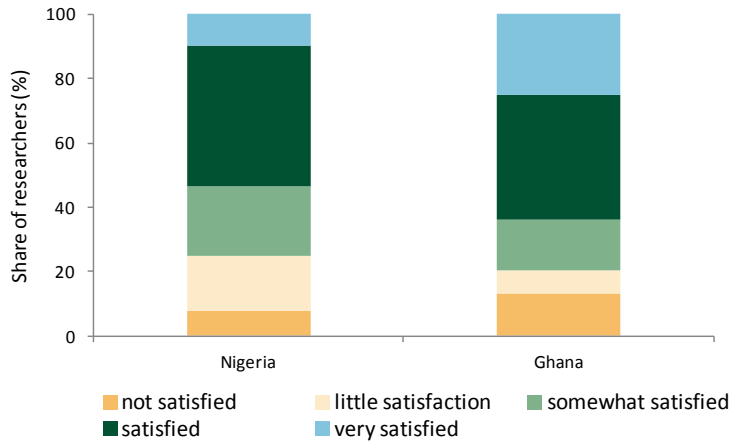
In Ghana, interaction with farmers is negatively associated with technology generated and publications produced per PhD-qualified researcher at both the organizational and individual levels (Appendix Table A4). Interaction with extension agents is positively correlated with average publications per MSc-qualified researcher, and negatively associated with perceptions of adoption. Interaction with NGOs is negatively correlated with the average number of technologies generated per PhD-qualified researcher. Interaction with the private sector is positively corelated with publications produced and the intensity with which they are disseminated by both MSc- and PhD-qualified researchers. Interaction with international organizations and MOA staff is positively correlated with the average number of publications produced per MSc-qualified researcher. International collaboration in producing publications is correlated with the average number of technologies generated and publications produced by PhD-qualified researchers.

In Nigeria, interaction with farmers, extension agents, NGOs, and international organizations are all correlated with the average number of technologies generated per PhD-qualfied researcher. Interaction with researchers at other organizations is correlated with the average number of publications produced per MSc-qualified researcher. Interaction with MOA staff is correlated with the average number of technologies generated and publications produced by MSc-qualified researchers. Average membership in associations is correlated with the average number of publications produced by PhD-qualified researchers. Finally, international and national collaboration are strongly and positively correlated with the number of publications produced per PhD- and MSc-qualified researcher.

Staff Morale

Researchers were asked to rate their satisfaction with their level of research output compared with other staff in a similar position or with the same qualifications within their own or in other organizations. Overall, more researchers in Nigeria reported being satisfied with their outputs than those in Ghana. Ten percent of researchers in Ghana and 25 percent in Nigeria were very satisfied, but 20 percent of researchers in each country reported having little or no satisfaction with their output levels (Figure 4). These researchers said they would like to produce more, which may be a valuable first step toward their achieving greater productivity under existing conditions.

Figure 4. Distribution of researchers based on satisfaction with their output



Source: IFPRI–ARCN survey (May–July 2010); IFPRI–STEPRI survey (May–July 2011).

It seems that researchers in both Ghana and Nigeria were satisfied with their jobs. About 21–24 percent were very satisfied with their job, 65–67 percent were satisfied, and 10–11 percent were not satisfied or were minimally satisfied (Figure 5). Almost all of the researchers said that they chose their job because they liked doing research, developing technologies and inventions, teaching, or helping to solve farmers' problems; 1 percent said they liked their job due to the prestige of research and the salary and benefits offered. These results may be helpful in indicating priorities for incentive structures.

Figure 5. Distribution of researchers based on their perceived satisfaction with their job, their output, the effectiveness of organization, and the work environment

Panel A. Nigeria

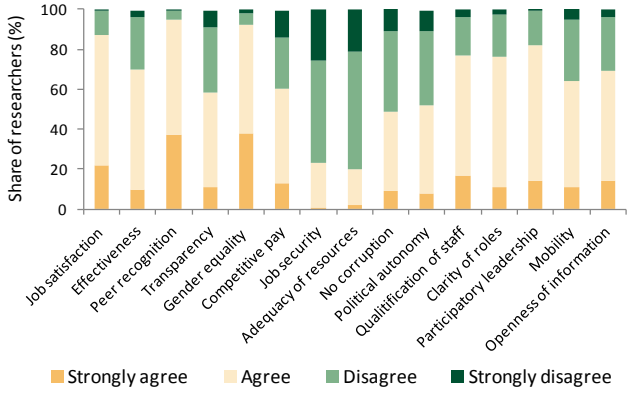
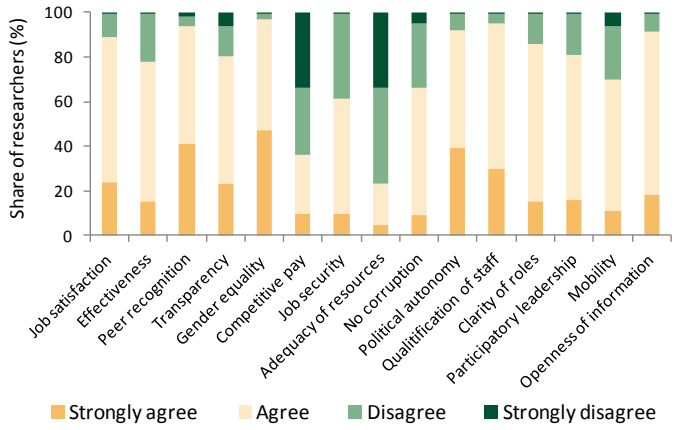


Figure 5. Continued

Panel B. Ghana



Source: IFPRI–ARCN survey (May–July 2010); IFPRI–STEPRI survey (May–July 2011).

In terms of effectiveness, more researchers in Ghana than in Nigeria perceived that their organizations were effective based on their budgets and resources. Fifteen percent of researchers in Ghana and 10 percent of those in Nigeria *strongly agreed* that their organization was effective (Figure 5). A further 63 and 60 percent of researchers in Ghana and Nigeria, respectively, merely agreed that their organization was effective. This perception of effectiveness was not statistically correlated with actual productivity measures or performance indicators.

These results coincide with researchers' perceptions that their working environment and organizational practices reflected transparency, accountability, gender equality, political autonomy, fair and competitive compensation, openness of information regarding output and performance of organization, and satisfaction regarding available resources within organization, among other factors. Researchers in Ghana reported greater satisfaction based on the majority of aforementioned organizational practices. Of these practices, respondents in both Nigeria and Ghana reported low satisfaction withthe adequacy of physical resources and research funding; themajority of respondents (78–80 percent) disagreed that resources wereadequate (Figure 5). Other factors that engenderedmuch dissatisfaction among respondents werefair and competitive compensation, which is rated low by most staff in Ghana, andjob security in Nigeria. Lack of a competitive salary and benefits seems to be a bigger problem for researchers in Ghana, whereas job security was a much bigger issuein Nigeria. Corruption or misuse of fundingin organizations was the next factorthat wasrated low inboth countries. Consistently high ratings were given for peer recognition and gender equality in opportunities (less than 20 percent of researchers weresatisfied with different aspects of their organization's climate).

The big differences between Ghana and Nigeria wereasfollows:

1. A higher proportion of respondents reportedjob security as being an issue in Nigeria than in Ghana,whereasa higher proportion of respondents reported fair and competitive compensation as an issue in Ghana than in Nigeria. The ratings forjob security in Nigeria weresurprisingbecause researchers employed at both the research instituteand higher education agencies were under tenure,and key informants could not recall any instance of a staff member beingfired. This anomoly requires further research.
2. A higher proportion of respondents in Nigeria than in Ghana reported that corruption was an issue in research organizations.
3. Proportionally more respondents in Nigeria than in Ghanareportedthat transparency in recruitment and promotion was an issue.

4. Proportionally more respondents in Ghana than in Nigeria reported satisfaction withthe qualifications of research staff in their position and in their organization.
5. Proportionally more researchers in Ghana than in Nigeriareported that there wasclarity of roles and responsibilties in theirresearch organizations.
6. Proportionally fewer researchers in Ghana than in Nigeria reported thatpolitical interference was an issue.
7. Proportionally more researchers in Ghana than in Nigeria reportedopenness of information about their organization's performance.
8. Slightly more researchers in Ghana than in Nigeria reportedhaving greater mobility within their operational areas.

Compared with other performance measures, a composite index for the working environment isstrongly and positively correlated with other performance measures in both countries. In Ghana, peer ratings and the average number of publications produced per MSc- and PhD-qualified researcher were positively correlated with reported satisfaction with the working environment. Perceptions of their organization's transparency were correlated with the average number of technologies generated per PhD- and MSc-qualified researcher.

In Nigeria, satisfaction with the work environment (based on almost all indicators, as well as their average) was positively and strongly correlated with peer ratings and the average number of technologies generated per MSc- and PhD-qualified researcher. Among the important aspects of the working environment that are correlated with performance measures, the perception of participatory leadership, the quality of human resources and peers within the organization, and the organization's responsiveness to clients' complaints, general effectiveness, and openness of information were associated with technologies generated per MSc- and PhD-qualified researcher.

In both Nigeria and Ghana, more frequent interaction with extension agents was positively correlated with higher operating funding per FTE researcher. Linkages with almost all actors were positively associated with satisfaction with the working environment. Perceptions of transparency in the organization's methods of promotion, recruitment, decisionmaking, political interference, and corruption were positively correlated with the frequency of interaction with all actors. Perceptions of mobility within the operating area were positively correlated with the frequency of interaction with researchers at other organizations. In Nigeria, access to the Internet was positively correlated with the frequency of interactions with researchers at other organizations. In Ghana, organizations located in Accra have more linkages with other actors, with the exception of farmers and extension agents. In Ghana, more frequent interaction with researchers at other organizations was positively correlated with funding for capital investments per FTE researcher. These results suggest that interaction and linkages largely depend on organizational issues and staff morale, which either hinder or encourage them. The survey indicated that important factors encouraging interaction include operating funds, greater mobility, improved transportation, improved Internet access, and other physical infrastructure.

Capacity and Incentive System

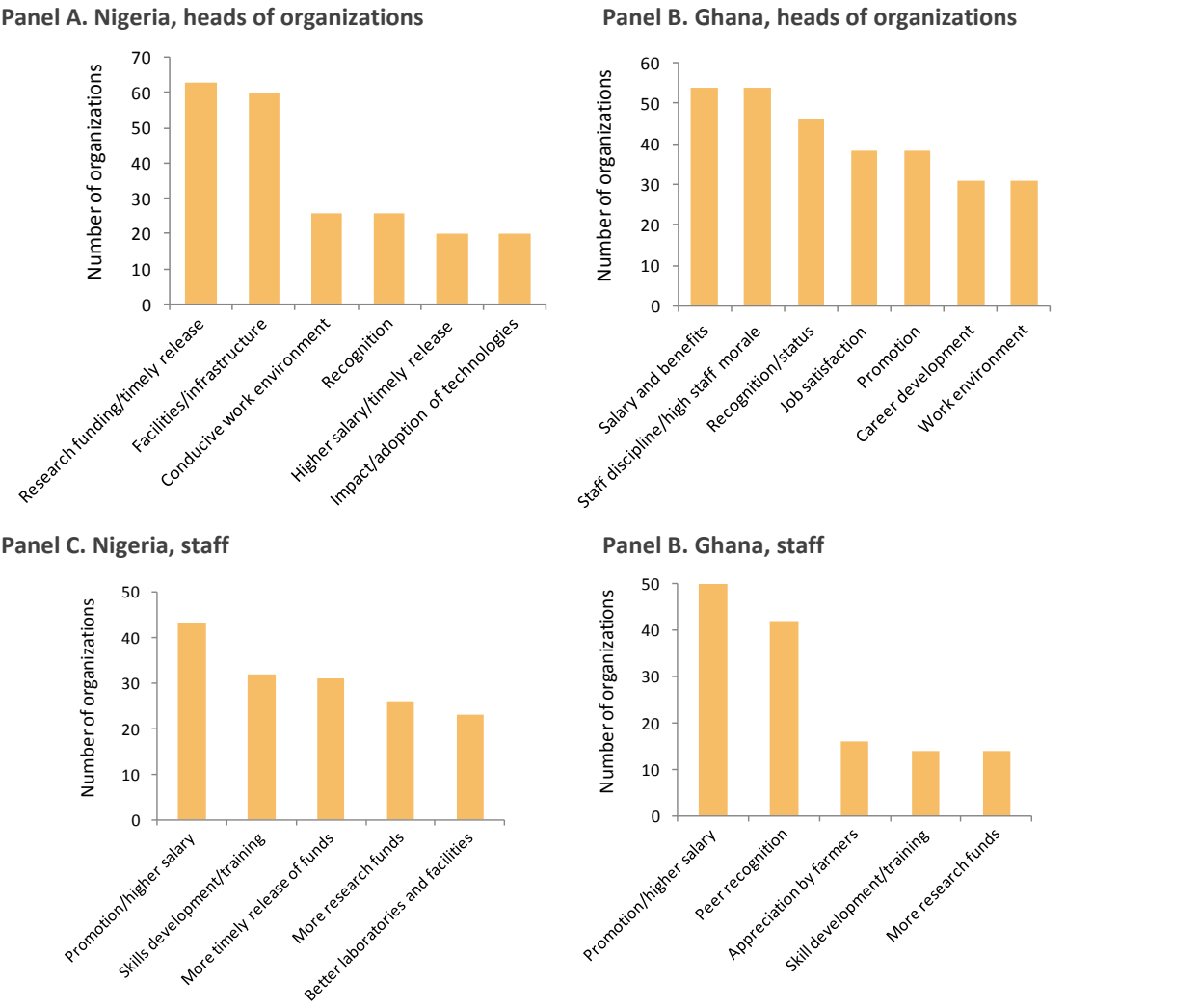
The cornerstone of an effective performance-based reward system is an understanding of what motivates researchers and research managers. Surprisingly, the data indicate that the distinguishing line between capacity and motivation is thin. When researchers and heads of organizations were asked about their motivations (through open-ended questions), most indicated the availability of basic resources, peer effects, and financial incentives.

Motivation among Researchers

A sample of researchers interviewed in both countries rated higher salary and promotion as the top motivating factor for increasing their productivity and performance (Figure 6). Skills development and

training, and more timely release of funding ranked2nd and 3rd in Nigeria, and peer recognition and appreciation by farmers ranked 2nd and 3rd in Ghana. Rounding out the list in Nigeria were more research funding followed by better laboratories and infrastructure. The most commonly mentioned factor in Nigeria was power supply. In Ghana, skills development and training, and more research funding completed the list of motivating factors. This reveals that incentives are not only financial, but are also based on the availability of advancement opportunities in terms of developing skills, and on a conducive work environment within which researchers can conduct their research. In Nigeria, for example, at many research institutes, researchers couldn't even stay in their offices because they were too hot and there was often no electricity for days at a time.

Figure 6. Distribution of organizations based on the top five motivations reported by the heads of organizations and individual scientists, Nigeria and Ghana



Source: IFPRI–ARCN survey (May–July 2010); IFPRI–STEPRI survey (May–July 2011).

Motivation among Heads of Organizations

Responses by heads of organizations differed in some respects in terms of motivating factors for increasing their productivity and performance. In Nigeria, 60 percent of heads of organizations cited research funding and/or the timely release of funds as the most important motivating factor. This was closely followed by facilities and physical infrastructure (all heads of federal colleges of agriculture mentioned this as the most important factor). A conducive work environment, peer recognition, high

salaries (and/or timely payment of salaries), and the impact/adoption of technologies generated were among the top motivating factors. In Ghana, high salaries (and/or health insurance) were the top motivating factor reported by 53 percent of heads of organizations. Closely following were recognition/status, staff morale or staff discipline and support, career development, and a conducive work environment.

Mission Orientation and Organizational Management System

Indicators of mission orientation included (1) satisfaction with the organization's management systems; (2) satisfaction with indicators used for monitoring and evaluating the performance of researchers; (3) the mission orientation of the head of the organization, and (4) the degree of control or flexibility the organization exerts through its culture. Measures of organizational management procedures and systems were not statistically correlated (and were even negatively associated in some cases) with measures of performance. Nevertheless, researchers rated the presence of and their satisfaction with implementation and management procedures as low. Half of the heads of organizations in both Nigeria and Ghana reported that they did not have an M&E system for organizational performance; half the heads of organizations in Nigeria and 25 percent of those in Ghana reported that they did not have a strategic plan; 35 and 7 percent, respectively, reported not having a staff performance appraisal system; 35 and 25 percent, respectively, reported not having a training and staff development plan; and 80 and 75 percent, respectively, reported not having a policy on intellectual property rights.

OPAS was implemented in Ghana in the early 1990s, which might explain the higher levels of satisfaction in Ghana and the presence of these management systems. Nevertheless, many organizations in Ghana have not implemented these systems despite OPAS. OPAS is currently being implemented in Nigeria, where it seems the issue is not lack of awareness or capacity to implement, but the commitment to sustained implementation. The Ghana Institute of Management and Public Administration (GIMPA) has organized leadership training sessions for CSIR on organizational management, including evaluation M&E; however, even though M&E elements exist at various levels of CSIR management, training on the application of the information and knowledge through GIMPA may be extremely useful. Key informants reported that the trainings vary in depth and quality, were mostly of a general nature, and required implementation by management. The fact that the systems were often not implemented signals that the trainings are often supply- rather than demand-driven. The other problem is that the reality of applying these organizational systems is often very different from the theory. Hence the problem boils down to a combined lack of commitment to implementation on the part of management, and lack of adequate practical knowledge on the implementation process.

Another area looked at was whether rewards or sanctions/disciplinary actions were used. Correlation and regression analysis suggests that rewards (that is, positive reinforcements) are positively associated with performance in both Ghana and Nigeria. This further suggests that incentive systems need to be implemented to provide a tangible "carrot" that increases productivity in research organizations as opposed to simply paying lip-service to M&E and staff appraisal systems.

Missionorientation manifests itself in the performance indicators used by anorganization. All the heads of organizations interviewedsaid that they report to and feel accountable to the executive director of CSIR or theprovost or dean of their university. They enumerated various factorswhen asked to name thefive performance indicators used by these people to judge both their performance and the performance of the organizations. In Nigeria, 20 different responses resulted, ranging from publications produced; totechnologies generated; to punctuality, comittment, and trainings conducted. Ghana returned 13 different responses from heads of organizations, ranging from internally generated funding to staff morale. In both countries, when the heads oforganization cited technology generation as a performance indicator, higher numbers of technologies were generated by the organization's researchers. If heads of organizations cited producing publications as a performance indicator, the average number of publications produced per researcher was higher. When impact on farmers or the

community was cited by the heads of organizations as a performance indicator, researchers tended to display greater knowledge of technologies and their adoption, and more knowledge of these and impact of their publications. This indicates that researchers respond to their organization's chosen performance indicators, signifying a point of entry for leaders and managers.

Organizational Capacity and Resources

Several indicators were used to capture differences in resources, the quality of human resources, and peer effects, which may explain variations in performance measures. For physical and financial resources, the following indicators were used: (1) expenditure on research during 1992–2003 (disaggregated as salaries, operating costs, and capital investments),which would roughly correspond to most technologies generated during 1997–2008; (2) the ratio of research expenditure to FTE researchers; and (3) the heads of organizations' satisfaction regarding the adequacy of physical resources. Total funding (in 2005 PPP dollars) is correlated with peer ratings. The ratio of operating costs to FTE researchers is positively correlated with the number of publications produced per MSc-qualified researcher in Ghana, and the frequency of interaction with innovation actors is strongly correlated with the operating budget per FTE researcher in both Nigeria and Ghana.

Research facilities and physical infrastructure are statistically correlated with technologies generated per PhD-qualified researcher in both Ghana and Nigeria, and with awards received and peer ratings in Nigeria. In both countries, more than 90 percent of organizations were not satisfied or had little satisfaction with computer and Internet facilities and their access to journals. About 92–95 percent of heads of organizations in Nigeria, and 69–73 percent of those in Ghana were not satisfied with their information and communications facilities and systems at their headquarters and substations. In terms of research facilities and other physical infrastructure, 55 and 12 percent of heads of organizations in Nigeria and Ghana, respectively, said that they were not satisfied with the adequacy of facilities at their headquarters. The rating was even worse for substations: 65 and 37 percent of heads of organizations in Nigeria and Ghana, respectively, said they were not satisfied with the adequacy of facilities at their substations. In both Nigeria and Ghana, satisfaction with facilities, communications, libraries, and transportation were associated with the average numbers of technologies generated and publications produced by PhD- and MSc-qualified staff.

One difference between the two countries is that more heads of organizations were dissatisfied with the adequacy of their facilities and systems in Nigeria than in Ghana. A related issue is the lack of modern research equipment, mentioned by 17 heads of organizations, and power supply, mentioned by 15 heads of organizations. In Nigeria, funding dropped sharply and became irregular from the 1960s to the mid-1990s, which negatively affected infrastructure and resources and seriously weakened organizations' ability to conduct research. Nigeria is, however, attempting to accelerate its infrastructure development. Capital investments accounted for only 2 percent of the CSIR agencies' research expenditures in 2008, whereas they constituted 45 percent of ARCN's total spending that year. As part of the reform process, Nigeria is undertaking a systematic assessment of optimal investments in their facilities and equipment. It seems that, in the past, there was too much focus on short-term training; observations from this study suggest that investment in human resources or training can only be effective with complementary investments to fill gaps in the physical resources.

For human resource capacity and peer effects, three indicators were used: (1) salary costs per FTE researcher; (2) researchers' perception of whether other researchers were well-qualified for their positions (signifying the quality of the pool and building on the peer-effect assumption within organizations); (2) perceptions of heads of organizations as to the adequacy of human resources; (3) the ratio of PhD- to MSc-qualified researchers in the organization; and (4) the percentage of researchers that reported having received technical training. In Nigeria, the ratio of PhD- to MSc-qualified staff and the number of technologies generated per FTE researcher were positively correlated. In Ghana, the ratio of PhD- to MSc-qualified researchers was positively correlated with the number of publications

produced per MSc-qualified researcher. In both countries, the higher the ratio of PhD- to MSc-qualified researchers, the more productive researchers wherein generating technologies and producing publications.

In Nigeria, on average, researcher perceptions that staff within their organization were well-qualified were correlated with higher perceived technology adoption rates, higher numbers of technologies generated per PhD-qualified researchers; and higher peer ratings. In Ghana, average numbers of publications produced per PhD-qualified researcher were positively correlated with perceptions that staff were well-qualified for their positions. In Nigeria, training appeared to be positively correlated with higher average numbers of publications produced per PhD-qualified researcher.

4. CONCLUSION AND POLICY IMPLICATIONS

The task and processes involved in designing and implementing this study were complex and challenging. The paper should be taken as a work in progress, requiring ongoing refinements of measurements and definitions, especially in the event that they are scaled out to other countries. Moreover, the results described in this paper only cover national agricultural research organizations (NAROs), so more research is needed to expand coverage to a wider set of innovation actors and to capture adoption rates and impacts on farmers and other end-users in order to fully assess the effectiveness of R&D investments and innovation performance of NARSs. Nonetheless, a number of observations and insights are informative from this ongoing pilot study in terms of entry points for strengthening capacity and performance of agricultural research organizations both in Ghana and Nigeria. Key observations and insights are summarized below.

Limited Farmer or Impact Orientation

Across all organizations in both Ghana and Nigeria, there is lack of farmer- or impact-orientation, and the approach being used is still supply-driven. The number of publications produced is heavily emphasized, especially in Nigeria, as is internally generated (nongovernmental) funding in Ghana. Some organizations emphasize the generation of technologies but stop short of follow-up on what happens to these technologies in terms of their adoption and impact. Many researchers in both Ghana and Nigeria do not interact with farmers or extension agents, and a large share has no knowledge or awareness of the adoption of the technologies they contributed to developing. Only a few researchers and heads of organizations cited that helping farmers or having an impact on community was a motivating factor in their work, an implicit or explicit measure of their performance, or a guiding value in their organization's culture. Although several workshops/trainings have been conducted in Nigeria and Ghana on the innovation systems perspective, international agricultural research for development, and similar approaches, no NARO has implemented or fully embraced these approaches. The closest involvement is in RELCs and REFILS, but sustained interaction with farmers and agribusiness, and participation in extension activities remain very weak.

On a more positive note, the output and productivity of researchers in some organizations in Ghana and Nigeria appears to shift in response to explicit performance indicators, suggesting some entry points for intervention. If heads of organizations cited that the number of publications produced was used as a performance indicator, more publications were likely to be produced by their organizations' researchers. If heads of organizations cited that the number of technologies generated was used as a performance indicator, researchers are likely to generate more technologies on average. The explicit inclusion of publications, technologies, adoption, impact, and solving farmers' problems could be tested and implemented as performance indicators, but an appropriate reward system would also need to be in place. As OPAS–based capacity strengthening is ongoing, an urgent action for ARCN is to ensure that measurable targets are included in terms of the productivity and efficiency of research,

the quality of research linkages, and the impacts on farmers and the community. Capacity strengthening efforts under the West Africa Agricultural Productivity Program (WAAPP) can also instigate stricter design and implementation of performance targets in organizations.

This process, however, would require stronger leadership and management commitment to increase researchers' accountability to farmers and end-users, and to ensure that M&E processes are sustainably integrated into organizations. For example, a more effective performance-based reward system with greater transparency would be necessary. External accountability would also help, as would openness of information about organizational performance. Increased levels of international research collaboration seem to be associated with higher levels of research output and productivity, greater awareness of adoption, and improved peer ratings. Innovations adopted in other countries to increase researcher accountability have potential in Ghana and Nigeria: (1) strengthening producer organizations to provide a leadership/management role in setting priorities, selecting service providers, and implementing competitive research and extension grants; and (2) hosting producer organizations in research institutes to cultivate their full engagement in developing research and technologies.

Policy and Perspectives Are Reflected in Observed Performance

Overall, performance measures used in Nigeria and Ghana differ according to national and institutional contexts and the different perspectives of their research councils. On average, researchers in Nigeria were more productive in terms of numbers of peer-reviewed publication per researcher compared with researchers in Ghana. Such differences can result from stronger organizational emphasis on publications as an explicit organizational performance indicator and an implicit measure of peer recognition. This is also associated with increased emphasis on internally generated and other nongovernment funding in Ghana, which are associated with increased consultancies rather than peer-reviewed publications. The results of this study are inconclusive when it comes to correlating technology generation with data constraints.

Researchers in Ghana are generally more satisfied with their working conditions than are researchers in Nigeria. In Ghana, a majority of heads of organizations cited staff morale as a top motivating factor, whereas none of the heads of organizations in Nigeria included staff morale in their rankings. Researchers in Ghana reported having better linkages with other innovation actors than in Nigeria, but researchers in Nigeria reported having better linkages with researchers in other organizations. This could stem from greater emphasis on research collaboration in CSIR policy, explicit NARO performance indicators, and implicit peer ratings on generating nongovernmental funding, which would require interaction and collaboration with the private sector, NGOs, and international organizations. These linkages among Nigerian researchers also seem to be correlated with a stronger emphasis on the number of publications produced as the performance indicator in NAROs and ARCN, which are generally enhanced by interactions with other researchers. It seems that stronger linkages with other researchers is also correlated with more tangible research outputs, but staff morale and increased linkages with end-users and other actors are not necessarily correlated.

Inconsistencies in Performance Indicators

Complementarity and consistency are limited across the different measures of performance used, suggesting multiple organizational objectives and perceptions of performance or performance measures. For example, more researchers in Ghana seems to have more linkages with innovation actors and are more satisfied with human and physical resources available to them, their organizations' management practices, and their working environment, but these do not seem to translate into higher productivity in terms of technologies generated or publications produced. More researchers in Ghana than in Nigeria perceived that their organizations were effective given their budget and resources. In Nigeria, more researchers perceived that adoption, awards, and peer ratings were all positively

correlated, but in reality they were seemingly negatively correlated with productivity in terms of the number of technologies generated and publications produced, and per PhD- and MSc-qualified researcher. In Ghana, productivity and peer ratings were positively correlated, but all were negatively correlated with perceived adoption levels. From a policy and operational perspective, these multiple and inconsistent/uncorrelated objectives suggest the need to rationalize and prioritize the indicators/targets used in order to achieve a realistic and balanced set that organizations can implement and commit to based on their mandates. Nevertheless, regardless of the methods employed, refocusing NAROs on their mission to have an impact on poor farmers and end-users would be beneficial. This scope of this study needs to be expanded to include an examination of actual technologies adopted and their impact, although this would depend on the availability of relevant data.

Variability within Countries

Differences were also found in performance and linkage measures among organizations within each country. There were pockets of organizations that perform well or poorly despite national and institutional continuity. One does not even have to go out of their own countries to find examples of good practices. It is important to draw lessons from well-performing organizations, which implies identifying scalable elements across similar organizations in a given country. Similarly, larger, well-performing organizations could offer insights and assistance to their smaller and less well-resourced counterparts.

Infrastructure Acts As a Binding Constraint

Satisfaction with physical infrastructure and the work environment were statistically significant in explaining variations in several performance measures analyzed. Among the indicators of work environment, those most often significant were the perception of participatory leadership, the absence of corruption and political interference, and the presence of well-qualified staff, transparency, and open information. Satisfaction with the adequacy of research facilities, physical infrastructure, and the Internet and communications systems were also statistically significant. Salary and benefit levels were consistently mentioned by researchers and heads of organizations, especially in Ghana, but variations in the perceived competitiveness of salaries, adequacy of salaries relative to living expenses, and salary costs per FTE researcher did not appear to be statistically correlated with variations in any of the performance indicators. Although further research is needed to investigate optimal salary levels, in recommending priority investments for increasing their productivity and output, the majority of researchers suggested improvements in basic facilities, which contrasts the much heavier emphasis on low salaries highlighted as the binding constraint in other studies, such as Byerlee 2004. Increasing capital investments and building physical resources will be important factors in both Nigeria and Ghana.

Constraints To Greater Linkages

A large majority of researchers was aware of the crucial importance of linkages with other innovation actors, but it seems that achieving them is hindered by structural barriers. Currently, researchers have limited linkages with innovations actors in both Ghana and Nigeria (although the situation is slightly better in Ghana). Improvement could be achieved, first, by shifting researchers' mindset and strengthening their capacity to link with other innovation actors and end-users, and second, by addressing the constraints to greater linkages, which include lack of funding and transportation, and lack of interest or motivation by both parties. In Nigeria, while there is relatively stronger collaboration between research institutes and higher education agencies, linkages with other stakeholders, including private-sector actors, service providers, and end-users are highly limited. New institutional and organizational frameworks are emerging from ongoing collaboration between ARCN and IFPRI to incorporate the promotion of industry funding and greater collaboration among stakeholders, which

were suggested in initial presentations of the results of this study to ARCN. It will be interesting to see how the Nigerian NARS develops in the next three to five years in light of the reform process.

Many of these actions require substantial investment from the government and partners. Infrastructure is a binding constraint, especially in Nigeria, and this requires investment. Linkages are crucial, but results indicate that they do not occur automatically but rather need to be encouraged through the use of incentives, and supported financially through explicit inclusion in research and extension budgets. Salary and benefit levels seem to be a greater issue in Ghana (although further study is needed to determine whether this is a binding constraint), and once again these require sustained investment. Strengthening human resources—including technical, scientific, management, innovation system, and value-chain capacity—which seems to be needed in both Ghana and Nigeria, also requires investment. While Ghana is close to reaching an agricultural budget allocation of 6 percent of GDP, its investment is still very low based the size and importance of its agricultural sector. The ratio of agricultural expenditure to agricultural GDP is less than 2 percent in Ghana, and only about 5 percent in Nigeria, compared with the average of 8–10 percent achieved in agriculture-based Asian countries since 2000 (Fan, Omilola, and Lambert 2009; Omilola and Lambert2010). Ghana and Nigeria need to invest much more in agriculture in general, and in agricultural R&D in particular.

APPENDIX

Appendix Table A1. Performance indicators employed in the study

Performance measure	Variable code	Definition
1. Conventional indicators		
Publications	PUBPHD; PUBMS	Number of peer-reviewed publications as first author or coauthor (international journals, national journals, books), disaggregated by MSc- and PhD-qualified staff
Technology	TECHFTE; TECHPHD; TECHMS	Biological or new breeds/varieties; mechanical and processing technologies; chemical technologies; and improved production, processing, management, conservation, and marketing practices and systems; at the organization-level, this variable is the total number of technologies completed and released during 1997–2008 and expressed as a ratio of FTE researchers; at the individual-level, this variable is the total number of technologies completed and released in the past five years to which the respondent/researcher has contributed, disaggregated by MSc- and PhD-qualified staff
Patents		Number of patents registered
2. Organizational theory and public-sector motivation		
Staff morale	JOBSATIS	Rating of the statement: "I am satisfied with my job." (LIkert scale: 1–4)
	EFFECTIVE	Rating of the statement: "My organization is effective given its budget and available resources." (Likert scale: 1–4)
Peer rating	PEERRATE	The number of times the organization is listed among the top five performing organizations rated by heads of other organizations (categorized by organization type); performance was determined based on productivity in publications and technologies and then by impact on the community; organizations were also given the chance to list additional performance measures and name organizations that met them.
Award	AWARD	Number of professional awards received by the organization or a researcher in the organization
Satisfaction with own performance	OUTPUTSATIS	Rating of the statement: "I am satisfied with my output compared with similar positions/qualifications in the organizations or other organizations." (Likert scale: 1–4)
3. Innovation systems perspective		
Linkages	FFARMER; FEXT; FNGO; FPRIV; FRES; FINTL; FMOA; RESINTL; RESNATL; ASSO	Frequency of interactions/meetings of researchers with farmers, the private sector, extension agents, other researchers, universities/colleges, international organizations, ministries of agriculture, policymakers, and political actors in the past year (Likert scale: 1–4); international or national research collaboration (dummy); Number of professional association memberships (dummy)
Adoption of joint priority-setting, participatory approaches, or innovation platforms	PARTICI	Whether the organization adopts joint priority-setting, participatory approaches, or is engaged in innovation platforms (dummy)
Level of dissemination	PUBDISS	Number of dissemination events where publications produced have been disseminated or communicated in the past three years
Perceived adoption rate of technologies	ADOPT	Whether respondents are aware of the adoption of their technologies produced (dummy);if they are aware, to provide an assessment of the adoption rate (from 1=no adoption to 5=wide adoption)
Perceived use and impact of publications	PUBUSE	Whether respondents are aware of the use or impact of publications produced (dummy);if they are aware, to provide details of how it is being used or making an impact

Source: Devised by authors.
Notes: The Likert scale is a rating based on whether respondents strongly agree (= 1), agree (= 2), disagree (= 3), or strongly disagree (= 4).

Appendix Table A2. Capacity and incentive indicators employed in the study

Indicators/variable codes	Definitions/measures/sources of data
1. Organizational capacity	Perceptions of head of organization and staff (ASTI data)
Human, financial, and physical resources (TOTALEXPEND; OPERATINGFTE; CAPITALFTE; EXPENDFTE; ADEQFUND; ADEQPHY; ADEQHUM; PHDMS)	Total expenditures; Ratio operating funds to FTEs (2000–02 average); ratio of capital funds to FTEs (2000–02 average); rating of the adequacy of research funds by head of organization and staff (Likert scale: 1–4); rating of the adequacy of physical resources by head of organization and staff (Likert scale: 1–4); rating of adequacy of human resources by head of organization and staff (Likert scale: 1–4); ratio of PhD- to MSc-qualified staff
2. Organizational management systems	Perceptions of head of organization and staff
Staff satisfaction on work environment (WORKENV; EFFECTIVE; JOBSATIS)	Response to 15 statements about the transparency of staff hiring and promotion, fair and competitive pay, gender equity in opportunities within the organization, political autonomy, coherence, mobility, responsiveness to clients' complaints and demands, job security, flexibility, and participatory leadership—for example: "My organization maintains a transparent process of hiring and promotion."(Likert scale: 1–4)
Availability of organizational management systems (PLAN)	Rating by head of organization of the adequacy of various organizational management systems, such as the systems of performance monitoring and evaluation, staff appraisals, strategic planning, operational planning, and staff development and training planning (Likert scale: 1–4); a composite index was also generated through factor analysis
Training (TRAIN)	Whether respondents were receiving technical and management training (dummy)
3. Organizational culture type	Perceptions of heads of organizations
Type of organizational culture (CONTROL)	Rating of head of organization on 12 statements pertaining to the organization's values, culture, strategic focus, and leadership style (percentage: 1–100)
4.Incentive systems and sources of external accountability	Perceptions of organization head and staff
Presence of reward (REWARD)	Responses of head of organization on whether rewards were given in the previous year (dummy)
Presence of sanction (SANCTION)	Responses of heads of organizations on whether disciplinary action was taken in the previous year (dummy)
Emphasis on technology as performance indicator (PERTECHNO)	Whether heads of organizations cite "technology" as a response to an open-ended question about the performance indicators used by the organization (dummy)
Emphasis on publication as performance indicator (PERPUB)	Whether heads of organizations cite "publication" as a response to and open-ended question about the performance indicators used by organization (dummy)
Emphasis of impact as performance indicator (PERIMPACT)	Whether heads of organizations cite "impact on community/farmers or adoption of technologies" as a response to an open-ended question about the performance indicators used by organization (dummy)
Salary (SALARYFTE; SALARYOTHER; SALARYLIVING)	Salaries per FTE; perception of staff on the fairness and competitiveness of salaries in relation to same position/qualifications in other organizations (Likert scale: 1–4); perception of staff on sufficiency of salary in relation to living expenses
Information shared to clients/stakeholders (INFO)	Responses to statements about sharing information on the organization and its performances with clients, stakeholders, and the media (Likert scale)
Presence of donor funding (DONOR)	Whether the organization has received donor funding (dummy)
Other controls: Type of organization and location	Research institute, higher education agency, federal college, non–CSIR research institute; and zones or regions where the headquarters are located

Source: Devised by authors.
Note: The Likert scale is a rating based on whether respondents strongly agree (= 1), agree (= 2), disagree (= 3), or strongly disagree (= 4).

Appendix Table A3. Correlation of performance measures for Nigeria and Ghana

Variables	ADOPT[a]	TECHPHD[a]	TECHMS[a]	PUBLIPHD	PUBLIMS	PUBUSE	PUBDISS	AWARD	PEERRATE
Nigeria									
ADOPT[a]									
TECHPHD[a]	– (RI)								
TECHMS[a]									
PUBLIPHD	– (RI)	+ (RI)							
PUBLIMS	– (RI)		+ (RI)						
PUBUSE									
PUBDISS				+ (UNI)					
AWARD	+ (RI)			– (All)	– (All)				
					–(UNI)				
PEERRATE				– (RI)					
	+ (RI)							+ (All)	
Ghana									
ADOPT[a]									
TECHPHD[a]	– (RI)								
TECHMS[a]									
PUBLIPHD	–(RI)	+ (RI)							
PUBLIMS			+ (RI)						
PUBUSE									
PUBDISS					+ (All)				
					+ (UNI)				
AWARD					–(FCA)				
PEERRATE	– (RI)			+ (RI)	+ (All)	+ (All)	+ (All)		
					+ (FCA)	+ (FCA)	+ (FCA)		

Source: Compiled by authors from IFPRI–ARCN survey (May–July 2010) and IFPRI–STEPRI survey (May–July 2011).
Note: RI indicates research institutes; UNI, universities; and FCA, federal colleges of agriculture. For descriptions of codes, see Tables A1 and A2.
a. Includes research institutes only.

Appendix Table A4. Correlations between performance measures, linkages, and other factors for Nigeria and Ghana

Factors	ADOPT[a]	TECHPHD[a]	TECHMS[a]	PUBPHD	PUBMS	PUBDISS	PUBUSE	AWARD	PEERRATE
Nigeria									
PHDMS									
RESINTL	+	+	+		+			+	
RESNATL		+	+						
FFARMER		+				+			
FEXT/FPRIV		+							
FRES					+		+		
FINTL									+
FMOA			+		+				
ASSO				+					
EFFECTIVE		+							
WORKENV	+	+	+						+
PLAN	+								
ADEQPHY		+						+	+
PERFPUB				+	+				
PERFTECHNO		+	+						
TOTALEXPEND									+
OPERATINGFTE			+		+				
REWARD			+		+				
Ghana									
PHDMS					+				
RESINTL		+		+	+			+	+
RESNATL		+		+	+			+	+
FPRIV				+	+	+			
FRES						+	+		+
FINTL					+				
FMOA					+				–
ASSO				+					
WORKENV		+		+	+				+
ADEQPHY		+		+					
CONTROL	+								
PERPUB				+	+				
PERTECHNO		+	+						
REWARD		+	+	+	+				
OPERATINGFTE					+				
EXPENDFTE					+				
TOTALEXPEND									+
ACCRA				+	+				–

Source: IFPRI–ARCN survey (May–July 2010); IFPRI–STEPRI survey (May–July 2011).
Note: For descriptions of codes, see Tables A1 and A2.
a. Includes research institutes only.

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2033 K Street, NW | Washington, DC 20006-1002 USA
Tel: +1.202.862.5600 | Skype: ifprihomeoffice
Fax: +1.202.467.4439 | Email: ifpri@cgiar.org

www.ifpri.org

FORUM FOR AGRICULTURAL RESEARCH IN AFRICA

PMB CT 173 | Accra, Ghana
Tel: +233.302.772823
Fax: +233.302.773676 | Email: info@fara-africa.org

www.fara-africa.org

The Agricultural Science and Technology Indicators (ASTI) initiative compiles, analyzes, and publishes data on levels and trends in agricultural R&D investments, capacities, and institutional arrangements in developing countries. ASTI is managed by the International Food Policy Research Institute (IFPRI) and involves collaborative alliances with many national and regional R&D agencies.

Jointly convened by ASTI/IFPRI and the Forum for Agricultural Research in Africa (FARA), the conference, "Agricultural R&D—Investing in Africa's Future: Analyzing Trends, Challenges, and Opportunities," brought together experts and stakeholders from the region to contribute their expertise for the purpose of distilling new insights and creating synergies to expand the current knowledge base. The themes under focus were (1) why African governments under invest in agricultural R&D; (2) how human resource capacity in agricultural R&D can be developed and sustained; (3) how institutional structures can be aligned and rationalized to support agricultural R&D; and (4) how the effectiveness of agricultural R&D systems can be measured and improved.

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