Transforming Agriculture Conference
8-9 November 2012

GHANA
Strategy Support Program

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI
A member of the CGIAR Consortium

New Directions for Revitalizing the National Agricultural Research System in the Context of Growing Private Sector R&D

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DISCUSSION NOTE # 017

SOME PRODUCTIVITY INCREASE BUT HUGE YIELD GAPS REMAIN

Ghana is widely regarded as an African success story due to its impressive achievements in accelerating growth and reducing poverty and hunger in line with the Millennium Development Goals. Strong agricultural output growth (4.5 percent annually from 1991 to 2009) has played an important role in this development. However, much of this growth has been through expansion of cultivated area; total factor productivity growth has averaged only 1.1 percent annually—around the African average of 1.0 percent, but well below the global average of 1.6 percent (Fuglie 2012). Higher agricultural commodity prices, especially for cocoa, have also been a factor in accelerating agricultural growth.

Despite these achievements, major technological challenges and yield gaps in Ghana persist. Achievable potential yields for cocoa are around 1–1.5 t/ha, at least 100 percent higher than average yield levels reported in 2010 (FAO 2007; Gockowski 2010; MoFA 2011). For staple crops, yields are generally less than half of economically attainable yields (MoFA 2011). Continued growth based on land expansion is unsustainable and has already exerted a heavy toll on remaining forests.

LOW PRODUCTIVITY REFLECTS LOW ADOPTION OF IMPROVED TECHNOLOGIES

The major reason for slow productivity growth is the low adoption of productivity-enhancing technologies, including improved varieties and management practices, and low use of purchased inputs, especially fertilizer.

In staple food crops, adoption rates vary from 36 percent for cassava to 57 percent in maize (Table 1). These rates are generally about the average for sub-Saharan Africa, but much lower than the major cassava- and maize-producing country, Nigeria. However, in all cases, even adopting farmers are using old varieties. For example, the average age of varieties sown by farmers[1] is 12 years for cassava and 13 years for maize, indicating that varietal turnover has been too slow to capture benefits from breeding research. Adoption levels have also generally stagnated. In the case of maize, there has been little apparent progress since the mid-1990s (Morris et al. 1999). Even for rice, despite the much-heralded NERICA varieties, adoption is estimated at only 33 percent (Diagne et al. 2012), and field visits by Ragasa et al. (2012) even found cases of disadoption among farmers after a year with NERICA.

The use of certified seeds remains low and there are high levels of seed recycling among farmers in Ghana (Ragasa et al. 2012). About 22 percent of sample households reported purchasing seeds (24 percent for maize) based on the Ghana Living Standards Survey (GLSS5) (Quiñones and Diao 2011), but only a part of these purchased seeds are certified. This apparent lack of demand for certified seeds hinders private interest in the development and diffusion of varieties and planting materials. Hybrid seed (Mamaba and Etubi) accounts for less than 5 percent of certified seed sales during the period 2001–2011.

Fertilizer has been actively promoted for decades. Most recently, the Ministry of Food and Agriculture (MoFA) has provided vouchers and direct subsidies to fertilizer traders to cover transport costs. After 40 years of active promotion, Ghana uses only 5kg nutrient per ha, below even the dismal average for Africa (FAO 2005). The proportion of households purchasing inorganic fertilizer in 2005/06 was estimated at 19 percent, according to GLSS5 data (Quiñones and Diao 2011). Herbicide is a relatively more recent introduction, and has been promoted for weeding and—to a more limited extent—for land preparation (zero tillage), but only 12 to 17 percent of farmers used herbicide (Ngeleza et al. 2010;Quiñones and Diao 2011). Adoption of management practices such as row planting, zero tillage, soil conservation measures, and water harvesting that can contribute to greater productivity is also limited. Most of these practices have remained at the experimental or local implementation stage as

[1] This index describes the age from the time a variety is released to the point of its commercial success or any time of analysis weighted by variety's proportionate area.

TABLE 1—ESTIMATES OF AGRICULTURAL TECHNOLOGY ADOPTION IN GHANA AND SELECTED COUNTRIES (%)

Commodity	Ghana		Sub-Saharan Africa		Nigeria	
	Adoption rate (%)	Variety turnover index (number of years)	Adoption rate (%)	Variety turnover index (number of years)[g]	Adoption rate (%)	Variety turnover index (number of years)
Cassava	36	12	36	12	46	19
Maize	57[a]	13	57	12	97	14
Cowpea	82	13	23	13	39	10
Soybean	94	12	82	12	96	19
Cocoa	44[b]	n.d.	n.d.	n.d.	n.d.	n.d.
Rice	71[c,d]	n.d.	70	10	55 (82[c,d])	11
Rainfed lowland	80[c]	n.d.	n.d.	n.d.	97[c]	n.d.
Rainfed upland	0[c,i]	n.d.	n.d.	n.d.	54[c,h]	n.d.
Irrigated	65[c]	n.d.	n.d.	n.d.	100[c]	n.d.
NERICA	33[e,i]	-	42[e,f]	-	43[e]	-

Note: Unless indicated otherwise, figures are based on DIIVA project estimates.
n.d.= No data available.
[a]Comparable to the estimates by Morris et al. (1998). This DIIVA project estimates the adoption of hybrid maize to be 22% (11% for Mamaba, 11% for Etubi), which is likely to be overestimated based on certified seed production data and field visits by Ragasa et al. (2012).
[b]Hybrid seed only based on Aneani et al. (2012).
[c]Dalton and Guei 2003.
[d]Authors' calculation based on Dalton and Guei (2003).
[e]Diagne et al. 2012.
[f]West Africa average.
[g]DIIVA countries average.
[h]Excluding purified traditional varieties introduced in the 1960s and 1970s).
[i]Since the promotion of NERICA rice starting in 2009, this figure has likely changed but stays minimal. Official records on certified seed multiplication from MoFA also show that only 5,000 kg of NERICA1 and NERICA2 was multiplied in 2008 (none in other years), which corresponds to only 83 hectares planted with NERICA (or 1 percent of total upland rice acreage) given a seeding rate of 60 kg/ha. Even when farmers began to grow and multiply NERICA rice after participatory varietal selection and farm demonstrations (and did not go through the official certification process), it is likely that the number of farmers selecting NERICA from farm demonstrations will not be substantial given the limited farm demonstrations.

part of ad-hoc projects, and in the case of conservation agriculture, CIRAD (2006)found that disadoption is quite common in Ashanti and Brong-Ahafo Regions.

In addition to production technologies, technological transformation is needed for postharvest and processing. Many efforts have been made to introduce promising cassava processing technologies, but most have had limited impact (UNCTAD 2011;Nweke et al. 2002). Only 2 percent of R&D spending is on postharvest research (Flaherty et al. 2010). There is also little evidence on uptake of livestock and fisheries research although anecdotal evidence suggests some progress in aquaculture technologies (Ofori et al. 2009; Hihelgo 2008).

Several studies have identified factors that may have contributed to this situation(Doss and Morris 2001; Drechsel et al. 2005; CIRAD 2006; Omari 2008; Udry 2011). Among them are inappropriate technologies due to a variety of reasons:

- Limited interaction between users (demand side) and developers and suppliers (supply side) of innovation
- Lack of trust in the technology or the providers
- Limited economic incentive due to lack of profitability or financial attractiveness
- Lack of information about the pros and cons of various technological options
- Lack of credit for liquidity-constrained farmers
- Lack of availability of labor and complementary inputs
- Insufficient land tenure security for long-term investments
- Risk of extreme weather events and pest attacks
- Low public and private investment in agriculture

Low investment in R&D in many commodities, inefficiency in the research system, and lack of a strong results orientation are major weaknesses (UNCTAD 2011) and the subject of this policy note.

FUTURE DEMAND FOR TECHNOLOGIES

Rapid income growth and urbanization offer major new opportunities for the agriculture sector that we estimate will increase demand for marketed products in urban areas by four times over the next 20 years. Demand for rice, horticulture, livestock, and other high-value commodities will grow rapidly. Along with this there will be additional demand for processed and value-added foods, requiring attention to improved processing, packaging, and logistics. Increasing demand for livestock will in turn promote demand for feeds derived from maize, cassava, and soybean, and there is also potential to use these products for biofuels. Also, demand for fish products will continue, and aquaculture technologies will be needed to fill the deficit of 615,000 tons projected in 2023 (Hiheglo 2008). If Ghana is to maintain a leading role in export crops such as cocoa, enhanced quality and management processes will be required to fit global standards.

The challenge for Ghana is to intensify agriculture, but in a sustainable way that confronts contemporary environmental challenges of land degradation, water pollution, and biodiversity loss. Climate change is projected to have significant impact (de Pinto et al. 2012), and technologies such as drought-tolerant and short-duration varieties and improved water management technologies are needed to address climate change.

Numerous other issues such as competing uses of scarce labor, land, and other resources; the rising cost of energy; the need to reduce the technological divide between social groups and regions; and the growing awareness and demand for nutrition, food safety, and traceability also pose serious challenges and require strong R&D firmly embedded within an innovation systems framework. To realize these opportunities will require a much more innovative and knowledge-intensive R&D system that can consistently produce results on the ground.

FUTURE SUPPLY OF TECHNOLOGIES

On the supply side, this is an exciting period in terms of technological innovations worldwide coming from the private sector, international organizations, and national research systems. The private sector is expanding investments in R&D globally, especially in export and commercial products where they can protect their intellectual property. In Ghana, the private sector is already active when farmers purchase hybrid seed or chicks (poultry). Syngenta and Wienco already market hybrid maize, and hybrid rice seed is now being explored by private rice companies such as Prairie Volta Ltd. Biotechnology and transgenics are also promising areas for private sector investment, but a strong biosafety and regulatory framework is needed to take advantage of their potential. Ghana has relatively strong personnel base with 38 biotechnology experts (FARA 2011) and it aims to position itself as a champion on biotechnology and biosafety in the ECOWAS region (UNCTAD 2011). Other technologies that are embodied in inputs such as agro-chemicals and machinery are also the province of the private sector. Finally, the private sector has been active in the cocoa and oil palm R&D in Ghana, as well as in processing and value addition.

Technologies for other crops, cereals and other orphan commodities, which are grown mainly by small and resource-poor farmers and offer little opportunity for private firms, continue to be led by the Consultative Group of International Agricultural Research (CGIAR) centers.[2] The recent re-investment in national breeding programs by the Bill and Melinda Gates Foundation and the Alliance for a Green Revolution in Africa (AGRA), and growing emphasis on regional breeding programs, can partially substitute for the centralized breeding programs at the CGIAR.

A range of technologies based on agroecological principles (in the form of integrated management practices such as integrated pest management) exist to mitigate the threat of crop losses from pests and climatic events, and potentially substitute for expensive and environmentally damaging external inputs. Many of these require intervention at the systems level such as crop rotation or intercropping with legumes, improved livestock feeding, and joint crop-livestock management. The challenge for the national research system is to effectively adapt these technologies to diverse groups of farmers, conditions, and ecologies while achieving a balance of economic, social, and environmental objectives.

Given the rapid pace of scientific progress and growing availability of technologies from the CGIAR, regional organizations, and the private sector worldwide, medium-sized countries such as Ghana require a strong national R&D system to seek out technologies and adapt them to local situations and context. The capacity of the Ghanaian R&D system to conduct adaptive research and develop strong partnerships with advisory services, the private sector, farmer organizations, and non-government organizations will be crucial. As in the past, research on improved agronomic practices and natural resources management systems, given their location-specific nature, will assume a crucial role for the national system.

KEY CHALLENGES AND OPTIONS FOR REVITALIZING R&D

Both the Government of Ghana (through its new Science, Technology and Innovation (STI) policy, the Food and Agricultural Sector Development Policy (FASDEP II),and external reviews and studies (UNCTAD 2011; Ragasa et al. 2011) have called for a new vision of the agricultural R&D and innovation system that imply far-reaching reforms. Bold action is needed to change priorities,

[2] These commodities include cereal crops, such as sorghum, barley, or millet; open-pollinated maize varieties for which farmer seed-saving practices cannot easily be controlled; vegetatively propagated crops, such as potatoes, sweet potatoes, yams, and cassava, for which similar farmer practices cannot easily be controlled; ruminant livestock; and many other underutilized crop species.

the amount and reallocation of funding, the way that research is organized and managed, orientation and interaction with clients, and new research partnerships.

Formulating a coherent national R&D strategy around priority value chains

Challenge: Ghanaian research tends to be highly fragmented among many small projects that do not provide a critical mass for solving major problems—nor are they attractive for engaging the private sector. Universities (with over 100 full-time equivalent researchers or 19 percent of Ghana's human R&D capacity) have substantial scientific capacity but are only marginally engaged in applied research programs. Competitive grants have been introduced, but the funding levels provided are very low and do not foster the development of larger integrated programs.

The STI policy framework in FASDEP II and the agriculture sector in the STI Policy do little to articulate a well-articulated strategy to meet Ghana's future food needs. At the same time, the public sector needs to define its role as regards a growing private sector. Public research institutes should focus on pro-poor, pro-nutrition, and orphan commodities neglected by the private sector, while providing conducive and supportive environments for private actors to more strongly engage in R&D. In addition, for many if not most activities, they require close partnerships with the private sector, especially in postharvest activities and technology testing and uptake. The current focus on production neglects critical dimensions in the value chain and impact pathways are limited by weak outreach.

Options: Ghana should consider focusing resources around a few key value chains of national strategic importance. Obvious priorities include cassava, rice, horticulture, aquaculture, and cattle. It could also help facilitate research on value chains around cocoa, oil palm, hybrid maize, and poultry with the private sector taking the lead role. A value chain framework with strong private sector participation would enhance research on postharvest, processing, and food safety. In addition, strong partnerships with producer organizations, industry associations, extension, and NGOs can serve a similar purpose in engaging critical skills and knowledge to articulate demands and facilitate technology uptake. Universities too have a potentially important role in both research and capacity building, perhaps in a consortia approach.

Recent experience in other African countries with innovation platforms within a value chain framework have demonstrated the benefits of engaging key partners from the beginning, as in maize in nearby Burkina Faso (Sanyang 2012). Likewise, India and other countries have reformulated research programs around innovation in priority value chains (Mudahar 2012).

This restructuring would require a major shift in the way funds are deployed. Core funds could be provided in block grants for priority value chains, supported by competitive research funds to support complementary research around production systems and natural resources, including outreach. An innovation fund to provide matching grants to private actors could focus on importing technology, testing and dissemination and organizational innovations in value chain. One option for this fund is to pilot agribusiness innovation centers as a way to implement partnerships with the private sector on processing and post-harvest activities (UNCTAD 2011).

Research driven by household food security and sustainable natural resources

Challenge: Research on commodities that are important for food and nutrition security for the poor are mostly underfunded in relation to their contribution to the agriculture GDP and in relation to other commodities (Table 2). Little attention is being paid to cassava, yam, cocoyam, plantain, groundnuts and millet. Given limited private sector interest, public R&D has to focus on food and nutrition security for poor households that may not be able to engage in emerging value chains. Engagement of smallholder farmers in priority setting and all stages of the innovation process is critical. RELCs were established as formal structures to link research and extension more effectively and ensure that farmers' needs and priorities are addressed in research planning and activities. However, RELCs are often criticized for being limited in coverage, having weak feedback mechanisms, and lacking effectiveness in fostering lasting relationships for collaboration and mutual interest among stakeholders. Even with increased support of RELC activities through WAAPP, activities and meetings have still been limited. Although there has been considerable attention given to establishing and supporting farmer groups, to date venues for producers to enforce accountability among research institutes are limited. These continuing issues surrounding the effectiveness of RELCs after decades of experience suggest that the supply side of innovation is more binding than the demand side.

Options: More funds for research and outreach must be allocated to food security crops. Back-of-the-envelope calculations suggest that an additional 20 million Ghana cedis (GHC) are needed to reach 1 percent of research intensity ratio for food security crops that are currently underfunded (cassava, yam, cocoyam, plantain, groundnuts, millet, and maize) (Table 2). These funds should be allocated to research on production, postharvest, and processing, in addition to a large extension and outreach agenda through RELCs, producer organizations, and other priority-setting platforms. Fueling the current competitive grant schemes with more resources will be necessary to make research outputs and advisory services more responsive to these priorities and needs of small farmers. The experience of

TABLE 2—RESEARCH INTENSITY RATIO AND REQUIRED FUNDS TO REACH 1% TARGET AMONG MAJOR FOOD CROPS

Commodity	Research intensity ratio (RIR)	Required total R&D funding to reach 1% RIR target (000 cedi)	Additional funding required to reach 1% RIR target ('000 cedi)
Cereals			
Maize	0.81	3,137	606
Rice	2.16	1,080	-1,257
Sorghum	1.04	790	-33
Millet	0.66	631	217
Roots			
Cassava	0.41	6,514	3,815
Yam	0.2	6,572	5,260
Cocoyam	0.49	1,405	712
Other staples			
Bananas and plantains	0.1	10,243	9,234
Groundnuts	0.33	2,468	1,652
Cowpea	1.51	690	-349
Soybeans	3.41	237	-572
Other crops			
Sweet potatoes	10.25	126	-1,165
Export crops			
Cocoa	4.4	4,250	-14,450
Oil palm	1.92	1,940	-1,777
Vegetables	5.61	312	-1,436
Fruits	2.52	392	-595
Other export crops (cotton, sugar cane, coffee, coconut, sheanut, etc.)	0.32	5,462	3,718
Livestock	**0.66**	**4,305**	**1,456**
Fisheries and forestry	**0.85**	**6,730**	**1,043**
Agriculture (without cocoa)	**0.57**	**34,800**	**26,253**

Source: Estimated R&D funding per crop from ASTI dataset (in 2008) and agriculture GDP per crop from MoFA (2010, 2011) and FAOSTAT (2008–2010).

Senegal's National Fund for Agricultural Research, a competitive funding scheme with strong leadership of producers, coupled with a demand-driven rural services fund where producers manage advisory and extension services projects, shows promising results in terms of higher incomes and greater food security (Spielman et al. 2011).

Options for more sustainable funding

Challenge: Although public spending on R&D in Ghana more than doubled from 2002 to 2008,Ghana's agricultural research investment is still low. Excluding cocoa, Ghana spends some US$0.57 for every $100 agricultural GDP spent on R&D, well under the NEPAD target and FAO recommendation of 1 percent that eight sub-Saharan African countries have already achieved, and much lower than comparable middle-income countries such as Kenya and South Africa that spend $1.40 and $2.00, respectively (Table 3).However, Ghanaian cocoa, with a research intensity of 4.4 percent, is one of the highest for cash crops anywhere, reflecting its special status within COCOBOD as a semi-autonomous agency (Byerlee 2011).

More alarming is that across all 33 Africa countries included in the Agricultural Science and Technology Indicators survey, Ghana has the highest proportion of salary costs (83 percent) and thus the smallest proportion of operating funds (14 percent) and capital funds (3 percent) (Flaherty et al. 2010). It has one of the highest ratio-of-salary costs per FTE researcher and the lowest ratio of operating and capital funds per FTE researcher (Table 2). According to UNCTAD (2011), only 4 percent of the CSIR budget is available as operating funds to scientists. High salary costs in part relate to the very high ratio of support staff to scientific staff in Ghana(nearly 7 to 1). Lack of a strong operating budget poses a major constraint on effective research, and lack of a capital budget means that infrastructure and equipment are obsolete and there are no funds to train a new cadre of scientists. CSIR has had a policy in place since 2009 to limit salary cost to 40 percent of total expenditure, but this is not being followed.

In the absence of public support to research, the other major source of funding is from donors and international organizations. Ghanaian scientists do have a wide range of such agreements but there are no aggregate data on the extent of this funding. In some cases, these sources may be significant, but often they involve very small sums (a few thousand dollars). Many research projects are driven then by outside funders and may not always be the highest priority for Ghana. Moreover, after completion of projects, funds for maintenance research and outreach are major concerns.

Options: CSIR, through dialogues with MoFA, MEST, and the Ministry of Finance, needs to institute a plan to increase funding for operations and capital to R&D in return for retiring staff, especially non-scientific staff. Also, it should be accompanied by measures to increase efficiency of the research system through re-organization into a few large programs with incentives to turn increased spending into development outcomes. The plan can include intensified capacity strengthening to young and promising researchers using various funding mechanisms such as the Skills and Technology Fund under the STI Policy. A total of GHC 5–10 million could be saved by cutting down on support staff in the short term, and retiring about quarter of the oldest and least productive scientists in the longer term. An agreement with MoFA would ensure that all savings would be channeled to operating and capital funds for the underfunded food security crops. The staff retrenchment plan, especially for scientists, has to be carefully undertaken with human resource assessment and recommendations from an independent panel.

Intensified mobilization of resources from the private sector will also be required. Research on some commodities such as oil palm can be gradually privatized, using levy funds at the processing point. There are already examples within sub-Saharan African where producer organizations are actively investing in agricultural R&D such as Inter-Professional Fund for Agricultural Research and Extension (FIRCA) (mainly of coffee, cocoa, rubber and oil palm) in Côte d'Ivoire. Funds for rice research could also be provided from a levy either or both on domestically milled rice or on imported rice. Uruguay, for example, funds most rice research through a levy. A back-of-the-envelope calculation shows about GHC1.5 million from the government's rice R&D program and another GHC1.4 million from the government's oil palm research program that can be shifted to underfunded food security crops, assuming matching grants by government and industry levies (Table 4). However, levies require strong industry organizations to ensure accountability and client orientation (Byerlee 2011).

Despite re-allocation of existing resources and increased funding from private sector through rice and oil palm levies, an additional GHC 20 million (in current prices) will have to be invested to reach a target of 1 percent R&D funding to AgGDP (excluding cocoa). There will be a need to promote awareness on the crucial importance of funding and fostering innovation, and impact data can be used for evidence-based negotiation within the Parliament and Ministry of Finance. Any proposed new resources should be conditional on substantial improvements in efficiency and incentives to turn new expenditures into development gains. An M&E system and impact assessment will be needed to enforce accountability.

Organizational and managerial changes

Challenge: There are serious organizational and incentive issues within the research institutes. There is lack of M&E and measurable targets that keep researchers and managers accountable for their activities. As a result, the adoption and impact of research and technologies produced are rarely assessed and there is no rigorous process for evaluating technologies for dissemination. A survey of 231 researchers highlights weak organizational climate to encourage innovation, partly due to funding limitations, as well as limited encouragement and support from management (Ragasa et al. 2011).Staff turnover is a serious concern among senior research staff. Promotion gives too few incentives to outstanding science in terms of international publications or significant impact achievements.

TABLE 3—AGRICULTURAL RESEARCH EXPENDITURE, STAFFING, AND OTHER R&D CAPACITY INDICATORS ON GHANA AND OTHER COUNTRIES, 2008

Country	R&D expenditure (US$ million PPP) (2005 constant prices)	No. of researchers (FTE)	Salary cost (%)	Operating cost (%)	Capital cost (%)	Operating and capital funds per researcher (US$ '000)	Salary funds per researcher (US$ '000)	Ag research spending to ag GDP (%)	Farmer-to-researcher ratio	Support-staff-to-scientist ratio
Ghana	95	537	83	14	3	30	147	0.94[/a]	11,111	6.9
Nigeria	392	2,062	43	11	46	108	82	0.4	5,952	4.2
South Africa	272	784	62	37	1	132	215	2	1,608	4.4
Kenya	154	1,012	52	43	5	73	79	1.4	12,658	5.3
Uganda	88	306	33	56	11	193	95	1.4	35,714	2.4
Tanzania	78	674	29	39	32	82	34	0.5	23,810	2.7
SSA	**1,250***	**12,120***	**48**	**40**	**12**	**53**	**50**	**0.61**	**14,706**	**n.d.**

Source: Compiled from various ASTI country notes.

*Total for sub-Saharan Africa (SSA), while the rest of the figures on SSA are averages.

[a]0.57 for non-cocoa; 4.40 for cocoa

TABLE 4—ESTIMATED GOVERNMENT FUNDS AND INDUSTRY LEVIES FOR RICE AND OIL PALM RESEARCH UNDER VARIOUS SCENARIOS

Scenarios	Total government R&D funds (2008, GHC '000)	% to value of production	Total contribution by government (GHC '000)	% levy to total value of rice imports	Total savings that can be used for other crops (GHC '000)
Rice					
Scenario 1: Maintain the same level of R&D funding (2008) with matching funds	3,096[a]	0.97[b]	1,548[c]	0.54[d]	1,548
Scenario 2: Maintain the same level of R&D funding (2008) with full private sector funding	3,096[a]	0.97[b]	0	1.09[d]	3,096
Oil palm					
Scenario 1: Maintain the same level of R&D funding (2008) with matching funds	2,770[e]	0.91[f]	1,385[g]	0.64	1,385
Scenario 2: Maintain the same level of R&D funding (2008) with full private sector funding	2,770[e]	0.91[f]	0	1.29	2,770

[a] Estimated using the proportion of FTE researchers from ASTI dataset.
[b] Nominal value of rice production is estimated at GHC 319 million from MoFA in 2011 (GHC 1.41 = US$1 exchange rate average in 2010).
[c] GHC1 from government for GHC1 of rice import levy.
[d] Estimated at US$202 million average, 2008–2010 (MoFA 2010).
[e] In addition, OPRI received GHC 800,000 from sales of services/goods and about GHC 140,000 from donor projects (source of raw data: ASTI)
[f] Used 215,000 MT crude palm oil production in 2010 (MASDAR 2011); US$1,000/MT average price in 2010 (MASDAR 2011) at GHC 1.41 = US$1 exchange rate average in 2010.
[g] GHC1 from government for GHC1 of industry levy at processing point.

Beyond remuneration, demotivating factors highlighted by managers and staff in research institutes include outdated research equipment and information facilities, limited transportation facilities and inadequate travel allowance, and delayed and minimal research or operating funds. The rating of satisfaction on physical infrastructure among managers and staff of research institutes interviewed is very low (lowest within a 1-5 Likert scale), signaling an urgent call for organizational and managerial changes (Ragasa et al. 2011).

Power generators, reliable irrigation systems, better laboratory facilities, a molecular biology laboratory for speeding breeding processes, and storage facilities for breeder seeds are needed. Reliable computers and anti-virus software are also often cited as priority needs. For example, CRI only buys computers for sections, and it since they have 18 sections, only 18 computers were purchased for about 80 scientists. By contrast, as early as2001, every scientist at Brazil's Embrapa's Cassava and Fruit Crop Research Institute had a computer on his/her desk and was connected to the internet (Nweke 2004).

Options: The research system could move to a few large interdisciplinary programs implemented nationally within an explicit results-based framework. Recent human resource development initiatives in the Kenya Agricultural Research Institute highlight that organizational changes are possible with strong management commitment and there are gains to be made in such reforms (see more details in Sène et al. 2011). A specific action for Ghana is to design and implement an M&E system with measurable output and outcome targets, defined indicators of progress, and means to enforce sanctions. This should be coupled by a well-designed staff performance management system, including defined and enforceable rewards for excellence in research, including impacts on the ground. As in Kenya, CSIR can commission comprehensive human resource documentation to ensure consistent, transparent, and predicable processes in human resource development and performance-based staff evaluation. As in the Embrapa performance evaluation system, the awards system should make a clear distinction between regular individual wage increases resulting from promotions, which are permanently incorporated into the salaries, and results-based bonuses that depend on performance in that year. In terms of working conditions, researchers should have the flexibility and encouragement from management to work and sign agreements with the private sector, and have the opportunity to take a leave of absence to undertake short-term work with other institutions that conduct research of relevance to CSIR.

International Partnerships

Challenges: Ghana is a small country with limited capacity and resources for R&D work. Ghana can potentially benefit from regional and sub-regional organizations and regional centers of excellence for supplying technologies. There has been progress under CORAF to establish centers of excellence in specific commodities, with the center for roots and tubers based in CRI.

However, regional networks to share varieties and germplasm have largely disappeared. The CGIAR centers too have until recently pulled back in direct support to national systems.

Options: More aggressive and systematic search by the research institutes for promising germplasm and technologies from other countries (private sector, CGIAR, and other national agricultural research systems) are preferred over ad-hoc projects. Funds should be allocated for travel and for regional and international partnerships. Given the experience of Embrapa, investment and strong emphasis on partnerships is paying off through improved research quality, improved international visibility, increased funding for international projects, increased number of international publications for its researchers, and up-to-date knowledge of latest innovations within the network worldwide.

In addition to CSIR's ongoing partnerships such as with the CGIAR, more focus is needed on:

- **Regional programs**: Promising opportunities for partnerships and economies of scale are present in the regional programs that Ghana research institutes should take full advantage of. There are often calls for research proposals for competitive research grants from CORAF and other sub-regional organizations. Regional networks can also serve as platforms to widen interactions and provide exposure to regional actors and international sources of latest innovation.
- **Public-private partnerships**: There are many examples of promising public-private partnerships in Africa. For example, the African Agricultural Technology Foundation (AATF) has been active in technology transfer. A promising experience is the water-efficient maize for Africa (WEMA) project, a 5-year PPP beginning 2008 and led by AATF. It is supported by CIMMYT and research institutes in Kenya, Mozambique, South Africa, Tanzania, and Uganda. Researchers should be encouraged and rewarded for their collaborative work and joint technology development with private sector.

SOUTH-SOUTH EXCHANGE

The Brazil-Africa Innovation Marketplace with EMBRAPA offers grants to engage with Brazil's premier research organization in tropical agriculture. Such partnerships could be especially valuable for cash crops where the CGIAR does not invest (such as oil palm, cotton, and rubber). Embrapa-Africa is currently in place in Ghana, but research activities and technology transfer to Ghana is still limited. Research institutes can initiate interactions, information sharing, and other activities for oil palm, cotton, and other crop technologies as well support in institutional arrangements and organizational changes that have been successfully implemented by Embrapa and can be adopted in Ghana.

CONCLUDING REMARKS

It is imperative that Ghana accelerates growth and sustains middle-income status not through business-as-usual measures but by taking bold action to revitalize its innovation system on par with fast-growing nations. To catch up and assert its middle income status in R&D will require reorienting research priorities and focusing on impacts, supported by adequate funding, organizational reforms, effective partnerships, and complementary investments in seed and extension systems at least on par with similar middle-income countries.

REFERENCES

Byerlee, D. 2011. *Producer Funding of R&D in Africa: An Underutilized Opportunity to Boost Commercial Agriculture.* Paper presented at the ASTI-FARA conference, Agricultural R&D: Investing in Africa's Future: Analyzing Trends, Challenges, and Opportunities, 5–7 Dec 2011. Accra.

CIRAD (Centre de coopérationinternationale en rechercheagronomiquepour le développement). 2006. *Experiences with the development and diffusion of conservation agriculture in Ashanti and BrongAhafo regions of Ghana*. Background paper for WDR2008, World Bank. Washington, DC.

Dalton, T., and R. Guei. 2003. "Productivity Gains from Rice Genetic Enhancements in West Africa: Countries and Ecologies." *World Development* 31(2):359–374.

De Pinto, A., A. Haruna, J. Koo, and M. Asamoah. 2012. *Climate Change, Agriculture, and Food Crop Production in Ghana*. Policy Note, IFPRI. Accra.

Diagne, A., P. Dontsop-Nguezet, F. Kinkingninhoun-Medagbe, D. Alia, P. Adegbola, M. Coulibaly, S. Diawara, L. Dibba, N. Mahamood, M.Mendy, V. Ojehomon, and A. N. Wiredu. 2012. *The Impact of Adoption of NERICA Rice Varieties in West Africa*. Paper presented during the SPIA Pre-conference workshop, 28th IAAE conference, Foz do Iguaçu, Brazil, 18 Aug 2012.

Doss, C., and M. Morris. 2001. "How does Gender Affect the Adoption of Agricultural Innovation? The Case of Improved Maize Technologies in Ghana."*Journal of Agricultural Economics*25:27–39.

Drechsel, P., A. Olaleye, A.Adeoti, L.Thiombiano, B. Barry, and K. Vohland. 2005. *Adoption Driver and Constraints of Resource Conservation Technologies in sub-Saharan Africa.*IWMI.

FAO (Food and Agriculture Organization of the United Nations). 2005. *Fertilizer use by Crop in Ghana.* FAO, Rome.ftp://ftp.fao.org/agl/agll/docs/fertuseghana.pdf

FAO. 2007. Online database. http://faostat.fao.org.

FARA (Forum for Agricultural Research in Africa). 2011. *Status of Biotechnology and Biosafety in Sub-Saharan Africa.* Study Report. FARA, Accra.

Flaherty, K., G. O. Essegbey, and R. Asare. 2010. *Ghana: Recent Developments in Agricultural Research.* ASTI Country Note. Washington, DC: International Food Policy Research Institute.

Fuglie, K. 2012.Personal Communication.

Gockowski, J., and D.Sonwa. 2011. "Cocoa Intensification Scenarios and Their Predicted Impact on CO_2 Emissions, Biodiversity Conservation, and Rural Livelihoods in the Guinea Rain Forest of West Africa." *Environmental Management* 48(2):307–321.

Hiheglo, P. K. 2008. *Aquaculture in Ghana: Prospects, Challenges, Antidotes and Future Perspectives*.Unpublished Master's Degree Thesis, Norwegian College of Fishery Science, University of Tromsø, Norway.

MoFA (Ministry of Food and Agriculture). 2011. *Agriculture in Ghana: Facts and Figures (2010)*. Statistics Research and Information Directorate. Accra.

Morris,M.L., R. Tripp, and A. A.Dankyi. 1999. *Adoption and Impact of Improved Maize Production Technologies: a Case Study of the Ghana Grains Development Project.*Economics Program Paper 99-01.International maize and Wheat Improvement Center (CIMMYT), Mexico.

Mudahar, M. 2012. "An innovative approach to Agricultural technology development and transfer in India." In *Agricultural Innovation Systems: an Investment Sourcebook.* Washington, DC: World Bank.

Ngeleza, G., R. Owusua, K. Jimah, and S. Kolavalli. 2011. *Cropping Practices and Labor Requirements in Field Operations for Major Crops in Ghana—What Needs to be Mechanized?*IFPRI Discussion Paper 01074. Accra.

Nweke, F. 2004. *New Challenges in the Cassava Transformation in Nigeria and Ghana.* Environment and Production Technology Division Discussion Paper No. 118.Washington, DC: IFPRI.

Nweke F., D. Spencer, and J. Lynam. 2002. *Cassava Transformation: Africa's Best Kept Secret*. East Lansing: Michigan State University Press.

Ofori, J. K., H. R.Dankwa, R.Brummett, and E. K. Abban. 2009. *Producing Tilapia in Small Cage in West Africa.* WorldFish Center Technical Manual No. 1952. Penang, Malaysia: Worldfish.

Omari, R. 2008. *Agricultural Technology Adoption and Related Policy Issues in Ghana.* Paper presented at the conference on Practicing Agricultural Innovation in Africa—a Platform for Action, 12–14 May 2008,Dares Salaam, Tanzania.

http://info.worldbank.org/etools/docs/library/243706/Agricultural%20Research%20and%20Policy%20Issues%20in%20Ghana.pdf

.

Quiñones, E., and X. Diao. 2011.*Assessing Crop Production and Input Use Patterns in Ghana—What Can We Learn from the Ghana Living Standards Survey (GLSS5)?*Ghana Strategy Support Program (GSSP) IFPRI Working Paper No. 0024. Accra.

Ragasa, C., A. S. Abdullahi, and G. O. Essegbey. 2011. "Measuring R&D Performance from an Agricultural Innovation Systems Perspective—an Illustration from the Nigeria and Ghana Agricultural Research Systems."In *Agricultural R&D: Investing in Africa's Future*. Accra: IFPRI.

Ragasa, C. 2012. *Technological Challenges and Opportunities for Rice and Maize Subsector in Ghana: Insights from the Field.* Draft paper. Washington, DC: IFPRI.

Sanyang, S., G.Muluh, J.Juiseu, S. Taonda, A. Kafando, and R.Stirzaker.2012. *Innovation Platform for Technology Adoption (IPTA): Maize Value Chain in Burkina Faso.* Dakar, Senegal: CORAF/WECARD.

Sène, L., F. Liebenberg, M. Mwala, F. Murithi, S. Kaboré, and N. Beintema. 2011. "Staff Aging and Turnover in African Agricultural R&D: Lessons from Five National Agricultural Research Institute." Conference Working Paper 17, Conference on Agricultural R&D: Investing in Africa's Future, 5–7 Dec 2011. Accra.

Spielman, D., C. Ragasa, and R. Rajalahti. 2012. "Designing Agricultural Research Linkages within an Agricultural Innovation Systems Framework," Agricultural Innovation Systems," In *Agricultural Innovation Systems: An Investment Sourcebook.* Washington, DC: World Bank.

Udry, C. 2011. Barriers and Constraints to Agriculture Technology Adoption in Africa," presentation/lecture during the "Agricultural Technology Adoption & Food Security in Africa Evidence Summit," held in Washington DC on June 1-2, 2011. http://agrilinks.kdid.org/sites/agrilinks/files/resource/files/Udry_atai-usaid.pdf

UNCTAD (United Nations Conference on Trade and Development). 2011. *Science, Technology, and Innovation Policy Review—Ghana*. Geneva: UNCTAD

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This publication has been prepared as an output of the Ghana Strategy Support Program, which is funded by USAID and facilitated by The International Water Management Institute (IWMI) headquarters. It has not been peer reviewed. Any opinions stated herein are those of the author(s) and do not necessarily reflect the policies of the International Food Policy Research Institute (www.ifpri.org), its partners, or its collaborators.