ASTI facilitated by IFPRI

The West Africa Agricultural Productivity Program

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The World Bank has been a major contributor to the institutional development of agricultural research in West Africa in the form of country-level projects financed through loans and supplemented by grants. Since 2008, the Bank has shifted from a country-level to a regional approach to financing agricultural research in Africa through the model of regional productivity programs, the goal of which was to facilitate regional cooperation in the generation and dissemination of agricultural technologies, and to establish a more differentiated, yet regionally relevant, research agenda by establishing national centers of excellence. WAAPP was initiated in 2008 under the auspices of ECOWAS with subregional coordination by CORAF/WECARD. WAAPP was designed as a mechanism for increasing agricultural productivity—a key objective of agricultural policy both for Africa's regional economic communities and under Pillar IV of CAADP. WAAPP was initially designed as a ten-year program implemented in two five-year phases. In Phase I, the objective was to generate and disseminate improved agricultural technologies in key priority areas; Phase II focused on intensifying the dissemination and adoption of the improved technologies in the program's beneficiary countries based on lessons learned (Box 1 on page 2).

WAAPP's Financial Contribution to West African Agricultural Research

Funding for National Agricultural Research

WAAPP supports the generation, dissemination, and adoption of improved technologies; the creation of enabling conditions for regional cooperation; and the development of human and institutional capacity across the subregion; along with the creation of youth employment, the participation of women, and adaptation to climate change. Consequently, the program supports a comparatively large number of recipients, both at the country and regional levels. These include research agencies, extension agencies, universities, the private sector, research coordination bodies, NGOs, farmers' organizations, international research institutes, and more. (For an overview of agricultural research spending and capacity trends in West Africa, see Box 2 on page 3; for a list of the acronyms used in this report see Box 3 on page 3.)

BOX 1 | PROGRAM STRUCTURE

WAAPP is organized around four components that form a framework to position the agricultural sector as an engine of growth in West Africa: (1) enabling conditions for regional cooperation in improved technologies generation and dissemination; (2) building the capacities of agricultural research institutions, particularly in terms of infrastructure and human resources; (3) funding demand-driven technology generation and adoption; and (4) building the administrative and financial capacities of institutions involved in the implementation of the project, including monitoring and evaluation, skills development, and information and communications management. WAAPP's financial structure reflects its regional scope. One-third of the program's resources are derived from World Bank allocations to each beneficiary country, and the remaining two-thirds are derived from the Bank's funds for the financing of regional programs. Of this, beneficiary countries contribute one-fifteenth to CORAF/WECARD to support regional coordination. In addition to the Bank's IDA funding, two other donors have contributed to WAAPP: the PHRD Fund, which is provided by the government of Japan to develop the rice value chain in the Mano River countries (Côte d'Ivoire, Guinea, Liberia, and Sierra Leone), and the GFRP donor trust fund, provided by the government of Spain in response to the 2010 global food price crisis to support the accelerated adoption of improved technologies.

The first phase of WAAPP was approved in March 2007 at a total value of US$45 million. Known as WAAPP-1A, the initial phase targeted high-priority value chains in Ghana (roots and tubers), Senegal (dryland cereals), and Mali (rice). WAAPP-1B, approved in September 2010 at a total value of US$116 million, expanded the program to Burkina Faso (horticulture), Côte d'Ivoire (bananas and plantains), and Nigeria (catfish and tilapia). WAAPP-1C, approved in March 2011 and valued at US$116 million, added a further seven countries: Benin, The Gambia, Guinea, Liberia, Niger, Sierra Leone, and Togo. Ghana, Mali, and Senegal have completed Phase 1 and are now undertaking Phase 2A at a total value of US$200 million. Additional financing was granted to Benin, Togo, Niger, and Guinea to extend Phase 1C for a further three years in these countries.

The World Bank decided to complete the WAAPP series and to prepare a follow-up program, the West Africa Agricultural Transformation Program, designed to build on the achievements of WAAPP and be even more transformative.

Source: Wiebe et al., 2017

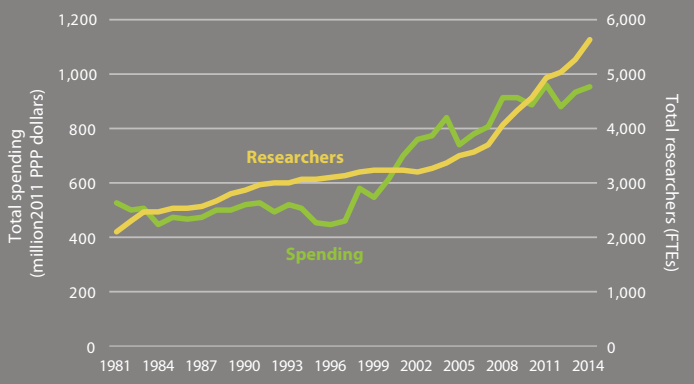
In undertaking this status report, ASTI sought detailed yearly financial data under a set of predefined World Bank cost categories, specifically targeting recipients that perform agricultural research. In small countries like Liberia and Sierra Leone, the only recipients of research-related funding under WAAPP were NARIs, whereas in large countries numerous separate entities received funding (for example, 140 agencies in Nigeria). Of the NARIs, ISRA (Senegal), CSIR (Ghana), and IER (Mali) received the highest levels of funding, which is not surprising given that WAAPP was initiated in these countries much earlier than elsewhere, and Phase 2 funding to these countries is four times higher than Phase 1 funding. The non-NARI recipients of research-related WAAPP funding include research coordinating bodies, such as CNRA (Mali and Niger) or CNRST (Burkina Faso); specialized government research institutes involved in livestock, soil, fisheries, or food technology research; universities and colleges; and NGOs, producer organizations, and the private sector. In addition to in-country recipients, a very small share of WAAPP funding was disbursed to international research centers (for example, CGIAR centers) or universities outside West Africa. During 2008–2016, on average, more than half of WAAPP's research-related funding was disbursed to NARIs (Table 1).

WAAPP funding to West African NARIs averaged 10 percent of their total funding in 2014. Staff salaries are typically funded by national governments; WAAPP funding is usually allocated to specific research programs and associated human resource capacity building and infrastructure upgrades. If staff salaries were excluded, WAAPP's average share of 2014 funding would rise to 24 percent. WAAPP funding represented an extremely high share of funding for certain NARIs in certain years. Examples include NARI

BOX 2 | SNAPSHOT OF AGRICULTURAL RESEARCH SPENDING AND CAPACITY TRENDS IN WEST AFRICA, 1981–2014

As of 2014, West Africa spent a combined total of $948 million on agricultural research, in 2011 PPP prices (excluding the private for-profit sector due to lack of available data). Nigeria alone accounted for nearly half of this total, followed by Ghana ($197 million), Côte d'Ivoire ($82 million), and Senegal ($51 million). In contrast, 6 of the 16 countries for which data were available spent less than $10 million each on agricultural research.

Agricultural research capacity and spending trends, 1981–2014



Note: Data for subperiods were estimated for some countries.

Agricultural research expenditures in West Africa grew by more than 50 percent between the late 1990s and 2014, following a long period of stagnation during the 1980s and the first half of the 1990s. This subregional growth was almost entirely driven by Nigeria and Ghana, and primarily stemmed from the urgent need to institute a degree of parity in salary levels between university- and government-based researchers in both countries, and to rehabilitate derelict infrastructure and equipment in Nigeria. Investment levels in many other countries in the subregion either stagnated or fell during 2000–2014, although data indicate an upsurge in spending levels in more recent years, largely in response to WAAPP.

As of 2014, West Africa employed more than 5,600 FTE researchers in agricultural and related sciences—up from 3,232 FTEs in 2000, representing a 73 percent increase. Once again, Nigeria accounted for more than half of this total. In 2014, Ghana employed 575 FTEs, followed by Burkina Faso (311), Mali (286), Guinea (259), and Côte d'Ivoire (253). Many of the subregion's other countries have considerably smaller NARSs: 5 of the 16 countries for which data were available employed fewer than 100 agricultural researchers in 2014 (in FTEs).

Source: Wiebe et al., 2017

BOX 3 | LIST OF ACRONYMS

ARCN	Agricultural Research Council of Nigeria
ASTI	Agricultural Science and Technology Indicators
CAADP	Comprehensive African Agriculture Development Programme
CARGS	Competitive Agricultural Research Grant Scheme
CARI	Central Agricultural Research Institute [Liberia]
CNRA	National Agricultural Research Center [Côte d'Ivoire]
CNRA	National Commission for Agricultural Research [Mali and Niger]
CNRST	National Center of Scientific and Technological Research [Burkina Faso]
CORAF/ WECARD	West and Central African Council for Agricultural Research and Development
CSIR	Council for Scientific and Industrial Research [Ghana]
ECOWAS	Economic Community of West African States
FTE(s)	Full-time equivalent (researchers)
GFRP	Global Food Crisis Response Program
IDA	International Development Association [World Bank]
IER	Institute of Rural Economy [Mali]
ILWAC	Integrated Land and Water Management for Adaptation to Climate Variability and Change
INERA	Institute of the Environment and Agricultural Research
INRAB	National Institute of Agricultural Research of Benin
INRAN	National Institute of Agricultural Research of Niger
IRAG	Guinean Agricultural Research Institute
IRSAT	Applied Science and Technology Research Institute [Burkina Faso]
ISRA	Senegalese Agricultural Research Institute
ITA	Food Technology Institute [Senegal]
ITRA	Togolese Agricultural Research Institute
LCV	Central Veterinary Laboratory [Mali]
MDTF	Multi Donor Trust Fund
NARI	National Agricultural Research Institute [The Gambia]
NARI(s)	national agricultural research institute(s)
NARS(s)	national agricultural research system(s)
NCOS	national center of specialization
NGO(s)	nongovernmental organization(s)
PHRD	Policy and Human Resources Development
PPP	Purchasing power parity
SLARI	Sierra Leone Agricultural Research Institute
WAAPP	West Africa Agricultural Productivity Program

TABLE 1 | WAAPP funding to national agricultural research institutes and other research entities, 2008–2016

Country	NARIs/other entities	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
		2011 PPP dollars (millions)									
Benin	INRAB						2.0	5.0	5.6	4.2	16.8
	Other entities						0.3	1.9	1.3	–	3.5
Burkina Faso	INERA						1.0	4.0	2.1	4.8	12.0
	Other entities						0.5	0.5	0.9	2.4	4.4
Côte d'Ivoire	CNRA					1.5	3.5	6.2	0.7	0.3	12.2
	Other entities					2.0	7.7	7.6	4.1	1.4	22.8
The Gambia	NARI					5.3	0.4	1.2	0.1	1.2	7.1
	Other entities					2.5	1.0	2.6	4.0	2.9	12.9
Ghana	CSIR institutes	0.4	1.8	2.9	5.0	2.0	4.1	8.8	14.4	3.7	43.1
	Other entities	na	na	na	na	na	na	na	na	na	na
Guinea	IRAG					0.9	1.6	2.4	1.6	0.4	6.9
	Other entities					1.2	2.4	1.7	0.2	–	5.5
Liberia	CARI					–	2.5	2.3	0.8	0.1	5.8
	Other entities					–	–	–	–	–	–
Mali	IER	6.7	4.6	5.2	3.9	2.3	0.1	1.5	4.0	4.2	32.6[a]
	Other entities	–	–	–	–	–	–	0.1	6.8	3.0	10.0
Niger	INRAN					–	0.1	0.1	0.2	1.9	2.4
	Other entities					1.7	2.4	7.1	8.4	8.5	28.1
Nigeria	ARCN institutes					2.4	3.1	4.6	4.2	na	14.4
	Other entities					2.8	8.0	23.4	17.5	na	52.3
Senegal	ISRA	0.2	1.5	2.4	4.4	3.3	6.8	6.4	11.9	8.2	45.2
	Other entities	–	0.3	0.3	0.2	0.1	1.2	0.7	0.8	0.2	3.8
Sierra Leone	SLARI					–	2.0	3.3	1.4	0.4	7.1
	Other entities					–	–	–	–	–	–
Togo	ITRA					0.4	0.9	3.7	1.5	0.5	7.0
	Other entities					–	2.7	2.2	0.4	–	5.3
Total	**NARIs**	**7.3**	**8.0**	**10.5**	**13.4**	**18.3**	**28.0**	**49.6**	**48.6**	**na**	**212.5[b]**
	Other entities[c]	–	*0.3*	*0.3*	*0.2*	*10.2*	*26.1*	*47.9*	*44.5*	*19.0*	*148.5*

Source: Compiled by authors from World Bank, unpublished surveys, 2017.

Notes: Data include allocations from IDA, the GFRP donor trust fund, and the PHRD Fund. na = data were not available; a dash = 0; empty cells = WAAPP not yet in operation.

a. IER received considerably less funding than ISRA and CSIR due to the suspension of aid to Mali in response to the 2012 military coup and conflict.

b. The total excludes funding received by Nigeria in 2016.

c. The other entities total excludes Ghana.

(The Gambia) and ITRA (Togo), both of which received significant funding for the construction and rehabilitation of research stations and laboratories, which they spent across multiple years. In 2014, 83 percent of nonsalary expenditures by Senegal's ISRA were funded by WAAPP. Other NARIs with high shares of nonsalary expenses funded by WAAPP (40–60 percent) include INRAB (Benin), CSIR (Ghana), and IRAG (Guinea). In contrast, WAAPP funding accounted for only a small share of total funding received by ARCN's institutes (Nigeria); universities and the private sector have been the main beneficiaries of WAAPP funding in Nigeria (Table 2).

A closer look at the composition of WAAPP funding to NARIs reveals some interesting cross-country variations. The bulk of WAAPP funding to INRAB (Benin), INERA (Burkina Faso), CNRA (Côte d'Ivoire), NARI (The Gambia), IRAG (Guinea), INRAN (Niger), and ITRA (Togo) was allocated to infrastructure upgrades, including the renovation or construction of research laboratories and investment in research equipment (Figure 1). In contrast, at all three WAAPP-1A recipient NARIs, as well as ARCN (Nigeria), investment in research programs constituted the vast majority of WAAPP funding. At SLARI (Sierra Leone), equal proportions of funding were allocated to research programs and infrastructure, whereas at CARI (Liberia), the bulk of WAAPP funding was spent on staff training.

Contribution through Competitive Agricultural Research Grants

In addition to direct World Bank support to countries, a portion of WAAPP funding is channeled through the Multi Donor Trust Fund (MDTF), which

TABLE 2 | WAAPP funding as a share of total funding to national agricultural research institutes, 2008–2014

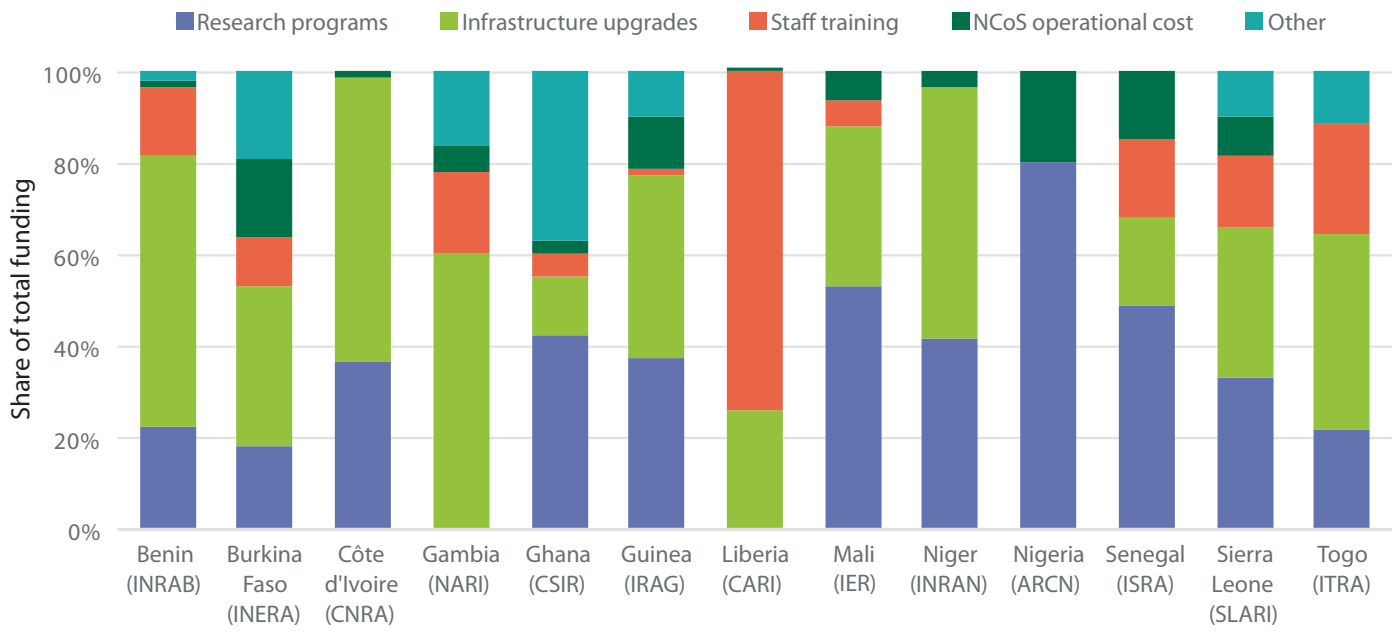
Country (institute)	2008	2009	2010	2011	2012	2013	2014	Total
	Share (%)							
Benin (INRAB)						14.9	35.2	25.3
Burkina Faso (INERA)						3.3	10.8	7.5
Côte d'Ivoire (CNRA)					2.9	6.4	10.3	6.7
The Gambia (NARI)					174.8[a]	15.7	53.9	89.9
Ghana (CSIR institutes)	0.8	2.8	4.8	8.5	2.7	4.0	9.5	5.0
Guinea (IRAG)					11.3	23.8	35.2	22.6
Mali (IER)	20.9	12.9	13.5	10.6	8.1	0.4	5.1	10.6
Niger (INRAN)					0.6	0.7	1.6	1.0
Nigeria (ARCN institutes)					1.3	2.8	2.7	1.9
Senegal (ISRA)	0.8	6.6	9.6	18.7	19.8	27.4	16.1	14.2
Sierra Leone (SLARI)					0.1	14.7	25.3	15.2
Togo (ITRA)					10.5	23.4	85.4[a]	41.5
Total	**6.9**	**6.4**	**8.4**	**11.2**	**4.6**	**5.5**	**9.9**	

Source: Compiled by authors from World Bank, unpublished surveys, 2017 and ASTI (2017).

Notes: Total funding to NARIs comprises all research-related expenditures, including salaries, operating and program costs, and capital investments. Data for Liberia were not available; empty cells = WAAPP not yet in operation.

a. These extremely high funding shares resulted from large disbursements for new construction and infrastructure upgrades.

FIGURE 1 | Composition of WAAPP funding to national agricultural research institutes, 2008–2016 average



Source: Compiled by authors from World Bank, unpublished surveys, 2017.
Notes: Data include allocations from IDA, the GFRP donor trust fund, and the PHRD Fund. NCoS = national center of specialization.

is managed by CORAF/WECARD. This fund consists of three main components: (1) research; (2) CORAF/WECARD's governance and administration; and (3) management, administration, and supervision of MDTF. Funding for research is channeled through CARGS, which consists of 7 regional competitive or commissioned projects financed within the WAAPP framework; 4 ILWAC Trust Fund subgrant projects implemented under WAAPP, and 17 MDTF-financed projects that don't involve WAAPP (but do involve CORAF/WECARD member countries). Although non-WAAPP countries do not benefit directly from WAAPP funding, complementarities and synergies exist between WAAPP and MDTF projects, both at the national and regional-coordination levels.

Between 2013 and 2017, a total of US$7.2 million of WAAPP-1B, WAAPP-1C, and WAAPP-2A funding was channeled to MDTF and allocated to the countries on a competitive or commissioned basis. These seven projects cover a wide variety of research topics and themes. Benin and Senegal have been the most successful in securing funding through CARGS: six of the seven projects target these two countries. In contrast, Guinea, Liberia, Sierra Leone, and Togo only received funding through two CARGS' projects (Exact funding allocations per country per year were not available). In addition to the seven regional projects that are funded within the WAAPP framework, the government of Denmark has funded a series of integrated land and water management projects that were implemented under WAAPP. These projects, with a total value of US$4.8 million, covered the 13 WAAPP countries, as well as Cameroon and Chad. The main objective of these projects was to improve the ability of African users of agricultural land and water resources to plan and manage climate change adaptation measures. These projects came to a close in 2015 (Table 3).

Overall Contribution to West Africa's Agricultural Research Investment

Undertaking a comprehensive analysis of the total contribution of agricultural research funding in

TABLE 3 | Projects funded under the WAAPP framework by the regional competitive agricultural research grant scheme

Project title	Objectives	Phase	Implementing countries	Total budget (million $US)	Duration
Upscaling the Nigerian flash drying experience for sustainable regional trade and income generation in West Africa	To improve access and usage of efficient drying technologies by small and medium-sized enterprises in project locations in West Africa	WAAPP-1B	Benin, Ghana, Nigeria, and Sierra Leone	1.2	April 2013 to March 2016
Identification of policy and strategic options for better adoption of research results by family farms in West Africa (AGRIFAM)	To propose policy and strategic options to support innovation adoption and up- scaling by smallholder farmers	WAAPP-1B	Benin, Burkina Faso, Mali, Niger, Senegal, and Togo	1.5	September 2013 to August 2016
Improvement and dissem-ination of intensive rice farming in West Africa	To improve the productivity and competitiveness of rice production and trade across the region	WAAPP-1C	All 13 WAAPP countries	1.0	July 2013 to June 2016
Development of a seed program	To sustainably increase the production of certified seed in Benin, The Gambia, Liberia, and Niger	WAAPP-1C	Benin, The Gambia, Burkina Faso, Liberia, Mali, Niger, and Senegal	0.2	March 2014 to February 2016
Dissemination of fruit fly control technologies and building the capacity of stakeholders in the West African fruit value chain	To promote the mango value chain by increasing productivity and improving quality and trade through the effective manage-ment of fruit flies in West Africa	WAAPP-1C	Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria, Senegal, The Gambia, and Togo	1.3	March 2014 to June 2016
Organic fertilizers project	To determine the technical and economic performance of the use of organic fertilizers and make recommendations	WAAPP-2A	Burkina Faso, Côte d'Ivoire, Ghana, Mali, Nigeria, and Senegal	0.6	2017 to 2018
Developing the capacity of actors in the West African cashew value chain	To improve the generation of jobs and income of actors in the cashew value chain in five participating countries and beyond. Specifically, the project aims to improve the productivity and value of cashews	WAAPP-2A	Benin, Burkina Faso, Côte d'Ivoire, Ghana, and Senegal	1.4	January 2015 to December 2017

Source: Compiled by authors from World Bank, unpublished surveys, 2017.

West Africa under WAAPP (to both NARIs and other entitites) is challenging based on fundamental methodological and data coverage differences in the ASTI and WAAPP datasets. Any results derived from a comparison between these two datasets should therefore be interpreted with care. For example, ASTI's data is categorized by research performer, so coordinating bodies—which are key recipients of WAAPP research funding—are not included. ASTI also makes FTE adjustments to reflect the amount of time and money spent on research versus nonresearch activities, whereas many WAAPP recipients do not have a full research mandate and spend a lot of their time on nonresearch activities. Finally, ASTI's coverage of private-sector agricultural research in West Africa is weak, but private entities are important WAAPP recipients, especially in Nigeria. Keeping these dis-crepancies in mind, an overview on total West African

TABLE 4 | Comparison of West Africa's total agricultural research expenditures and WAAPP funding to research performers, 2008–2016

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Million PPP dollars (2011 prices)									
Total agricultural research spending	913.6	909.4	885.2	957.9	875.5	930.6	948.2	na	na
WAAPP research funding									
directly to countries	7.3	8.3	10.8	13.6	28.6	54.1	97.4	93.0	na
through regional CARGS	–	–	–	–	–	1.4	4.4	7.0	3.9
Million US dollars (current prices)									
WAAPP research funding									
directly to countries	2.8	3.3	4.4	6.4	17.5	35.6	71.4	53.4	na
through regional CARGS	–	–	–	–	–	0.6	2.1	2.7	1.5

Sources: Total agricultural research spending are from ASTI's database; total WAAPP funding are from World Bank, unpublished surveys, 2017.

Notes: Total agricultural research spending includes salaries, operating and program costs, and capital investments from government, higher education, and nonprofit agencies involved in agricultural research (and excludes the private for-profit sector); total WAAPP funding includes all public and private recipients of research funding. National ASTI data are based on full-time equivalents (FTEs) and hence only take into account time spent on research; WAAPP funding data have not been FTE adjusted and hence include both research- and nonresearch-related activities. WAAPP data exclude non-CSIR recipients in Ghana. WAAPP data on research funding through regional CARGS have been estimated by allocating aggregated data equally over time. na = data were not available; a dash = 0.

agricultural research investment and WAAPP funding is provided for the 2008–2015 period (Table 4).

Contribution to the Development of West Africa's Research Capacity

Growing concern exists regarding the lack of human resource capacity in agricultural research to respond effectively to the challenges that agriculture in West Africa is facing. In nearly all West African countries, the majority of PhD-qualified researchers are due to retire by 2025, which means that a growing number of agricultural research institutes will be left without the critical mass of senior researchers needed to lead research programs and mentor and train junior staff. Without adequate succession strategies and training, significant knowledge gaps will emerge, raising concerns about the quality of future research outputs. WAAPP's training component aims to address the most acute staff shortages, especially in the smaller countries where gaps are greatest. WAAPP funding has supported (MSc- and PhD-level) training in priority areas for more than 1,000 young scientists, 30 percent of whom are female. Not all those trained are researchers, however. WAAPP also supports postgraduate training of staff at extension agencies, universities, NGOs, and farmer organizations.

Data confirm that a considerable number of researchers employed at West African NARIs have undergone or are currently undergoing MSc- and PhD-level training under WAAPP (Table 5). The vast majority are attending universities in their own countries, unless postgraduate training is limited (such as in The Gambia, Liberia, Sierra Leone, and Togo). A large number of Senegalese researchers (from ISRA and ITA) are pursuing PhD training outside Africa, mostly at universities in Belgium and France. Postgraduate training of research staff was not a component of WAAPP-1C in Guinea, but many Guinean researchers have received short-term training, both locally and abroad. The data clearly indicate that WAAPP funding for capacity building has significantly offset the capacity losses anticipated through retirement in the coming years. It will be crucial, however, that these younger (and relatively inexperienced) MSc- and PhD-qualified researchers receive sufficient

TABLE 5 | Number of staff receiving WAAPP-funded postgraduate training by gender and location, 2008–2016

Country (institute)	Female		Male		Total		Nationally		In Africa		Outside Africa	
	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD	MSc	PhD
	(Headcount)											
Benin (INRAB)	10	18	16	18	26	36	26	36				
Burkina Faso (INERA)	2	4	5	12	7	16	7	16				
Burkina Faso (IRSAT)	3	1	3		6	1	6	1				
Côte d'Ivoire (CNRA)	7	3	18	19	25	22	25	20		1		1
Ghana (CSIR institutes)	16	6	12	19	28	25	27	23		1	1	1
The Gambia (NARI)			6	2	6	2			6	2		
Guinea (IRAG)												
Liberia (CARI)	2			2	2	2			2	2		
Mali (IER)	2	12	1	24	3	36	2	36	1			
Mali (LCV)				6		6		6				
Niger (INRAN)	5	3	4	14	9	17	7	9	2	7		1
Nigeria (ARCN institutes)	4	6	11	7	15	13	2	2	5	9	8	2
Senegal (ISRA)	2	9	7	18	9	27	6	5	1	5	2	17
Senegal (ITA)	6	7	6	7	12	14	11	8		1	1	5
Sierra Leone (SLARI)	3	5	25	4	28	9	5	2	23	7		
Togo (ITRA)	2	4	18	16	20	20	1	8	18	9	1	3

Source: Compiled by authors from World Bank, unpublished surveys, 2017.

Notes: Data focus on the main agricultural research institutes; a large number of additional scientists at smaller government research agencies or universities also received WAAPP funding MSc- and PhD-degree training.

training and mentoring from their older, more experienced colleagues before they retire.

Allocation of WAAPP-Related Research Resources

The congruency or parity model is a commonly used method of assessing the allocation of research resources, in this case to specific commodities based on their corresponding contribution to the value of agricultural production. For example, if the value of rice output were twice that of maize, then congruence would be achieved if research on rice were to employ twice as many scientists as research on maize. The concept of congruency can be useful in assessing the distribution of research effort across commodities, but it is not a rule. Research effort might be allocated disproportionately to a product with modest current value because demand for that product is projected to grow. In addition, multiple objectives for agricultural development might channel research effort toward a product with lesser weight in sectoral value-added, but particular relevance, for example, for improving nutrition or generating employment.

FIGURE 2 | Comparison of research allocation and production value for selected countries and crops, selected countries, 2014

Sources: Data on researchers' commodity focus are calculated by authors based on ASTI (2017); data on production values are from the Food and Agriculture Organization of the United Nation's FAOSTAT dataset.

Note: Please consult Wiebe et al. 2017 for comparisons of research allocation and production value for other West African countries.

Yams are the most important crop in terms of production value in Benin, Ghana, Nigeria, and Togo, and the second most-important crop in Côte d'Ivoire. Yet, in all these five countries, yams' share of the total value of crop production was considerably higher than the corresponding share of crop researchers, implying that yams are comparatively under-researched (Figure 2). In contrast, more researcher time was allocated to maize relative to its crop production value in five of the seven countries where maize is an important crop in terms of production value. For rice, the results were mixed, with some countries recording shares of crop researchers higher than shares of crop production value, and other countries recording shares of researchers lower than shares of crop production value.

The NCoS approach of WAAPP has strengthened incongruences between crop production value and research focus at the country level, highlighting the importance of viewing research priorities in a regional context and of strengthening regional linkages. Congruency in a regional context would require assessment of the combined investment in specific crops and livestock products across countries

TABLE 6 | Crop varieties registered and released or adapted and diffused with WAAPP (co)funding, 2010–2017

Country	Crop	Number of new varieties	Germplasm source
Benin	Maize	3	CGIAR
Burkina Faso	Tomatoes	5	Local
Côte d'Ivoire	Maize	8	CGIAR
	Cassava	4	CGIAR
	Potatoes	2	CGIAR
	Plantain	2	CGIAR/local
Ghana	Cassava	10	CGIAR/local
	Cocoyam	3	Local
	Sweet potatoes	4	CGIAR
	Yams	4	CGIAR
Mali	Rice	5	CGIAR/local
Senegal	Groundnuts	7	Local
	Cowpeas	5	Local
	Sorghum	6	Local
	Millet	3	Local
Sierra Leone	Rice	12	CGIAR

Source: Compiled by authors from World Bank, unpublished surveys, 2017.

compared with the regional value of production. Meaningful interpretation of congruency would further require that barriers to moving new technologies across national boundaries be low.

Contribution of Newly Released or Adapted Varieties

Detailed information was collected on varieties released by NARSs under WAAPP, although it was difficult to determine which varieties were developed and disseminated with WAAPP funding, and which were only disseminated. The three WAAPP-1A countries were the most productive in terms of releasing varieties (again, not surprising given WAAPP's earlier commencement in these countries). WAAPP-1A funded research on dryland cereals in Senegal, which led to the release of new millet (2011), sorghum (2011 and 2015), cowpea (2015), and groundnut (2016) varieties, all based on local germplasm (Table 6). WAAPP-1A support for roots and tuber research in Ghana resulted in the release of a number of cassava (2010 and 2015), cocoyam (2012), sweet potato (2012), and yam (2017) varieties, based on a combination of both CGIAR and local germplasm. WAAPP-1A and WAAPP-2A funding directly contributed to the development and release of five new rice varieties in Mali (in 2012 and 2016), and the dissemination of many more new varieties developed through different funding sources. Similarly, the development of five new tomato varieties in Burkina Faso were developed through other sources, but disseminated with the aid of WAAPP funding (No WAAPP-supported crop varieties were released in Niger or Nigeria because WAAPP targets the livestock and fisheries sectors of these countries, respectively).

Conclusion

WAAPP has injected significant funding into West African NARSs since 2008 and made substantial progress in addressing the subregion's most acute agricultural research challenges. The program has invested extensively in the construction and rehabilitation of research infrastructure and in the provision of laboratory equipment for predefined priority commodities. As such, it has strengthened the position of West African countries to perform high-quality, priority research over the coming years. WAAPP has also invested in postgraduate training for more than 1,000 young scientists across West Africa—30 percent of whom are female—which has significantly contributed to offsetting impending large-scale human capacity losses due to the retirement of senior researchers.

Despite these important achievements, a few critical challenges remain. WAAPP funding has targeted priority commodities, so a number of important research priorities have been overlooked. Yams, for instance, are of critical economic importance in West Africa's tropical zones, but WAAPP has not focused on establishing a regional center of excellence in yam research. The same can be said for cowpeas in the Sahel. Farmers growing these crops need new, high-yielding varieties that are resilient to drought, floods, or extreme temperatures and are less vulnerable to pests and diseases. It is therefore essential that research on these orphan crops—which are also researched less extensively by CGIAR centers than rice, maize, and wheat, for example—not be ignored. In addition—notwithstanding the important strides made by WAAPP in stimulating technology transfer by bringing researchers, extension services, cooperatives, and other civil society organizations to work together—more needs to be done to scale up the adoption of improved technologies to meet the food and nutritional needs of the population and to drive economic development and poverty reduction throughout West Africa. The proposed West Africa Agricultural Transformation Program is set to address these challenges by scaling up the adoption of climate-smart technologies to sustainably enhance productivity, reduce postharvest losses, increase value addition, improve nutrition, promote an enabling policy environment, strengthen the regional market, and generate youth employment.

Another of WAAPP's important accomplishments is laying the foundation for a truly subregional approach to agricultural research. Most West African NARSs are small and fragmented, and have traditionally focused on the same range of research issues as their larger neighbors. Through the establishment of national centers of excellence, subregional research coordination, and new funding mechanisms, WAAPP has promoted cross-country research collaboration, reduced duplication of research effort, and enhanced the flow of relevant technologies across the region. To cement this regionalization as a long-term reality, regional research priorities must be identified, coordinated (for example, by CORAF/WECARD or ECOWAS), and assigned to countries best suited to carry out the specific research required. National governments must also decide how to allocate their research funding across national and regional priorities. Importantly, intellectual property rights issues related to the regional use of research outputs produced by NARSs need to be resolved so that countries can benefit from regional cooperation in alignment with their contributions.

Further Reading

ASTI (Agricultural Science and Technology Indicators). 2017. ASTI database. Washington, DC: International Food Policy Research Institute.www.asti.cgiar.org.

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