



FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative



FEED THE FUTURE GHANA AGRICULTURE TECHNOLOGY TRANSFER PROJECT FINAL PROJECT REPORT 2013-2018

**Feed the Future Ghana Agriculture Technology Transfer Project
Final Project Report
2013-2018**

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Acronyms

APSP	Agricultural Policy Support Project	ISU	Iowa State University
ATT	Agricultural Technology Transfer (project)	IWMI	International Water Management Institute
CBO	Community-Based Organization	LIP	local implementing partner
CDI	Centre for Development Innovation	LOP	Life of the Project
COP	Chief of Party	M&E	Monitoring and Evaluation
CRI	Crops Research Institute	MOFA	Ministry of Food and Agriculture
CRS	Catholic Relief Services	MSMEs	micro, small, and medium enterprises
FBO	farmer-based organization	NARO	National Agriculture Research Organization
FTF	Feed the Future	NASTAG	National Seed Traders Association of Ghana
FY	Fiscal Year	NGO	non-governmental organization
GAABIC	Ghana Agricultural Associations Business and Information Center	PFJ	Planting for Food and Jobs
GAPs	good agricultural practices	RELC	Research-Extension Linkage Committee
GHS	Ghanaian cedi	SARI	Savanna Agricultural Research Institute
GMO	genetically modified organism	SEEDPAG	Seed Producers Association of Ghana
GPS	Global Positioning System	SIR	Sub-Intermediate Result
GSID	Ghana Seed Inspection Division	UDP	Urea Deep Placement
ICOUR	Irrigation Company of the Upper Region Ltd.	UDS	University for Development Studies
ICT	Information and Communications Technology	USAID	U.S. Agency for International Development
IFDC	International Fertilizer Development Center	USAID/Ghana	U.S. Agency for International Development's Ghana Mission
IR	Intermediate Result	USG	U.S. Government
ISFM	Integrated Soil Fertility Management		

Executive Summary

The Feed the Future Ghana Agriculture Technology Transfer (ATT) Project was funded by the U.S. Agency for International Development's Ghana Mission (USAID/Ghana) to increase the competitiveness of rice, maize, and soybean value chains to foster broad-based and sustained economic growth through the increased availability of agricultural technologies in northern Ghana. The project focused on the Ghana Feed the Future intervention zone, which covers the three northern regions of Ghana (Northern, Upper West, and Upper East), and addressed technology constraints in Ghana's FTF target crops of rice, maize, and soybean.

IFDC was the lead implementer, with technical support provided through Iowa State University (ISU) and the Center for Development Innovation through the University of Wageningen, as well as local organizations and public and private sector institutions in Ghana. Research institutions and departments of the Ministry of Agriculture and other offices within the Government of Ghana also played an important role in project implementation.

The project supported various stakeholders including producers, agro-input dealers, agricultural marketing enterprises, farm service providers, industrial food and feed processors, private sector actors involved in seed and fertilizer production and distribution, research

institutions/laboratories, and government and regulatory bodies responsible for creating and maintaining an enabling environment for a dynamic agricultural sector.

ATT interventions were organized around the following three intermediate results that fed into the overall projects goal of a more competitive rice, maize, and soybean value chain in northern Ghana:

- IR 1: Increased private sector actors' role and capacity in developing and disseminating improved technologies
- IR 2: Increased efficiency and transparency of government functions to support seed, fertilizer, and ISFM technology development, release, and dissemination
- IR 3: Increased efficiency of targeted agricultural research to develop, release, and communicate technologies that support sustainable agricultural productivity

This report presents the results achieved since the inception of the project. Results are briefly discussed in the following pages and presented in more detail throughout the document. Major activities are organized by topic: Soil, Seed, Water, Research, ICT, and Cross-Cutting Issues (including Gender). A section on Lessons Learned and the Way Forward concludes the report.

Achievements

By increasing producers' access to agricultural technologies and building the capacities of the private sector, public regulatory and research institutions, and farmers, the ATT project achieved the following results:

- 204,175 smallholder farmers reached.
- Significant increase in crop yields:¹
 - 3.88 mt/ha for maize (228% increase)
 - 5.16 mt/ha for rice (287% increase)
 - 2.66 mt/ha for soybean (266% increase)
- Over \$7.8 million in incremental sales of seeds and fertilizer by the private sector.
- 124 public-private partnerships formed.
- \$5.9 million in grants to beneficiaries, stimulating additional private sector investments.
- Over \$2.77 million leveraged in new private sector investment in agriculture.

¹ The achievements indicated here are compared to the baseline year (2014).

Seed



ATT spurred improvements across the seed value chain by building the capacity of private seed suppliers, government research and regulatory agencies, and seed producers. Through logistics and infrastructure support and public-private coordination, the project eased the seed varietal release and certification process. Now, seed labs and research institutions in ATT areas are better equipped with the state-of-the-art technologies. These efforts have significantly improved access to seeds and other inputs for smallholder farmers living in last-mile locations, with better service provision through a network of trained last-mile actors (such as input dealers/micro-retailers) and innovative last-mile distribution mechanisms(e.g., mobile vans).

As a result, demand for certified seed has grown, with its use rising from 10% of total seed use in 2013 to 25% in 2018. Significantly, these efforts have also improved partnerships between private seed companies and public research and regulatory institutions. In 2017, the private sector produced 1,420 mt of certified seed – most of which the Government of Ghana used to support its flagship agricultural initiative. By facilitating a more competitive private seed industry and stronger public research system, ATT has laid the groundwork to foster further sustainable growth in the seed sector.

Soil



ATT identified the best soil fertility management technologies available for maize, rice, and soybean and scaled them for maximum impact among project beneficiaries. Through various dissemination mechanisms, from demonstration plots to starter packs to video extension, ATT created sustained demand for certified seed, ISFM technologies, and good agricultural practices. With the improved fertilizer application practice, viz., urea deep placement (UDP) technology, farmers in the Northern Region improved their rice output and gross margins.

In addition, ATT introduced soil testing through an emerging private sector soil lab and advanced a national dialogue among stakeholders on soil fertility and fertilizer recommendations through its forum, *The State of Soil Fertility in Northern Ghana, Fertilizer Recommendations, Utilization and Farm-level Access*, to disseminate the learnings from the project and encourage the production and distribution of fertilizer products based on crops' needs.

Water



ATT confirmed the technical feasibility of harvesting floodwater using PAVE and Bhungroo water management technologies. Since the northern regions of Ghana have just one rainy season, this gives farmers the opportunity to plant two crops in one season (“Double Cropping, Dual Income”). With double cropping, i.e., incorporating improved varieties of high-value crops into their farming systems, farmers have the potential to move out of poverty and enhance their families’ nutrition and income opportunities.

Research



ATT's research activities prioritized regional and local needs of smallholders and ensured new technologies and research outputs reached and could be accessed by beneficiaries in the project's zone of influence, through better coordination between existing researchers, extension agents and government entities, and private stakeholders. By supporting national research and regulatory institutions, such as SARI and GSID, ATT helped create a better functioning and dynamic agricultural research system that would remain sustainable after the project closed. ATT's adaptive trials confirmed a range of technologies ready to be deployed across northern Ghana. In addition, through collaborative research with Iowa State University, ATT found that drone technology can assess crop health and estimate yields early in the season, rapidly, and cost-effectively. The research employed Ghanaian graduate students at ISU and the University of Development Studies.

ICT



Digital classroom technology enabled ATT to expand its dissemination of new agricultural technologies from hundreds of farmers attending field days to thousands of farmers viewing video presentations in local dialects, in their local communities. Through innovative extension delivery mechanisms, which included radio and e-extension (including audio and video methods), ATT made sure that information reached those who needed it the most – farming communities at the last mile. ATT enlisted local organizations and private sector partners to deploy ICT solutions, ensuring that such knowledge transfer continues even after the project has ended.

Gender



Women's empowerment was a major focus of ATT. At the end of project (2018), over 98,000 female farmers had applied one or more improved technologies or management practices as a result of ATT activities. This represents 98% of total farmers targeted (100,000) and nearly half of total farmers reached (201,700).

The creation of labor geared toward women engaged in skilled activities (such as line transplanting) has helped women to remain within their local communities and families, thus reducing their migration to look for work in urban areas of southern Ghana. In addition, the introduction of labor-saving technologies using agri-machinery also created more opportunities for women to earn income by renting their equipment or providing services for a fee.

Achievements by Indicators

Indicator	Baseline Value	LOP Target	LOP Target Achieved	LOP Achievement (%) ²	Indicator Category
Ind. 1 – Yield per hectare of targeted commodity (maize, rice and soy)					
Yields for Maize (mt/ha)	1.70	3.40	3.9	115%	Custom
Yields for Rice (mt/ha)	1.80	3.60	5.33	148%	
Yields for Soybean (mt/ha)	1.00	2.00	2.71	136%	
Ind. 2 – Number of hectares under improved technologies or management practices as a result of U.S. Government (USG) assistance (FTF Indicator # EG.3.2-18)	0	100,000	165,260.00	165%	FTF
Ind. 3 – Number of farmers and others who have applied improved technologies or management practices as a result of USG assistance (FTF Indicator # EG.3.2-17)	0	100,000	201,716	202%	FTF
Ind. 4 – Number of private enterprises, producer organizations, water users associations, women’s groups, trade and business associations and community-based organizations (CBOs) that applied improved technologies or management practices as a result of USG assistance (FTF Indicator # 4.5.2-42)	0	800	863	108%	FTF
Ind. 1.1 – Value of incremental sales of targeted ATT’s commodities (seed, fertilizers and other soil amendments) attributed to FTF implementation	N/A	1,000,000	\$7,890,606.20	789%	Custom
Ind. 1.2 – Value of new private sector investment in the agriculture sector or food chain leveraged by FTF implementation (FTF Indicator # 4.5.2-38)	0	1,200,000	\$5,023,137.31	419%	FTF
Ind. 1.3 – Number of individuals who have received USG-supported short-term agricultural sector productivity and food security training (FTF Indicator # 4.5.2-7)	0	140,000	177,105	127%	FTF
Ind. 1.4 – Number of individuals who have received USG supported degree-granting agricultural sector productivity or food security training (FTF Indicator # EG.3.2-2)	0	50	52	104%	FTF
Ind. 1.5 – Number of food security private enterprises (for profit), producer organizations, water users associations, women's groups, trade and business associations, and CBOs receiving USG assistance	0	800	1,502	188%	FTF

² A deviation narrative is presented in Table 5. An indicator dashboard/performance summary is presented in Annex 1.

Indicator	Baseline Value	LOP Target	LOP Target Achieved	LOP Achievement (%) ²	Indicator Category
Ind. 2.1 – Number of public-private partnerships formed as a result of FTF (FTF Indicator # 4.5.2-12)	0	25	124	496%	FTF
Ind. 2.2 - Number of technical publications made available for dissemination	0	44	49	111%	Custom
Ind. 1.1.1 - Volume and value of seed (rice, soybean, maize) available for Northern Ghana, as a result of USG assistance		5,760.61	11,810.75	205%	Custom
Ind. 1.1.2 - Number of MSMEs, and others registered and are producing seeds (certified and foundation)	0	116	142	122%	Custom
Ind. 1.2.1 - Number of farmers, and others accessing market and technology information on seed, ISFM and general agricultural practices through ICT mechanisms:				1635%	Custom
Video Screening	0	100,000	119,347	189%	
Radio & TV Shows	0		1,634,775	1634.8%	
Ind. 1.2.2 - Number of field trials implemented by privately owned/operated seed companies and other partners receiving USG assistance	0	100	189	189%	Custom
Ind. 1.3.1 - Number of Policies/ Regulations/Administrative Procedures in each of the following stages of development as a result of USG assistance in each case: (FTF Indicator # EG.3.1-12)	0	5	5	100%	Custom
Ind. 1.4.1 - Number of private enterprises, NGOs, sector actors, etc. promoting new technologies	0	250	253	101%	Custom
Ind. 1.4.2 - Number of links between international and local companies that result in accessing new technologies	0	25	25	100%	Custom
Ind. 2.1.2 - Number of Seed Testing Laboratories set up to facilitate seed testing and certification	0	3	3	100%	Custom
Ind. 2.1.3 - Number of Seed Processing Plants established to enhance seed quality	0	3	5	167%	Custom
Ind. 3.1.1 – Number of technologies or management practices in one of the following phases of development:					
In Phase I: Under research as a result of USG assistance	0	7	0	0%	FTF
In Phase II: Under field testing as a result of USG assistance	0	44	27	61%	
In Phase III: Made available for transfer as a results of USG assistance (FTF Indicator # 4.5.2-39)	0	15	3	20%	
Ind. 3.2.1 - Number of conferences, forums etc. attended by project partners with USG assistance	0	20	23	115%	Custom
Ind. 3.3.1 - Number of communication messages on plant biotechnology produced	0	9	7	78%	Custom
Ind. 3.3.2 - Number of farmers, processors or others who received information on biotechnology	0	4,075	Over 6 million	<i>Messages aired on community and national radio stations, thereby far exceeding the target.</i>	Custom

Introduction

The Feed the Future Ghana Agriculture Technology Transfer (ATT) project was implemented by the International Fertilizer Development Center (IFDC) and funded by the United States Agency for International Development (USAID) in the Feed the Future intervention zone covering Northern, Upper East, and Upper West regions of Ghana (Figure 1). The five-year project aimed to increase access to and the availability of key technologies related to seed, soil, and water across northern Ghana from April 2013 to December 2018.

Historically, the three northern regions have had the highest poverty rates and lowest per capita incomes in the country. According to the ATT Baseline Survey Report conducted by the University for Development Studies (2014), yields of maize, rice, and soybean in northern Ghana lagged far behind national averages when the ATT first began. A major cause has been farmers' low use of improved certified seed. Most producers use saved seed, which is low quality. Most increases in agricultural production were a result of expanding area farmed instead of increasing yields on the same amount of land.

In addition, flooding, waterlogging, and drought impede agricultural productivity in the northern regions. And during the dry season, most of the waterlogged farmland becomes dry, making it less usable for farming. The situation is compounded

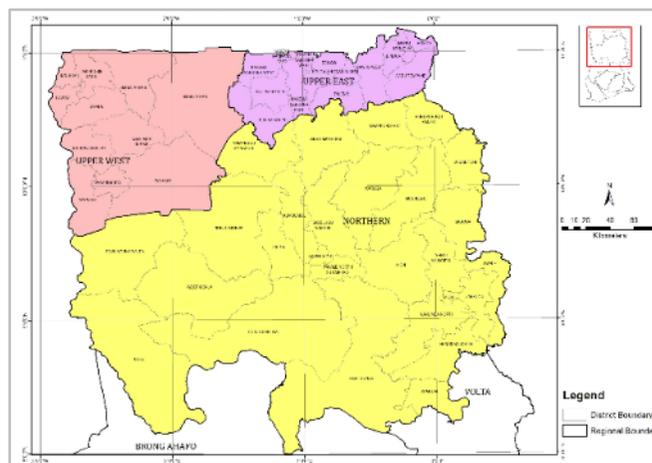


Figure 1. Feed the Future Ghana ATT Project Intervention Area

by limited access to irrigation schemes to support farming activities during the dry season.

Taking into account the constraints inherent to the northern regions of Ghana, the ATT project was designed to address issues surrounding the rice, maize, and soybean value chains – major crops targeted by Feed the Future (FTF) and by the Government of Ghana's new agricultural strategy "Planting for Food and Jobs" (2017). The overall goal of ATT was therefore to increase the competitiveness of the value chains of the selected crops to foster broad and sustained economic growth and agricultural productivity among small farmer households and agribusiness entrepreneurs in the region. Through various interventions, ATT addressed constraints facing FTF target crops in northern Ghana in a holistic manner that involved strengthening the seed and

agro-input value chains and promoting good agricultural practices (GAPs), ISFM practices, and water management technologies.

In short, the major results from the project were aimed at:

- Increasing the role and capacity of private sector actors in developing and disseminating improved seed and ISFM technologies.
- Increasing the efficiency and transparency of government functions to support seed, fertilizer, and ISFM technology development, release, and dissemination.
- Increasing the efficiency of targeted agricultural research to develop, release, and communicate technologies that support sustainable agricultural productivity.

These three objectives have resulted in significant improvements in crop productivity levels and increased uptake of technologies.

ATT's most significant achievement is improved productivity of maize, rice, and soybean. Yield increased by 228% for maize (from 1.70 to 3.88 mt/ha), 287% for rice (from 1.80 to 5.16 mt/ha), and 266% for soybean (from 1.00 to 2.66 mt/ha), according to ATT Crop Cut Surveys.

In addition, ATT's introduction of improved technologies led to \$7.8 million in incremental sales of targeted input commodities (seeds, fertilizers, and soil amendments).

A. Results Framework

Goal: Increased competitiveness of rice, maize, and soy value chains to foster broad-based and sustained economic growth

Strategic Objective: Increased availability and use of agricultural technologies to increase and sustain productivity in Northern Ghana

Intermediate Result 1 (IR 1)

Increased private sector actors' role and capacity in developing and disseminating improved technologies

Intermediate Result 2 (IR 2)

Increased efficiency and transparency of government functions to support seed, fertilizer, and ISFM technology development, release, and dissemination

Intermediate Result 3 (IR 3)

Increased efficiency of targeted agricultural research to develop, release, and communicate technologies that support sustainable agricultural productivity

Sub-Intermediate Results (SIR)

SIR 1.1 – Increased capacity and competitiveness of Ghana's seed sector to produce, or access from outside Ghana, high-quality certified seed

SIR 1.2 – Increased demand for market and technology information on seed and ISFM through ICT mechanisms

SIR 1.3 – Effective advocacy by well-organized seed and fertilizer industries

SIR 1.4 – Increased dissemination of ISFM technologies

Sub-Intermediate Results (SIR)

SIR 2.1 – Increased level of satisfaction of clients (small and medium enterprises and farmers) on product quality (seed, fertilizer, ISFM technologies) and delivery

SIR 2.2 – Improved control mechanisms for seed certification and functional varietal release processes

Sub-Intermediate Results (SIR)

SIR 3.1 – Increased number of seed and ISFM technologies developed and released

SIR 3.2 – Improved communication for technology dissemination capacities

SIR 3.3 – Increased knowledge and capacities on biotechnology development and biosafety guidelines

B. Implementation Strategy

ATT project interventions were integrated in a strategy that simultaneously focused on the essential elements of agricultural production – seed, soil, and water. The approach consisted of identifying scientifically sound and socio-economically appropriate climate-smart technologies that improve the quality and use of these three elements. Extending from this three-pronged intervention approach was an integrated implementation strategy aimed at transferring identified technologies (Figure 2).

An important principle behind ATT's overall approach was to portray smallholder agriculture as a business proposition, through improved productivity at each level – from crop production to processing – thus optimizing input use levels (land, labor, and capital) and improving the profit shares to all stakeholders involved. This was accomplished through adopting novel approaches that included developing or upgrading the capacities of public institutions and private enterprises, to enable them to introduce new technologies and supply agricultural inputs that are affordable and accessible to smallholder farmers. In addition, solid public-private partnerships were developed, particularly through promoting investment in improved seed development, production, processing/branding, and marketing involving farm inputs and outputs.

This further allowed the ATT project to accomplish project goals with effective outcomes and results – both in the short term and aimed at long-term sustainability in the intervention areas. To ensure that the implementation strategy led to sustainable results, ATT improved the capacity of local regulatory and research institutions and worked through local partners to carry out project interventions at the community level. This was accomplished through the following means:



Figure 2. ATT Intervention and Implementation Strategy: Seed-Soil-Water

i. Improving capacities of local institutions

A major focus of ATT was creating the regulatory and institutional environment needed for a private sector-driven seed sector in northern Ghana. This included strengthening national research institutions and regulatory units. ATT also helped establish platforms to encourage dialogue among all stakeholders in the seed value chain. In addition, the project included a \$6 million grant mechanism to build the capacities of nascent local organization, such as private seed businesses, public extension agencies, and non-governmental organizations (NGOs).

ATT Development Hypothesis

If smallholder adoption of comprehensive, productivity-improving agricultural technology (products, processes, and practices) is increased in northern Ghana's maize, soybean, and rice value chains, *then* household income will improve, and poverty and food insecurity will be reduced."

ii. Improving last-mile delivery services

Since the project's inception, ATT has worked through 33 local implementing partners (LIPs) instead of focusing on direct implementation. This has built the capacity of local organizations while ensuring interventions continue after the project closes. The LIPs were the main agents of change at the community level. Because they had worked for years in the target communities, they served as the interface between the project and the beneficiaries. This allowed the project to reach a wide area and remain visible in remote communities. A database of LIPs is provided in Annex 2.

To clearly present the results of the ATT project, this final report is organized in sections on the following elements of agricultural productivity and technology dissemination:

- Seed
- Soil
- Water
- Research
- ICT
- Cross-Cutting – Gender, Grants, M&E, Communications, Project Management

ATT Partners

To ensure outcomes and opportunities created through ATT are sustainable, the project shaped and cultivated extensive partnerships with existing institutions – public and private – for continued oversight and accountability. From the beginning, ATT collaborated extensively on technical aspects with various national and international organizations involved in similar activities in the region. In addition, the project worked closely with the Government of Ghana, particularly offices within the Ministry of Food and Agriculture. These partnerships are critical for fostering continued implementation of regulatory and institutional reforms needed for a private sector-driven seed and fertilizer systems development in Ghana.

International Research Institutions

- Iowa State University (ISU)
- Centre for Development Innovation (CDI) of Wageningen University and Research

National Research Institutions

- Savanna Agricultural Research Institute (SARI)
- University for Development Studies (UDS)

Local Implementing Partners

- Ghana Agricultural Associations Business and Information Center (GAABIC)
- Local non-governmental organizations
- Local private sector enterprises

Government Agencies

- Three northern regional offices of the Ministry of Food and Agriculture (MOFA)
- Ghana Seed Inspection Division (GSID)
- Plant Protection and Regulatory Services Directorate (PPRSD)

Seed

ATT spurred improvements across the seed value chain by providing seed producers, government research agencies, and private sector seed suppliers access to innovative technologies, demonstrations and training, infrastructure development, logistics support, and private-public coordination.



A. Status at Project Inception

When the ATT project began in 2013, farmers faced several constraints in access to and use of seed in northern Ghana. Their primary source of seed for major crops, such as rice and maize, was farmer-saved seed, which they retained from previous seasons. This informal seed system accounted for about 80% of total seed supply in the region. In addition, the varieties used were old and poor quality. For example, the most dominant variety (*Obatanpa*) was over 25 years old (Tripp and Mensah-Bonsu, 2013)³; it was a long duration variety that could not withstand changes in weather conditions, particularly with delayed or short annual rains. This often resulted in poor yields and low farm incomes.

Certified seed for the target crops accounted for just 10% of the total seed market in the three northern regions (2013).⁴ A primary limitation to certified seed use was low accessibility. While seed producers and companies existed, their distribution network did not always extend to farmers in hard-to-reach communities. Seed growers were few in number, and their

production often was limited by low expertise and poor agronomy, equipment, infrastructure, and financial resources. Skilled labor for seed production was expensive and barely available.

Lack of demand forecasting and market information also made it difficult for breeders and seed companies to plan production and supply good quality seeds of desired quantities in the targeted communities. This often resulted in poor business linkages among seed growers and agro-input dealers and thus caused inadequate seed supply and distribution. The region also lacked guides or manuals documenting best practices in seed production and marketing, which contributed to the lack of professional capacity of seed producers and agro-input dealers to market seed. Most seed varieties available were from the public sector and not exclusive to any one seed company; this made companies hesitant to invest in promotion and outreach programs.

In addition, the public seed policy and regulatory system was inadequate and characterized by poor

seed processing equipment, outdated seed labs for testing, and lack of irrigation infrastructure for year-round varietal development and quality testing. The Seed Inspection Division (GSID) was understaffed, lacked the needed logistics to test and certify seed, and had no means of transport to inspect fields. Regulators, however, were reluctant to accredit private seed companies to undertake field inspections.

Furthermore, collaboration between the public and private seed sector was inadequate. No national platform existed to bring together stakeholders to plan and discuss policies. In addition, the existing seed association was weak and limited in scope and mandate.

The region needed a certified seed system in which private enterprises and public research institutions worked together to ensure improved seed and other productivity-enhancing technologies reached farmers who needed it the most.

³ Tripp, R. and A. Mensah-Bonsu. 2013. "Ghana's Commercial Seed Sector: New Incentives or Continued Complacency?"

⁴ ATT Gap Analysis confirmed Ministry of Food and Agriculture statistics for 2013-14.

B. Transformation

To address the constraints faced by the region, ATT interventions were designed to provide greater access to good quality seeds of improved varieties through better partnerships between private seed enterprises and public regulatory and research institutions, upgraded infrastructure, and last-mile seed and extension delivery.⁵

The following sections describe ATT's seed activities that address IR 1 (improving the capacity of private seed producers in developing and disseminating new technologies), IR 2 (improving the capacity of government functions to support seed and ISFM technology development, dissemination, and release), and IR 3 (improving the capacity of agricultural research to develop, release, and communicate technologies). ATT activities in seed also addressed the following sub-IRs:

- Sub-IR 1.1 – Increased capacity of Ghana's seed sector to produce high-quality certified seed
- Sub-IR 1.3 – Effective advocacy by well-organized seed and fertilizer industries
- Sub-IR 2.1 – Increased level of satisfaction of small and medium enterprises and farmers on product quality (seed, fertilizer, and ISFM technologies) and delivery
- Sub-IR 2.2 – Improved control mechanisms for seed certification and functional varietal release processes
- Sub-IR 3.1 – Increased number of seed and ISFM technologies developed and released
- Sub-IR 3.2 – Improved communication for technology dissemination capacities



⁵ For more details on results achieved, see *Monitoring and Evaluation* in the *Cross-Cutting* section.

i. Improving the Capacity of Private Seed Producers (IR 1)

When ATT began in 2013, seed growers' only options for getting their seed certified and cleaned were through government-operated processing facilities that were in disrepair. In addition, the public sector lacked the capacity to establish an effective seed distribution network. As a result, the seed distributed was often of poor quality and reached the market too late for the planting season.

ATT's interventions focused on engaging the private sector toward production of certified seeds in a timely manner and complementing public sector efforts to meet demand for good quality seeds. Currently, registered private firms are involved in seed processing in all three northern regions (Upper West, Upper East, and Northern) and marketing through major input

distributors and their trained community-based sales agents (30 in number). The agents sell seeds in small packs (1 to 2 kg/pack), the preferred size of most small farmer households. Farmers in hard-to-reach communities are able to purchase seed supplied by seed enterprises through the ATT seed van initiative (Table 1). *(For more information, see Success Story 1).*

Prior to ATT, the Seed Producers Association of Ghana (SEEDPAG) comprised only seed growers and focused just on seed production without any strategy to market the seed. Through widespread consultations with stakeholders, ATT facilitated the setup of the National Seed Trade Association of Ghana (NASTAG) to be the umbrella body of all the actors of the seed value chain. NASTAG has proven to provide a strong,

organized forum for private sector industry. ATT further helped NASTAG network with the Government of Ghana in the implementation of its "Planting for Food and Jobs" (PFJ) program. The government now recognizes NASTAG as a key player in the seed industry. ATT-sponsored/supported seed companies also are actively participating in the supply of inputs through the PFJ program.

In addition, ATT helped establish the Northern Ghana Seed Platform in 2016, which brings public and private stakeholders together to organize, mobilize, advocate, and coordinate activities to promote the growth of the seed sector across the three northern regions of Ghana. ATT built the capacity of NASTAG to organize and lead the Platform in the future.

Table 1. Quantity of Seed Distributed by ATT Seed Vans, 2018

Region	No. of Seed Van Recipients	Qty of Seeds Distributed (mt)				Total	No. of "Last-Mile" Communities Served
		Maize	Soybean	Rice	Other ^a		
Upper West Region	11	47.2	28.8	1.12	0	77.18	153
Upper East Region	6	66.6	1.15	45	5.83	118.63	76
Northern Region	5	38	14.05	3.26	8.09	63.4	81
Total	22	151.8	44.05	49.38	13.92	259.21	310

Source: ATT Field Survey, 2018.

a. Other seeds included cowpea and groundnut. Other agricultural inputs, including urea briquettes, were also distributed via seed vans.

ACHIEVEMENTS

Seed Processing

- ATT funded the installation of modern processing equipment for five private seed processors.
- Companies with improved machines are now able to process up to 40 mt of seed a day. In 2018, the processors conditioned seed for 33 other seed producers, who together sold 1,143 mt of certified seed.
- Farmers now are able to access an increased supply of certified seed in a timelier manner.

Capacity Building

- 73 seed companies received technical guidance and financial support to shift toward production of certified seed. 97 seed companies were trained in seed certification, post-harvest practices, and business management.
- 8,739 mt of certified seed were brought to market in FY18 by scaling up improved seed varieties.
- By the end of the project, private sector actors supported by ATT had incremental sales of \$7,890,606 in targeted commodities.

Public-Private Partnerships

- ATT activities were implemented through 30 local implementing partners.
- ATT helped establish the Northern Ghana Seed Platform and the National Seed Trade Association of Ghana, bringing together public and private stakeholders to strengthen the sector.
- Through private-public partnership arrangements, ATT helped establish 142 micro, small, and medium enterprises (MSMEs) in northern Ghana.

Last-Mile Delivery

- ATT provided 22 seed vans and training to private seed companies.
- In 2018, seed vans delivered 259 mt of certified seed and other inputs to 310 communities in hard-to-reach areas across northern Ghana.
- Farmers typically unable to access certified seed were supplied enough to plant 16,870 acres of maize, 12,345 acres of rice, and 2,450 acres of soybean.

Success Story I. ATT Reaches the Unreached Through Seed Distribution Vans

Most smallholder farmers in northern Ghana lack access to high-quality certified seed. They often use seed that they save from one season to the next. With saved seeds, these farmers barely produce enough to feed their household year-round. To ensure that certified seeds get to farmers located far from market points, ATT designed an initiative that delivers inputs to farmers and builds business for seed enterprises. Through ATT's small grant support program, 22 vans were provided to seed producers that travel to hard-to-reach communities – at the last mile. Vans were provided on a 70:30 cost-sharing basis.

The vans are motorized tricycles (also known as “Motor King”) modified to transport seeds, particularly to remote areas, during the planting season. The vans also supply other agricultural inputs. Using the vans, seed producers distributed 260 mt of certified maize, rice, and soybean seeds to farmers across northern Ghana in 2018. The vans are branded to promote the seed producers' businesses and equipped with loudspeakers that play jingles and advertise the certified seeds in local languages.

“Because the vans were properly branded, our visibility has increased,” said Seidu Mubarak, Deputy Managing Director of Antika Company Limited, an ATT-supported seed company. “The vans came as a blessing to us.” After Antika's participation in the seed van initiative, the business distributed certified maize and rice seed to the government's Planting for Food and Jobs program in 2017 and 2018. The company's production increased from 150 mt to 600 mt a year.

“We reached more farmers with certified seeds in 2017 and 2018 than any other period, thanks to the ATT Seed Van Initiative,” said Mashood Dori, Managing Director of Dori Farms. “Our business is now recognized at the community level,” he added. Dori says the seed value chain is growing stronger, with seed production, cleaning, conditioning, and testing services becoming available in all three northern regions.



ii. Improving the Capacity of Public Regulatory and Research Services (IRs 2 and 3)

In addition to improving seed production facilities, ATT also supported public regulatory services to create a more efficient and transparent seed certification system. ATT assisted GSID, the regulatory body of the Ministry of Food and Agriculture, with logistics solutions needed to test and certify seed. ATT provided GSID with motor bikes, GPS devices, tablets, and inspector training to improve field-level monitoring and technical support to seed producers. The project also installed intranet facilities and equipped GSID units to enable better communication among the unit staff.

In order to enhance seed quality assurance practices to meet international standards, ATT facilitated the establishment of three state-of-the-art seed labs (one per region) equipped with modern equipment. Staff were trained by the Seed Science Center of Iowa State University. Tests that previously took months to complete, are now completed in days. (*See Success Story 2 for more information*).

ATT also strengthened the research capacity of the Savanna Agricultural Research Institute (SARI), an institute mandated to provide agricultural technologies to farmers in northern Ghana. Prior to ATT, SARI's breeding efforts were subject to the rainfed production limitations similar to crop producers in the region.

In a major effort, ATT rehabilitated a 10-hectare irrigation scheme at the Wambong Dam. This has provided SARI stable and much-required irrigation to conduct year-round production of early generation seeds – breeder and foundation

seeds of major crops. As a result, SARI accelerated the development and release of new crop varieties, with three hybrid maize varieties released in 2017. Currently, foundation seed of the new varieties is under production by private sector growers, and licensing agreements are being discussed. The agreements would allow for SARI breeders to reap royalties for their research, incentivizing them to continue innovating.

Previously, the breeding program of the Crops Research Institute (CRI), SARI's sister institution, lost 45% of its germplasm due to poor cold room storage conditions. Through an ATT grant, the breeder and foundation seed imported or developed by SARI can now also be stored almost indefinitely at CRI's newly refurbished seed cold storage facility.



Dr. Stella Ama Ennin, CRI Director (right), and Jenna Tajchman, USAID/Ghana Agriculture Team Leader, unveil a plaque commemorating the new CRI seed cold storage facility.

ACHIEVEMENTS

Regulatory Services Support

- ATT helped establish three modern seed labs to increase the efficiency and accuracy of the seed certification process.
- GSID staff received motor bikes, GPS devices, tablets, and training to enable in-field seed inspections.

Research / Infrastructure Support

- Wambong Dam was rehabilitated to ensure SARI's ability to conduct year-round research.
- With ATT support, SARI released three hybrid maize varieties in 2017.
- CRI's cold storage facility was refurbished to reduce loss of germplasm due to poor storage conditions.

Public-Private Partnerships

- ATT supported the development of the government's National Seed Plan.

Success Story 2. New Seed Labs Get High-Quality Seed in Farmers' Hands

Processing and testing seeds used to be a time-consuming process (up to three months) for staff at the Tamale Seed Laboratory in Ghana. With new facilities and technology enabled through ATT interventions, the laboratory personnel can conduct the tests much more efficiently and accurately.

Delays in seed analysis due to obsolete equipment affected the seed certification process, which in turn affected the early release and supply of certified seeds to farmers at the right time. Most smallholder farmers say they prefer to sow on time with their saved seeds and get low yields rather than wait for certified seeds, which are more expensive and often come late, causing farmers to miss out on the proper planting season.

Scientists at the GSID Tamale Seed Lab received modern buildings and equipment funded by USAID through the ATT project. The new facilities and lab technology help them run specialized tests on seeds, getting quality seeds to farmers faster.

Mr. Christopher Akia, head of the GSID Tamale Lab, explained that the unit had obsolete seed testing equipment installed in the 1970s during the establishment of the laboratory. “At the old laboratory, we had only one functional non-calibrated seed moisture meter,” Akia said. “The seed germinators were out of use, and we did not have an enabling environment to conduct crucial tests with regard to purity and moisture and get reliable test results.”

This often resulted in loss of germination quality, so the seed could no longer meet minimum germination qualifications.

“Now, with ATT-sponsored labs, a large number of seed samples can be tested at once,” Akia said. “We have a modern purity board and a magnifying microscope that enhances the speed and accuracy of purity test results. We’ve reduced time spent monitoring the germination process since the germinators work accurately. With the walk-in seed germinator now in use, the number of germination tests have doubled and the length of time it takes to complete a round of germination tests has been reduced.”

The Tamale Seed Laboratory is not the only location to receive a new facility: Wa and Bolgatanga in the Upper West and Upper East regions also received the same facility. Now, more Ghanaian farmers are getting quality seed at faster speeds and for a better value.



From top to bottom: Groundbreaking on the new seed lab in Tamale; ribbon-cutting ceremony with former U.S. Ambassador to Ghana, Robert Jackson, and former Deputy Minister for Food and Agriculture in Charge of Crops Dr. Alhassan Yakubu; completed seed lab in Tamale.

iii. Improving Development and Dissemination of Targeted Research (IR 3)

Outreach and communication – critical components of technology transfer – lie at the heart of well-functioning research systems. Before ATT, climate-resilient varieties recently released by SARI for maize and soybean were not widely known or introduced to seed producers, dealers, or farmers. To ensure that research actually benefits farmers, ATT helped SARI improve the way it functions. This included helping the institution create better systems for gathering information from the field, develop solutions that address farmers’ problems, and communicate those solutions to farmers. With rehabilitation of the Wambong Dam and a better system for communicating research in place, SARI is better positioned to provide and promote agricultural solutions for farmers in northern Ghana.

Through its 30 local implementing partners (LIPs), ATT facilitated field demonstrations, learning centers, and video screenings to create demand for certified seed and disseminate technologies to farmers. Good agricultural practices and technologies demonstrated included: intercropping maize and pigeon peas; rotation cropping maize and soybeans; newly released soybean, rice, and maize varieties; local and imported hybrid maize seed; line transplanting; and urea deep placement (UDP) on rice. Also, the project demonstrated mechanized equipment, such as the direct paddy seeder, bicycle maize sheller, and multi-crop planters. The LIPs served as links between farmers and private sector businesses and also conduits for sources of the certified seed. (For more details on

field demonstrations and video screening, see sections on Soil and ICT.)

Certified seed was also promoted through “starter packs” given to farmers at technology fairs. The packs included certified seed, fertilizers, soil amendments, supplies, and crop production fact sheets. (For more details on the starter packs, see *Success Story 3* in section on Soil.)

As a result of ATT efforts to promote improved certified seed and agricultural technologies, farmer demand for certified maize seed increased

from 11% in 2013 to 38% in 2018 within the zone of influence (ATT Gap Analysis, 2018).

As indicated in the earlier sections, the most common variety planted by farmers was *Obatanpa*, largely due to re-use of farmer-saved seed and continued production and sale of these age-old varieties by firms. In 2015, *Obatanpa* accounted for 69% of the total area covered with certified seed, followed by a few less popular varieties, such as *Wang-Dataa* and *Sanzal-Sima*, which are drought-tolerant and early-maturing and accounted for 9% and 1% of area covered, respectively (Figure 3). At its inception, ATT

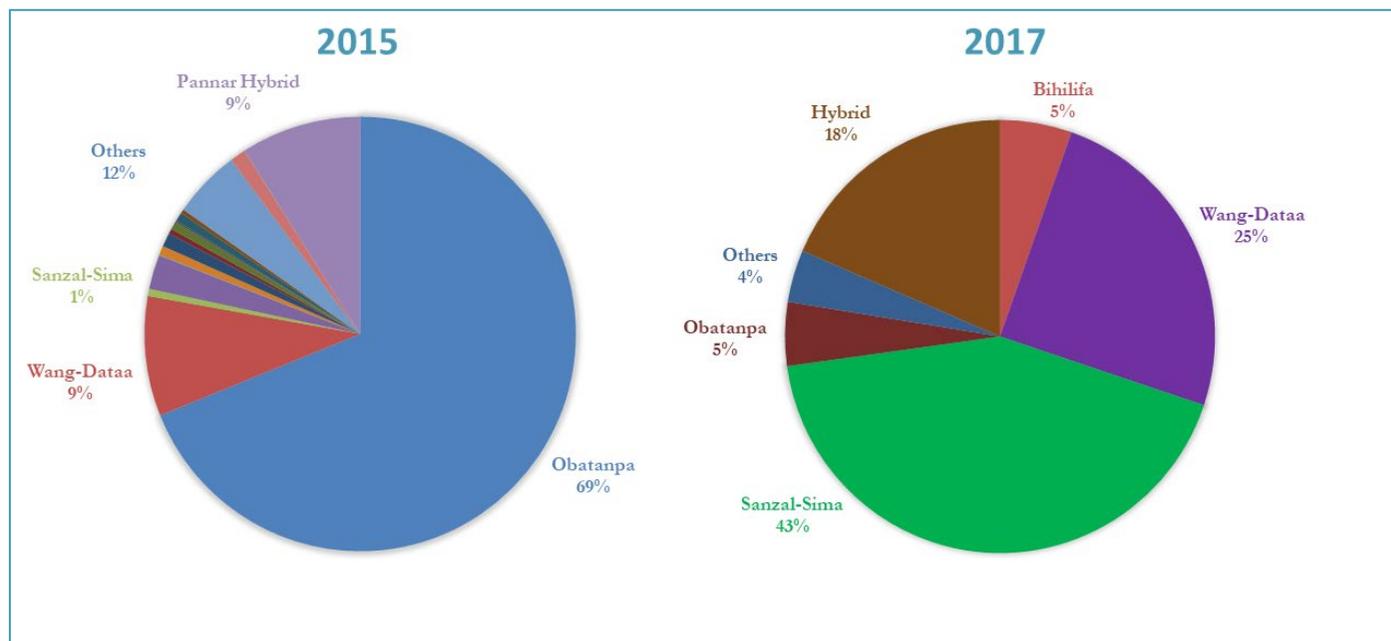


Figure 3. Commonly used maize varieties in three northern regions of Ghana.

started bulking up breeder and foundation seeds of *Wang-Dataa* and *Sanzal-Sima* through partnerships with research and seed companies. Following the seed bulking, extensive promotion for effective technology transfer toward promoting new varieties was initiated in 2016. In addition, from 2017 onward, aggressive delivery mechanisms were designed to provide the benefits of certified seeds to last-mile customers. This resulted in a significant increase in the use of certified seeds of *Sanzal-Sima* by about 43% and *Wang-Dataa* by 25% acreage. Area covered under *Obatanpa* was reduced significantly, with its use

decreasing from 69% in 2015 to just 5% in 2017. The results provide support to the fact that farmers are willing to use new and improved varieties if they are made available and accessible at the right time and place and generate profitable incomes.

After ATT's interventions, infrastructure is in place to improve the availability of high-quality certified seed for farmers. The ATT project interventions were thus able to achieve i) increased supply of quality seeds, with participation of the private sector; ii) improved

seed supply to smallholders, in particular those living at the last mile, through better delivery mechanisms; and iii) supported and improved public research, through provision of infrastructure in terms of upgrading seed certification procedures through better seed quality labs, equipment, and irrigation facilities.

The activities implemented aligned well with the seed security agenda of the Ministry of Food and Agriculture.

ACHIEVEMENTS

Outreach

- ATT published crop variety guides and a manual documenting best practices in seed production – publications that previously did not exist in northern Ghana.
- ATT helped establish a communications unit at SARI.

Technology Transfer

- Through videos and demonstrations led by the LIPS, ATT reached about 42,000 with information on the benefits of certified seed and GAPs.
- Farmer demand for certified maize seed rose from 11% in 2013 to 38% in 2018.



Soil

ATT identified the best soil fertility management technologies available for maize, rice, and soybean and disseminated the technologies and practices among project beneficiaries using approaches that reached the last mile.

Soil scientists and staff of ATT, SARI, and Green-Ef participate in a training program on soil sampling, analysis, and fertilizer recommendations, 2018.

A. Status at Project Inception

Poor crop production practices, misuse of agrochemicals, and burning of crop residues have left soils in northern Ghana deficient in many essential plant nutrients and organic matter. In essence, the soils are being “mined” of nutrients, leading to progressively declining productivity.

Farmers in northern Ghana use very little,⁶ if any, fertilizer to replenish lost soil nutrients. In addition, the fertilizer rates used are from soil fertility tests conducted in the 1970s. Most of the fertilizers recommended for various crops in sub-Saharan Africa, particularly Ghana, are outdated because of their blanket pan-territorial application, which fails to account for the

dynamics of soil fertility and the related productivity constraints. For example, in maize the recommendation for the entire country was two (50-kg) bags of NPK fertilizer (irrespective of the nutrient content) for one acre to be applied about two weeks after planting and one bag of urea or ammonium sulfate (despite the differences in N content between urea and ammonium sulfate) to be applied six weeks after planting, despite varying agro-ecological zones. Use of inappropriate fertilizer products relative to crop and soil needs results in low profitability, and low crop response; thus, there have been few incentives for farmers to use fertilizers.

To restore soil health and increase yields and income, producers in northern Ghana needed capacity building in good agricultural practices, which include planting techniques, such as line planting (or transplanting in the case of rice) crop production and using the appropriate isolation distance for different varieties and classes of seed production; adopting fertilizer application and management technologies, such as urea deep placement (UDP) and integrated soil fertility management (ISFM) practices; proper weed and pest control; and the use of farm mechanization for better land preparation and drainage.

B. Transformation

To address soil fertility constraints in northern Ghana, ATT interventions were designed to identify the best soil fertility management technologies available for maize, rice, and soybean and to scale them for maximum impact among project beneficiaries. The specific interventions designed to address the soil health and fertility issues are addressed under the

following IRs and sub-IRs and the activities associated:

- IR 1 – Improving the capacity of the private sector in developing and dissemination new technologies
- Sub-IR 1.4 – Increased dissemination of ISFM technology

- IR 3 – Improving the capacity of agricultural research to develop, release, and communicate technologies
- Sub-IR 3.1 – Increased number of seed and ISFM technologies developed and released

⁶ Fertilizer use was 20.9 kg/ha in 2016, according to the World Bank (World Development Indicators, 2016).

i. Increasing the Number of ISFM Technologies Developed (Sub-IR 3.1) and Disseminated (Sub-IR 1.4)

When selecting a technology for transfer, ATT first identified technologies that had proven successful in similar agro-ecologies and social environments elsewhere. ATT then moved these technologies to locations where adaptive trials are conducted to ensure they are indeed appropriate for the climatic and socio-cultural context (Figure 4). ATT conducted over 80 adaptive trials designed to scientifically confirm a range of theoretically beneficial varietal, fertilizer, soil amendment, and conservation agriculture practices across northern Ghana. Results were

used to generate evidence-based technical packages that ATT disseminated to farmers.

To improve soil health and thus farmers' productivity and incomes in northern Ghana, ATT combined its promotion of certified seed use with intensive messaging through awareness campaigns and demonstration of ISFM technologies (*see box*) and their benefits. ISFM strategies center on the combined use of mineral fertilizers and locally available soil amendments and organic matter to condition the soils and in some cases, to replenish soil nutrients.

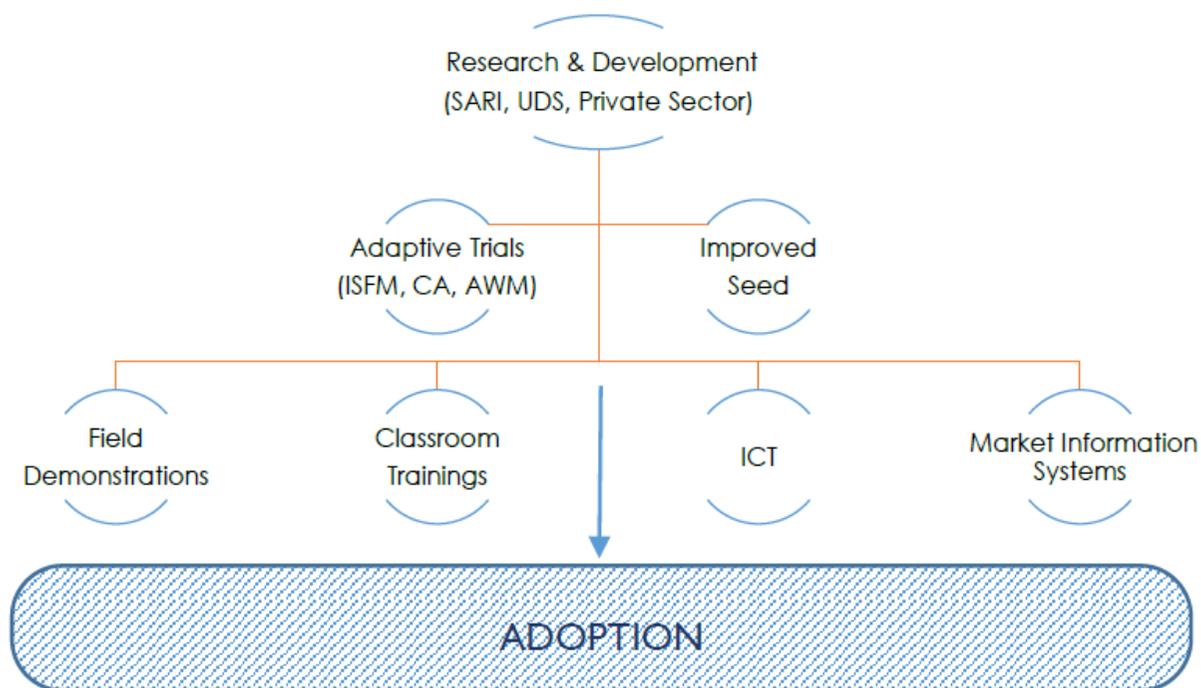


Figure 4. ATT Process for Technology Development and Transfer

ISFM Technologies Promoted by ATT

- Urea deep placement in lowland rice and upland maize production
- Use of rhizobial inoculation and phosphate fertilizers in soybean production systems
- Use of soil amendments, such as lime, for amelioration of acidic soils
- Conservation agriculture practices, such as minimum or no-till farming, cover cropping, use of crop residues, mixed cropping, and crop rotation
- Proper seed spacing and planting (or transplanting in the case of rice)
- Fertilizer blends (including secondary and micronutrient fertilizers) that meet specific crop and soil nutrient needs to achieve balanced fertilization
- Innovative composting techniques of crop residues and animals waste to improve soil organic matter status and improve soil health
- Soil sampling and analysis to aid crop- and site-specific fertilizer use
- Agricultural water management methods, such as PAVE and Bhungroo systems
- Use of labor-saving equipment, such as multi-crop threshers and direct paddy seeders

The dissemination mechanisms adopted by ATT interventions to create sustained demand for improved seed and ISFM technologies combined with GAPs include:

Mini-Demonstrations: 10 x 10 meter (100 m²) plots established on farmers' own fields. This allowed the beneficiary farmers to participate in hands-on testing of the new technologies and be convinced of the benefits.

Learning Centers: 1 acre plots for demonstrating a technology compared to farmers' traditional practices. The plots are established by farmers with oversight from ATT and in collaboration with LIPs. The learning centers often served as sites for hands-on training on soil and fertilizer management technologies, including GAPS, and certified seed production.

Field Days: Events held at learning centers to give farmers the opportunity to observe the benefits of a technology or GAPs at various stages of production and fertilizer application techniques (e.g., application of urea briquettes). The "green" field days allowed farmers to observe plant growth at the end of the vegetative phase, and "brown" field days showcased the crop just at harvest for farmers to observe differences in crop yields between the ones resulting from the improved technology and that of their own practices.



Field Day at Baleo-Filli Irrigation Scheme

Video Screening/Digital Classroom: Films primarily shown by LIPs to reach more farmers at the community level with information on ATT-promoted technologies (*for more information, see section on ICT*).

Technology Fairs: Events organized by LIPs to distribute "starter packs" and train farmers in their use. Agro-dealers, seed producers, and agro-equipment suppliers participated in the fairs to promote their products and services.

Starter Packs: Small packages containing improved input technologies (certified seed, fertilizers, and soil amendments), supplies (planting rope, gloves, and dust mask), and crop production fact sheets. The packs were branded by private sector agro-input suppliers and given to farmers at ATT-organized technology fairs. This allowed farmers to establish mini-demonstrations on their own farms (10 x 10 m plot for rice and soybean and 20 x 20 m for maize). (*See Success Story 3 for more information on starter packs.*)

Success Story 3. ATT “Starter Packs” Reach Risk-Averse Farmers

Starter packs were a new technology dissemination approach targeting late-adopter, risk-averse farmers. ATT collaborated with Catholic Relief Services (CRS) and 30 LIPs to distribute the packaged technologies at technology fairs, video screenings, and through seed vans. The ATT ISFM team trained CRS staff, 30 government agriculture extension agents, and 30 LIPs on ISFM technologies and practices and the strategy behind starter packs as a tool for catalyzing adoption.

Technology fairs gave starter pack recipients the opportunity to network with Ministry of Food and Agriculture (MOFA) representatives, local government officials, produce aggregators, local seed dealers, tractor service providers, and other farmers. They were able to link with private sector actors for follow-on purchases. A total of 19,000 starter packs (12,183 for maize, 2,345 for rice, and 4,552 for soybean) were distributed during the entire duration of the project.

In 2018, the University for Development Studies in Ghana conducted an assessment to determine uptake of the improved technologies as a result of the starter pack approach (Annex 3). A total of 1,009 farmers (744 beneficiary and 265 non-beneficiary) were interviewed. The study found that the starter packs increased the level of awareness of certified seed varieties and UDP for farmers who would likely not have known about the technology otherwise. The uptake of the technologies was greater if starter pack dissemination was preceded by technology fairs. In addition, LIP and private sector involvement in starter pack dissemination gave farmers another source of extension delivery.



Women farmers celebrating their achievements and awards, including ATT-sponsored starter packs and Green-Ef inoculant and soil testing coupons, at the 5th Annual MEDA GROW Fair



Contents of the soybean starter pack included 500 g lime, 1 kg certified seeds, 1.4 kg TSP fertilizer, a planting line, glove, dust mask, and coupons for inoculant and soil testing services.

ATT also established learning centers in irrigation schemes in each of the three northern regions (Sankana, Daffiama, Guo, and Baleo-Filli in Upper West Region, Tono and Vea in Upper East Region, and Bontanga, Golinga, and Libga in Northern Region) to introduce and scale up use of certified seed and ISFM technology, particularly the UDP technology.

The UDP technology involves the placement of urea briquettes (1-3 g) deep into the soil so that the nitrogen is absorbed more effectively.⁷ ATT farmer participatory trials indicated the technology significantly increases farmer yields and profits, with less nutrient losses than the traditional practice of broadcasting fertilizer.

As early as 2015, rice farmers using the UDP technology at Bontanga Irrigation Scheme realized higher yields and incomes (Table 2). By 2018, farmers in the Northern Region were receiving enormous increases in their gross margins (Table 3). The technology was tested extensively and adapted to local conditions. According to a study (Azumah et al., 2017)⁸ analyzing the effects of UDP among farmers operating in the Golinga and Bontanga irrigation schemes, farmers who adopted the technology had higher rice output (about 21.5%) than non-adopters. UDP was successful, in part, because it was introduced as part of an integrated package that included GAPs and improved seeds.

Table 2. Yield and Economic Returns for Rice Farmers at Bontanga Irrigation Scheme, 2015 Dry Season

Application	Yield (mt/ha)	Gross Margin (GHS/ha)	Gross Margin/Cost Ratio
<i>Farmer Practice</i>	2.48	2,667.60	2.03
UDP	8.52	6,182.50	2.64

Source: ATT Crop Cut Survey, 2015.

Table 3. Gross Margin Analyses for Rice Production at Irrigation Schemes in the Northern Region, 2018

	Golinga		Bontanga		Libga	
	Farmer	UDP	Farmer	UDP	Farmer	UDP
<i>Total Cost of Production/ Acre (GHS)</i>	742	1,445	960	1,623	1,115	1,310
<i>Yield (100-kg bag)</i>	9	30	12	30	15	27
<i>Total Revenue (GHS 100/ bag)</i>	900	3,000	1,200	3,000	1,500	2,700
<i>Gross Margin/ Acre (GHS)</i>	158	1,555	240	1,377	385	1,390
<i>Percentage Increase in Gross Margin from Farmer Practice to UDP Technology</i>	884%		473%		261%	

Source: ATT Gross Margin Analysis (2018).

⁷ Working with farmers (particularly in Bangladesh) for over 25 years, IFDC developed the UDP technology as an innovative alternative to the traditional method of broadcasting fertilizer across a field or paddy. When used to fertilize irrigated rice, urea briquettes are inserted at a depth of 7-10 centimeters between every four rice plants seven days after transplanting. More than 2 million farmers in Bangladesh are experiencing increased production and income using the technology. Results are being replicated in several countries in sub-Saharan Africa and with crops other than rice.

⁸ Shaibu Baanni Azumah, Ignatius Tindjina, Stella Obanyi, Tara N. Wood. 2017. *Productivity Effect of Urea Deep Placement Technology: An Empirical Analysis from Irrigation Rice Farmers in the Northern Region of Ghana.*

Use of UDP resulted in several benefits. At the farm level, increased yields were realized; in addition, UDP created profitable business opportunities through urea briquetting production for local entrepreneurs in rural communities (*see Success Story 4*). Urea briquettes are currently produced by four private companies and two farmer groups with small-scale briquetting machines (imported from Bangladesh) in the three northern regions through the support of ATT grants.

The technology has also boosted rural employment. The ATT project trained and supported women groups in the Tono and Vea irrigation schemes in row rice transplanting and UDP application as an income-generating venture. The women in these groups now earn incomes of up to GHS 17 (U.S. \$3.54) per day through transplantation and fertilizer briquette application services, according to a 2017 ATT field report on transplanting gangs. (*For more information, see Success Story 10 in Gender section.*)

However, it has been evident that UDP application is labor-intensive and calls for more mechanization solutions to further expand the technology.

ACHIEVEMENTS

Technology Dissemination

- 19,000 producers received starter packs containing the supplies and instructions to create their own mini-demonstrations
- 33 learning centers were established showcasing various ISFM methods for maize, rice, and soybean.
- Over 201,000 farmers applied one or more improved technologies or management practices on 165,260 ha.

Capacity Building

- 99,821 women were trained in GAPs and ISFM.
- 177,105 people were trained in improved agricultural technologies related to seed production, post-harvest management, certification, climate-smart agriculture, conservation agriculture, ISFM, and farm business management, among others.

Success Story 4. UDP Technology Creates Opportunities for Local Entrepreneurs



Prince Yao Koreh is realizing the potential offered by sale of urea briquettes for UDP technology. The fertilizer application technology was introduced to farmers in the Tono irrigation scheme in the Upper East Region in 2014. Now, 59-year-old Koreh, owner of Simple Prince Agro-Input Company, is a successful entrepreneur and owes much of his achievement to the sale of urea briquettes.

The success of UDP demonstration plots organized by ATT created demand for urea briquettes. This began the collaboration between the ATT project, Simple Prince, and Koreh's distributors to produce and market urea briquettes to farmers in the Tono and Veia irrigation schemes.

After a series of trainings in Ghana and Burkina Faso (through ATT sponsorship), Koreh became more knowledgeable about the nature and the benefits of the technology. At the time, he was the only input dealer in the region using a urea briquetting machine bought by ATT to produce briquettes for rice farmers.

Koreh attributes much of his business's growth to a successful marketing campaign and a delivery system.

“To facilitate the upscaling of the technology and the use of the urea briquettes, in subsequent years I created new sales points at the various irrigation facilities and also started a massive radio and on-farm campaign to advertise the fertilizer,” said Koreh. “As part of our marketing strategy, we have fabricated a carrier for transporting the urea briquetting machine to the farmers' required locations for bulk briquetting. We are also providing a transport service to convey briquettes from the urea briquette production site to farmers' rice fields as well as offering a briquette application process printed on polo-style shirts for farmers.

Koreh remarked that the sale of the briquettes was not very profitable in the first year of introduction (2015), as he was able to sell only about 75 percent of the briquettes he produced. “However, the situation in the subsequent season improved, and as a result I produced and marketed a total of 10.6 metric tons of urea briquettes to rice farmers in the Tono and Veia irrigation schemes. In addition, I am using ATT-supplied vans to sell certified seeds and other agro-inputs in the hard-to-reach communities,” noted Koreh.

The support from ATT has not only helped him to grow his business, but he has gained recognition, even at the national level. As a result, the regional office of the Ghana Ministry of Food and Agriculture has made him a resource person on agro-inputs, and Prince's business is doing well.

ii. Improving the Capacity of the Private Sector (IR 1) and Agricultural Research (IR 3) in Developing and Disseminating ISFM Technologies

Most smallholder farmers in northern Ghana apply fertilizers that do not meet the nutrient needs of their specific crops and soils, which often leads to problems related to unbalanced fertilization. To encourage appropriate fertilizer use, ATT promoted *soil sampling and analysis* as a basic first step in farming. However, only public

institutions provided such soil sampling services, often with high fees and considerable delays. To address this, the project introduced soil testing services in the region through an emerging private sector soil lab, *Green-Ef*. Through ATT intervention, the lab is now fully equipped and upgraded to carry out soil tests and make tailored

fertilizer recommendations for farmers in the region.

While demand for soil testing from farm households is improving, the fertilizer sector in Ghana does not currently have the capacity to provide tailored products for smallholder farmers' needs. To help get balanced fertilizer into farmers' hands, ATT collected over 15,000 geo-referenced soil samples in the three northern regions to develop soil fertility maps (Figure 5) to aid in developing site- and crop-specific fertilizer recommendations, which were based on maps over 40 years old.

To encourage private sector fertilizer importers and blenders to deliver fertilizer products based on the crops' needs to farmers, ATT held the Northern Ghana Soils and Fertilizer Forum on "The State of Soil Fertility in Northern Ghana, Fertilizer Recommendations, Utilization and Farm-level Access" during April 11-12, 2018, in Accra. The event brought together about 70 delegates representing agricultural producer organizations, public policymakers, private sector input providers, and other stakeholders to discuss the latest scientific information on the state of soils in the region. Participants expressed their hope that the recommendations made would be transformed into implementable action plans to improve and preserve soil fertility and sustain long-term crop productivity through strengthened

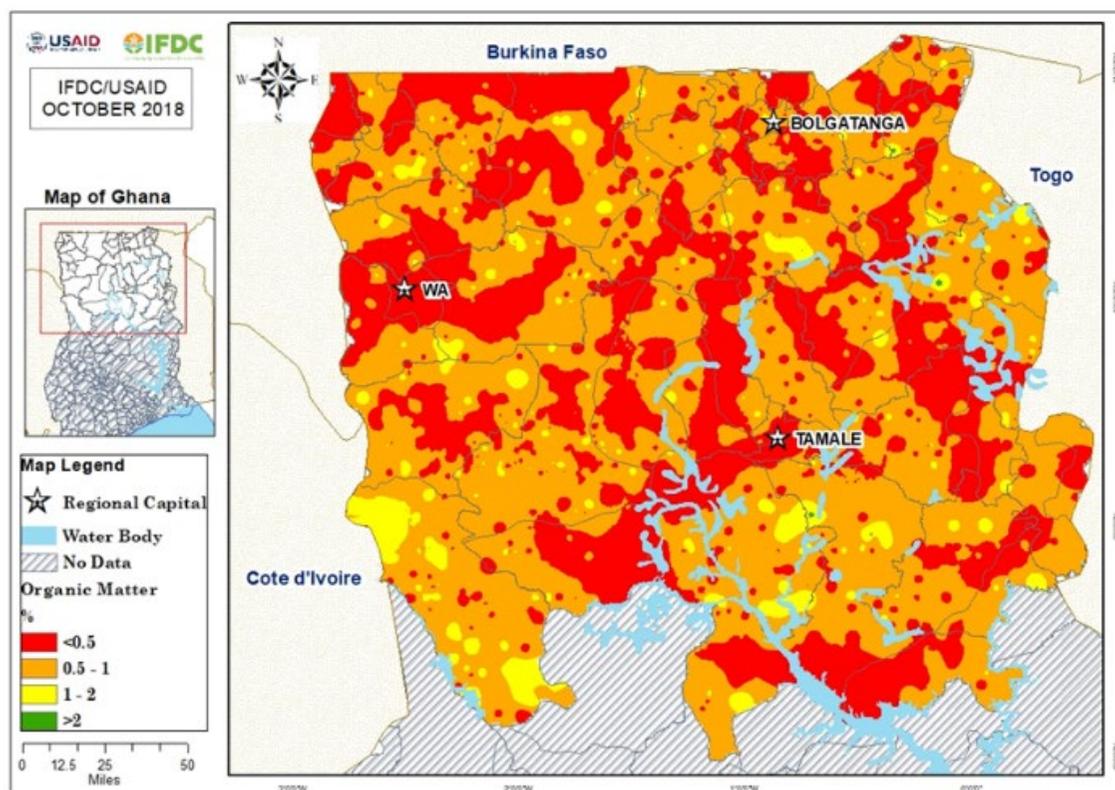


Figure 5. Spatial Distribution of Soil Organic Matter Content in Northern Ghana

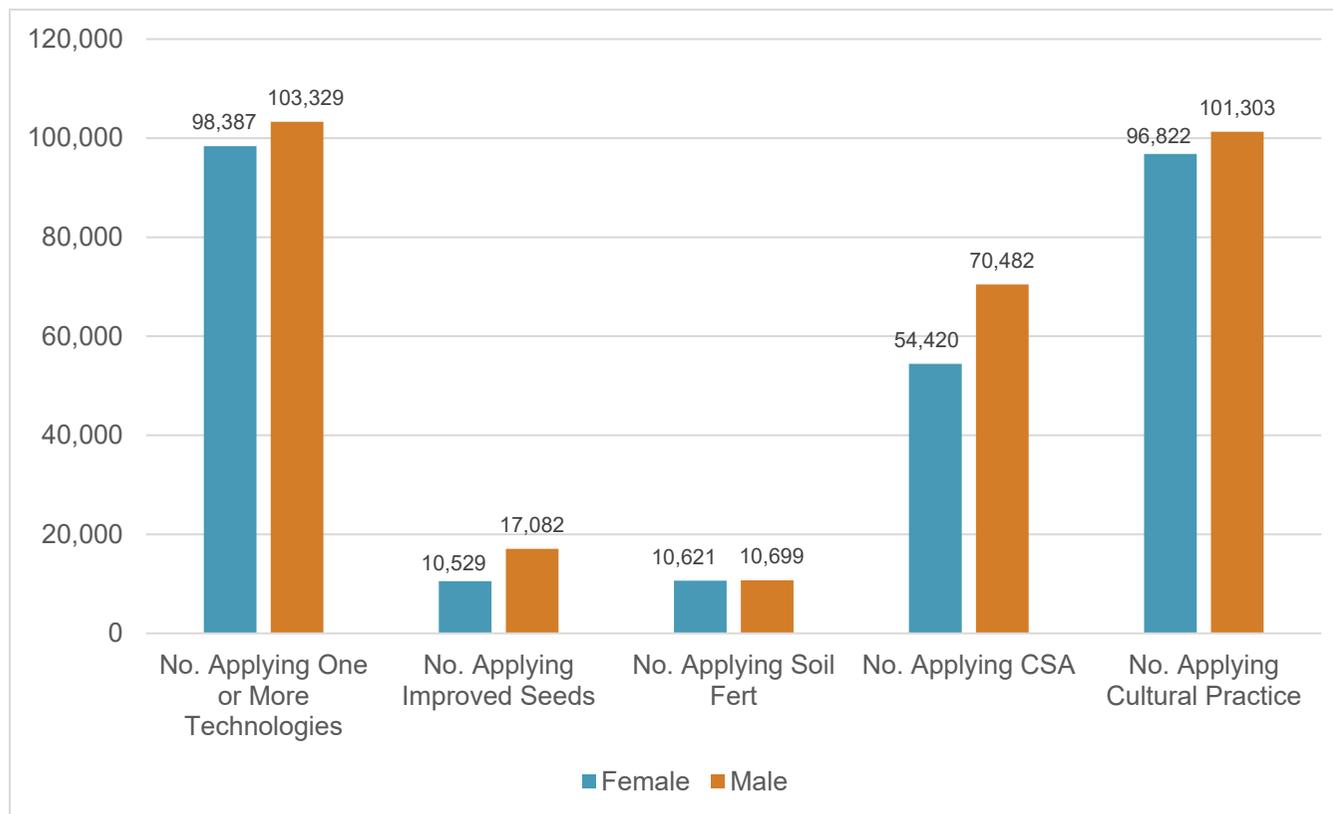
partnerships that will drive the Green Revolution agenda.

Outcomes of ATT Soil Health Initiatives

Recognizing that a more competitive seed sector in northern Ghana cannot be attained without also integrating practices that improve soil, ATT capacity building efforts focused on a package of

ISFM practices, including the UDP technology for rice and upland maize, use of rhizobial inoculation and phosphate fertilizer for soybean production, conservation agriculture practices, etc. As a result, more than 200,000 farmers used one or more improved technologies or management practices (Figure 6) over the life of the project. Almost half of these farmers are women.

Use of these technologies and practices paid off. According to ATT's 2018 Crop Cut Survey, ATT rice producers averaged 5.16 mt/ha – 287% higher than those using traditional rice farming practices. ATT maize producers obtained 3.88 mt/ha (228% higher), and ATT soybean producers averaged 2.66 mt/ha (266% higher) in 2018.



Source: ATT M&E team.

Figure 6. People Applying Improved Technology or Management Practices, by Type and Gender, FY2018

Water

Through the promotion of water-harvesting technologies, ATT facilitated agricultural production of high-value crops during the dry season – Double Cropping, Dual Income.

A young woman in the Zhiang community of the Northern Region harvests okra grown using PAVE technology, which enables irrigation for dry season farming (2017).



A. Status at Project Inception

Smallholder farmers in northern Ghana mainly cultivate cereal crops, such as maize, millet, and soy, on an average of just 1.3 ha of farmland, according to the APSP 2013-2014 Agricultural Production Survey.⁹ This limits producers' earning potential. In addition, the region's climate allows for only one farming season. During the rainy season, parts of northern Ghana suffer

from flash floods that cause extensive damage to crops, but in the dry season, water available for farming is scarce and the once-waterlogged land becomes too dry for farming. The situation is compounded by farmers' limited access to irrigation schemes. Under these conditions, farmers are unable to rise above the poverty line and provide their families with nutritious foods.

To conserve water and improve household income and nutrition, farmers in northern Ghana needed water management interventions that enabled production of vegetable crops during the dry season.

B. Transformation

To address seasonal flooding and drought conditions, ATT funded pilot activities exploring the potential of water-harvesting technologies that facilitate dry-season agricultural production. By enabling two cropping seasons per year, these methods provide an opportunity for farmers in flood-prone areas to earn more income and improve their livelihoods. ATT interventions

were designed to address challenges toward improving water use and availability through activities associated with the following IRs and sub-IRs:¹⁰

- Sub-IR 1.4 – Increased dissemination of ISFM technology

- IR 3 – Improving the capacity of agricultural research to develop, release, and communicate technologies
- Sub-IR 3.1 – Increased number of seed and ISFM technologies developed and released

⁹ Agricultural Policy Support Project (APSP). 2014. *Agricultural Production Survey for Northern Regions of Ghana 2013-2014*.

¹⁰ Since water-related interventions are integrated into improving the overall farming context, the results from improving water use and availability were one of the outcomes of improved adoption of soil and fertility management practices, along with use of improved GAPs. Therefore, water management activities are associated with IRs and sub-IRs related to ISFM technologies.

i. Double Cropping, Dual Income (Sub-IRs 1.4 and 3.1)

A single season of cereal-based farming will not bring farmers out of poverty, especially smallholder farmers living in marginal environments. ATT recognized that for farmers in northern Ghana to increase their household income and move above the poverty line, high-value crops must be added into their system. The concept of Double Cropping, Dual Income has been proven effective in improving farm incomes in the ATT intervention area through the introduction of a high-value second crop (e.g., chili pepper) into the existing cereal-based cropping system (e.g., hybrid or improved maize variety).

In an ATT study on moving farmers in northern Ghana out of poverty, ATT compared the income generated from four different types of cropping systems in ATT intervention areas (Figure 7). It was demonstrated that a small farm household can improve or double farm income opportunities by improving the cropping intensity of the farming system through the production of high-value crops along with cereal crops. The Double Cropping, Dual Income approach can result in improved cropping intensities, incomes, and value-added land productivity. In the study, farm income increased from about \$1 to \$9.70 when the farmers' second crop was a high-value

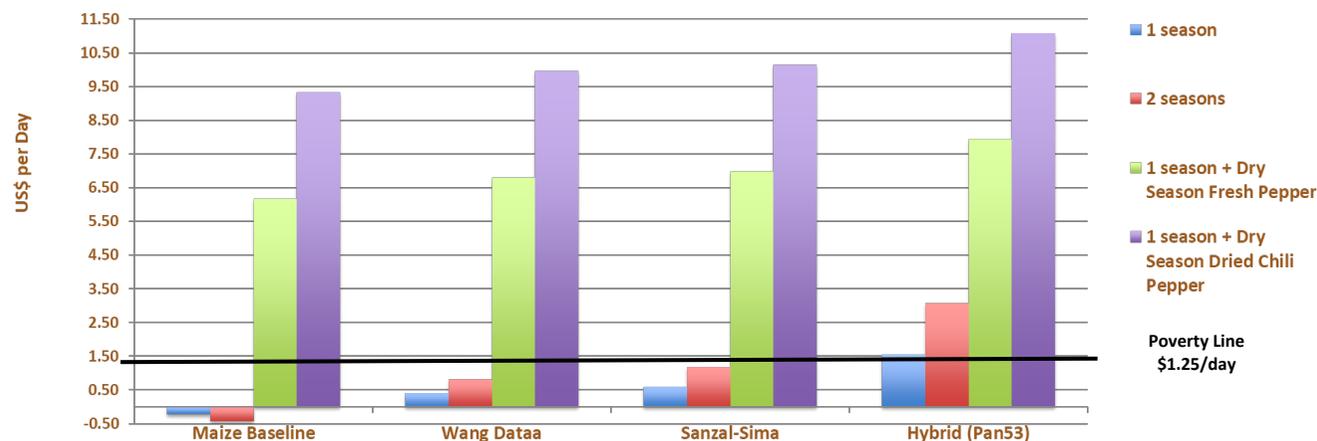
crop. The project therefore concluded that to bring farmers out of poverty in northern Ghana, they must have a double cropping season and the second crop must be a high-value cash crop.

To help farmers increase their income through second-season production, ATT, in partnership with the Conservation Alliance and International Water Management Institute (IWMI), trialed and introduced *Bhungroo*¹¹ and *PAVE*¹² irrigation technologies in northern Ghana. As with all of ATT's transferred technologies, the water-harvesting methods were selected based on their potential to be environmentally friendly and socioeconomically appropriate.

Both technologies act as “artificial aquifers” that capture and store excess floodwater during the rainy season for use during the dry season (Figure 8). This creates an additional opportunity for the cereal farmers with a second cropping season for the production of a high-value vegetable crop.

Through eight PAVE and three Bhungroo demonstration sites that were managed under different business models, ATT and partners proved the technical viability of Bhungroo and PAVE for capturing and sequestering floodwater for extraction and use during the dry season. In just two short seasons, the water-harvesting innovations individually supplied over 2.3 million liters of water per site (2.5 ha) (Conservation Alliance Progress Report, 2018). The water can

Comparing Daily Income Generated From Different Maize Varieties on 1 Hectare per Year by Cropping Once, Twice or Once with Pepper as a Second (Dry Season) Crop



Source: ATT Study, 2015.

Figure 7. Daily Income of Maize Varieties During One and Two Seasons and Combined with Dry Season Crops

¹¹ Bhungroo is a floodwater harvesting and storage system developed and used in parts of India. The Bhungroo technology uses a borehole to infiltrate and recover water.

¹² PAVE technology was developed by Conservation Alliance to store water during the rainy season and pump it out for irrigation during the dry season.

be stored in the soil for up to 180 days and can provide farmers with at least six months of irrigation. With agricultural water management interventions, dry season vegetable irrigation can contribute positive gross margins between \$1,500 and \$4,200 per ha per season. According to a 2018 technical brief by Conservation Alliance, 550 farmers in the Zhiang community in the Northern Region who sold vegetables during the dry season increased their income by about 35%.

The introduction of the water harvesting technology, particularly in the Zhiang community, was an inclusive process in which community members participated in various ways, including donating land, identifying specific vegetables to be cropped, and providing labor on the farm.

Overall, however, the project experienced poor management under the community-based approach. Bhungroo and PAVE were proven to be *technically* sound, but beneficiaries did not invest in proper management. In addition, while the technologies have the *potential* to bring additional income and nutrition to farmers, the crops grown were low-value and the revenue generated was small and inadequate to cover the cost of capital/operations.

The agricultural and economic possibilities through these water-harvesting technologies need further exploration and no concrete conclusions were evident from the piloting of such technologies, which need to be more fully explored. *A working paper on the Double Cropping, Dual Income approach is provided in Annex 4.*

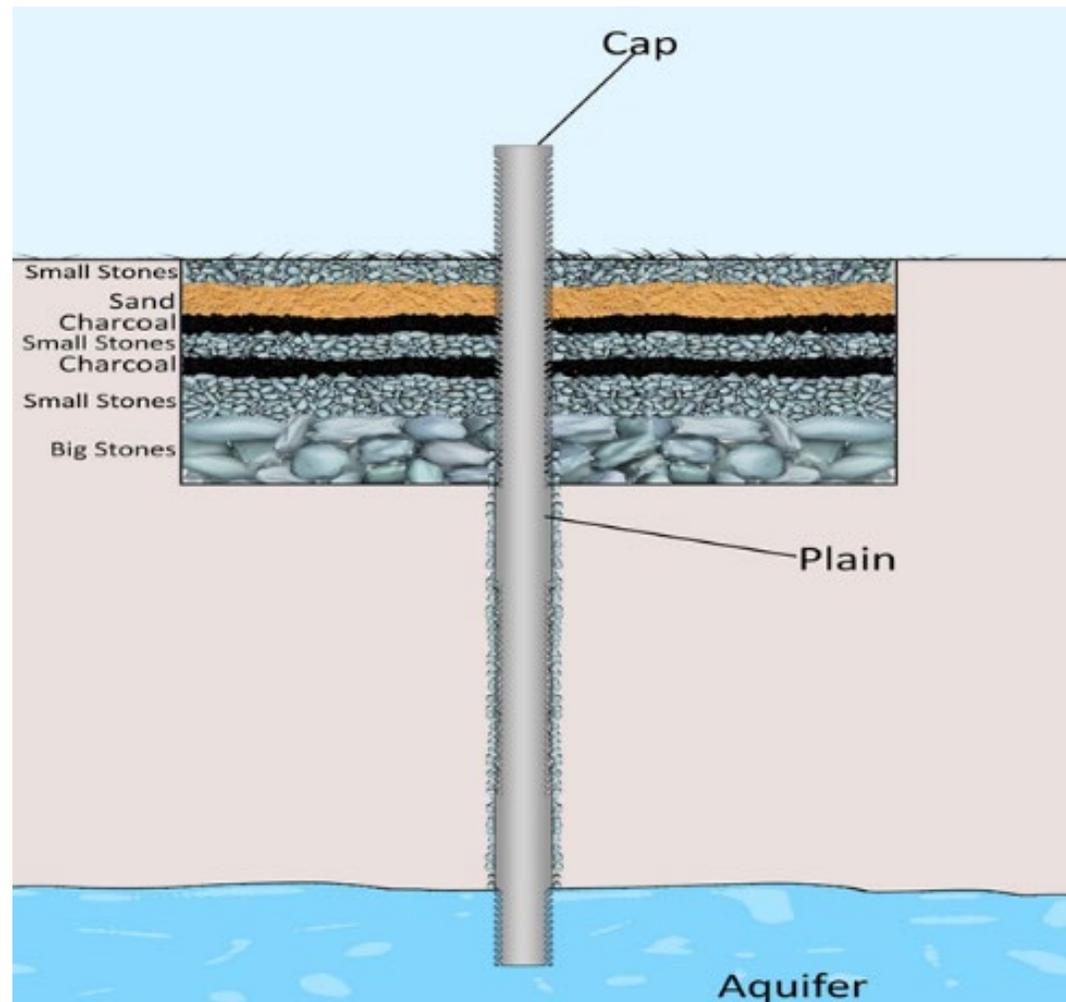


Figure 8. PAVE Irrigation Technology

An aquifer is created below the earth (dugout) and filled with water filtration materials that trap, collect, and store excess water during the rainy season. The stored water is then pumped out and held in an overhead tank for the purpose of irrigating vegetables. Vegetable fields are managed using drip irrigation technology. (Source: Conservation Alliance)



ATT agronomists at a PAVE irrigation site in the Zhiang community, 2017

ACHIEVEMENTS

Water Management Technology Dissemination

- 8 PAVE and 3 Bhungroo irrigation systems were installed across northern Ghana.

Livelihood Improvement

- Concept of Double Cropping, Dual Income was established as a proven approach to improve farmers' income, through inclusion of high-value commercial cropping.
- 550 farmers in the Zhiang Community improved incomes by an average of 35% as a result of PAVE and Bhungroo technologies, indirectly benefiting 3,300.

Success Story 5. Double Cropping, Dual Income: A Lifeline in Northern Ghana

Being a woman comes with challenges in Zhiang, a farming community in the Savelugu/Naton Municipality of the Northern Region of Ghana. The community is largely smallholder farmers, and access to fertile lands is a challenge – particularly to women farmers. Aside from issues of access to land, social and religious restrictions prevent women from exploring new opportunities. However, women in the Zhiang community are still faced with the herculean task of caring for their entire households' food and nutritional needs, as well as financial support.

Fuseina Iddrisu, 49, is responsible for feeding her family, paying her five children's school fees, and caring for fowl and goats, which she keeps at home. While she had no formal education, she prioritizes her children's education and empowerment. "I want them to be established, and when I grow older, they will be able to provide and care for me too," she said.

Fuseina was inspired to do more by and for herself after participating in a series of PAVE irrigation trainings organized by the ATT project in partnership with Conservation Alliance. Through the trainings, Fuseina and others learned to participate in household decision-making processes. "Now my husband and I discuss family issues and make decisions together," she said. "Decision-making was one of the key lessons we've learned working together as a team."

The PAVE irrigation project provided an additional opportunity for Fuseina to make extra income from the sale of vegetables and provide supplementary nutrition to her family. Fuseina learned about livelihood diversification strategies and managing farm resources, such as fertilizer and water, through the PAVE trainings. The PAVE irrigation project provides another cropping opportunity to farmers in the Zhiang community who otherwise would have been idle during the harsh dry season. "This project introduced dry season farming to the community," Fuseina said. "We didn't know this was possible."

By creating an underground aquifer during the rainy season, the PAVE irrigation system pumps rainwater from underground and stores it in large containers for the dry season. The technology has created a double cropping, dual income strategy in which farmers can now grow twice a year and have more money in their pockets. Fuseina and her farmer group grew three crops during the 2018 dry season: pepper, cucumber, and carrot.

"I have learned many things about agriculture extension and livelihood diversification through this project," she said. She's hopeful to access an acre plot of land for another irrigation project. "I saw the potential in dry season farming, particularly with vegetables. Plans are far advanced for me to access a plot of land near our dam site to undertake dry season farming." Through the project, Fuseina learned how to grow vegetables such as bra, okra, cucumber, pepper, eggplants, lettuce, cabbage, and watermelon. In addition to getting extra income from the sale of vegetables, farmers also consume the produce, improving overall household nutrition.

Because of her initiative and her ability to adopt best practices, Fuseina is able to care for her home with fewer challenges than before. Her husband and children are eating more and better food, and they are thankful to her for her hard work.



Fuseina Iddrisu shows a cucumber grown on a field irrigated by PAVE technology

Research

ATT adaptive trials and applied research generated evidence-based technical packages for dissemination to farmers. By empowering public institutions, ATT enabled regional agricultural research systems to re-orient their strategies focusing on “local – regional needs.”



A GSID lab technician participates in a Seed Quality Testing Workshop at a rehabilitated lab in Tamale (2016).

A. Status at Project Inception

When the ATT project began, agricultural research in northern Ghana was primarily through donor-funded projects, and government agencies, namely the Savanna Agricultural Research Institute (SARI), faced financial and logistical constraints. SARI was responsible for developing crop varieties for release by the National Variety Release and Registration Committee (NVRRC), which required that varieties intended for release must undergo evaluation during two production cycles. Without adequate irrigation, potential new varieties could only be tested during the rainy season. This stretched the release process over at least two

calendar years, limiting access to breeder and foundation seed.

Communicating research was also an issue. As mentioned earlier, the climate-resilient seed varieties released by SARI were not properly introduced to seed producers, seed dealers, and farmers. Due to this and the lack of capacity and resources of the Ghana Seed Inspection Division (GSID), there was long-standing mistrust in the quality of certified seeds made available for sale to farmers.

In addition, despite advancement in GIS mapping, remote sensing, and soil testing technology useful for approximating soil fertility requirements at specific sites, farmers in northern Ghana used blanket fertilizer recommendations based on decades-old research. This resulted in inefficient fertilizer use that hindered crop productivity.

The region needed a highly functional and dynamic agricultural research system that involved a variety of stakeholders, benefited producers and private agribusinesses, and would remain sustainable after the project's close.

B. Transformation

ATT's approach was to bring together researchers, extension agents, government entities, and smallholder producers to ensure research was relevant to the region's needs and research outputs reached beneficiaries in the project's zone of influence.

The section describes ATT's research activities that address the following IRs and Sub-IRs:

- IR 2 – Increasing efficiency and transparency of government functions to support seed, fertilizer, and ISFM technology development, release, and dissemination.

- Sub-IR 2.2 – Improved mechanisms for seed certification and varietal release processes
- IR 3 – Improving the capacity of agricultural research to develop, release, and communicate technologies
- Sub-IR 3.3 – Building research capacity on biotechnology

i. Improving Seed Certification and Varietal Release Processes (Sub-IR 2.2)

To address constraints limiting seed certification and variety release, ATT assisted SARI and GSID with funding, training, and logistics support.

Enhanced funding and rehabilitation of the Wambong Dam allowed SARI to scale up research and produce breeder and foundation seed during the dry season. To further build SARI's capacity, ATT's partner, the University of Wageningen's Centre for Development Innovation (CDI), trained SARI crop scientists on irrigation scheduling and water management. The Wambong facility will accelerate the rate at which SARI can respond to farmers' needs through their research and development of new crop varieties, and its size (10 ha) will also permit private sector leasing, which can generate important income for SARI to sustain its crop breeding programs.

With its partner institutions, Iowa State University and CDI, ATT assisted SARI's maize, soybean, and rice breeders to access breeder seed of new climate-resilient varieties and to take them through the process of testing and release. This culminated in the release of three new hybrid maize varieties.

ATT also helped SARI establish a communication unit, which was non-existent, and strengthened its ICT unit with training, equipment, and a consultant. This improved SARI's internal and external communication network and improved the visibility of its research, including releases and availability of



Demonstrating modern seed testing equipment at new seed lab in Upper West region



Wambong Dam Irrigation Facility after rehabilitation

breeder and foundation seeds. *(For more information on ATT's support to SARI, see section on Seed.)*

The provision of modern equipment and seed laboratories enabled GSID to increase the speed and quality of seed testing and certification processes. Replacing aging seed testing, analysis, and certification equipment allowed GSID to supply certified seed to farmers in a timely manner. *(For more information on ATT's support to GSID, see Success Story 2 in the Soil section.)*

ACHIEVEMENTS

Varietal Release

- With ATT support, SARI released three new hybrid maize varieties.
- The quality of SARI's breeder and foundation seed germination has improved from 75% to 99%, and purity increased from 68% to 100%, according to the SARI seed system specialist.

Seed Certification

- State-of-the-art seed labs enabled GSID to improve the seed certification process, reducing seed analysis time from up to three months to just a few days.

Success Story 6. Enhanced Research Capacity Increases Smallholder Farmers' Demand for Certified Seed



Alhaji Issahaku Mahama, SEEDPAG North President

Inspection Division of the Ministry of Food and Agriculture. Since the project's intervention in the seed value chain, including the provision of three ultra-modern seed laboratories, there has been tremendous improvement in seed production and certification processes in northern Ghana.

SEEDPAG members now produce enough seed to supply the government's flagship agriculture program, Planting for Food and Jobs. "If not for the improved capacity of SARI and GSID, it would have been impossible for our members to produce enough certified seed for Planting for Food and Jobs," Mahama observed. "We've realized an improved seed value chain in Northern Ghana. We are overwhelmed by the demand for certified seed from smallholder farmers," said Mahama.

Research

In the 2017 cropping season, the Northern Region Seed Producers Association of Ghana (SEEDPAG North) accessed 400 metric tons of certified rice foundation seed from SARI. This enabled SEEDPAG to produce and supply seed to the Government's Planting for Food and Jobs (PFJ) program. In 2018, SEEDPAG members requested 800 mt from SARI, which they were able to supply.

"We realize that SARI's research capacity and efficiency have improved, and they can now be relied upon to supply foundation seed to our members," said Alhaji Issahaku Mahama, president of SEEDPAG North. "Previously, this was not possible. It was difficult for association members to access certified seed from the institute. They often used saved seed, which eventually affected yields. Thankfully, that era is gone."

SEEDPAG's business has improved because members can access certified breeder and foundation seed and quality seed testing, analysis, and certification by the Ghana Seed



Certified seed packaged for PFJ, SEEDPAG

ii. Increasing the Number of Seed and ISFM Technologies Developed and Released (Sub-IR 3.1)

In its first three years of implementation, ATT conducted over 80 adaptive trials to confirm a range of technologies (seed varieties, fertilizers and application rates, soil amendments, and good agricultural practices) across northern Ghana. Results were used to generate evidence-based technical packages that ATT disseminated to farmers. The project scaled up the technologies during Years 4 and 5 of implementation. *(For more information on transferring research to farmers, see section on Soil.)*

To help create a rice yield-forecasting model and further validate the effectiveness of ISFM technologies, such as the UDP technology, ATT partnered with Iowa State University (ISU) in the use of drone technology. Using drones to evaluate crop health could help producers better plan for harvest, storage, and marketing of their crop. *(For more information, see Success Story 7.)*

Through extensive geo-referenced soil sampling and analyses, ATT developed soil fertility maps for the three northern regions of Ghana to aid site- and crop-specific fertilizer recommendations. Based on the maps, nutrient omission trials were established in collaboration with Soybean Innovation Lab (SIL), MOFA, the University for Development Studies, and the Feed the Future Soil Fertility Technology project, funded by USAID. Several essential plant nutrients, including nitrogen, phosphorus, potassium, zinc, sulfur, and boron, were identified as limiting crop growth in the regions. With the updated soil fertility maps and nutrient omission trials, researchers in northern Ghana are better positioned to provide fertilizer recommendations that meet crop and soil needs.

ACHIEVEMENTS

Technology Dissemination

- 70 adaptive trials were conducted to develop and disseminate technologies and practices to farmers.

Crop Forecasting and Evaluation

- Drones enabled crop evaluation and forecasting in hard-to-reach areas.

ATT Adaptive Trials*

- Seed variety release trials
- UDP in upland maize crops using climate-resilient maize varieties
- UDP with submergence-tolerant rice varieties
- UDP with vegetable crops
- Effectiveness of “activated” phosphate rock
- Effect of rhizobial inoculation and basal phosphate application on soybean yield
- Use of rhizobial inoculant and organic fertilizer on soybean yield
- Effect of UDP on locally adapted rice intensification system (SRI)
- Effect of organic fertilizer use on UDP technology
- Use of FDP briquettes vs. urea supergranules
- Participatory trials on conservation agriculture (intercropping, use of crop residues)
- Technical feasibility of PAVE and Bhungroo irrigation technology

* Some trials were conducted with partial funding from the Feed the Future Soil Fertility Technology Adoption, Policy Reform, and Knowledge Management Project, funded by USAID for the Bureau for Food Security.

Success Story 7. Drone Technology Evaluates Crop Health in Northern Ghana

Iowa State University (ISU), through the ATT project, is using drones to evaluate rice production under nitrogen management systems at the Tono irrigation scheme in the Upper East Region of Ghana. With drone technology, ISU compared the health and productivity of rice fertilized using UDP and rice grown under non-UDP fertilizer application.

In 2014, ATT introduced UDP, as part of an integrated soil fertility management (ISFM) package, to smallholder rice producers at Tono (as well as other irrigation schemes in northern Ghana). Farmer participatory trials indicated the technology significantly increases farmer yields and profits, with less nutrient losses. The ISU remote sensing team, which includes students from Ghana's University for Development Studies (UDS), sought to validate these results from UDP use and create a rice yield-forecasting model using drone-captured data. Such a model could help producers better plan for harvest, storage, and marketing of their crop, as well as better understand the specific determinants of smallholder rice productivity under irrigated conditions. Ghana's Ministry of Food and Agriculture and other governmental agencies also could use the model to make decisions on annual importation or exportation of rice.

The objectives of the study were to:

- Capture and produce Red-Blue-Green and Near Infrared images at midseason stage of the rice crop.
- Compare the health of the rice crop under UDP and non-UDP treatments.
- Correlate midseason health of rice with end-of-season yield performance.
- Develop a model using midseason remotely sensed information supported by other management parameters to predict end-of-season rice yields.

Results showed that nitrogen management, transplanting date, and vegetation index were the most significant determinants of yield. The study supports the assertion that UDP results in increased yields under flooded conditions. It also found that data collected midseason can be used to predict end-of-season rice yields.

One of the more notable conclusions of the study is that rice planted under UDP fertilization matured at an accelerated rate. This means that UDP is also a “climate-smart” technology. By reducing the time it takes to form grain and become ready for harvest, UDP reduces the crop's exposure to adverse events, such as bird or pest attack, drought, fire, and other uncontrollable impacts.

The ISU remote sensing team has also used drones to assess the performance of private sector seed producers who were assisted by ATT to produce high-quality, certified maize seeds. The study evaluated producers' management practices, weed control, and end-of-season yields.



The research team installed time-lapse cameras to collect data on the physiological development of the rice crop.



The boundaries of farmers' fields were mapped using drone-mounted GPS in a fraction of the time required if undertaken by walking.

iii. Building Research Capacity on Biotechnology (Sub-IR 3.3)

Misinformation about biotechnology, particularly genetically modified organisms (GMOs), is prevalent in Ghana. The topic is heavily polarized, and various stakeholders are creating a climate of fear, without scientific basis. For example, hybrid maize, as a GMO, is being presented to farmers as a threat to indigenous biodiversity in West Africa. Biotechnology was a key activity area for ATT, but due to the controversy, any activity or perceived advocacy for GMOs could affect ATT's interventions and the supply of improved certified seeds in northern Ghana.

To promote better understanding of biotechnology and biosafety in northern Ghana, ATT organized workshops to educate seed producers, students, and media. Topics included basic biotechnology (Bt), Ghana biosafety law, and Bt cowpea. Experts from ISU, Ghana Program for Biosafety Systems, and SARI answered participants' questions and dispelled myths about Bt. After attending the workshops, media practitioners produced communication messages and shared them via radio, television, and newspaper. In addition, ATT assisted SARI in the production of a documentary on Bt cotton.

Although ATT targeted the three northern regions of Ghana, project trainings and other capacity-building activities on biotechnology included national institutions, such as the Biotechnology and Nuclear Agricultural Research Institute (BNARI), Crops Research Institute (CRI), Food and Drugs Authority (FDA), and universities, polytechnic institutions, and the private sector.

ATT provided education on the benefits and disadvantages of biotechnology and granted farmers and other users the option to choose technologies that will improve productivity, profits, and standard of living.

ICT

Innovative and behavior-changing ICT solutions enabled ATT to widen its reach with agricultural education in last-mile communities.

ATT ICT expert uses a pico camera to film a farmer in Libga for the production of a video on UDP.



A. Status at Project Inception

In 2013, information about new agricultural technologies, such as variety releases or research on fertilizer formulations, did not reach end users in northern Ghana. For example, SARI did not have a communications unit to demonstrate its research to farmers, and GSID lacked IT

infrastructure to share information among their internal units. In addition, the ratio of agricultural extension agents to farmers was 1 to 1,200 and 1 to 3,000 in the most hard-to-reach areas. The resulting information gaps restricted progress, with many farmers in remote areas never learning

about new technologies that could improve their yields and incomes. The region needed innovation in agricultural extension delivery mechanisms to ensure information reached those who needed it the most, including last-mile groups.

B. Transformation

To fill the knowledge gap, ATT designed an ICT approach that ensured information on new technologies, research, and good agricultural practices reached a wide range of beneficiaries. This section describes ATT's activities that address the following IRs and Sub-IRs:

- Sub-IR 1.2 – Increased demand for market and technical information on seed and ISFM through ICT mechanisms
- Sub-IR 1.4 – Increased dissemination of ISFM technologies
- Sub-3.2 – Improved communication for technology dissemination capacities

i. Improving Technology Dissemination Using ICT Approaches (Sub-IRs 1.2, 1.4, and 3.2)

When ATT first began, it implemented traditional methods of technology dissemination – establishing demonstration plots to showcase technologies to farmers. While physical demonstrations were effective in providing hands-on learning, they were costly and also limited the number of farmers who could participate in field days for effective learning. During the 2015 production season, ATT spent GHS 2,202,704 (U.S. \$524,000) to reach 32,213 farmers through demonstrations. This translated to GHS 68.38 (U.S. \$16.28) as cost per farmer (totaling U.S. \$524,000). To reach all 120,000 beneficiaries targeted through traditional field demonstrations would have cost nearly four times this amount.

ATT, therefore, developed an approach to reach a larger number of farmers at a much lower cost with ICT, using video screenings, radio broadcasts, and e-extension with cell phones, which delivered messages on a real-time basis.

Video Screening – ATT partnered with the ICT development organization *Digital Green* to use its community-based video approach to disseminate and scale technologies. ATT produced 25 videos featuring local farmers who shared their experiences with labor-saving equipment, such as bicycle-mounted maize shellers, and best practices, such as using certified seed, transplanting rice, applying UDP, managing crop residues, and using improved soybean harvesting

techniques. With videos, a full cropping cycle can be covered in just 15 minutes.

LIPs were trained to operate the Digital Classroom System (DCS) – a lightweight user-friendly kit comprising equipment needed to screen videos in an “offline” format where electricity is limited. In partnership with an NGO specializing in video production, *CountryWise Communications*, LIPs also used mobile video vans that traveled across 31 rice farming communities around the main irrigation schemes in northern Ghana (Bontanga, Golinga, Tono, Ve, Libga, Daffiama, and Sankana), thereby extensively covering the last-mile population.

Video screening events were hosted by lead farmers or community chiefs and included special guests to provide live testimonies to the community. With this peer-to-peer learning process, farmers told their own stories in their own languages, which built trust and facilitated adoption. In addition, the cost is significantly less than traditional extension systems. In 2016, the project spent just \$2.80 in reaching a farmer (versus \$16 in 2015).

Radio Broadcasts – Radio stations in northern Ghana have an extensive following. To leverage this, ATT partnered with the non-profit

organization *Farm Radio International* to produce audio content on ISFM, conservation agriculture, composting, dry season farming practices, improved seed, UDP, and other improved production and management practices. Formats included “Regular Farmer Programs,” an interactive radio magazine series and storytelling program, and the “Participatory Radio Campaign,” which featured small-scale farmers through village debates, phone-in shows, and music. According to *Farm Radio International*, the radio broadcasts reached an audience of 1.2 million over the life of the project.



Components of the Digital Classroom System



Video Screening in the Tolon District, Northern Region

E-Extension – The project partnered with *Esoko*, a local e-extension service provider, to scale up their “Farmer Helpline” networks. Through the helpline, experts answer farmers’ questions and offer advice and information on weather, market prices, and agronomic advice in local dialects. ATT strengthened the system by updating Esoko’s knowledge base through a public-private partnership with SARI. SARI regularly reviews Esoko’s technical content and makes its scientists available to address unresolved issues flagged by the call center attendants. This partnership ensures that farmers calling into the helpline are provided with the latest research and guidance from northern Ghana’s leading agricultural research institution, SARI. According to a 2018 Esoko report, 5,000 farmers from ATT’s zone of influence benefited from the helpline, and 150,000 smallholders received text and voice messages on UDP technology, GAPs, certified seed, and market and weather information.

To ensure that ATT interventions continue after the project's completion, ATT shared its technologies with members of the Research-Extension Linkage Committees (RELC) in the three northern regions. Coordinated by the public sector, RELC members are researchers and extension officers that aim to bridge the gap between research institutions, such as SARI, MOFA extensionists and farmers in each region of Ghana. ATT demonstrated GAPS for maize, soybean, and rice production, including UDP, and showed RELC members how to use Digital Classroom technology to reach a wide audience at a low cost.

For more information on ATT's use of ICT, see Annex 5.



A farmer in northern Ghana checks market prices on her mobile phone.

ACHIEVEMENTS

Reaching the Last-Mile Through ICT

- 25 videos were produced and screened, reaching an audience of 400,000 smallholder farmers.
- Video screening decreased costs by 83% (from \$16 to \$2 per farmer) compared to physical demonstrations.
- A total of 228 hours of radio programming on agricultural technologies for soybean, maize, and rice aired to farming communities in northern Ghana, reaching 1.2 million farmers.
- Through Esoko, about 150,000 smallholder farmers were reached with text and interactive voice response messages.
- 29 Ghanaian journalists benefited from capacity-building training from Farm Radio International.
- 6 million farmers were reached through radio and television broadcasts through the Kuapa Television series.

Success Story 8. Rural Radio Reaches Farmers Eager to Learn



Awitsika Atuah, farmer and Radio URA listener

Awitsika Wisdom Atuah has been farming since he was a child, but he knows there is more to learn. The 37-year-old farmer from Dubila, in the Upper East Region, enjoys listening to farm improvement programs on Radio URA.

While Atuah produces many crops (including groundnut, pepper, and millet), he was interested in the program because it addresses rice, maize, and soybean production. Awitsika has listened to all of the ATT-funded radio programs. He says that while bush fires and erosion are often a problem for farmers in the local area, the radio shows are providing much-needed information to tackle them effectively. He has learned techniques to prevent bush fire, such as fire belts, as well as how to properly plow and clear his land.

“When you listen to the radio, you are listening to farmers who have already done/demonstrated this in their field, so you know it works,” he says. He hopes that more farmers will be invited to participate in the shows and that they will describe how others have successfully used the new techniques.

“Learning together helps,” he says. “If I don’t understand something from the radio, I can ask someone else who has listened or who is practicing the new technologies, and they will teach me.” Awitsika also tries to make sure that other people benefit from the USAID-funded program. “I learn how to use the new technologies and then I go to other farmers to inform them,” he says. “I teach them how to adopt the new technologies because the old ways use a lot of land and don’t give good results.”

Through ATT’s use of innovative and behavior-changing ICT technologies, agricultural education reaches a wide audience at a low cost. ICT tools improve information access, increase agricultural knowledge, increase farmer-buyer linkages, improve access to agricultural input and output markets, and encourage data sharing and dissemination. By making ICT solutions available and creating extension delivery mechanisms led by local partners, ATT has ensured that these benefits continue after the project has ended.



A radio program host interviewing a participant after a focus group discussion.

Cross-Cutting

A. Gender

Women comprise more than half of the agricultural labor force in Ghana (SEND-Ghana, 2014)¹³ but often lack access to resources, such as agricultural inputs and training, that are necessary for success in farming. If female farmers had the same access to resources as men, it is estimated that farm productivity and household nutrition could improve 20-30% (Feed the Future, 2018).¹⁴ Therefore, women's empowerment is a main focus of Feed the Future and the ATT project.

ATT activities aimed at improving the participation of women and improving their productivity. This was accomplished through **capacity-building activities**, i.e., to improve their technology skills and application; through the introduction of **technologies for labor saving**, thus removing drudgery; and by creating **value-addition opportunities** through business engagement.

i. Capacity Building

Over the life of the project, ATT strengthened women's access to training, improved technologies, and income-earning opportunities in northern Ghana. Since 2014, a total of 99,821 women were trained in GAPs and ISFM, including line transplanting, use of labor-saving

equipment, UDP application, use of certified seed, and composting. As a result, 98,387 women farmers used one or more improved technology or management practice, according to ATT data in 2018 (Figure 9). This represents 98% of total farmers targeted (100,000) and nearly half of total farmers reached (201,700).

The project's technology dissemination activities were held at times and locations convenient for women's participation. For example, video screenings were ideal for female farmers because they were held in the evenings after women had completed their household tasks.

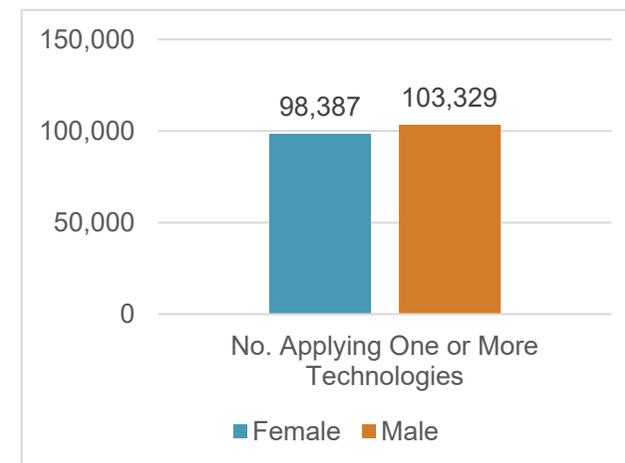


Figure 9. Number of Women Applying New Technologies, 2018



On the left, USAID-Ghana Mission Director hands over planters to beneficiaries. On the right, a farmer operates the equipment at a demonstration site.

¹³ SEND-Ghana. 2014. *Women and Smallholder Agriculture in Ghana*. Policy Brief No 4.

¹⁴ Feed the Future. 2018. *Empowering Women in Agriculture*. https://www.feedthefuture.gov/wp-content/uploads/2018/03/FTF_WomenEmpowerment_Factsheet_2018.pdf

ii. Labor-Saving Technology

By introducing labor-saving machinery, ATT helped women more easily perform agricultural tasks and use the technologies to generate additional income. For example, through its matching grant mechanism, ATT provided 120 women with manual multi-crop planters in 2015; the equipment is light and easy to handle. After planting their fields, some women rented their equipment to their peers. With increased income, these women are able to pay their children's school fees and invest in next season's harvest. *(For more information, see Success Story 9.)*

In addition, ATT's Double Cropping, Dual Income approach provided women farmers opportunities for growing vegetables during the dry season – a time when they are unable to farm and thus earn income. *(For more information, see Success Story 5 in the Water section.)*

iii. Value Addition for Women Laborers

Because of the employment created by ATT-promoted technologies, the demand for farm labor increased in northern Ghana. Based on ATT's observations, this demand is being met mostly by women and unemployed youth. For example, ATT encouraged women trained in rice seedling transplanting and UDP application to provide these services for a fee. Now, women in communities near ATT-supported irrigation schemes are forming “transplanting gangs” that perform line transplanting for rice producers. They also provide labor for UDP application. At

the Bontanga Irrigation Scheme, transplanting and UDP application services generated GHS 18,000 (approximately U.S. \$4,090) for the transplanting groups (according to an ATT survey of transplanting gangs in 2017). On average, the women earn up to GHS 17 (U.S. \$3.54) in a day. The increased employment opportunities prevent women from migrating to cities in southern Ghana for work, an often dangerous and unfruitful venture.

By improving women's access to agricultural technologies and training, ATT empowered them with opportunities for business ventures that improved their livelihoods. The project's involvement in northern Ghana improved laborers' skills, adding value to their services and improving their income. With access to product

resources, agricultural machinery, and training in seed production and good agricultural practices, women turned their daily farming tasks into enterprises. In addition, with a second cropping season for high-value vegetable crops (Double Cropping, Dual Income), women in communities using water management technology are better positioned to rise above the poverty line and improve their family's nutrition. The creation of labor geared toward women (such as line transplanting and vegetable production) has helped women to remain with their families, reducing their migration to look for work in urban areas of southern Ghana.

For examples of how ATT-promoted technologies are improving women's lives, *see Success Story 9.*



A transplanting gang provides services at the Bontanga Irrigation Scheme in the Northern Region of Ghana

Success Story 9. ATT Helps Women Turn Tools and Training Into Enterprises

ATT-Trained Laborers Increase Income through Local Employment Opportunities

One of the major development issues in northern Ghana is the migration of youth, particularly women, from the north to the south to engage in menial jobs because they believe that financial gains are not possible in the north. After migrating to southern Ghana, women often become involved in *kayaye*, in which they are paid very little to sell items in the street. The practice leaves the women at risk for exploitation and violence.

To encourage alternative livelihood and income-generating ventures, ATT trained women's groups in communities near irrigation schemes in row rice transplanting and UDP application. Women's "transplanting gangs" offer skilled and fast transplanting and UDP services to large-scale farmers who rely on qualified labor. The need for these services begins in January, which coincides with the migration period and incentivizes women to remain in their communities.

Joana Atampaka, a 30-year-old mother of three, returned home from the city after hearing about women's transplanting groups in the Tono Irrigation Scheme. She and her group members make a daily wage of GHS 15 (U.S. \$3.54), well above the poverty line (\$1.25 per day).

"Before I started this transplanting business, I traveled to Kumasi in the Ashanti Region to work a menial job to feed my children back home. Fortunately, I don't need to travel far from home again because I have a sustainable job for survival.

The solution was right under my nose," she said. Thanks to her new business, Atampaka is now able to pay her children's school fees and afford other domestic expenses. She is pleased with the UDP technology, which has increased the demand for transplanting and urea briquette application services.

Another source of income for women in northern Ghana is providing agricultural machinery services and rental. Below are examples of women entrepreneurs turning tools they accessed through ATT's grants program into enterprises.



A young woman engages in row transplanting at the Tono rice irrigation scheme.

Agricultural Machinery Reduces Drudgery and Empowers Women Entrepreneurs



Janet Nyabasey is the leader of the farmer-based organization, Atinvabe Cooperative, and mother of four. After receiving a power tiller through ATT's grants program, she has become an entrepreneur, providing affordable land preparation services to other farmers in the Tono Irrigation Scheme.

"I was privileged to represent my farmer group in observing an ATT demonstration field from land preparation to harvest in the 2014 dry season. The lesson I learned was the importance of proper leveling. This is where I formed the idea to provide such services. With the tractor plowing and harrowing service, a farmer pays GHS 150 [U.S. \$38] for an acre of land and hires additional labor for GHS 130 [\$33] to do the manual leveling. However, with my power tiller service, a farmer pays GHS 160 [\$41] for the same piece of land to be expertly prepared."

According to Ataata Apaanya, one of Nyabasey's clients, "I am now spending less money and getting a very well rotovated field for my UDP."

As one of the conditions of the matching grant program, Nyabasey paid GHS 5,400 (\$1,381) – 30% of the total cost of the power tiller. ATT, through USAID, paid 70%. "I did not have money to pay for the 30% so I procured a loan from Builsa Community Bank to honor my fee," said Nyabasey. "I paid back the loan using the profit I generated from my rotovating services." Now, the rest of my savings have taken care of my daughter's school fees at the University for Development Studies.

In 2015, ATT provided women farmers multi-crop planters through its grants program. One recipient, Comfort Angbing, 39-year-old mother of five, used the planter to create new business. She rented the machine to other women farmers, generating an extra GHS 165 (about \$44) during the planting season.

Angbing, the lead farmer of the Balanang Women's group, saw the planter in action during a sowing demonstration the previous season. There, she imagined creating a rental business using the machine.

By using the machine to sow 7 acres of maize and soy instead of hiring laborers, Angbing saved GHS 280 (about \$74). With the extra money, she bought educational materials, a uniform, and food for her son.



B. Grants – Leveraging the Power of the Private Sector

Since 2014, ATT utilized its grant mechanism to encourage public-private partnerships to expand the availability and use of new technologies (improved seed, fertilizers, mechanization equipment, ICT platforms, among others) by actors in the maize, rice and/or soybean value chains. The grant process helps organizations and partners leverage their existing resources and maximize the impact of scaling up the new technologies introduced by ATT, as well as those technologies promoted directly by private sector actors. The outcome is the development of new markets for mature businesses as well as enhanced capacities of nascent local organizations to become stronger partners with sector stakeholders.

ATT disbursed about \$6 million in grants to strengthen the private sector and ensure agricultural research and technologies reached farmers and agribusinesses (Table 4). The major objectives of the grants program were to:

- Build the capacity of local organizations to become stronger partners with maize, rice, and soybean stakeholders.
- Encourage public-private partnerships to expand the availability and use of new agricultural technologies.
- Catalyze adaptive research in northern Ghana and the transfer of scientifically sound technologies.

- Directly support the introduction of appropriate technologies for widespread adoption in northern Ghana.
- Support smallholder farmers to adopt new technologies.

A diverse range of funding mechanisms were used, including in-kind matching grants in which the grantee provided 30% of the investment. Over the life of the project, private entities invested \$2.7 million in the Ghanaian seed sector and maize, rice, and soybean value chain through cost-sharing via the grant support program. The project also implemented a loan support program, which leveraged ATT grant funds to attract private commercial bank and borrower investment in the seed value chain.

Table 4. ATT Grants by Size, 2013-2019

Grant Type	Value of Grant (USD)
Large Grants	2,140,748.67
Medium Grants	2,224,846.40
Small Grants	1,537,002.58
Total Grants	5,902,597.65

Source: ATT Grants Database (see Annex 6 for more details).

NOTABLE GRANTS

Seed Certification Improvement

- Three modern seed labs were equipped with state-of-the-art seed testing equipment for the Ghana Seed Inspection Division.

ISFM and Water Management

- 20,000 “starter packs” of inputs were provided to farmers.
- PAVE and Bhungroo water-harvesting technology was piloted.
- Farmers and agribusinesses were able to access agricultural machinery, including fertilizer briquetting machines, power tillers, and multi-crop planters, threshers, and shellers.

Seed Multiplication/ Production

- 73 seed companies received technical guidance and financial support to shift toward production of certified seed.
- 1,079 ha of seed fields were cultivated by seed producers supported through ATT grants.
- Wambong Dam was rehabilitated so that SARI could conduct year-long trials.
- SARI received support to enhance research on new seed varieties.

Seed Processing and Marketing

- CRI's seed storage facility was refurbished.
- Five private seed companies were awarded with seed processing and cleaning equipment.
- 22 customized motorized tricycles were supplied to seed producers, agro-input dealers, and LIPs to distribute seed in remote areas.

ICT/ Communications

- Support to Farm Radio International ensured ISFM messaging was promoted through community radio programs.
- LIPs accessed Digital Classroom technology and training.
- A communication consultant was supplied to SARI to enhance the institution's ability to communicate research to stakeholders.

C. Monitoring and Evaluation

ATT had 25 performance indicators (10 FTF indicators and 15 custom indicators) and achieved or exceeded 23 indicators (92%). Achievement of performance indicators is presented in the Performance Matrix in Table 5.

i. Training

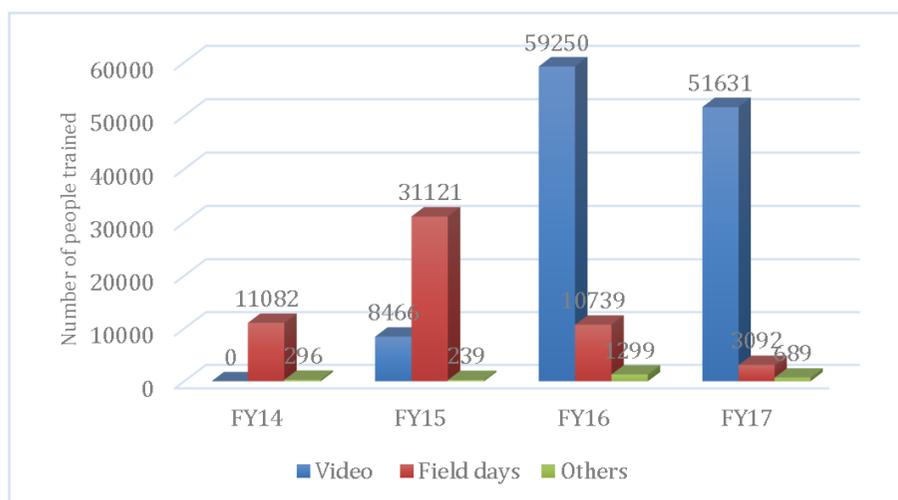
ATT trained over 177,000 people in improved agricultural technologies related to seed production, post-harvest management, certification, climate-smart agriculture, conservation agriculture, ISFM, and farm business management, among others. The long-term impact of these trainings is improved

welfare resulting from efficiently functioning, competitive maize, rice and soybean sectors and from increased production and productivity. From 2013 to 2015, training was primarily through field demonstrations, field days, and workshops. Beginning in 2016-17, ATT expanded its ICT approach to technology dissemination (Figure 10). The project exceeded its short-term training goal of 120,000 by 26.5%. About half of those trained were women (Figure 11).

technology application by farmers and areas under improved technologies. According to ATT's 2018 Crop Cut Survey, over 201,000 farmers applied one or more improved technology or management practice in FY18 on 165,260 ha, exceeding the project target by 102% and 65%, respectively (see Figures 12 and 13).

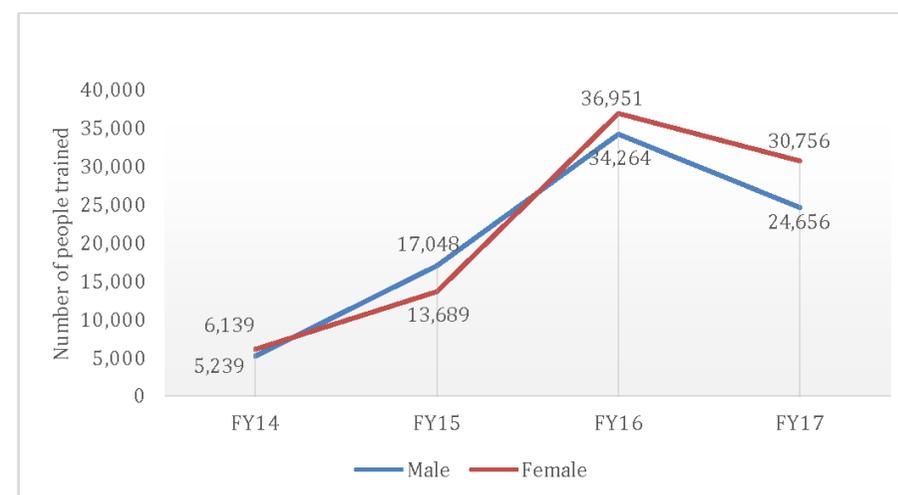
ii. Area Under Improved Technologies

Historically, adoption rates of new technologies and practices have been low among farmers in northern Ghana. ATT challenged this trend and contributed strongly to the increase in improved



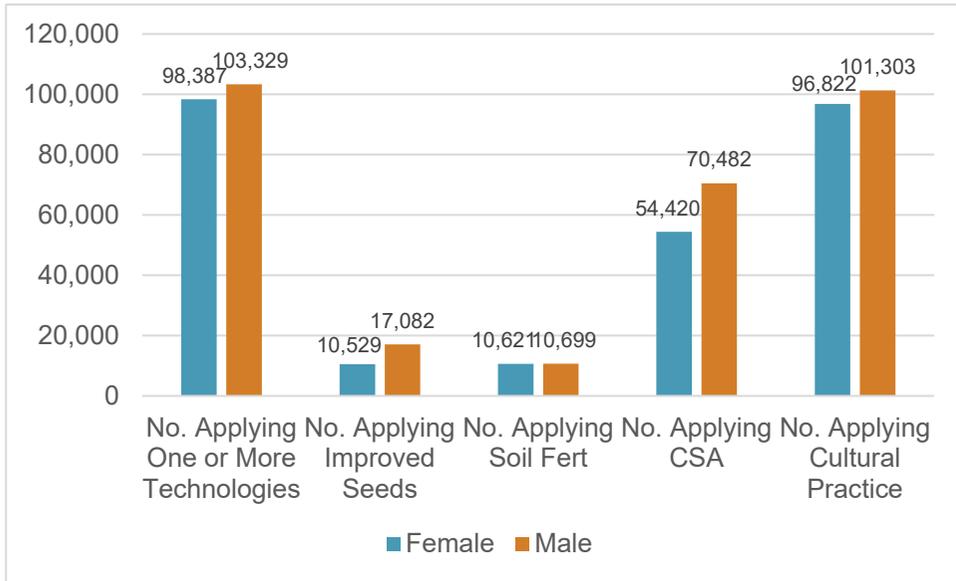
Source: Field data, 2014-2017.

Figure 10. Short-Term Training by Type of Activity, FY 2014-2017



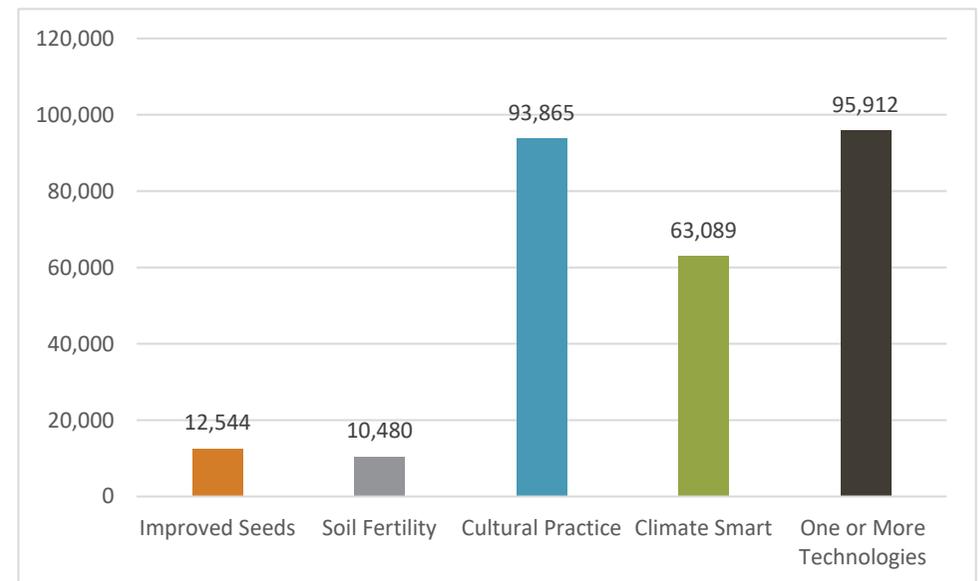
Source: Field data, 2014-2017.

Figure 11. Short-Term Training by Gender, 2014-2017



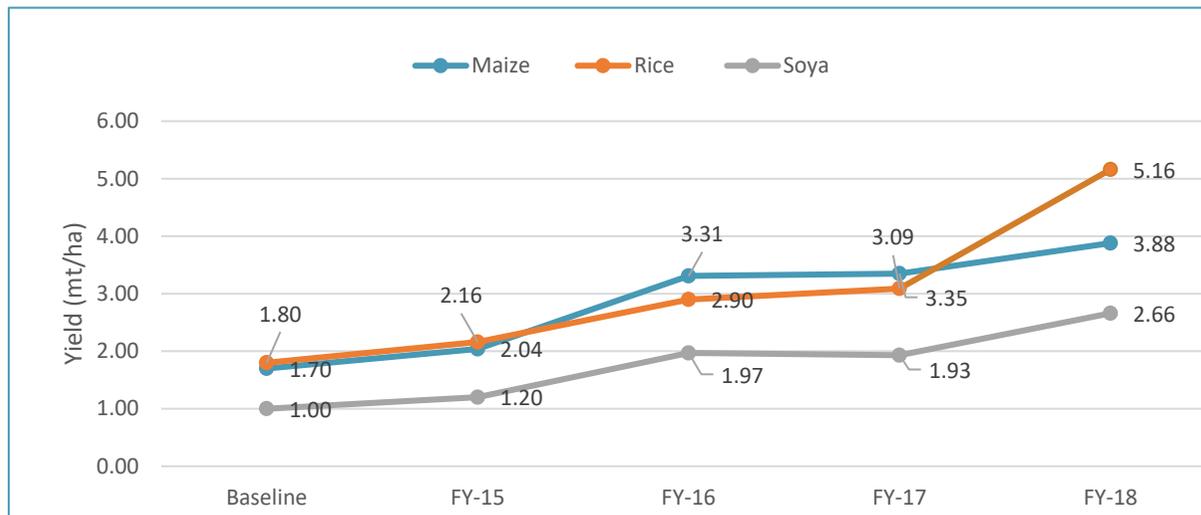
Source: ATT M&E team.

Figure 12. People Applying Improved Technology or Management Practices, by Type and Gender, FY2018



Source: ATT M&E team.

Figure 13. Area (ha) under Improved Technology by Type of Technology Applied, FY2018



Source: ATT Crop Cut Surveys, 2015-2018.

Figure 14. Productivity Increases in ATT Target Crops

iii. Yields

ATT's most significant achievement is improved productivity of maize, rice, and soybean. Yield increased by 228% for maize (from 1.70 to 3.88 mt/ha), 287% for rice (from 1.80 to 5.16 mt/ha), and 266% for soybean (from 1.00 to 2.66 mt/ha), according to ATT Crop Cut Surveys (Figure 14).

In addition, ATT's introduction of improved technologies let to \$7.8 million in incremental sales of targeted commodities (seeds, fertilizers, and soil amendments).

Table 5. Project Indicator Performance Matrix

USAID-FTF-ATT Objective, Results and Indicators	Baseline Value	LOP Target	LOP Target Achieved	% of LOP Target Achieved	Deviation Narrative
Goal: Ind. 1 – Increased competitiveness of rice, maize, and soy value chains to foster					
Goal Level Indicator(s)					
Ind. 1 – Yield per hectare of targeted commodity (maize, rice and soy)					2018 technology adoption surveys to determine yields due to ATT interventions among beneficiaries confirm that yields have doubled since the baseline. This is attributed mainly to improved use of technologies due to innovative technology transfer mechanisms, including use of ICT tools, to reach the last-mile farmers.
Yields for Maize (mt/ha)	1.70	3.40	3.9	114.71%	
Yields for Rice (mt/ha)	1.80	3.60	5.33	148.06%	
Yields for Soybean (mt/ha)	1.00	2.00	2.71	135.50%	
SO: Increased availability and use of agricultural technologies to increase and sustain productivity in Northern Ghana					
SO Level Indicator (s)					
Ind. 2 – Number of hectares under improved technologies or management practices as a result of USG assistance (FTF Indicator # EG.3.2-18)	0	100,000	165,260.00	165.26%	2018 technology adoption surveys indicate farm households across 165,260 ha have used one or more technologies promoted through ATT interventions, viz., improved crop genetics, soil fertility management, climate-smart agriculture, and cultural practices. This is 165% higher than the target, since in FY18 Q2 about 15,000 smallholder farmers trained by ATT benefited from input promotion kits. Also, during FY17 Q2, an additional 178.8 ha were brought under ICOUR irrigation site and 1.7 ha by SPRING farmers who benefited from the Vit-A maize distribution program. In addition, 20,000 starter packs containing improved seeds (rice, maize, or soy) and other inputs were distributed to farmers for use during the FY17 season. This cumulatively resulted in an additional 352.00 ha. Seventy-three seed producers supported by the project in FY17 also applied improved technologies/management practices on about 1,078.8 ha of land.
Ind. 3 – Number of farmers and others who have applied improved technologies or management practices as a result of USG assistance (FTF Indicator # EG.3.2-17)	0	100,000	201,716	201.72%	In FY18, a survey was conducted to determine the level of achievement. The results were extrapolated to reflect from 2014 to the end of the project. The survey results indicated that 201,716 (out of a total of 204,175 beneficiaries) have applied one or more of the four categories of technologies promoted by ATT interventions, i.e., crop genetics, soil fertility management, climate-smart agriculture, and cultural practices.

USAID-FTF-ATT Objective, Results and Indicators	Baseline Value	LOP Target	LOP Target Achieved	% of LOP Target Achieved	Deviation Narrative
Ind. 4 – Number of private enterprises, producer organizations, water users associations, women’s groups, trade and business associations, and community-based organizations (CBOs) that applied improved technologies or management practices as a result of USG assistance (FTF Indicator # 4.5.2-42)	0	800	863	107.88%	All 863 actors that received USG assistance from the project since FY14 were reported to be applying improved technologies/management practices.
Intermediate Results and Indicators					
IR 1: Increased private sector actors’ role and capacity in developing and disseminating improved seed and ISFM technologies					
Ind. 1.1 – Value of incremental sales of targeted ATT’s commodities (seed, fertilizers and other soil amendments) attributed to FTF implementation	N/A	1,000,000	\$7,890,606.20	789.1%	ATT implementing partner, GAABIC, conducted a survey to determine the volumes and values of targeted ATT commodities that were sold to farmers in the 2017 farming season in the Northern, Upper East, and Upper West regions. The increased incremental sales volumes can be attributed to the high adoption rate among ATT project beneficiaries who had the opportunity to try ATT-promoted technologies, leading to the overachievement of the LOP target.
Ind. 1.2 – Value of new private sector investment in the agriculture sector or food chain leveraged by FTF implementation (FTF Indicator # 4.5.2-38)	0	1,200,000	\$5,023,137.31	418.59%	ATT used in-kind grant agreements to stimulate \$5,023,137.31 into the agriculture sector in northern Ghana over the life of the project to generate sustainable partnerships.
Ind. 1.3 – Number of individuals who have received USG-supported short-term agricultural sector productivity and food security training (FTF Indicator # 4.5.2-7)	0	140,000	177,105	126.5%	ATT has trained various categories of beneficiaries using different training mechanisms. The main strategies used were field days at the demonstration sites and mobile vans with projection facilities to educate farmers on GAPs in their villages and communities, thus reaching even remote communities. Over the life of the project, a total of 177,105 project beneficiaries were trained via video screening, field day sessions, trainings on crop budget and production planning as well as seed production, etc.
Ind. 1.4 – Number of individuals who have received USG supported degree-granting agricultural sector productivity or food security training (FTF Indicator # EG.3.2-2)	0	50	52	104.0%	ATT supported two researchers to undertake Ph.D. studies in the United States. Four (4) M.Sc. research students received support to conduct research. Sixteen (16) students also completed a six-month certificate course on seed technology and business management, organized by ISU. Thirty-one (31) students (12 undergraduate and 19 post-graduate) from the Faculty of Agriculture and Faculty of Agribusiness and Communication Sciences of UDS were assisted by the ATT Project Agricultural Studies Bursary Support Program to complete their studies.

USAID-FTF-ATT Objective, Results and Indicators	Baseline Value	LOP Target	LOP Target Achieved	% of LOP Target Achieved	Deviation Narrative
Ind. 1.5 – Number of food security private enterprises (for profit), producer organizations, water users associations, women's groups, trade and business associations, and community-based organizations (CBOs) receiving USG assistance (FTF Indicator # 4.5.2-11)	0	800	1502	187.8%	This indicator counted the local implementing partners (LIPs), seed producers, seed processors, farmer-based organizations (FBOs)/CBOs; hence, 1,502 actors were trained in total.
IR 2: Increased efficiency and transparency of government functions to support seed, fertilizer and ISFM technology development, release, and dissemination					
Ind. 2.1 – Number of public-private partnerships formed as a result of FTF (FTF Indicator # 4.5.2-12)	0	25	124	496.0%	Counting of this indicator previously focused more on agreements with international private companies and a few local companies, mainly because of the targets set. However, a review of the indicator definition shows that all private sector actors, such as equipment manufacturers, fertilizer companies, seed companies, and other projects and local partners (NGOs/CBOs/FBOs), can be counted once there was a clear and written agreement to work together to achieve a common objective. In this context, ATT has established strong relationships with the various private sector stakeholders and signed agreements with 80 such establishments between FY14 and FY16. In FY17, 43 new partnership agreements (made up of nine new LIPs or NGOs and 34 registered seed producers) were signed to help achieve the project's goals. One Memorandum of Understanding was signed in the fourth quarter of FY18 with the Faculty of Agriculture and Faculty of Agriculture and Communication Sciences of UDS to support 31 students to complete their studies.
Ind. 2.2 – Number of technical publications made available for public dissemination (Ind. 2.2)	0	44	49	111.4%	ATT exceeded this target in its first two years due to the wide range of training materials it developed. In FY14, ATT produced 20 training guidelines for use and also facilitated the drafting of the <i>National Seed Plan</i> and the <i>Seed Guide</i> . In FY15, ATT finalized the <i>National Seed Plan</i> and the <i>Seed Guide</i> and also developed three fieldbooks, three handbooks, three flipcharts, and three posters on maize, rice, and soybean. A Senior Soil Scientist on the project (Sampson Agyin-Birikorang, PhD) also published a paper titled: "Understanding the Scientific Basis for the Urea Deep Placement (UDP) Technology," while ATT's Communications Specialist embedded in SARI published scientific articles, including "Basic Steps in Seed Inoculation," in a Soil Health Newsletter. Six (6) additional technical papers have been produced by Agyin-Birikorang and Shaibu Bani Azumah, including a power thresher operation manual in FY16. In FY17, six more additions were made, resulting in a cumulative achievement of 49, representing 111.4.8% of the LOP target.

USAID-FTF-ATT Objective, Results and Indicators	Baseline Value	LOP Target	LOP Target Achieved	% of LOP Target Achieved	Deviation Narrative
IR 3: Increased efficiency of targeted agricultural research to develop, release, and communicate technologies that support sustainable agricultural productivity					
Sub-Intermediate Results and Indicators					
SIR 1.1 – Increased capacity and competitiveness of Ghana’s seed sector capable to produce or access from outside Ghana high-quality certified seed					
Ind. 1.1.1 – Volume and value of seed (rice, soybean, maize) available for northern Ghana, as a result of USG assistance		5,760.61	11,810.75	205.03%	This yield data was compiled by the ATT Seed Team, based on the seeds mobilized and processed by GSID/MOFA and the three private seed companies supported to process seed. This overachievement is largely due to ATT’s support to the 142 seed producers it works with.
Maize (mt)	381.4 mt		5662.68		
Maize (\$)	262,184.10		9,010,894.55		
Soy (mt)	278.56 mt		1777.46		
Soy (\$)	191,496.20		2,698,161.23		
Rice (mt)	589.63 mt		4371.61		
Rice (\$)	368,526.90		5,841,239.40		
Ind. 1.1.2 – Number of MSMEs, and others registered and are producing seeds (certified and foundation)	0	116	142	122.41%	ATT supported 142 seed producers to undertake seed production.
SIR 1.2 – Increased demand for market and technology information on seed and ISFM through ICT mechanism					
Ind. 1.2.1 – Number of farmers, and others accessing market and technology information on seed, ISFM and general agricultural practices through ICT mechanisms	Video Screening (0)	100,000	119,347	119.3%	The ATT project employed various strategies to ensure that farmers have access to information on improved technologies. These strategies include the use of Video Vans and Digital Classroom devices to disseminate market and technology information on seed, ISFM, and GAPs to farmers. The project supported Modern African Productions to produce and broadcast a television series (Kuapa1) targeting smallholder farmers. Research by Geopoll (http://blog.geopoll.com/november-tv-audience-size-ghana) shows that GTV had an average of 356,000 viewers per half-hour. Radio talk shows that were organized also reached a 1,278,775 listenership, resulting in a total of 1,634,775 via radio and television. Kuapa has recently developed three additional series that are being shown on GTV. Hence, the project has far exceeded the LOP target for this indicator.
	Radio & TV Shows (0)		1,634,775	1634.8%	

USAID-FTF-ATT Objective, Results and Indicators	Baseline Value	LOP Target	LOP Target Achieved	% of LOP Target Achieved	Deviation Narrative
Ind. 1.2.2 – Number of field trials implemented by privately owned/operated seed companies and other partners receiving USG assistance	0	100	189	189.0%	Due to ATT's commitment to aggressively test and make available improved technologies that are suitable to the Savannah agro-ecological zone, it has undertaken and/or supported a number of field trials in collaboration with SARI, UDS, IPA/IFPRI, IITA, seed companies, etc. These included crop varietal testing, UDP/FDP, ISFM, rhizobial inoculation, intercropping, minimum-tillage, among others. In FY16, the project assisted over 50 seed companies/growers to produce certified seeds. As part of the grant agreement, seed companies were required to establish demonstration plots (0.25 acre) for every 10-acre seed farm to showcase the potential and viability of the seed to community members. As a result, 103 such fields were established across the three regions by these private companies, leading to an overachievement of the LOP targets.
SIR 1.3 – Effective advocacy by a well- organized seed and fertilizer Industries					
Ind. 1.3.1 – Number of policies/ regulations/administrative procedures in each of the following stages of development as a result of USG assistance in each case:	0	5	5	100.0%	ATT, in collaboration with the Directorate of Crop Services, the Scaling Seed and Technologies Partnership (SSTP) and the Agricultural Policy Support Project (APSP), facilitated the development of a <i>National Seed Plan</i> . The plan, which has an objective to formulate actionable items from the National Seed Policy document that passed through Parliament in 2013 and officially launched in June 2014, has been finalized and approved for implementation by MOFA. ATT also worked to draft protocols on variety registration. In addition, ATT collaborated with APSP to build the technical capacity of the National Agriculture Research Organizations (NAROs) and seed companies to enhance the process of releasing materials for expanding availability of improved seeds, including implementation of a crop variety licensing agreement.
Stage 1: Analyzed			2		
Stage 2: Drafted and presented for public/stakeholder consultation			2		
Stage 3: Presented for legislation/decreed					
Stage 4: Passed/approved					
Stage 5: Passed for which implementation has begun			1		
SIR 1.4 – Increased dissemination of ISFM technologies					
Ind. 1.4.1 – Number of private enterprises, NGOs, sector actors, etc. promoting new technologies	0	250	253	101.2%	This included all the local implementing partners selected and engaged to promote improved technologies in communities across the three regions.

USAID-FTF-ATT Objective, Results and Indicators	Baseline Value	LOP Target	LOP Target Achieved	% of LOP Target Achieved	Deviation Narrative
Ind. 1.4.2 – Number of links between international and local companies that result in accessing new technologies	0	25	25	100.0%	The ATT project has been sponsoring the participation of the National Seed Trade Association of Ghana (NASTAG) members in the African Seed Trade Association (AFSTA) Congress every year. In 2014 and 2015, the congress was held in Tunisia and Zimbabwe, respectively. These fora have provided NASTAG members the opportunity to establish links with their international counterparts, and they have begun exchanging information, goods, and services. The 2017 congress was held in Senegal, during which NASTAG members used the opportunity to strengthen links already established and also established two additional links.
SIR 2.1 Improved control mechanisms for seed certification and varietal release processes functional					
Ind. 2.1.2 – Number of seed testing laboratories set up to facilitate seed testing and certification	0	3	3	100.0%	The project constructed and equipped three regional seed laboratories and trained technicians on how to use and manage the facilities.
Ind. 2.1.3 – Number of Seed Processing Plants established to enhance seed quality	0	3	5	166.7%	In FY16, three seed processing machines purchased through the Grant Program’s matching grant mechanism were delivered to three private seed companies (Heritage Seed Company Ltd, Ariku Company Ltd, and Antika Company Limited) in Northern, Upper East, and Upper West regions, respectively. Two additional machines were procured and submitted to Ganorma and Integrated Water & Agricultural Development Ghana Limited (IWAD) in the fourth quarter of FY17. These machines have been installed and are being used to process seeds.

USAID-FTF-ATT Objective, Results and Indicators	Baseline Value	LOP Target	LOP Target Achieved	% of LOP Target Achieved	Deviation Narrative
SIR 3.1 Increased number of seed and ISFM technologies developed and released					
Ind. 3.1.1 – Number of technologies or management practices in one of the following phases of development:					<p>In FY14, the project collaborated with SARI to test maize and rice varieties from Brazil, China, and India. These varieties were in the research pipeline and being studied for possible release in Ghana. The maize varieties included CZH04008, CZH079, JH1204, SHS 5550, SHS 5560, SHS 5090, BM 820, BM 207, IND-C3-SYN F2, TZE-WPOP DT SRT, DT SYN-1-W, TZE YPOP STR DT C4, GM 1, GM2, INDAM 7 and INDAM 8, and the rice varieties were INDAM 100-001, INDAM 100-012, DAM 100-022, GR 1, GR 2 and GR 3. In FY15, the project focused on only eight varieties – three studied in FY14 (CZH04008, CZH079 and JH1204) and five new ones (CZH0928, MH1466, CZH04032, MS1 and MH1463). In FY16, three (MS1, MH1463 and MH1466) of these eight varieties were selected and planted for the final round of testing required in the release process. However, due to harsh weather conditions, the fields could not be used for the release process. SARI re-planted the seeds for possible release in 2016 by Ghana’s National Variety Release Committee. Three of the maize seed varieties were released for use in April 2017. The strategy to focus on only a few select varieties for release resulted in the team’s inability to achieve the expected target. In 2017-2018, ATT focused on scaling released seed varieties for regional markets. The project also introduced UDP technology for maize, inoculation, and liming in soybean, and a new rice thresher for farmers in the Savannah Accelerated Development Authority (SADA) zone.</p>
In Phase I: Under research as a result of USG assistance	0	7	0	0.0%	
In Phase II: Under field testing as a result of USG assistance	0	44	27	61.4%	
In Phase III: Made available for transfer as a results of USG assistance (FTF Indicator # 4.5.2-39)	0	15	3	20.0%	
SIR 3.2 Improved technology communication for dissemination capacities					
Ind. 3.2.1 – Number of conferences, forums etc. attended by project partners with USG assistance.	0	20	23	115.0%	<p>The ATT team provided support to various actors to participate in a number of conferences and forums to increase knowledge sharing, exchange and learning. Notable among them were the Pre-Season and Pre-Harvest events it organized annually in collaboration with the Ghana Agricultural Development and Value Chain Enhancement (ADVANCE) project and other stakeholders. These provided opportunities for producers, private sector actors, civil societies, and government agencies to share information and establish linkages. Others included assistance to staff of these agencies to attend both local and international conferences. In FY18, the project supported various actors to attend two different conferences/forums. These were (1) Fall Armyworm Management, A Critical Global Food Security Threat in Africa, Benin, February 13-15, 2018 and (2) 2018 Pre-Season Event, Tamale, Ghana, March 21, 2018, in addition to the Northern Ghana Seed Platform and National Seed Forum.</p>

USAID-FTF-ATT Objective, Results and Indicators	Baseline Value	LOP Target	LOP Target Achieved	% of LOP Target Achieved	Deviation Narrative
SIR 3.3 Increased knowledge and capacities on plant biotechnology development and biosafety guidelines					
Ind. 3.3.1 – Number of communication messages on plant biotechnology produced	0	9	7	77.8%	Three media practitioners who participated in a biotechnology workshop facilitated by Iowa State University in FY15 produced communication messages and shared via radio, newspaper reports, emails, etc. These included: (1) The relevance of Biotech and Biosafety-Cowpea Production, (2) Relevance of Genetic Engineering in Agriculture, and (3) National Biosafety and Institutional Biosafety Committee Collaboration in Biotech Research. Four more news bulletins filed by video journalist Noah Nash of ViaSat 1 Television Station who attended the biotech communications seminar-workshop in August 2015 were also published. In addition to the communication messages, ATT assisted the SARI communication unit to produce a documentary on biotech cotton in FY16.
Ind. 3.3.2 – Number of farmers, processors or others who received information on biotechnology	0	4,075	Over 6 million		These messages were aired on community and national radios, such as the Ghana Broadcasting Corporation (Ghana Today News), which has a listenership of about 6,000,000. Hence, the target for this indicator has to be reviewed. We far exceeded our LOP target of 4,075 farmers.

D. Communication and Outreach

Throughout the project, ATT facilitated media publications (print, online, and television) on its agricultural development activities. The media outreach further disseminated improved technologies and enhanced the image of USAID and the project. During 2017-18, the project expanded its social media presence with active Twitter (www.twitter.com/ifdctamale) and Facebook (www.facebook.com/ifdctamale) accounts that documented project activities.

In addition, informational bi-weekly bulletins were submitted to USAID outlining the project's key activities, results, and when possible, impact. The project also produced and submitted numerous success stories on the project's activities and beneficiaries (many of which are presented in this report and available at www.ifdc.org).

The project supported several networking forums, including Northern Ghana's Annual Preseason Event, which brought together farmers, seed producers and companies, agro-dealers, processors, transporters, farm equipment vendors and services providers, and financial institutions across Ghana to forge partnerships and establish market linkages. Conferences and workshops, including the 2018 Northern Ghana Soils and Fertilizer Forum and the National Seed Value Chain Business Networking Forum, were held to further disseminate agricultural technologies and research and facilitate dialogue among stakeholders.

ATT published several journal articles, fact sheets, and production guides on maize, rice, and soybean. See Annex 7 for a list of ATT technical publications.

To assist the emerging private sector seed industry, ATT produced a seed production guide, *Principles and Practices of Seed Production*, written by Cletus Achaab, ATT senior seed industry advisor, in 2018. The manual will serve as a guide to seed producers throughout Ghana and will facilitate the standardization and quality assurance of foundation and certified seed for years to come.

E. Project Management

IFDC recruited a team of experienced, highly specialized and recognized staff who utilized their local and international expertise to meet the needs of the project beneficiaries as well as deliverables as enshrined in the cooperative agreement with USAID. The Chief of Party (COP) was both the technical and administrative head of the project, supported by a deputy and four other key staff. The core team was based in Tamale.

Though the project experienced a high rate of transitions of leadership (COPs), this did not adversely affect the overall project functioning and delivery of outputs on time. The highly motivated field-level staff, with strong support from the divisional office based in Ghana and headquarters of IFDC, ensured that the momentum was always maintained.

Technical services provided by ATT's experienced and specialized sub-awardees, ISU

and CDI, also ensured that results were achieved and reported in a timely manner.

There were 35 core staff members in addition to the staff of the sub-awardees and local partners who were directly involved in the project implementation. The project also engaged 30 local organizations as extension partners (see a list of LIPs in Annex 2) in disseminating project interventions.

The project established two satellite offices, embedded at regional MOFA offices in Wa and Bolgatanga, to provide better guidance and coordination with local implementation partners, local nucleus farmers, and agro-dealers, while working more closely with MOFA and sister FTF projects in the Upper East and Upper West regions.

Project management closely focused on delivering all expected results in a timely manner and within the award budget. Almost 98% of the project activities as outlined in the original proposal were ably completed in November 2018. This was done within the obligated budget, an indication that expenditure was efficiently tracked.

Management maintained a strong relationship with the donor and other FTF projects through frequent engagement and full participation in all donor-led initiatives, such as the implementing partners' meetings, learning events, etc. Other ways through which ATT kept the donor informed and coordinated with other FTF projects included the following:

- **Biweekly Updates to USAID:** Every two weeks, the project updated USAID with brief

reports, pictures, and upcoming events on the various activities being implemented in the zone of influence. The updates were also shared with project staff, partners, and other FTF projects.

- **Inter-Project Collaboration:** COP meetings of FTF projects (including ADVANCE, GCAP, RING, APSP, AFRICA LEAD, and SPRING) were held on a regular basis. Key outcomes were a consensus on shared indicators, a willingness to work together while avoiding duplication, sharing grant information to avoid duplication, and better coordination of activities to avoid potential “double dipping,” especially in documenting

project benefits and outputs. Another important outcome is that M&E and communication specialists of the projects met on a regular basis to share experiences and work together on sharing measurement of project results and lessons learned, thus creating “learning,” a key component of the Monitoring, Evaluation and Learning (MEL) activities. There was also a subcommittee on grants, which regularly was able to track, oversee, and ensure complementarity in funding.

- Throughout the year, the project facilitated various media (print, online, and television) publications on the entire component of the

project to further enhance the image of USAID. There were media visits to some of the project areas to report on successes emerging from various activities.

- ATT regularly hosted donors, partners, and government officials visiting to learn about project activities. For example, in 2018, a delegation of congressional staff, through the CSIS Global Food Security Project, visited the ATT office in Tamale during a tour of USAID-funded projects in Ghana.¹⁵

The overall organogram with its core structure for the life of the project is given in Figure 15.

¹⁵ “Feed the Future in Ghana: Promising Progress, Choices Ahead” – A trip report of the CSIS delegation to Ghana: https://csis-prod.s3.amazonaws.com/s3fs-public/publication/180614_Cooke_FeedFutureGhana_Web.pdf?CPwCm0L1uzTok5ZGWv0ZGgz5TMwLD4H9

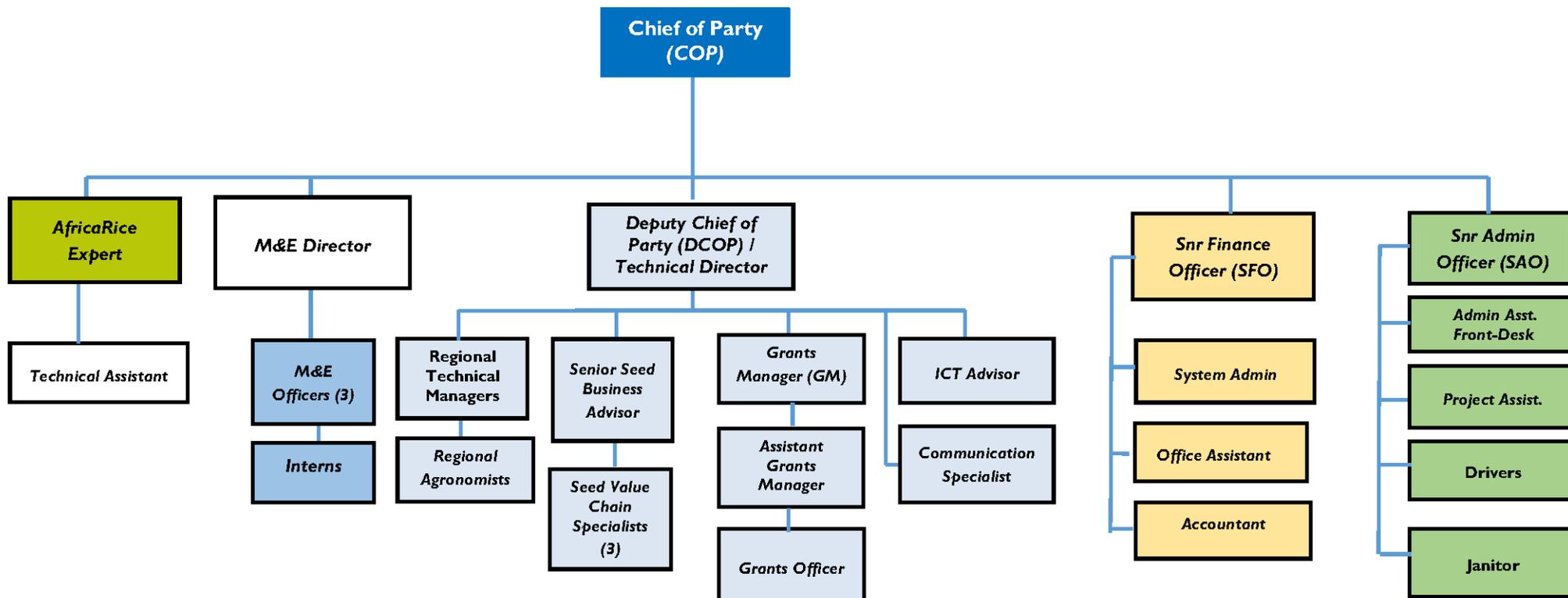


Figure 15. Project Organogram

Lessons Learned and Way Forward

This section highlights lessons learned by the project to guide future initiatives supported by USAID. Multiple stakeholders, who were a part of implementing ATT program initiatives, were engaged through a series of learning and dissemination workshops and events conducted toward the end of the project to share their experiences and to discuss and develop plans to sustain the momentum created by the project through key recommendations. Such lessons were compiled during workshops held in Wa, Bolgatanga, and Tamale during November and December 2018. *See Annex 8 for a full report on the lessons learned workshops.*

The following are a set of lessons learned and recommendations that emerged around the key sectors and interventions associated with ATT.

A. Seed

Seed Market: Due to farmers' longstanding mistrust in the quality of certified seeds, continuing efforts are required in promoting their use in the zone of intervention. The market for certified maize seed is still emerging and is dominated by a single open-pollinated variety in the case of maize; still, opportunities are available for expansion and for the use of hybrids and other varieties that address biotic and abiotic stresses faced by smallholder farmers in the northern regions. The project also was able to demonstrate the suitability of inclusion of other crops into the system to suit different agro-

ecological environments. While the project has invested in technologies and infrastructure to increase demand for and use of certified seed, these efforts must be sustained with follow-on activities.

Farmer Uptake: In the past, certified seeds were not typically available in a timely manner due to poor accessibility, with distance as the major constraint, along with poor seed quality issues due to lack of proper seed testing facilities. ATT tackled this by upgrading seed processing and quality control facilities in the region and improved farmer accessibility to quality seeds by introducing mobile seed vans that served as an effective means to bring certified seed to the doorsteps of farmers living in remote communities.

Recommendations:

- For measurable impact or transformation, interventions must target the whole system, along with its actors, rather than just one aspect of the value chain. For example, promoting the use of certified seed must not only focus on the users; it must start with researchers and breeding agencies.
- Through infrastructure and logistics support to research and regulatory institutions, ATT removed bottlenecks in the development and release of certified seeds. The foundation has been set for these institutions to provide enhanced seed varietal development, release,

and inspection services, but continuing efforts are needed to further increase their effectiveness and efficiency.

- In addition, the Seed Inspection Division of MOFA should be decentralized and resourced to strengthen the monitoring functions at the divisional level.
- ATT enhanced the capacity of local seed companies and LIPs to distribute seeds to last-mile customers using mobile seed vans and trained community sales agents. These efforts increased farmers' access, built farmer demand, and strengthened business for local companies. More vans are needed to further assist retailers to travel to hard-to-reach communities. This can be enabled by designing proper financing mechanisms through innovative partnerships. Moreover, additional seed laboratories at the district level could reduce transportation costs for seed producers and LIPs.
- ATT engaged the private sector to produce certified seed in a timelier manner by helping them access modern seed processing equipment. Financing mechanisms can help additional seed processor procure new seed testing and processing equipment to replace obsolete ones.

B. Soil

Soil Testing: ATT realized that farm-level soil testing supported by nutrient management decision support tools often resulted in higher yields. Yet, there is a need to develop such capacities in the region, particularly to enable extensive soil mapping that includes secondary and micronutrients in addition to major nutrients (N, P, K), that should be supported by specific crop-level fertilizer recommendations. Infrastructure is needed in terms of either establishing new soil testing labs or upgrading existing facilities with new technology and tools.

UDP: Time-lapse photography from drone-based research has shown that rice fields using UDP application attained faster growth and maturity and also resulted in higher yields compared to non-UDP field plots. Despite these benefits, inadequate access to briquetting machines remains a constraint to farmer uptake of this technology at a larger scale.

Recommendations:

- ATT promoted soil sampling and analysis as a basic first step in farming. Greater access to simple soil testing methods is needed. For example, soil test labs should be established at the district level to make the service accessible to all farmers.
- Training of agriculture officers and farmers in soil mapping should be expanded and sustained to provide location-specific fertilizer recommendations.

- It is important to promote urea briquetting as a key entrepreneurial activity across local communities to improve the uptake of products and thus adoption of the UDP method. UDP briquettes also are proven to be more efficient compared to traditional nitrogenous fertilizers, such as ammonium sulfate.
- Still, a huge knowledge gap exists among farmers in understanding the availability of fertilizer types and recommendations and the quantity and timing of their application. This warrants more capacity building and knowledge transfer mechanisms.
- Fertilizer blending companies should be encouraged to supply site-specific fertilizers to various regions and districts in order to promote balanced fertilization among farmers.

C. Water

Double Cropping, Dual Income: Dry season farming using rainwater harvesting technology is a major strategy for increasing farmers' incomes and helping them move out of poverty. Double cropping is particularly effective when the first crop is maize and the second crop is a high-value vegetable, such as pepper. More research is needed on different forms and scale-up of water-harvesting technologies, such as PAVE and Bhungroo technology, that will make second cropping a possibility in northern Ghana.

Recommendations:

- Water harvesting and storage technology should be further explored and expanded/scaled up to more farming areas and communities. The Department of Agriculture should promote expansion of the Bhungroo and PAVE technology.
- A program for organizing farmer groups or associations to make efficient use of the Bhungroo and PAVE technology is one option for scale up.
- Women can earn extra income and increase family-level nutrition through the production and sale of vegetables grown using water-harvesting and small-scale irrigation methods that facilitate dry season farming. Any future award of grants in this area should be gender-sensitive to capitalize on these benefits.

D. Technology Dissemination

To increase farmer demand for and adoption of new technologies, multiple approaches and broad-based information dissemination methods that inspire behavior change are needed. In all ATT-based interventions, state-of-the-art dissemination mechanisms using ICT tools were employed to reach a maximum number of farmers in a short period of time and at a lower cost.

ATT moved from reaching hundreds of farmers through traditional field days to thousands of farmers in remote communities through the integrated use of ICT as a technology dissemination mechanism. One of the key

ICT-based tools, viz., video screening, was used to reach farmers with agricultural extension information across rural communities in Northern Ghana. Also included were the use of e-extension, radio broadcasting, enhanced ICT capacities of research institutions, drone technology for crop evaluations, etc. All ICT extension efforts were focused on reaching the last-mile clientele – small farm households.

E. Partnerships for Sustainability

In order to ensure sustainability of ATT-based interventions, even after the end of the project, ATT activities focused on developing three types of key partnerships from the beginning:

- i. **Partnerships with local communities and stakeholders for implementation purposes.** Working with LIPs who already had a local presence in their operational areas further strengthened the implementation of project interventions and also ensured sustainability after the project ended. The involvement of key local stakeholders in project activities is therefore key to knowledge generation, adaptation, and thus overall adoption.
- ii. **Public-private partnerships.** Strengthening partnerships among key

stakeholders and capacity building in critical areas are prerequisites for sustaining the momentum set by the project.

- iii. **Partnerships to ensure government support.** It is important that the priorities of the host country are synchronized with project objectives. When the priorities are disjointed, it affects the level of buy-in and impedes smooth implementation of activities that require national support by the host agency.

F. Project Management

Maintaining a core project team speeds up delivery. Higher staffing turnover, especially at the management level, results in changes in vision and strategic direction, which can slow the pace of implementation. Efforts must be made to maintain a core intact team so there is not a lag in project implementation. Another key is decentralized management through local implementation and partnerships.

G. Gender

Improving value-added skills through better crop management practices and creating better business opportunities (e.g., GAPs training, line transplanting, and fertilizer application and irrigation) at three different levels – targeting

women farm **laborers, farmers, and entrepreneurs** – resulted in increased incomes and enhanced their skills and knowledge.

H. Climate Resilience

Weather uncertainties, with delayed onset and earlier withdrawal of rains and uneven rain distribution, have greatly influenced the cropping systems and calendar in the areas where ATT was in operation. Any interventions or technologies must therefore offer climate-smart and resilience approaches that adequately respond to weather uncertainties. ATT activities focused on the efficient use of inputs, such as introducing drought-tolerant crops and varieties into the system, through research and technology transfer; soil fertility-enhancing and efficient technologies such as UDP; and water conservation measures through the introduction of dry season farming using rainwater harvesting.

I. Finance and Grants

ATT extended grants or facilitated direct financing for selected projects that enabled the development of crucial infrastructure and technical capacities for the agriculture sector. Future grants and financing mechanisms should be well targeted and further build private sector capacity and investment.

Annexes

- Annex 1. ATT Indicator Dashboard and Performance Summary
- Annex 2. ATT Local Implementing Partner Database
- Annex 3. ATT Starter Pack Assessment
- Annex 4. Working Paper – ATT’s Double Cropping Dual Income Strategy
- Annex 5. Working Paper – ATT’s Capitalization of Technology Dissemination Using ICT
- Annex 6. ATT Grant Database
- Annex 7. ATT Technical Publications
- Annex 8. Report on ATT Lessons Learned Workshops

