Fertilizer Sector Improvement (FSI+) in Burma

PROJECT COMPLETION REPORT

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Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ASEAN	Association of Southeast Asian Nations
CFA	Cooperative Framework Agreement
COP	Chief of Party
DAR	Department of Agricultural Research
DOA	Department of Agriculture
DZ	Dry Zone Agro-Input and Farm Services Project
EIRR	Economic Internal Rate of Return
FAW	Fall Armyworm
FSI	Fertilizer Sector Improvement. A project funded by USAID
FSI+	Fertilizer Sector Improvement. A project funded by USAID – extended and expanded
FTF	Feed the Future
GAP	Good Agricultural Practice
GFSS	Global Food Security Strategy
GDRI	Group of Development Research and Index
GUoM	Government of the Republic of the Union of Myanmar
ha	hectare
IFC	International Finance Corporation
IFDC	International Fertilizer Development Center
IRRI	International Rice Research Institute
kg	kilogram
LIFT	Livelihoods and Food Security Fund
LUD	Land Use Division
M&E	Monitoring and Evaluation
MOALI	Ministry of Agriculture, Livestock and Irrigation
MOU	Memorandum of Understanding
MSU	Michigan State University
mt	metric ton
NGO	Non-Governmental Organization
PERSUAP	Programmatic Pesticide Evaluation Report and Safer Use Action Plan
PPD	Plant Protection Division
PPP	Public-Private Partnership
TAF	Technical Alliance for Farmers
UDP	Urea Deep Placement
USAID	United States Agency for International Development
USG	U.S. Government
YAU	Yezin Agricultural University

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Project Completion Report

Executive Summary

The five-year Fertilizer Sector Improvement (FSI+) project initiated in 2014 led the way for USAID interventions in the agricultural sector of Myanmar. Over two-thirds of the country's population is engaged in agriculture, which is dominated by small-scale farming. As implemented by the International Fertilizer Development Center (IFDC), the project contributed to building a strong and resilient food and agriculture system that can have a transformational effect on people's lives. It achieved that by improving incomes equitably and by enhancing food security for small-scale farmers in target districts of the Delta and Shan regions.

The approach focused on increasing production and income from crops in rice-based farming systems and on building the capacity of agricultural input and other service providers to supply and advise farmers. The guiding mantra was to harness the power of science, technology, innovation, and markets to improve food and agricultural system practices dramatically and sustainably. Such advances were tailored to promote more inclusive income growth for empowered small-scale farmers so they can benefit from the country's economic progress.

The initial FSI plan concentrated on introducing the technology of urea deep placement (UDP) to smallholder rice producers as a more cost-effective way to fertilize their fields and achieve higher yields. The practice of applying urea briquettes near the root level instead of broadcasting the fertilizer had proven successful in Bangladesh and some African countries. IFDC thought UDP could be a breakthrough for the rice farmers of Myanmar as well. It was thought they would rapidly adopt the technology and spread it exponentially. That proved to be a miscalculation because of the larger size of farms and the shortage of labor available to hand-place the briquettes.

While not abandoning the UDP concept, the United States Agency for International Development (USAID) and IFDC wisely adjusted the strategy after two years to address more broadly soil degradation and other obstacles impeding farmer progress. The agricultural system in general had languished under 60 years of military rule and the concurrent lack of direction

in the government agencies assigned to help farmers. Seeing the need and opportunity, USAID agreed to extend the project from three to five years and to increase the budget to an eventual $7.05 million total.

The first step in the project pivot involved expanding the range of field trials to discover the best seed-fertilizer-soils combinations. The information helped fill the existing research gaps and was continually updated through more trials and seasonal crop cuts. The project organized staff specialists and non-governmental organization (NGO) partners to show farmers the results of UDP. The training modules and over 300 field demonstrations were then expanded to all aspects of the cropping system and best practices to achieve increased yields and profits. The research-extension interface enabled FSI+ to find answers to questions from farmers through trials in the next season and to tailor training to their interests and needs. This in turn helped capture and establish the enduring impacts of the site-specific integrated soil fertility management strategy.

In addition, IFDC entered into a partnership with Syngenta. This enabled the project to capitalize on USAID's global agreement with Syngenta and obtain cost-sharing for joint training of retailers and field demonstrations for maize farmers in southern Shan State.

To meet the expected demand for high-yielding varieties of seed and more balanced fertilization, project staff recruited small and medium retailers of agricultural inputs in the project zones and trained them on both technical aspects of agricultural inputs and the management and marketing tools that would help grow their businesses. The project ensured that about 40% of selected farmers and almost half of recruited retailers were women, because they were enterprising and would be instrumental in transforming rural quality of life.

Over the five years of implementation, the FSI+ project:

- Trained over 13,000 farmers, more than one-third of whom were given refresher courses.
- Reached another 5,000 farmers through field days and organized visits to model farms.
- Encouraged trained farmers to share information with their neighbors, of whom an estimated minimum of 17%, or 2,500, adopted improved technologies.
- Trained 345 agro-input retailers who in turn educated and encouraged their clients in modern inputs and good practices. At least 25%, or over 50,000 farmer customers, have adopted improved technologies as a result.

A rigorous monitoring and evaluation (M&E) system employed independent household surveys and used crop cuts to assess progress by the trained farmers, who are regarded as "direct beneficiaries." Those in the second category above who participated in other project activities are considered "indirect beneficiaries" in the official terminology.

Except for the activities and results indicators related to adoption of UDP, the project met or exceeded all the targets for activities and for the economic returns for farmers, measured by gross margins. They are defined as the value of production minus the cost of inputs. According to the survey results from the Project Impact Report submitted in August 2019:

- Gross margins increased by 28% for wet season rice and 18% for the dry season crop against the target increases of 15% in each season.
- The impact on households was an average annual net income increase of $890 per farm, with 50% of this attributed to FSI+.

Beyond the positive economic impacts for farmers and retailers, the project team set the stage at multiple levels for sustained progress and for resilience in the face of likely shocks and stresses. Disaster-prone, Myanmar is one of the most affected countries by climate change. Its farmers also face shocks from policies and trade barriers. FSI+ helped strengthen the capacity of individuals, institutions, and governments. It improved the quality of data and research. In short, the project contributed to the pipeline of innovations, tools, and approaches designed to improve agriculture and food security – and to help reduce susceptibility to food crises.

The U.S. Government Global Food Security Strategy (GFSS) states that "scaling requires promoting the diffusion of adoption beyond direct beneficiaries of development interventions. We will do this by working with delivery pathways (public and private) to demonstrate value and make technologies available."

FSI+ accomplished this by:

- Convincing a nucleus of farmers that good agricultural practices are profitable.
- Developing a cadre of agro-input dealers who form a strong private sector-led value chain that will provide the supplies and services that farmers need because it is good business.
- Training and engaging public extension and research staff so they are better informed and motivated to help farmers adopt good practices and adapt to changed conditions. The project introduced *extension informed by data* through its research to update best practices.

- Helping design and implement research investments that anticipate and treat recurrent shocks and stresses as perennial features, not as unanticipated anomalies.
- Organizing an influential national conference and producing studies and a strategy for the government to advance soil fertility and fertilizer management. Ministry officials respect and appreciate the project's help, including on UDP, and they are using the strategy to guide the agricultural research masterplan. As a result, soil fertility is now a top priority.

The USAID Mission asked the project to respond to the impending threat of a fall armyworm (FAW) infestation of the maize crop in 2019. The FSI+ team mobilized its network of retailers, relationships with the Department of Agriculture (DOA), companies producing and supplying inputs, and the confidence of farmers built over the years. As a result, the project was able to respond swiftly and cost-effectively to the threat. The coordinated plan of action and prepared platform supports the GFSS IR 5: Improve proactive risk reduction, mitigation, and management.

The initial project proposal focusing on UDP was ahead of its time. Everyone involved learned a valuable lesson about trying to replicate a successful approach without fully understanding local conditions and constraints. Fortunately, USAID enabled the project to change course. Being flexible and adaptable to new opportunities is another important lesson and one that will be applicable to future projects when adaptation to shocks and stresses will become the norm. Of course, critical factors in successful project implementation hinge on the caliber and dedication of the leadership and staff – and their ability to discover, develop, and deploy what will make a difference in farmer livelihoods.

Despite the impediments and disappointments, IFDC and the project did not abandon the concept of UDP as an eventual breakthrough for Myanmar rice and maize farmers, some of whom are continuing to apply it. Recognizing the need for mechanization, especially for deep placement of fertilizer whether in briquette or prilled form, FSI+ entered informal partnerships with John Deere and an Indian firm. The project engineer worked with them and local machine shops to design prototype seed and fertilizer applicators that could be produced commercially at affordable prices. There is expectation that the working models today will be on the market within a few years and thus open the way for an eventual UDP take-off.

Based on the FSI+ and Dry Zone project experience, IFDC recommends that USAID and other donors continue to support small-scale farmers in the production of rice, maize, and alternative

crops. Many improvements are required – from land preparation to good seed and balanced fertilization to post-harvest drying and processing. Myanmar farmers should be able to achieve yields and quality of rice that match their counterparts in Southeast Asia.

In conclusion, the FSI+ project pioneered and helped embed new and improved technologies and a private sector-led delivery mechanism. They hold promise for the rural poor of Myanmar to achieve sustainable income growth and food security.

I. Introduction and Background

Context

After the USAID Mission re-opened in Myanmar in 2012, it began to focus on ways to address pervasive rural poverty and the plight of small-scale farmers, who make up 75% of the farming population. Decades of military rule had isolated the country and led to weakened governmental service programs, such as extension and research that support farmers.

As a result, the most important sector of the economy was characterized by low input-low output. For example, Myanmar farmers did not have access to high-yielding varieties of seed and were using less than 10 kilograms (kg) of nutrients per hectare (ha) of arable land. In comparison, Thai farmers used 162 kg of fertilizer nutrients per hectare. The low level and unbalanced fertilizer application severely constrained rice yields far below those achieved in Thailand and Vietnam.

The key to agricultural and rural development in much of the country was to increase rice yields. In 2013-2014, the net profit from producing monsoon paddy in Myanmar averaged $114 per hectare. That was only one-tenth of the income achieved from a hectare of paddy in China. During monsoon season, one day of work generated only 23 kg of paddy in Myanmar, compared to 62 kg in Cambodia, 429 kg in Vietnam, and 547 kg in Thailand. Comparisons with other crops were similar.

Basically, it meant that farm profits in general were insufficient to raise household income above the regional rural poverty lines. Low labor productivity is the main reason why agricultural wages are some of the lowest in Asia. An agricultural worker in Myanmar earned only $1.8-$2.5 per day during monsoon season and $3.0-$3.5 during the dry season. In comparison, a farm laborer in Thailand earned $8.5 per day, and a Philippine farmer earned, on average, $7 per day. The differentials spurred the large emigration of farm labor to other countries of the Association of Southeast Asian Nations (ASEAN).

Myanmar is one of the world's most disaster-prone countries, exposed to multiple hazards, including floods, cyclones, earthquakes, landslides, and droughts. It is also one of the most affected by climate change in the last 20 years, ranking third out of 184 countries in the 2019 Global Climate Risk Index.

The country's leadership was facing a major challenge of how to improve the "productive capacity of Myanmar soils" after years of neglect. The low intensity of fertilizer application

and the unbalanced focus on nitrogen were depleting the other nutrients and organic matter in the soil.

When the government ended the controls on rice production, farmers were free to choose and sell their production mix. However, there were few services to advise them. Government land consolidation and other polices seemed to favor large-scale farming over small-scale.

In 2013 the fertilizer market was estimated to be only 800,000 metric tons (mt) of inorganic fertilizer annually, mainly urea nitrogen. The policies and regulations governing fertilizer were generally conducive to private sector participation, but demand and supply were constrained.

It seemed to make sense for IFDC to propose to the USAID Burma Mission in 2014 an intervention aimed at replicating the successful rice-system UDP project that USAID was funding in nearby Bangladesh. The UDP technology was effective and widely adopted by small-scale farmers in Bangladesh, so it was thought to be readily transferable to the paddy-intensive Delta region of Myanmar.

The USAID-IFDC Cooperative Agreement of 2014

The proposed FSI project would directly support the USAID Burma food security objective of increasing the productivity and incomes of small-scale farmers. The USAID program planned to invest in research; improve nutritional outcomes; expand farmer access to agricultural inputs, finance, and markets; build capacity of the public and private sectors; improve agricultural education; and support sustainable natural resource management.

USAID approved the IFDC unsolicited proposal as the first agricultural project since the Mission re-opened in 2012. The USAID Administrator announced the award of a $3,845,000 grant to IFDC during his visit to Myanmar in February 2014.

The goal of the three-year project, called Fertilizer Sector Improvement (FSI), was to increase profitability and enhance food security for small-scale farmers in target districts. IFDC produced an initial assessment report in June 2014 that directed project focus on major rice-growing townships in three regions in the Delta zone, where 60% of total rice is produced under paddy monoculture. The report also prescribed field trial sites and protocols for the 2014 wet season.

IFDC planned a market-oriented approach to agricultural input technology dissemination, which initially focused on the introduction of UDP technology into the country. From the

beginning IFDC planned to engage commercial input dealers and NGOs as partners. A separate IFDC study analyzed the agro-input supply system and identified importers and retailers.

UDP is extremely well-suited to rice production and has demonstrated good results in other crops, such as horticulture and maize. UDP involves point placement of a large size (1.8 to 2.7 grams) urea briquette at a depth of 10 cm near the root zone of the plant. On average, farmers can realize an increase of 500 kg of rice per hectare while using less fertilizer. The benefit from UDP is its more efficient use of nitrogen. When urea is broadcast onto the surface of a paddy field, as much as 70% of the nutrient content is lost to air and runoff. UDP technology reduces "losses" of applied urea by up to 50%. It improves nitrogen use efficiency and offers environmental benefits due to more efficient uptake and reduced runoff and greenhouse gas emissions.

Under the award IFDC was to take a proactive approach to challenges confronting the introduction of UDP and to remain flexible to adapt as needed. This flexibility provision was fortuitous as it allowed the project to adjust as unforeseen obstacles arose that impeded UDP adoption in the Myanmar context of labor scarcity and larger farms.

IFDC was not registered with the Government of the Republic of the Union of Myanmar (GUoM) to operate in the country, so it entered a memorandum of understanding with the International Rice Research Institute (IRRI), which was accredited. Under those auspices the new project was able to hire staff and begin field trials and other operations in time for the May 2014 monsoon season. The Chief of Party (COP) transferred from Bangladesh and jump-started project activities.

FSI+ in 2015 and Beyond

USAID staff was impressed with the rapid launch, positive results coming from UDP field trials, and the identification of input retailers who would be trained as extension resources. In May 2015, about a year after project mobilization, USAID agreed to extend the project life to a little over five years and nearly double the budget to a total of $7.5 million. The project name was amended to FSI+ to reflect the extension through September 2019.

The new cooperative agreement retained the goal and major activities, but it emphasized rice-based farming systems and added a component related to improving the capacity of agro-input retailers to provide farm advisory services. It also expanded the geographic area from 23 to 45 townships and added a new maize pilot activity in southern Shan State to reflect the talks

underway with the Syngenta Corporation for joint work in that area. The initial M&E Plan was revised to accommodate the extension and to incorporate new Feed the Future (FTF) results indicators and definitions.

Annex 1 describes the logical framework for the project.

In October 2015, IFDC signed a public-private partnership (PPP) agreement with the Syngenta corporation for a program on maize production in southern Shan State. Syngenta agreed to contribute $100,000 in cash and kind.

The GUoM registration process was completed with a Record of Discussion signed in May 2015, allowing IFDC to operate officially on its own. It then terminated the arrangement with IRRI. The IFDC-GUoM relationship graduated to a five-year Cooperative Framework Agreement (CFA) signed in October 2017 with the Ministry of Agriculture, Livestock and Irrigation (MOALI). The CFA covered working relationships of IFDC and the FSI+ project with the DOA (and its extension and land use divisions), Department of Agricultural Research (DAR), and the national Yezin Agricultural University (YAU).

Cooperation with MOALI was important to fulfilling project objectives, but it was complicated because of USAID guidance that allowed engagement with, but not support to, government agencies due to broader U.S. policy issues. The CFA required IFDC to report monthly and quarterly on project performance.

In August 2016, the USAID Agreement Officer Representative reviewed the project and made recommendations, the most significant being: "*IFDC should modify project indicators to recognize and capture benefits to producers from all technology innovations and management practices and not limit this to those from UDP. Adoption of UDP should continue to be tracked but as a custom indicator*."

In 2017 USAID had to make program budget cuts that included a $450,000 reduction to the FSI+ project, bringing the total down to $7.05 million. However, in 2019, faced with a growing outlook for a FAW infestation of the maize crop, USAID agreed to provide $200,000 to IFDC. That enabled the FSI+ staff to engage the dealer network and to train and equip farmers in the project zones to combat the threat.

Project Reporting

Under the agreement with USAID, the project staff submitted quarterly reports during the first fiscal year and then semi-annual reports that provided details and analyses of project performance. The COP voluntarily sent weekly updates to the USAID Mission so it would be current on upcoming activities and any issues.

The project produced dozens of reports on field trials, crop cuts, and other activities. IFDC experts prepared assessments, scientific and strategy papers that provided guidance to the project – and to government and private sector actors in Myanmar agriculture. The documents form part of the project legacy, knowledge base – and sustainability. For example, The Myanmar Soil Fertility and Fertilizer Management Conference Proceedings and the follow-up strategy prepared by IFDC in 2018 are being used and implemented by the DAR and DOA.

Annex 2 provides a list of project reports and publications.

In April 2019, the project commissioned a survey to assess economic impact on farmers and the country. A report based on the findings was prepared and submitted in August. It highlights the concrete and measurable outcomes, and it serves as a companion to this project completion report, which is intended as an overview and summary of the project.

II. Project Description

Objectives and Approach

The goal of the FSI+ project was to improve incomes and enhance food security for small-scale farmers in target districts in Myanmar. It would do that by increasing:

- *Production and income from crops produced in rice-based farming systems.*
- *Capacity of service providers to supply and advise farmers.*

The hypothesis, or theory of change, for the project is based on demand and supply and is rooted in the economic interests of farmers and agro-input retailers. Project research activities would help fill the existing knowledge gaps related to soils, seed varieties, and fertilizers – and the site-specific combinations that produced the most cost-effective results. The trials would generate the information needed to conduct field demonstrations so that farmers could observe for themselves the advantages of buying quality inputs and adopting good agricultural practices. The project would then organize training programs and field demonstrations for the

farmers on how the right inputs and farming practices could transform rural incomes and opportunities.

The COP hired qualified and experienced staff and worked with them to implement results-driven, sustainable, and equitable agricultural development. The team of 22 Myanmar staff members was organized around the major project activities, for example:

- Agronomists and soil scientists to undertake field trials.
- Technical transfer, training, and farm advisory specialists supported by four field officers to organize the project and partner training and other field activities.
- A business management specialist and marketing officer to network with and train retailers.
- M&E specialists to monitor and report all aspects of project performance.
- A mechanical engineer to help local manufacturers of briquette machines and lead research and development of mechanical applicators.
- Public outreach officer to provide information about project objectives and activities.
- Administration and grants specialist and accountants to manage the project according to the IFDC operations and financial management policies.

To help promote the conversion from traditional practices and to reach thousands of farmers, the FSI project contracted with seven prospective NGOs that specialized in agricultural consulting. This was planned as an interim measure for reaching farmers until the private sector agro-input retailers could be trained and motivated. The grants to NGOs accounted for about 10% of the total project budget and included the cost of activities they implemented on the project's behalf. Project staff had to devote considerable time for hands-on training to NGO partners in the early years because of their lack of experience in agricultural innovation and in the accounting and reporting that projects require.

The public extension service was widely regarded as inadequate, under-resourced, and more concerned with regulation than education. The project and NGO agricultural specialists had personal connections and relationships with DOA and DAR staff from former employment. They made a point of inviting extension, research, and other field staff to participate in the project training and other activities. The project shared the results of fertilizer and seed trials, seasonal crop cuts, and other research with the DOA and DAR. As a result, they became project cooperators and are now better prepared to promote scientifically recommended and sustainable practices.

Simultaneously, the project was identifying and training small and medium agro-input retailers in both business management and agricultural technical skills. Some were just general shopkeepers who were initially skeptical about taking time to undergo training to expand their agro-input business. But the entrepreneurs among them saw the sales potential of becoming suppliers of the quality inputs and extension and other services the farmers would need and want in order to achieve higher yields and profits.

During the 2018/19 seasons, the retailers were prepared and willing to replace the NGOs as organizers of farmer field days and trainings. The retailers continued to draw on the NGO experts and public extension staff as resource persons for agronomy, soil science, and other technical subjects. With the mechanization evolution in the country, the retailers are well positioned to capitalize on this and offer a range of tractor and other farm services.

Initially, FSI focused on convincing farmers of the value of adopting UDP in their rice fields and assuring retailers of the new business that would accrue from purchasing a urea briquette machine, which the project subsidized. As an introduction to UDP, each trainee farmer received a 10-kg sack of briquettes so they could see first-hand the difference in yield.

Below is an example of initial success on a small farm.

Nwe Nwe Win is a model woman farmer living in Htantabin Township of Yangon Region. In the summer of 2015, she received training from FSI+ and applied her 10-kg sample of urea briquettes. She realized the benefits of UDP and became a demonstration farmer for the project during the 2015 wet season. She then purchased and applied urea briquettes along with high-yielding variety seeds, which produced 6.3 mt of paddy on her 1-hectare farm. The family had enough to feed themselves and a surplus to sell. As production increased so did their quality of life and their investments in livestock, irrigation pumps, and other equipment.

Nwe Nwe convinced farmers in nearby villages to adopt UDP technology. An agricultural NGO in the area noticed her success and began promoting the technology.

As interest in UDP stalled because of the extra labor involved and lack of practical mechanical applicators, FSI+ used the same methodologies to expand its portfolio to *balanced fertilization* and the best seed-soil-fertilizer combinations based on project field research. The principal focus was on rice, where there was and remains much potential for increased yields and quality.

In the wet season, farmers devote 90% of their land to growing rice. In the dry season, there has been a significant shift. Farmers in the project zone have increased their cropped area of

rice in the dry season from 17% to 70%. The reasons include reduced demand for the alternative gram (pulse) crops, and improved yields of rice stemming from better access to motorized irrigation pumping units and to combine harvesters and other equipment. While dry season rice yield potential in the Delta is around 10 mt/ha, only 8% of farmers are achieving yields of even 6 mt/ha because of poor agronomic practices.

The fertilizer market in Myanmar was estimated to be growing at a compound growth rate of 10-15% per year over the previous 10 years to about 1.6 million metric tons in 2016. Despite the rapid growth, the intensity of fertilizer use in Myanmar was only about 25% of the global average. Moreover, farmers were using unbalanced application, with a typical N:P:K ratio of 6.5:1.6:1. Therefore, the project sought to improve fertilizer efficiency by enhancing farmer knowledge of the specific crop and soil nutrient recommendations and the fertilizer products that would best match them.

Myanmar farmers had limited knowledge of modern agricultural technologies, including the critical selection of fertilizers. Additionally, the top-down national recommendations for fertilizer were by crop. Site-specific recommendations were unavailable. According to the World Bank's Agricultural Public Expenditure Review in 2017, Myanmar invested the equivalent of only 0.04% of agricultural GDP in agricultural research. Other Asian countries invested 0.60% of their agricultural GDP in research.

The project therefore undertook research that would help discover and deploy the information farmers needed to invest wisely in fertilizer and seed according to local conditions. The project was able to develop and update critical information for farmers and stimulate the DAR to do more to address the GUoM concern about soil degradation, as noted below.

> "Agriculture sector performance is key to economic growth and food security in Myanmar. Recently, the Government of the Myanmar Republic has engaged in the preparation of numerous strategic action plans and strategy-related documents that target improved agriculture sector performance. Each document identifies soil degradation (problems related to soil erosion, soil fertility, and soil salinity) as a significant concern that must be properly addressed to support sustainable agricultural growth and the government's goal of transforming the agriculture sector."
>
> – *Soil and Fertilizer Management Strategy for Myanmar*, prepared by IFDC in 2018.

FSI also looked for opportunities to leverage its resources by partnering with private companies such as Syngenta on maize and John Deere and others on mechanization. It collaborated with Yoma Bank as it developed agro-dealer finance schemes and had close working relations with large agro-input importers on technical support for retailers.

The project recruited and trained NGOs, retailers, and DOA and DAR staff as partners and multipliers. The training and experience with the project strengthened their abilities and confidence to continue to help farmers and sustain project objectives.

Moreover, they as well as farmers are convinced of the advantages of UDP and will be active promoters of the technology once mechanized equipment is commercially available.

Annex 3 lists the various technologies promoted by the project staff and its partners.

Table 1 summarizes the expected outputs in support of the interlinked objectives.

Table 1. Expected Outputs in Support of Objectives

Goal	Increase incomes and enhance food security for smallholder farmers in target districts in Myanmar	
Objectives	1. Increase production and income from crops produced in rice-based farming systems	2. Increase capacity of service providers to supply and advise farmers
Outputs	1.1. Farmers with crop yield increments and higher gross margins 1.2. Farmers trained in technology innovations and management practices 1.3. Farmers using technology innovations and management practices 1.4. Area of crop under technology innovations and management practices 1.5. Extension methods to promote technology innovations and management practices	2.1. Fertilizer briquette supply chain 2.2. Retailers capable of providing technical information on input use for rice, gram, and, in some cases, maize 2.3. Retailers establishing their own demonstrations and preparing their own promotional materials 2.4. On a pilot basis, retailers linked to a major multinational agribusiness, enhancing product diversity and knowledge

Project Activities and Targets

The project proposed an ambitious set of activity and results targets, with the bottom line being an increase in yields of 15-20% for rice, gram, and maize among direct beneficiary farmers, who would then realize a 15% increase in gross margins (defined as the total value from production minus the total cost of all inputs for which the farmer paid).

To achieve that goal, the project planned to conduct:

- Scores of on-farm trials and field demonstrations for UDP and other technologies related to improving soil fertility management.
- Training for thousands of farmers, tailored to their needs and informed by research.
- Motivational visits by farmers to observe progressive model farms.
- Extensive business and technical training for retailers.

The project also planned to support research and development of UDP machinery, organize national workshops, produce reports on the fertilizer market and other relevant topics, including women in agriculture, and undertake public outreach.

Table 2 summarizes the actual numbers achieved against the targets for FSI+ activities

Table 2. Summary of FSI+ Achievements Against Targets

Activity	Unit	End-of-Project Target	Dry	Wet	Actual at End
Training of Trainers – Farmer Training	batches	7	6	4	10
Farmer Training – Rice	farmers	11,850	6,454	6,360	12,814
Farmer Training – Revision for Rice Farmers	farmers		2,879	2,246	5,125
Field Demonstrations	demos	186	138	134	272
Field Demonstrations – Rice with DOA	demos		14	6	20
Motivational Field Trips – Rice	trips farmers	15	20	18	38 1,000
Motivational Field Trips – Maize	trips			2	2
Field Days – Rice	field days	59	40	36	76
Field Days – Maize	field days			2	2
Crop Cuts	crop cuts		468	439	907
Field Trials – Rice	trials	90	58	62	120
Field Trials – Maize	trials			7	7
Training for Retailers in Southern Shan State	retailers	160	140	43	183
Training for Retailers in Delta Region	retailers	140	122	20	162
Briquette Machine Local Manufacture	no.	2	2		2
Cost-Share Local Briquette Machines	no.	35	12	6	18
Post-Harvest Technology Demonstrations	demos	5		5	5
Agriculture Trade Fair	no.	2	8	1	9
National Workshops and Seminars	no.	2		2	2
Farmer Training – Maize	farmers			562	562
Field Demonstrations – Maize	demos			8	8
Field Demonstrations – Maize with Syngenta	demos	50		41	41

Note: 38% of farmers trained and 46% of retailers trained are women.

M&E

The project's M&E system and implementation were comprehensive, intensive, and impressive. A baseline household survey completed in the first year of the project was designed to define the pre-project socio-economic characteristics and rice farming practices of rural households in the FSI+ target regions. The survey also provided baseline estimates where needed as indicators within the logical framework.

Field-level data were collected at regular intervals in order to monitor pre-established input and output indicators of the project. The field officers observed and reported weekly on the NGO

grantee activities. In collecting data, all FSI+ staff strictly adhered to USAID's five criteria for data quality: Validity, Integrity, Precision, Reliability, and Timeliness.

Independent professionals conducted household surveys after each wet and dry cropping season. The surveys were invaluable learning and adaptive tools because they provided information on barriers to adoption of UDP and other technologies as well as the percentages of famers adopting better practices in each season and the amount of land that group farmed. The household surveys provided cost-benefit analysis, details on gross margins, and efficiency of farm input use.

The M&E team developed a large database of all aspects of the project and designed a new M&E plan in 2017. It reflected the changes in project activity and the corresponding measurements for both the new FTF results indicators and the continuation of the project's custom indicators under the Cooperative Agreement. Each semi-annual report displayed details of the surveys and a current picture of project progress.

III. Project Performance – Technology Transfer and Capacity Building

FSI+ worked directly to increase production and income from crops produced in rice-based systems. It focused on helping small-scale rice farmers gain access to improved inputs and practices in order to increase both yields and soil fertility. There was also a small pilot program with maize farmers in southern Shan State. As such the project directly supported the GFSS of September 2016. FSI+ performance exemplifies progress toward Objective 1 of the GFSS – Inclusive and Sustainable Agricultural-Led Economic Growth. Moreover, the project contributed to the research, nutrition, capacity development, and women's empowerment objectives.

Investments in small-scale agricultural producers are shown to have significantly higher job and rural economy multipliers than investments in other sectors. These gains accrue to low income rural households, which supports inclusive growth, food security, and development. The USAID investment in FSI+ further demonstrated the validity of those hypotheses.

Results

In 2016, the project shifted from reporting essentially only on measurements related to UDP adoption to reporting on additional disaggregates that widened the scope and impact of technology transfer and complied with FTF results indicators. These include:

- Gross margins per hectare of selected products.
- Value of incremental sales (collected at farm-level) attributed to the project.
- Number of farmers and others applying improved technologies or management.
- Practices as a result of U.S. Government (USG) assistance.
- Number of hectares of land under improved technologies or management practices as a result of USG assistance.

The project revised its targets to include all rice production and gross margins among the farmer beneficiaries. (Reporting on aspects of UDP was retained.) Use of quality seed and balanced fertilization are examples of improved technologies by both the direct beneficiaries (defined as receiving project training) and indirect beneficiaries (additional farmers who attended field days and motivational visits organized by the project).

Table 3 lists the results indicators and describes project performance.

Note: Some indicators were required by FTF (F); others were part of the 2015 Agreement (A).

Table 3. Results Indicators and Project Performance

Results Indicator	Report A=Agree't F = FTF	Units	Target	Actual at FSI+ Completion	
				Wet	Dry
Increase production and profitability of crops produced in rice-based farming systems					
Gross margins – rice with UDP	A	USD/ha	424	614	621
Gross margins – gram with UDP in the rice rotation	A	USD/ha	1,004		694
Gross margins – whole rice farm (UDP plus non-UDP fields)	A	USD/ha		434	419
Gross margins – direct beneficiaries household survey	F	USD/ha		374	315
Farmers trained – rice	A & F	no.	11,850		12,814
Farmers trained – maize	A & F	no.		562	
Farmers applying UDP technology	A	no.	5,632	1,812	1,241
Farmers applying at least one technology disaggregate	F	no.	14,945	11,925	2,571
Area of rice under UDP	A	ha	2,816	573	243
Area of rice with at least one technology disaggregate	F	ha	44,836	52,225	9,019
Area of gram after rice with UDP	A & F	ha	489	281	
Incremental yield of milled rice arising from UDP	A	mt	32,021		1,658
Incremental yield of milled gram arising after rice with UDP	A	mt	5,037		80
Value of incremental rice production arising from UDP	A	U.S. $	9.7 M		638,281

Results Indicator	Report A=Agree't F = FTF	Units	Target	Actual at FSI+ Completion	
				Wet	Dry
Value of incremental gram production arising after rice with UDP	A	U.S. $	2 M		90,203
Increase capacity of service providers to supply and advise farmers					
Number of small business briquette manufacturing enterprises established	A	no.	35		18
Number of retailers trained to deliver advisory services	A	no.	180	345+9+11*	
Businesses providing contracting services	A	no.	120*		
Number of rural households benefiting	F	no.	12,065		13,739
Farmer training		Batches	395		411
In training of trainers		Batches	6		6
Retailer training in Southern Shan State		Batches	10		8

* The training program for retailers included those who provide services plus nine contractors (tractor, harvesting, etc.) and 11 briquetting machine operators.

It is noteworthy that FSI+ contributed to the top three USAID Burma Mission achievements listed on its website, namely:

- Introduced a proven model known as "fertilizer deep placement" that resulted in an average 28% increase in rice yield using one-third less fertilizer.
- Assisted over 2.8 million people, including some of the poorest and most vulnerable rural families, with better agricultural technologies and finance.
- Supported the development, testing, selection, multiplication, and diffusion of new varieties of stress-tolerant rice for farmers in both the Delta and the Dry Zone to help millions of farmers to better withstand or recover from natural disasters and adapt to climate.

Capacity Building – Retailers

The project's second objective focused on increasing the capacity of service providers to supply and advise farmers. Agro-input retailers and farmer service providers, such as farm machinery contractors, are key to achieving the GFSS objectives of inclusive and sustainable agricultural-led growth – and strengthened farmer resilience. They are the main interface with farmers and have an economic incentive to help them progress. The project recruited and helped transform agro-input retailers into business-oriented and knowledgeable sources of products and providers of extension services for smallholder farmers.

The project organized six-day residential training for six batches of an average of 27 retailers in the Delta and for eight batches of an average of 23 retailers in southern Shan State for a

combined total of 345 retailers, of whom 46% are women. Half of each day was devoted to business topics – recordkeeping, costing and pricing, marketing, etc. – and the other half to technical subjects such as agronomy, plant nutrition, extension methodology, and in conjunction with Syngenta, safety and use of plant protection products.

Most of the dealers never had formal training and did not understand basic concepts such as cost analysis. During training follow-up visits, staff found that 80% of the retailers had enhanced their record keeping in accord with the training, and 92% were managing stocks so they could calculate net profit.

Despite their initially small business size, the 345 retailers who partnered with the project have prospered and gained market share because of their increased customer bases and sales of inputs. (Their progress is more remarkable because the competition has grown – from 3,000 agro-input dealers in 2014 to over 5,000 in 2017.) Farmers have come to trust the trained retailers and the products they carry, in part because of their interactions with and exposure from the project. Partner retailers are now better positioned to offer credit, soil testing, and other services, a greater variety of inputs and information about them, and sometimes a link for famers to new markets.

> "Against a backdrop of significant growth in the number of agro-input retail outlets across Myanmar (62%), and hence increased competition, FSI+-trained agro-input retailers have generally strengthened both their position in the market and their capital structure and, thus, their prospects for long-term sustainability. Both rice and maize crop agro-input retailers who have participated in FSI+ training have increased their volumes and revenues of fertilizer sales, as well as their customer base. They have achieved this in the face of an increased number of competitors in their township and in a commercial environment in which profit margins per unit are falling."
>
> *– FSI+ Impact Assessment Report 2019*

Staff members established regular communication with the retailers via the Viber app and Facebook, and the project encouraged continued exchange of information among them. The retailers can continue to keep abreast of developments and opportunities, such as consolidated purchasing, advocacy on policy and regulations, coordination for organizing farmer training,

and other activities after the project.[1] The trained retailers serve over 205,000 farmer clients, who in effect become second-tier beneficiaries of the project research and recommendations.

Annex 4 lists the success stories generated by the project. Below is an example of an enterprising young retailer and project partner.

Nay Nay Tun is an agro-input retailer in Phayar Gyi in Bago Region. She is a young woman from an agribusiness family. Her father encouraged her to open an agro-input shop because there was only one in Bago town. When she started at the age of 20 in 2004, she did not have much business or technical experience. But she is hard working and continuously expanded her agricultural knowledge so she could better serve her farmer customers. She asked her input suppliers to provide her technical training as well as goods on credit.

In 2016, Nay Nay was able to partner with IFDC's FSI+ Project funded by USAID. She said, "I heard about and then attended a six-day FSI training program that included business management and accounting. The information really helped me set the stage for major expansion. The training inspired many ideas on ways to improve my business. My sales increased by over 30%." Under her leadership, the shop is growing, with sales of fertilizer for rice production leading the way.

Nay Nay is now the largest of eight dealers in Bago town and she employees eight full-time staff. Her best profit margin is on crop protection products, for which she provides protective gloves and masks at no additional cost. Nay Nay attributes her success to building trust with farmers by carrying good quality products and by extending credit. "Farmers are our top priority and I always provide my customers with good products and advice. I ensure that the inputs I purchase from suppliers are high quality, cost effective, and environmentally safe. I also test the products in my father's farm before I sell them," she remarked.

Capacity Building for Others

In addition to working closely with retailers to upgrade their capabilities, the project established a solid foundation of partnerships so that the knowledge and momentum generated would continue.

For example, the FSI+ project:

- Shared with the relevant government departments and made publicly available the field trial results on seeding and fertilizer for site-specific recommendations.

[1] The recently concluded IFDC project funded by LIFT in the Dry Zone similarly groomed a cadre of 53 input and service providers and advocated for them to form township sub-groups and an association. They now have an organization with a professional executive director. The members consolidate purchases to achieve economies of scale, discuss business information, share lessons on continued training of farmers, and coordinate with the DOA.

- Engaged the DOA extension staff in programs to boost their confidence and skills so they could better serve smallholder farmers and contribute to agricultural-led growth.
- Conducted some field demonstrations jointly with DOA and provided training for 57 staff within the retailer training plus special training in mid-2019 for 59 DOA staff to help combat the FAW threat.

Below is an example of a DOA field staff partner.

> Khin Myint Myint, District Officer, Land Use Division (LUD) in Bago, helped select the trial sites and the farmers for training at the beginning of the project. She praised the project for doing more research trials than other projects and opined that much more training is needed to overcome the lack of understanding by extension staff and farmers about soil fertility management. Her other concerns include the trade barriers and uncertainty about export markets that drive down crop prices and hurt farmers. She would like to see creation of more farmer marketing cooperatives.

- Encouraged direct farmer beneficiaries to convince friends and neighbors to adopt the profitable and sustainable agricultural practices they learned. The project reinforced the lessons through revision training for over 5,000 farmers and expanded the audience via Facebook, the media, participation in nine agricultural trade fairs, and mobile apps connecting tens of thousands more.
- Trained seven NGO partners in business management, provided manuals, and instructed them how to conduct training and field demonstrations. The project applied over $700,000 (about 10% of the total budget) to seasonal grants for NGOs for their services contributing to the implementation of the project workplan. As a result, they are much more proficient and better prepared as businesses to pursue agricultural consulting services in the future.

NGOs were able to extend the project messages to many more farmers and agricultural extension staff. As members of the cadre of knowledgeable and connected professionals, the lead agriculturalists contracted by FSI will reinforce and disseminate the practices developed and recommended by the project.

Below are comments from one of the project's NGO agricultural partners.

Myo Myint, Co-Founder of the Technical Alliance for Farmers (TAF), is retired from the DOA. He headed a three-person team assisting the project. He was pleased with the FSI project approach, management, impact, and contribution to the livelihoods of smallholder farmers. He said the NGO partners worked well together and with the FSI field staff to organize the sites and allocate locations of the field demonstrations and trainings. He appreciated the experience and the confidence it gave his NGO staff. TAF also plans to compete for new LIFT projects. Myo wants to develop and commercialize affordable seeders for smallholder farmers.

IV. Project Performance – Farmer and System Resilience

Helping Farmers Manage Uncertainty

"Catalyze agriculture-led economic growth by focusing on environmentally sustainable productivity gains through research that is purpose-driven and impact-oriented, and that operates in close coordination with deployment of research outputs through extension, education, evaluation, and feedback at the individual country level. Our strategy calls for closer ties and sharing of information across the three stages of research – discovery, development, and deployment."

– FTF Sustainable Intensification Objective

The FSI+ project embodied the FTF objectives stated above as it demonstrated the economic advantages of increasing yields and income by tailoring farm production to the most efficient inputs and practices. Farmers were able to observe the research-based results in field demonstrations and crop cuts that convinced them to adopt:

- Balanced fertilization and application at recommended rates.
- UDP.
- Site-specific nutrient management.
- Quality seed varieties applied properly.

Project training along with reinforcement by retailers helped farmers to manage better the increasingly frequent and intense shocks and stresses that threaten the ability of rural families to emerge from poverty. There is now a nucleus of informed farmers. In the recent two seasons, for example, there were 9,055 direct beneficiary farmers applying at least one of the project's technologies[2] on 48,458 ha, plus another 3,064 indirect beneficiaries on 12,786 ha. (That exceeds the targets and excludes double counting.) The project generated a surge in awareness

[2] Use of good seed, recommended seeding rates, UDP, balanced fertilizer application.

of balanced fertilizer application. This coincided with a growth in compound fertilizers in the market, some locally manufactured and some imported.

Another indication that farmers are better prepared to weather uncertainty is their shift to better sources of information. To a recent household survey question, farmers responded that they now obtain information about fertilizer increasingly from retailers, private companies, and the extension service. This represents a significant transition from traditional sources of information, namely family and friends – and is a direct result of the confidence built by the project.

The key to *helping farmers strengthen their resilience and system resilience (GFSS Objective 2)* is to demonstrate the economic incentives as well as the techniques for adopting smarter practices. The bottom line for farmers is their gross margins. That determines how much money they will have to invest in inputs and equipment and to improve the family's nutrition, healthcare, and education.

Direct beneficiary farmers in the dry season 2017/18 achieved gross margins of $606/ha, which represents a substantial improvement from the baseline. It is also 14% higher than indirect beneficiaries ($530/ha), thus demonstrating a significant return on the project training programs. The wet season gross margins are by nature substantially lower. In 2018 direct beneficiaries achieved $374/ha and indirect beneficiaries $295/ha, again reflecting the advantage of training.

However, as an example of shocks, in the dry season of 2018/19, even with good yields, the gross margins fell to $315/ha on the back of a dramatic drop in farm gate price for paddy and a rise in input costs. The project preached that price and cost volatility make it imperative to increase yields and quality that garners higher prices – and concurrently to ensure efficient application of inputs in order to control costs.

Despite the slow adoption of UDP due to labor shortages, the project continued to promote and report on UDP use with rice and maize because it embodies *IR 4 in the GFSS, namely increased sustainable production, particularly via climate-smart approaches*. UDP, whether in briquette or prilled form, is also an economic approach. The project demonstrated how to apply UDP in fields where seeded rice is broadcast rather than sowed in lines or transplanted. (In Bangladesh, UDP is practiced by placing briquettes into transplanted rice.)

The latest seasonal household surveys indicate that 14% of wet season farmers used UDP on 9% of their land, and 10% of dry season farmers used UDP on 5% of their land. There has been greater success with UDP adoption in southern Shan State, where 47% of trained farmers surveyed used UDP on their maize crops in 2018. At the time of the impact assessment, most small- and all medium-size retailers that had been trained by the project were stocking briquettes.

Over 214,000 kg of urea briquettes have been sold in the country, and the owners of the machines to make them are poised to respond as soon as mechanical applicators are commercially available. Climate change, latent demand, economic opportunities, and mechanization are expected to put UDP technology on an upward trajectory in the foreseeable future.

Below is an example of an expert who believes that UDP is an effective climate-smart technology.

U Hla Min, Co-Founder of the NGO Group of Development Research and Index (GDRI), managed their seasonal contracts over three years with FSI. He is an advisor to the Myanmar Rice Federation and a System of Rice Intensification specialist. Retired from the DOA, he has many personal connections, which he drew on to arrange DOA staff participation in the field demonstrations and farmer trainings.

Like most others, he is convinced of the benefits of UDP and will actively promote it once mechanical applicators are available. Hla Min is worried about the future of rice farming as the climate changes. He said, however, "the skills and experience from partnering with the project are now ingrained and will help us adapt to the coming challenges."

Building Resilience Capacity in the Public Agricultural System

The project also followed the FTF strategy noted at the beginning of this chapter by coordinating with public and private partners in the deployment of purpose-driven and impact-oriented research findings. The CFA between IFDC and MOALI of October 2017 highlighted areas for IFDC specialization. They are soil fertility management, crop nutrient management, fertilizer, agricultural production, and agro-input markets and businesses. In pursuing those topics, IFDC and the project worked to help the government construct sustainable systems that would help farmers prepare for shocks and stresses.

Although policy reform was not an objective of the project, IFDC was able to take advantage of opportunities that will serve well the GFSS and USAID Mission objectives regarding system

resilience and climate-smart agriculture. There is a history of collaboration and confidence building with the DOA and DAR since the project inception in 2014. For example, FSI+:

- Conducted some field trials jointly with the DAR and the Land Use Division (LUD) at their research stations and farmer fields and routinely shared the results of all project trials and crop cuts with MOALI and the public via the website. That research, regarded as outstanding by experts, will help the Ministry offer informed recommendations to farmers and better prepare them to deal with shocks and stresses.
- Trained extension staff and encouraged their participation in field demonstrations and training (without any direct support for travel, equipment, etc.).
- Maintained regular contact with DOA, DAR, and YAU scientists.
- Participated in nine agricultural trade fairs.

The cooperative agreement included a provision for a national conference to present project results. The Permanent Secretary of MOALI had requested FSI+ to prepare a *Soil Fertility and Fertilizer Management Strategy for Myanmar* and, with USAID consent, to use project funds. The COP planned to use the conference as an opportunity also to conduct a workshop on such a strategy paper. He began planning in 2016 and drew on his contacts with Australian research projects in the country. He convinced the Australian Centre for International Agricultural Research (ACIAR) to co-fund the conference with USAID as an example of donor cooperation (and another example of leveraging FSI+ resources).

IFDC/FSI+ and DAR co-hosted the conference in October 2017 in the capital, where the project showcased its research and extension results. IFDC produced a publication of conference proceedings of 28 quality papers. The event was a first of its kind in Myanmar and brought together scientists from the public and private sectors to present findings on soil fertility and fertilizer management in Myanmar.

The Permanent Secretary of MOALI opened the conference with a request – "What I want is sustainable agriculture through fertilizer management." At the workshop immediately following the conference, IFDC presented a draft for discussion of the Soil Fertility and Fertilizer Management Strategy that MOALI had requested. That document, completed in 2018, would serve as a blueprint for his goal – and contribute to the Ministry's master action plan. The conference and strategy convinced the government to focus attention on their soil as a critical natural resource. The ongoing implementation of the master action plan serves as an important aspect of the FSI+ legacy and lasting influence.

The reputation earned though its work in the country led the International Finance Corporation (IFC) to offer IFDC a $225,000 grant to undertake assessments of the Myanmar fertilizer regulatory and value chain environment, including fertilizer quality and risk assessment, and the capacity of LUD to regulate the burgeoning industry. IFC provided the study to MOALI and the World Bank, and it serves as another contribution to the repository of knowledge for future actions.

Below are some recent comments by five representative Ministry officials as they reflected on the fruitful relationship with the project and offered some requests to IFDC for future collaboration.

Dr. Thandar Nyi is the Assistant Director of the Land Use Division (LUD) based in Yangon, where she manages the laboratory.

She worked in Africa on integrated soil fertility management (ISFM) and wants the DOA to do more to adopt and implement the *IFDC Soil Fertility and Fertilizer Management Strategy* and to take advantage of the crop cut reports and other material posted on the project website, which she said represents an important part of the legacy. She would like IFDC in its next presence to consolidate all the research conducted by FSI+.

In a similar vein, Daw Thuzar Myint, Director of LUD in DOA, praised the strong relationship with the project and wants IFDC to return. She would like to see IFDC and ACIAR collaborate and integrate their research into a common report.

Dr. Soe Soe Thein, Deputy Rector of the Yezin Agricultural University (YAU), noted that DAR and YAU have demonstrated the value of UDP at their research stations with briquettes supplied by the project. She thanked the project for the conference, which aligned well with YAU focuses on fertilizer, plant nutrient, and soil and water sciences. She asked IFDC in its next incarnation to conduct a seminar for MS and PhD students and to take on student interns.

Dr. Thant Lwin Oo, Deputy Director General of the DAR, carried out his doctorate on UDP as an efficient method for increasing uptake of N in hybrid maize production in Shan State. He is excited about the potential for mechanical applicators and the new DAR regional research center in Shan. He wants IFDC to work there and in Kayah next because of their great potential and need for conservation agriculture.

Dr. Ni Ni Tint, Assistant Director, Soil Science Section of the DAR, said that the Director and she consider the conference organized by IFDC and DAR in 2017 as a major achievement that helped shift the focus in DAR and DOA from plant breeding to soil science. She that added FSI has produced a great legacy.

She remarked that the soil fertility management and fertilizer strategy produced by the FSI project last year is proving invaluable as DAR begins to shape and implement the Research Master Plan. “We need more projects like FSI to shift greater emphasis on soils and what can be done to enrich essential soil organic matter.”

Advancing Private Sector Response Capabilities – The Fall Armyworm Example

Through training, engagement with partners, and networking, the project helped motivate 345 shopkeepers who sold agro-inputs to become effective businesses and development multipliers. The retailers are now providing extension services to farmer clients and becoming effective organizers of programs because they realize the economic returns from doing so.

Recognizing those capabilities, the USAID Mission asked the FSI+ team in early May 2019 to gear up for an expected infestation of FAW that could devastate the important maize crop. USAID indicated that additional funds would be forthcoming to cover the extra costs, since the project was beginning the process of phasing down and expending remaining funds.

The project team quickly mobilized retailers and private companies and collaborated with the DOA Plant Protection Division (PPD) to prepare educational materials, manuals, posters, and pamphlets to be distributed during training. Within a few weeks, the project had conducted training on FAW for 90 retailers (33 women) and 58 DOA staff members (43 women) across four townships in the maize belt of southern Shan State. Facilitators from Impact Terra, Awba, and BASF gave presentations on their support systems and products. The Senior Researcher for Bio-Control in the PPD participated in all facets of preparation and training.

FSI+ established 12 demonstration field schools with retailers to teach the principles of FAW management at seven townships in southern Shan State in June 2019. The field schools were designed to offer a practical learning experience for retailers and their farmers. They were led by a collaborating retailer and started with lessons on good agricultural practices (GAPs) for maize, including the application of UDP. The FSI+ extension team delivered FAW management trainings at each field school and distributed educational materials, posters, and pamphlets. A total of 467 farmers (150 women) attended the field schools.

For each of five weeks, the FSI+ extension team conducted training for a total of 452 maize farmers on how to scout for FAW to determine FAW incidence, action thresholds, treatment decisions, and best practices for application.

The project assisted with the supply of Bacillus thuringiensis (Bt) spray as a preferred first response to be sold through the retailer outlets. Using the Global Fall Armyworm Management Programmatic Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP), the project prepared a Safer Use Action Plan for Myanmar and submitted it to USAID.

The IFDC Upland project, funded by the Livelihoods and Food Security Fund (LIFT), is undertaking a similar response action plan in Kayah State. Although the areas covered are only a small portion of the maize area, USAID and LIFT were impressed with the rapid and cost-effective response. FSI+ worked with a USAID-funded policy project implemented by Michigan State University (MSU) to better assess the impact and lessons learned country-wide. LIFT agreed that the Upland project could fund crop cut surveys to measure the impact of the training on yields and gross margins.

V. Collaboration

Public-Private Partnership with Syngenta

The large global agribusiness company Syngenta and USAID began collaborating in 2013 under a Memorandum of Understanding (MOU) with the aim of promoting food security among small-scale farmers. Cooperation on improving research and development, technology adoption, and farmer know-how would boost farm productivity. The FSI+ project was able to tap into that arrangement by entering a partnership with Syngenta to conduct trainings and demonstrations related to maize production in southern Shan State.

Under the contract signed in October 2015, Syngenta agreed to provide $100,000 in cash and kind to help fund trainings for retailers and contract service providers and demonstrations of maize using Syngenta hybrid seed along with IFDC fertilizer management practices. A joint mission identified potential maize demonstration sites and retailer training opportunities. Eight six-day residential courses were conducted in southern Shan State and six in the Delta. Forty-one maize demonstrations were completed in southern Shan State. They were designed to highlight the yields from the Syngenta maize hybrid NK 261 or NK 625 with UDP. (The project bore the time and cost for setup for each activity, and this proved to be both time-consuming and over budget.) IFDC produced a seasonal report for each year in 2016, 2017, and 2018.

Table 4 describes the number and type of people trained under the PPP with Syngenta.

Table 4. Number and Type of People Trained under the PPP with Syngenta

Location	Participants														
	Retailers			Service Contractor			Briquetting Machine Owners			DOA			Total		
	M	F	Tot	M	F	Tot	M	F	Tot	M	F	Tot	M	F	Tot
Delta Regions	86	76	162	7	0	7	5	5	10	4	1	5	102	83	185
Southern Shan State	97	86	183	2	0	2	0	1	1	14	38	52	114	125	239
Total	183	162	345	9	0	9	5	5	11	18	39	57	216	208	424

After observing this collaboration, Corteva Agrisciences (a company founded on the heritage of Dow, DuPont, and Pioneer) expressed interest in mid-2019 in signing an MOU with IFDC, particularly for farmer education on corn agronomics in key cropping areas.

Below is an example of how the training helped one entrepreneur grow her business.

Sandar Myint is a successful agro-input retailer in Taunggyi Township in southern Shan State. The 30-year-old mother of two owns a seed and fertilizer shop, which is one of the largest in the highly productive agricultural area. Sandar said the joint FSI-Syngenta training in 2016 improved her knowledge of products, customer service, warehousing, and logistics and her marketing skills; it also helped her gain more working capital. As a result of her skill in implementing the lessons, she transformed the shop from a family business into a leading competitor using modern business management techniques. She organizes training events for farmers and provides services, personal contact, and gifts to keep her customer base loyal and growing.

Already a leader in fertilizer sales, she is working hard to increase volume so she can reduce margins and enable farmers to purchase more. Sandar's fertilizer sales are growing 30-40% each year. She received the best regional and national level retailer award in 2017 and 2018 from a coalition of Myanmar's largest manufacturers and distributors of agricultural technology and inputs. She is building a larger warehouse and proceeding to open three new agro-input shops in 2019. "I really appreciate USAID and IFDC for my successful business development, and I recommend to all retailers and young entrepreneurs that they attend the FSI project trainings."

Partnerships in the Development of Mechanical Fertilizer Applicators

In the project's early years when the major focus was on UDP, the project's engineering priority was to encourage local production of machines to make urea fertilizer briquettes. FSI imported five machines from Bangladesh, where IFDC had originally designed them. With blueprints from IFDC, the project engineer worked with local machine shops to produce and sell 13 more machines with a project subsidy. Two sold outside the project zone at full commercial price.

With the realization that labor shortages impeded manual application, the project shifted to testing injectors and push applicators imported from Bangladesh that could deep-place urea into the soil. But these also were labor intensive and not suitable in all soil conditions. The next phase was the design and development of prototypes for mechanical seed and fertilizer application that would help smallholder farmers achieve more profitable and sustainable production.

In 2016, FSI+ began to collaborate informally with John Deere, the U.S.-based agri-machinery manufacturer linked with local partner Capital Diamond Star, to develop mechanized applicators. The company also provided tractors and other equipment for field demonstrations.

John Deere also introduced Khedut Agro-Engineering, based in India, which also began working with the project to research, design, develop, and test a fully mechanized combined seed and fertilizer applicator with additional UDP application capability. The company has a distribution channel in Myanmar and is considering a production facility for UDP applicators in Myanmar for domestic sales and for export to India, where there is also great potential for UDP. Khedut is currently testing prototypes that the project helped design. For example, FSI+ staff had modified a prototype maize planter imported from India to be a combine for seed, UDP, and compound fertilizer. It is undergoing field testing.

In addition, in the last year of the project, National Agro Industries (NAI), also based in India, designed and delivered a combined seed and fertilizer applicator, with UDP application capacity, for testing in Myanmar. It can be used for rice and maize.

When it ended, the project had four working prototypes for deep placement of urea in rice and maize fields being tested on power tillers and four-wheel tractors. Other prototypes combine the planting of seed along with fertilizer. All are being demonstrated in farmer fields in order to gauge market interest. Part of the research and testing includes an assessment in upland areas of yields with granular urea deep placement. Indications are that in some cases granular UDP is as effective as briquettes, which would make application easier and reduce costs.

Until demand solidifies, local manufacturers are unwilling to proceed despite the potential commercial market and relatively affordable prices to produce and sell the equipment. Being risk-averse they want commercial orders before starting up production. Another obstacle is the import tariff on steel and other materials for local manufacturers, while imports of farm equipment from India, China, and elsewhere are duty free.

The IFDC partnership with Kansas State University will provide new opportunities for evaluation and refinement of UDP applicators. The aim is to ensure that the mechanization work continues beyond FSI+ because of the enormous potential it holds for increasing rice output globally.

Links and Leveraging with Other Projects

The experience from FSI+ helped IFDC compete for another overlapping project in Myanmar. LIFT, to which USAID is a major contributor, awarded IFDC in late 2015 an Agro-Input and Farm Services project in the Magwe and Mandalay regions of the Central Dry Zone. In late 2018, LIFT added similar work for 18 months in the uplands of Kayin and Kayah states.

The IFDC team implementing the LIFT Dry Zone (DZ) project benefited greatly from FSI+ research, experiences, and lessons. For example, the DZ project introduced UDP as part of its field demonstrations to show farmers the difference that the application technology, along with other good practices, could make in their yields and gross margins. The DZ project quickly replicated the FSI+ pioneering work in partnering with input and service providers and with DOA extension staff. Myanmar specialists from both projects helped the experts from IFDC analyze fertilizer quality and prepare soil and fertilizer assessments, thus building their capabilities.

The FSI+ project coordinated with other USAID implementing partners, particularly with MSU, in matters relating to research and extension policy and more recently the FAW monitoring and evaluation.

FSI+ leadership communicated with the Wageningen University (the Netherlands) presence in the country and with ACIAR and its implementing partners Melbourne University, University of New England, and the Commonwealth Scientific and Industrial Research Organization. The dialogue included an exchange of experience, data, and information related to soil fertility and fertilizer management. As noted in the Introduction, the project initially worked under the auspices of IRRI, which has been in Myanmar for decades and in May 2015 launched the Myanmar Rice Sector Development Strategy.

In short, those relationships helped the project keep current in research and development, leverage funding for its activities, draw on private sector and other outside expertise, coordinate to avoid duplication in activities, and promote the private sector approach and lessons. If there had been time and remaining funds, USAID wanted the project to convoke a gathering of

implementers and interested parties in order to provide an overview of the project and its achievements.

VI. Crosscutting and Complementary Activities

Contribution to "A Well-Nourished Population" (GFSS Objective 3)

The major contribution by FSI+ to improving nutrition in the country can be measured in the increased production of and incomes from rice, gram, maize, and other crops. Previous chapters have described the higher yields and gross margins accruing to the thousands of smallholder farm families who benefited from the project's research, demonstrations, and training.

The next chapter highlights the economic impact of the project on the lives of farmers and how it will be replicated for years to come because of the sustainable nature of the good practices; and the storehouse of research, innovation, and recommendations bequeathed to government agencies, private retailers, and NGOs.

In 2017, the project began working with staff from Save the Children who offered their services as resource persons for retailer training. Their expertise in behavioral change melded neatly with FSI+ retailer training, particularly as it relates to adult education and farm advisory services. The final year of the project also included messages on health and nutrition for the farm family. The participating retailers continue to relay that information to farmers.

By selecting significant representation of women in all project training and other activities, FSI+ helped ensure that the incremental family incomes generated would be spent wisely on investments in the farm, education, health, and nutrition of women and children.

Gender

The annual household surveys, when compared to the baseline, indicate that women are actively benefiting from FSI+. Participation in project training by female farmers and agro-input retailers has translated into significant positive impact on household incomes. Over 25% of the participating farm households have made additional business investments, including machinery and land purchases. Households are also increasing expenditure on their quality of life; for example: (i) 11% of households invested in additional education (typically spending $522 per household, with 80% of the expenditure going toward educating female household members); (ii) 6% invested in housing (typically $800); and (iii) 5% invested in healthcare ($745, of which 80% was devoted to women in the household).

From project design and launch to its completion, inclusion of women remained a key priority. All project activities recorded participation by gender and reported the numbers to the M&E specialists. FSI in its first year hired the consulting and research firm Cultural Practice LLC to conduct a gender assessment to identify the relationship between women's adoption of UDP technology and their empowerment in agriculture.

Half of the project's eight senior Myanmar staff are women, and all had supervisory responsibility. Women account for 46% of the retailer partners, 38% of all farmers trained, and 70% of DOA staff trained by the project. (Women comprised a high percentage of the DOA and DAR field and headquarters staff with whom FSI+ coordinated on trainee and site selection.)

Most of the success stories generated by the project and carried on its Myanmar language websites featured women. That is because the project worked with and publicized enterprising retailers who would not only grow their agro-input sales but would also reach out to provide information and other services to farmers. The retailers do it because they care and genuinely want to help farmers – and because they recognize that such customer service is good for business. As highlighted in text boxes in this report, many of the most successful retailers are young women.

Below is an anecdote about another enterprising businesswoman, who is an FSI+ alumna and advocate of its legacy. It demonstrates how the project helped women gain greater access to inputs, extension, and other services, skills, resource management capacity, networking, bargaining power, financing, technologies and innovations, and market connections needed to sustain their long-term economic prosperity.

Zin Mar Kyaw is an entrepreneur who started as an input retailer and invested her earnings in agricultural land. Starting with 25 acres, she now owns 180 acres, which is devoted mainly to rice production. Zin Mar saw the value of UDP technology and was the first in the country to purchase a briquetting machine via the FSI project.

She plants 30 acres of rice using UDP and promotes the use of UDP with retailers and NGOs, including for broadcast rice. She participated in research, such as nutrient omission trials, with the Land Use Division. After gaining publicity about her briquette operation, Zin Mar was selected by USAID for a study tour in the United States for small and medium enterprise owners.

In cooperation with the FSI+ team, Zin Mar used her fields for farmer demonstrations, including mechanical application of UDP. Since her farm is located on a major highway, many people can observe the better results achieved with UDP technology. Her rice yield from UDP is 10-12% higher than with broadcast fertilizer, and the cost is less. She also grows sesame and rice in the dry season.

An enterprising investor, Zin Mar purchased a rice mill and farm equipment to provide plowing and harvesting services to farmers in addition to supplying inputs. She has 15 full-time and 30-35 seasonal workers. As added service she provides credit and door-to-door input supply service to farmers.

"I'm very happy working with the FSI team as a family since the project began. I really appreciate USAID and IFDC for their support in bringing us good technology, briquetting machines, valuable trainings, and other productive opportunities," noted Zin Mar.

Environment

Almost all project activities directly or indirectly supported the protection of natural resources and GFSS objectives. For example, UDP is a prime example of a technology that improves nitrogen uptake efficiency and reduces greenhouse gas emissions while producing higher yields at less cost. The project training and emphasis on balanced fertilizer use at recommended rates tailored to the soil and the crop promoted the restoration and retention of soil fertility while minimizing harmful side effects. The project advocated and provided training in the safe and appropriate use of crop protection products, such as those used in the campaign to control the FAW.

Project agronomists and soil scientists coordinated with counterparts at IFDC headquarters and in Bangladesh, in addition to those in Myanmar. Project specialists co-authored articles with IFDC scientists for the national conference. The environmental expert located in Dhaka has published a paper titled: "Mitigating Greenhouse Gas (GHG) Emissions from Rice-Based Cropping Systems through Efficient Fertilizer and Water Management." He visited the project, helped with some of the research papers, and set up trials for sulfur and other nutrients.

The reports on the hundreds of project trials, field demonstrations, and crop cuts and the research papers, assessments, and strategies related to soil fertility management will serve well the Myanmar government, donors, and successor agricultural projects that aim to feed the country while protecting the environment and preparing for the inevitable challenges to come.

VII. Economic Impact

The project commissioned an independent impact assessment that organized four surveys in April 2019 to gather information on project results. They were then compared to the 2015/16 baseline survey. The data was used to estimate the incremental difference that FSI+ contributed to farmers: gross margins (profitability), production, and value of yield increases from rice as a result of smallholder adoption of FSI+ extension messages. The surveys included farmers trained by FSI+ and their neighbors who were not trained but some of whom adopted the improved practices because of what they observed.

The Project Impact Report was completed and submitted to the USAID Mission in August 2019. It provides measurable economic results and impact and supplements this project completion report. The conclusions were very positive, especially considering that the project targets were based on an anticipated successful take-off and trajectory of UDP, which did not occur. The project had to pivot its operations in 2016 to a broader campaign and new FTF indicators while still saddled with many UDP-based results goals. The team's ability to meet or exceed so many targets without the benefit of UDP exponential growth is therefore more remarkable.

Some examples of tangible project impact include:

- The incremental rice yield attributed to the project amounted to 29,500 mt of milled white rice. Incremental value attributed to FSI+ is assessed at $9.04 million (versus a target of $9.7 million). That return on investment encourages farmers to continue to use improved technologies that also conserve resources and sustain soil fertility.
- Gross margins increased by 28% for wet season rice and 18% for the dry season crop (the targets were 15% increases for each).
- Household profitability rose annually by $890, with 50% of this attributed to FSI+. This represents a high impact at a relatively low per farm project cost.
- A very conservative estimate of 25% of the trained retailer customer base of over 200,000 farmers are now using improved inputs and practices as a result of the project. The mutual

economic incentives and the sales growth trends of the retailers are expected to drive the message uptake to a steady and significant 60% of retailer clients.

The report assessed the Economic Internal Rate of Return (EIRR) for FSI+ at 30.3% and the net present value of the net benefit flow (with discount rate of 9%) as $29.88 million. A decrease of various project benefits by 20% makes little impact on the EIRR but a 20% reduction in the sustainable rate of adoption by farmers reduces the EIRR to 13.7% – which is still above the opportunity cost of capital (9%).

FSI+ extension delivery was cost-effective. With total farmer beneficiaries of 66,830 to 97,730 (depending on estimates of retailer customers adopting improved technologies), the total cost per beneficiary is between $75 and $109. The corresponding financial benefit to individual farm households is $445 annually – a benefit that continues to accrue for several years.

Project reports explained how gross margins tend to follow the yield when price and input costs maintain the same relationship. However, when the price and input costs diverge, the gross margin is influenced more by these data than by yield. Thus, farmers in the last dry season have experienced reduced gross margins even with higher yields because input costs went up and the price of paddy went down. Even smallholder farmers produce for export markets and therefore the farm gate prices they receive are subject to external trade barriers, particularly by China for rice and India for pulses. With the resultant glut on the domestic market, prices tumble. For example, gross margins for gram dropped precipitously from $800/mt in 2017 to $400/mt in 2018 after India stopped allowing gram importation from Myanmar. In the last dry season (2018/19), input costs rose and farm gate prices fell causing the gross margin to drop to $315.

Table 5 depicts the relationships among commodity price, input cost, yield, and gross margins.

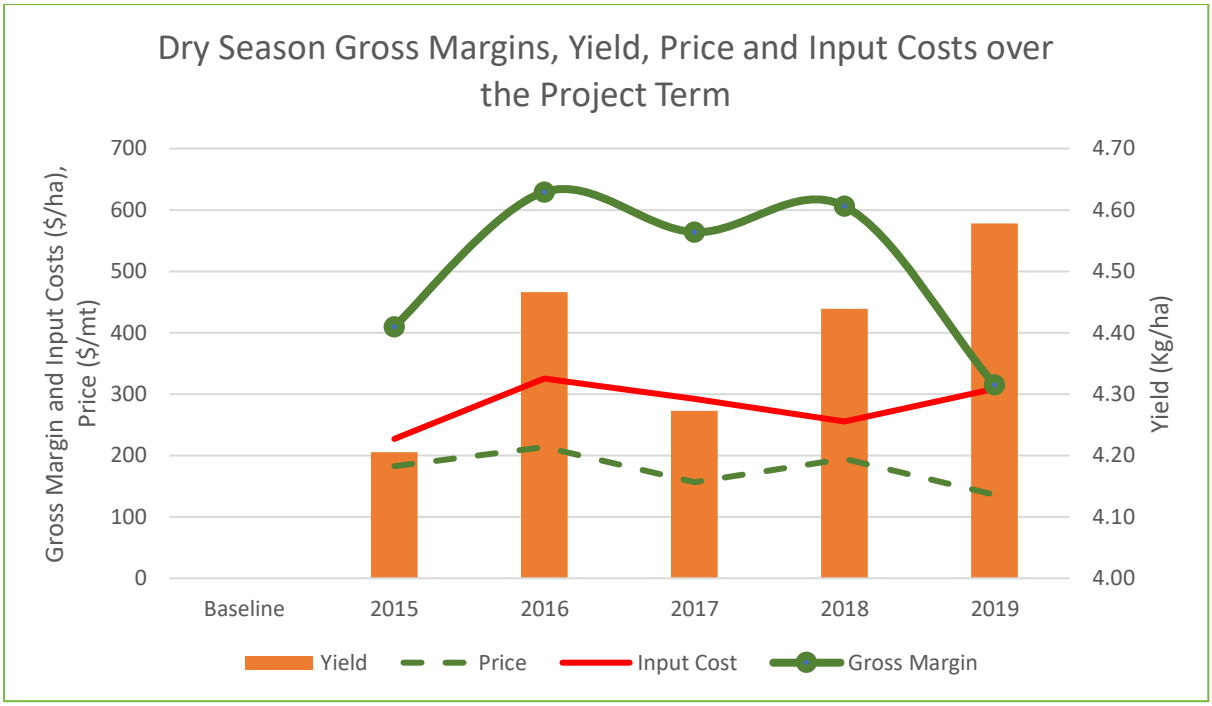

Figure 1. Dry Season Gross Margins, Yield, Price, and Input Costs over the Project Term

It is also noteworthy that:

- Farmers who received training from the project generated gross margins that are 20% greater than farmers who only attended field days and motivational visits.
- UDP increased rice yields over broadcast fertilizer by 18% and gross margins by 50% consistently over the life of project. In last dry and wet seasons, about 15% of direct beneficiaries used UDP technology.
- In addition to the economic impact, the project leadership and staff generated a solid reputation for professionalism and knowledge that has brought about attitudinal changes in the minds of farmers, retailers, and government officials about the possibilities for small- and medium-scale farming as a business.

Below is a description of how the project and UDP helped change the life of one farmer, who continues to spread the good news to dozens of other farmers.

Daw Kyin Sai farms 15 acres of land in Ayeyarwaddy Region and is a demonstration farmer for the project. Having seen the benefits of UDP technology on her own farm, she now promotes it to others. In 2016, she attended a training course and then invited the FSI+ project to establish a demonstration plot on her farm to compare results from the application of UDP, compound fertilizers, and broadcast urea. During later training sessions, Sai learned about balanced nutrient management and how to maximize fertilizer efficiency according to crop needs.

Because of the labor cost involved, she could only apply UDP on 2 acres. In 2018, she met U Than Oo, a briquetting machine operator who has a workshop and invented a mechanical briquette applicator. Daw Kyin Sai purchased an applicator and, in early 2019, was finally able to apply UDP with her mechanical applicator on her entire farm.

She said, "This season alone, I reduced my urea consumption by 22 bags, saving me U.S. $440, which is about equal to the cost of the machine. I was thus able quickly to break even on my investment. Soon I will begin renting my applicator to other farmers for only a small fee, because I would like to contribute to the development of my village and help provide for their needs."

Recently, Daw Kyin Sai was selected as a role model for the Regional Seed Fair in Ayeyarwaddy and acts as a liaison between development organizations and her village. She is also a leader in her village administration and agricultural development. She commented, "I really appreciated having received farmer training from the USAID-funded IFDC project. Without that help, we could not know about UDP technology. I will use this new technology forever."

VIII. Sustainability, Lessons Learned, and Recommendations

Sustainability

The project embedded a plan for sustainability in the early stages and adjusted it in line with partner performance and beneficiary requirements. The goal was to create conditions so that foreign assistance is no longer needed to support the project objectives in the areas it worked.

The key to sustainability is the economic results described in the Project Impact Report and highlighted in the previous chapter. The 13,376 trained farmers have acquired the knowledge and access to resources needed to maintain the adoption of improved technologies that generate economic incentives to continue. The indirect and secondary beneficiaries, numbering over 55,000, have been exposed to the ways and means of improving their livelihoods that will reinforce the evolution from traditional methods to modern agriculture.

As part of its exit strategy, the project gave the 345 participating retailers the opportunity to organize training and field demonstrations. The retailers thus gained hands-on experience and observed the increased business that accrues from extension and other services for current and potential clients. The proof is in the increased sales and market share. Partner retailers have economic incentives to keep providing services to farmers in addition to quality inputs.

The DOA extension staff and NGO staff trained by the project show every indication, subject to funding, of continuing to disseminate the GAP messages delivered by the project. Moreover, the senior field personnel and their supervisors in the DOA and DAR will encourage them, thanks to the policy-related work of the project. There is political will and fact-based action plans to promote balanced fertilization and soil fertility management at the ministry and field levels.

The public repository of research papers, trial protocols, crop cuts, training manuals, and other reports produced by the project will aid government and others in continuing the modernization of Myanmar small-scale agriculture and equitable economic development.

Below is a note about an official motivated by the project.

U Kyaw Shwe, is the DOA Township Officer for Hlegu Township in Yangon Region. He appreciates the many field trials and demonstrations and farmer training organized by FSI+ in the region. His staff members were involved in the site selection and invited to the events, which they often attended. He has been pleased with the project operations and approach. He applauds that agro-input retailers are now taking over the organization of demonstrations and training programs. His township office is voluntarily conducting more training to help retailers improve their technical knowledge and extension skills.

Lessons Learned

The initial FSI project design was based on the miscalculation that conditions regarding smallholder rice production in Myanmar were like those in Bangladesh. It was assumed that Myanmar farmers would welcome UDP technology – and it would spread exponentially. The premier lesson from the project, therefore, is to avoid trying to drop in a program that was successful elsewhere without a thorough understanding of the new setting and constraints.

A related lesson is the need for donors and implementers to be flexible and prepared to make changes to accommodate on-the-ground truths and evolving situations. USAID made the decision to shift the project focus from essentially promoting UDP toward more broadly

balanced fertilization and other GAPs that were desperately needed in order to improve the agricultural system and welfare of the millions of rural poor. That involved more research and collaboration than previously envisioned.

In view of the major changes in direction in 2016, more time should have been allocated to develop and implement the framework for reaching and sustaining more indirect beneficiaries and the related targets for increased rice production. An extension would have also enabled USAID to reap and document the rewards and return on investment from the project's field research and from the progress in mechanizing UDP applicators.

> The program pivot demonstrates an important, but unplanned feature of the project – and a lesson for other projects. USAID gave FSI+ the freedom under the cooperative agreement to change with conditions and opportunities. As the COP remarked: "Being adaptable is the new norm. In the future, it is unlikely that projects will finish the way they were designed at the start."

A lesson that does convey across countries is the rationale for and successful inclusion of private sector agro-input retailers in the extension process. In a score of countries, IFDC has shown that enterprising retailers will seize the opportunity to receive training and to partner with projects to help farmers understand the benefits of using good seed and proper types of fertilizer in recommended amounts. The increased sales and customer base demonstrate to retailers the virtues of entrepreneurship and honest business practices – and inspire the foundation for sustained activity after the project.

The FSI+ project also upgraded the skills of and then engaged public extension staff as technical trainers as they began to show interest. The active participation of business-motivated retailers and AED staff enabled the phasing out of grants to NGO partners and set the stage for continuing service to farmers from local rather than donor resources.

FSI+ pioneered in Myanmar the concepts of enlisting retailers and extension staff as implementing partners in modernizing smallholder farming. It took some time to convince retailers to invest their time in a six-day residential course, but within months there was a waiting list and tighter selection. The FSI+ experience helped IFDC design and implement the subsequent LIFT Dry Zone and Upland projects without the cost of hiring NGOs. Those

projects from the start centered delivery of services to farmers on project-trained agro-input dealers and public extension staff.

Although U.S. government funds could not be used to support the government in any manner, USAID allowed the project team and IFDC consultants to engage public agriculture officials as needed to achieve project objectives. Thanks to personal relationships and networking, the project was able to develop productive and appreciated cooperation with various departments and divisions within the Ministry. That is paying off in terms of policy actions toward inclusive economic development and sustainability.

Recommendations

Future MOALI and donor interventions should continue to focus on rice production, which is becoming even more important to rural welfare. There is tremendous scope for improvement – from land preparation to post-harvest processing and marketing. Rice yields are low due to poor agronomic practices. For example, only 30% of farmers are using quality rice seeds. Most farmers still follow traditional practices, such as broadcasting seed and fertilizer, and conduct little or no soil testing. Yields are far below other ASEAN countries.

The project demonstrated the value of incorporating both research and extension that reinforce and update each other so they address the real-time problems and questions vexing farmers. Many projects downplay and skip research aspects to focus on measurable achievements in terms of farmers, yields, and money. This is due in part by the requirement for hard results in the relatively short duration of implementation.

The ability to provide timely scientific and innovative solutions helps to convince farmers of the relevance and economic benefits of adopting improved practices and spreading the word. Relying on outdated inherited research and recommendations is insufficient. Energizing the public research organizations lays the foundation for sustainable and resilient agricultural development.

Post-harvest drying and milling results in 25% broken rice – a high rate means discounted prices in international markets. A value chain approach to future rice sector improvement would help address the myriad weaknesses and capitalize on opportunities.

Either directly or through LIFT, USAID should continue to engage IFDC to help guide DOA, LUD, and DAR in policies and action plans for soil fertility and fertilizer management,

including the new LUD efforts to test and regulate fertilizer. There is a risk of the government undermining the free and efficient markets in agro-inputs in the name of protecting farmers and generating revenue from registrations.

Donors should support mechanization aimed at small-scale farmers. FSI+ helped lay the groundwork for progress on applicators for fertilizer and combine planters for rice and maize. Machinery for small-scale farmers helps promote inclusive and equitable economic growth.

The expected new LIFT projects in agriculture should build on the FSI+, DZ, and Upland cadres of retailers and encourage regional associations (as is the case in the DZ project) and a national association of agro-input dealers and service providers. The government should listen to their positions and take them into account when shaping policies and regulations. The aim should be to encourage greater finance and investment in the agro-input sector and more participation by retailers in educating and serving farmers. The long-standing agro-input entrepreneurs' association represents the large companies. While there will be many common objectives, it is important that retailers have their own advocacy voice because they are the interface with farmers.

There is consensus that Shan State holds great untapped potential in agriculture, as demonstrated by the FSI+ project pilot work there in maize and rice. The DAR plans to establish a regional research center in Shan that will work with DOA, NGOs, and farmers. It is important that Shan and all the regional research plans incorporate site-specific soil fertility management as a priority.

In conclusion, we recommend more projects like FSI+ that reflect and support USAID and GFSS strategies and objectives for inclusive and sustainable agricultural development. Such projects succeed when they are grounded in science and economics and predicated on the incentives of markets, value chains, and private enterprise.

Annex 1 Logical Framework for FSI+

Statement	Indicator Targets	Assumptions
Goal Increased incomes and enhanced food security for smallholder farmers in rice-based farming systems of target districts in Burma.	• Gross margins per hectare increase by an average of 15%.	• There are no spikes in either input costs or commodity prices. • As is currently the case, farmers can sell produce without significant difficulties. • On-farm storage has the capacity to hold additional quantity and losses are minimal.
Objectives		
1. Increase production and income from crops produced in rice-based farming systems.	• Rice yields increase by 17%, or an estimated 600 kg/hectare, on average. • Gross margins from rice production increase by 15%. • Maize yields increase by 10% (kg/hectare amount to be determined). • Gross margins from maize production (on a pilot basis) increase by 15%. • Gram yields increase by 15%, or an estimated 180 kg/hectare, on average. • Value of incremental rice production reaches $9.7 million by the end of the project. • Value of incremental gram production reaches $2.01 million by the end of the project. • Incremental production of rice reaches 32,000 mt by the end of the project. • Incremental production of gram reaches 5,000 mt by the end of the project.	• Farmers have access to best practice technology and the required inputs. • Farmers are connected to markets that reflect the true value of commodity prices.
2. Increase capacity of service providers to supply and advise farmers.	• An estimated 35 new briquette producers are established, capable of producing a combined 14,000 mt annually by the end of the project, contributing to the productivity and profitability impact indicators of Objective 1 above. • 180 fertilizer and agro-input retailers are providing diversified product offerings and/or advisory services to farmers by the end of the project, contributing to the productivity impact indicators of Objective 1 above. • 120 agricultural service providers are providing plant protection services to farmers, contributing to the productivity impact indicators of Objective 1 above.	• Retailers have a reliable supply chain for crop inputs. • Retailers have regular access to technical information through wholesalers and DOA. • Retailer margins can increase to the point at which the provision of advisory services is feasible.

<table>
<tr><th>Statement</th><th colspan="5">Indicator Targets</th><th>Assumptions</th></tr>
<tr><td colspan="7">Outputs</td></tr>
<tr><td colspan="7">Increase production of and income from crops produced in rice-based farming systems</td></tr>
<tr><td>1.1 Farmers with crop yield increments and higher gross margins</td><td colspan="5">• Rice yield and gross margin increased for 14,945 farmers, 30% of whom also achieve (green and black) gram yield and gross margin increases.
• Maize estimates to be determined once the scope of the pilot is finalized.</td><td>• Some farmers may belong to more than one group, but they can be identified by crop. Those farming more than one crop in a cropping pattern (for example, rice-gram) will not be double counted.</td></tr>
<tr><td>1.2 Farmers trained to use technology innovations and best management practices</td><td colspan="5">• 11,850 rice farmers trained, 30% of whom (approx. 3,555) are also gram farmers.
• 395 farmer training programs completed.</td><td></td></tr>
<tr><td>1.3 Farmers using technology innovations and best management practices</td><td colspan="5">• 14,945 for rice.
• Maize to be determined.</td><td>• A diffusion rate that slowly increases over the term of the project up to 3:1 in Year 5 has been applied for this revision.
• 80% of farmers using a project technology will continue to use UDP in subsequent seasons.</td></tr>
<tr><td>1.4 Area of crop under technology innovations and best management practices</td><td colspan="5">• 44,836 ha for rice, of which 35,870 ha is under UDP and approximately 30% (approx. over 10,761 ha) is also for gram after UDP in rice in seasonal rotations.
• Maize to be determined.</td><td>• Area per farmer slowly increases over the term of the project up to 3 ha in Year 5.
• 30% of rice farmers farm a rice-gram cropping pattern.</td></tr>
<tr><td>1.5 Balanced use of fertilizer</td><td colspan="5">• Appropriate N:P:K ratio and rate of secondary macronutrients and micronutrients determined for agro-ecological zones through consultation with the Department of Agricultural Research.
• Improved knowledge and practice of nitrogen fertilizer use efficiency in rice and maize (UDP).
• Improved knowledge and practice of phosphorus fertilizer use efficiency in gram.</td><td>• Other element deficiencies can also be corrected (e.g., sulfur and zinc).</td></tr>
<tr><td rowspan="3">1.6 Extension methods to promote technology innovations and management practices</td><td></td><td>Demos</td><td>Trials</td><td>Field Days</td><td>Field Trips</td><td rowspan="3">• Collaboration with DOA; NGO and private sector demos include UDP, balanced fertilizer use, seed variety, and pest management.
• Approx. 30% of rice activity figures will incorporate work with gram.</td></tr>
<tr><td>Rice</td><td>186</td><td>90</td><td>59</td><td>15</td></tr>
<tr><td>Maize</td><td>50</td><td></td><td></td><td></td></tr>
</table>

Statement	Indicator Targets	Assumptions
1.7. Reduced post-harvest losses of rice in rice-gram cropping patterns	• 15 demonstrations of on-farm post-harvest rice storage methods, involving at least 200 farmers.	• The most locally appropriate storage methods will be used.
1.8 Rigorous research study testing the relationship between adoption of technology innovations and dimensions of women's empowerment	• Complete assessment of ole of women in agriculture in project regions and opportunities for empowerment under FSI+; action recommendations made and targets established for inclusion of women.	• Women have a key role to play in providing labor in application of technology innovations. • Women entrepreneurs will show interest to engage as UDP product suppliers. • Women will participate in capacity building events.
Increase capacity of service providers to supply and advise farmers		
2.1 Fertilizer briquette supply chain	• One local manufacturer of briquette machines facilitated. • 35 briquette manufacturers licensed and producing briquettes to supply the area of crops under UDP. • Participation in two agriculture trade shows to introduce new technologies to farmers, dealers, and NGOs. • Briquette manufacturers selling to farmers and through other dealers, with network of UDP supply points estimated at 215 (inclusive of the 35 manufacturers). • Total annual UDP briquette sales up to 14,000 mt midway through Year 5. • Two applicator types introduced into Burma.	• Regulations will allow registration of manufacturers and products. • Network of retailers will give all farmers access to UDP products within 4 km of farm gate at affordable prices (competitive with other forms of fertilizer). • Retailers are motivated to invest in UDP briquetting machines and upgrade product mix with associated yield-enhancing technologies.
2.2 Retailers capable of providing technical information on input use for rice, gram, and, in some cases, maize	• 180 retailers trained in technical and business management subjects. • 120 retailers trained in plant protection service provision.	• Retailers are prepared to take time for training. • Sources of information are DOA and agro-input supply companies that are willing to provide retailers with technical information in Burma.
2.3 Retailers establishing their own demonstrations and preparing their own promotional materials	• 180 retailers with UDP demonstrations. • 180 retailers printing their own promotional material.	• Retailers have land available for demonstrations. • Retailers have access to printing services.
2.4 On a pilot basis, retailers linked to a major multi-national agribusiness, enhancing product diversity and knowledge	• Syngenta participates in 50 demonstrations, 20 retailer trainings, and 10 plant protection contract service provider trainings	• Timeline of FSI+ approval and implementation allow for Syngenta participation.

Statement	Indicator Targets	Assumptions
Project Management		
Start-up	• Completed for FSI; will extend to FSI+ as of Year 2. • Extend scope to new target zones.	
M&E	• Established to provide robust M&E for FSI+ to enable USAID/Burma to meet requirements of U.S. Government FTF Results Framework and custom project indicators.	
Impact assessment	• One farmer-level baseline survey for FSI; extended to new geographies to include FSI+. • One retailer-level baseline survey for FSI; extended to new geographies to include FSI+. • One mid-term evaluation (farmer and retailer level). • One final evaluation (farmer and retailer level).	
MOUs		
Syngenta collaborative MOU	Parameters of this collaboration have been negotiated, and an MOU will be signed once FSI+ is approved; Syngenta will contribute $100,000 toward this partnership.	
Sub-Awards/Grants		
CPP sub-award on women's empowerment	Initial assessment completed; women empowerment seamlessly integrated in project activities.	
I/NGO and local agribusiness sub-grants to facilitate extension and technology transfer	Number of townships, trainings, and demonstrations supported through I/NGO and local agribusiness partnerships.	
M&E firm sub-award to augment data-gathering capacity as required	Third Eye consulting hired under FSI; relationship to continue with Third Eye or similar firms under FSI+.	
Initial environment examination	One report completed.	
Reporting		
Monthly Reports	60 over LOP	
Quarterly Reports	5 over LOP	
Semi-Annual Reports	8 over LOP	
Annual Plan	5 over LOP	
Final Report	One (1)	

Annex 2. Reports and Publications

Required Reports for USAID

2014/15 – Quarterly Progress Reports
2015-2019 – 10 Semi-Annual Reports
Annual Work Plans – one each year
M&E Plans – 2014 and revised in 2017

Project Reports Published on the Website https://ifdc.org/fsi-project-reports/

Research

1. Myanmar Response of Transplanted HYV to UDP- Wet Season 2014
   Download>
2. Report of 2014/2015 Dry Season Trials in Myanmar
   Download>
3. Report of 2015 Wet Season Trials
   Download>
4. Report of 2016 Dry Season Trials
   Download>
5. 2016 Wet Season Trials
   Download>
6. 2016-17 Dry Season Trials
   Download>
7. 2017 Wet Season Trials
   Download>
8. Report on Omission Pot Trials for 2017-18 Seasons
   Download>
9. Trials with UDP on Transplanted Rice and Direct Seeded Rice (2018 Dry Season)
   Download>
10. Trials with UDP on Transplanted Rice (2018 Wet Season)
    Download>
11. Trials with UDP and Prilled UDP on Transplanted Rice and Nutrient Omission and Rate Trials (2019 Dry Season)
    Download>

Crop Cuts

Rice

1. Crop Cut Survey Report (2015/16 Dry Season)
   Download>
2. Crop Cut Survey Report (2016 Wet Season)
   Download>
3. FSI Crop Cut Survey (2017 Dry Season)
   Download>
4. Crop Cut Survey Report (2017 Wet Season)
   Download>
5. Crop Cut Survey Report (2018 Dry Season)
   Download>

6. Crop Cut Survey Report (Wet Season 2018)
   Download>
7. Crop Cut Survey Report (Dry Season 2019)
   Download>

Maize

1. Maize Crop Cut Survey Report (2017 Wet Season)
   Download>
2. Maize Crop Cut Survey Report (Wet Season 2018)
   Download>

Syngenta Agreement Reports

1. Report of Variety and Fertilizer Management Demonstration Plots on Maize in Southern Shan State, Myanmar (2016 Wet Season)
   Download>
2. Report on Variety and Fertilizer Management Demonstration Plots on Maize at Southern Shan State in Myanmar (2018 Wet Season)
   Download>
3. 2017 Dry Season Report on Maize Demonstration Plots
   Download>

Special Reports

USAID/Fertilizer Sector Improvement Project Gender Assessment
Download>

Myanmar Fertilizer Policy Evaluation
Download>

Fertilizer Sector Improvement Project Fertilizer Dealer Survey (2015)
Download>

A Soil Fertility and Fertilizer Management Strategy for Myanmar (2018)
Download>

Myanmar Soil Fertility and Fertilizer Management Conference Proceedings (2018)
Download>

Other Reports Submitted to USAID

Voluntary – 250 weekly reports on project activities and upcoming events

Myanmar Soil Fertility and Fertilizer Management Conference Proceedings (2018)

A Soil Fertility and Fertilizer Management Strategy for Myanmar (2018)

FAW Training Manual – August 2019

Project Impact Report – August 2019

Project Completion Report – October 2019

Other Technical Publications

Aung, H.H., T.H. Aung, T.T. Aung, A.A. Cho, T. Naing, M.M. Kyaw, and Z.H. Hlyan. 2018. "Urea Deep Placement Technology and Its Extension to Farmers in Myanmar," IN *Myanmar Soil Fertility and Fertilizer Management Conference Proceedings*, pp. 117-134, IFDC and DAR, Nay Pyi Taw, Myanmar.

Aung, M., Z.Y. Myint, S. Thura, G. Hunter, U. Singh, and J. Sanabria. 2018. "Comparison of Yield Response and Nutrient Use Efficiency Between Urea Deep Place Technology and Farmers' Practice of Surface Broadcasting Urea on Transplanted Lowland Rice in Myanmar," IN *Myanmar Soil Fertility and Fertilizer Management Conference Proceedings*, pp. 47-54, IFDC and DAR, Nay Pyi Taw, Myanmar.

Kyaw, D. and G. Hunter. 2018. "UDP Technology and Rice Yields Among Farmer Beneficiaries of Rainfed Lowland Project Areas in Myanmar," IN *Myanmar Soil Fertility and Fertilizer Management Conference Proceedings*, pp. 135-149, IFDC and DAR, Nay Pyi Taw, Myanmar.

Win, Z.M. 2018. "The Role of Agribusiness in Advisory and Marketing Services in Myanmar," IN *Myanmar Soil Fertility and Fertilizer Management Conference Proceedings*, pp. 181-193, IFDC and DAR, Nay Pyi Taw, Myanmar.

Annex 3. New Technologies Promoted by FSI+

For Rice/Gram System and Maize

1. Crop Genetics:
   Use of good seed for high-yielding varieties (HYV)/improved local varieties or hybrids. Sourced from DOA, DOA seed grower, seed company, or own (rice) seed garden, as per FSI+ training.

2. Cultural Practices:
   Germination tests to verify >80%

   For transplanted rice:
   - Well-managed nursery – saltwater seed selection; 1 kg/70 ft^2; 20-30 kg/ac transplanted; balanced fertilizer.
   - Transplant 20-25 days after seeding (DAS) for early maturing varieties or 25-30 DAS for late maturing varieties; 8 x 8 or 8 x 6 inch line planting.

   For broadcast seeded rice: Wet season – 75-80 kg/ha; Dry season – <100 kg/ha

3. Pest Management:
   Follow the Five Golden Rules for CPPs (occupational health and safety).

   The five golden rules are defined as follows:

   - Exercise caution at all times
   - Read and understand the product label
   - Practice good personal hygiene
   - Maintain application equipment
   - Wear appropriate personal protective clothing and equipment

4. Soil-Related Fertility and Conservation:
   Apply UDP

   Apply balanced fertilizer – urea, TSP, MOP, and/or gypsum with or without compound fertilizer, according to DOA recommendations and/or FSI+ research by location.

5. Marketing and Distribution:
   Retailers and BMO in FSI+ marketing and distribution networks

6. Other:
   Use of manual applicator for UDP

   Use of mechanical applicator for either UDP or prilled urea

   Use of bookkeeping by retailers and BMOs trained by FSI+

Annex 4. Success Stories from the Project

First Briquetting Machine Adopter in Myanmar Continues to Grow Business

Zin Mar Kyaw is an entrepreneur who started as an input retailer and invested her earnings in agricultural land.

Enterprising Young Woman Expands Her Agro-Input Business

Nay Nay Tun is an agro-input retailer in Phayar Gyi in the Bago Region of Myanmar.

FSI+ Project Responds to Fall Army Worm Infestation

The FSI+ project conducted an Agro-Input Retailers Training on Fall Armyworm at Taunggyi, Aung Ban, Nyaung Shwe, and Pindaya Townships.

School Teacher Turns Village Leader

Daw Kyin Sai farms 15 acres of land in the Ayeyarwaddy Region of Myanmar and is a demonstration farmer.

Leading the Charge in UDP Adoption

Kyaw Win, 73-year-old former Department of Agriculture employee-turned-producer, farms ten acres of rice in the Yangon Region of Myanmar.

Training with a Purpose

Sandar Myint is a successful agro-input retailer in Taunggyi Township in the Shan region of Myanmar. “Since my training, my whole life has changed because I know exactly what to do and how to do it.”

Never Too Old to Learn Something New

Nwe Nwe Win, 50, is a model woman farmer living in Htoo Lay Su Village, Htantabin Township of Yangon Region. Her husband Ye Win is also a farmer.

Seeing is Believing

U Min Zaw owns a 25-acre rice farm in Tei Tei Ku village, Kyaiklat Township, Ayeyarwady.

Farmer-Engineer Innovates New Machinery

U Than Oo and his family own a 30-acre rice farm in Mawgun Township.

FSI+: Improving Rice Productivity in Myanmar

Gross margin ($/ha) in rice plots with UDP increased by 26%.