BILL & MELINDA GATES foundation

Progress Narrative

General Information	
Investment Title	CSISA Phase 3: Cereal Systems Initiative for South Asia
Grantee/Vendor	Centro Internacional de Mejoramiento de Maiz y Trigo

Progress and Results

1. Progress Details

Provide information regarding the current period's progress toward achieving the investment outputs and outcomes as well as the work planned or anticipated for the next period. In addition, submit the Results Tracker with actual results as requested.

This report covers progress and challenges realized in India during CSISA Phase III's first year, December 2015 to November 2016. The flow of the progress narrative aligns with the structure of the Results Tracker, categorizing activities into (A) Innovation Towards Impact, (B) Systemic Change Towards Impact, and (C) Achieving Impact at Scale and (D) Policy Reform. We begin with our most important achievements and challenges, and follow with more detailed updates.

KEY ACHIEVEMENTS

- ADJUSTING PRIORITIES: *Ex ante* analysis (i.e. yield, economics, potential niche wrt adopters + area, and scaling considerations within and beyond project lifecycle) of CSISA's 'core' technologies was completed as part of the 6-months extended planning period. This gave us time to pause, carefully consider our data and assumptions, and develop a clearer view of what the project should prioritize and why. Just as importantly, rigorous foresight and targeting rarely informs the investment priorities of state actors or other development partners in South Asia. Our analysis is being used as a positive example to anchor conversations with partners and something we are sharing as a model with other projects.
- FORMALIZED COLLABORATION AGREEMENT WITH THE INDIAN COUNCIL OF AGRICULTURE RESEARCH (ICAR): Agricultural extension in India is dominated by 'linear' technology transfer models that is insufficiently targeted and responsive to geographically differentiated (and quantitatively proven) opportunities. In consultation with Dr. AK Singh (DDG Extension, ICAR) CSISA began a dialogue on making extension in India more participatory and evidence-based in mid-2015. This dialogue culminated in a presentation to the ICAR Director General (Dr. T. Mohapatra) in May 2016 where we presented a vision for the creative utilization of the Krishi Vigyan Kendra (KVK) network to generate adapted and demand-driven extension messages and investment priorities at the district level. Dr. Mohapatra sanctioned the collaboration with CSISA to move forward with the full commitment of ICAR; a sub-agreement to this effect was signed by CIMMYT and ICAR in July, 2016. Collaborations with 8 KVKs in Bihar, 2 KVKs in Eastern UP, and 2 KVKs in Odisha have been initiated and field activities in the form of applied on-farm research have been implemented for 2016-17 winter cropping cycle.
- GOVERNMENT ENDORSEMENT OF CSISA'S TECHNICAL PRIORITIES: In India, it is often said that agriculture is a 'state' subject. This sentiment acknowledges that the majority of funding and impetus for agriculture development in India resides within the State Departments of Agriculture and not with centrally-based institutions. CSISA continues to leverage relationships with the State Departments in Bihar, UP, and Odisha to influence investment priorities and recommendations. By presenting data at planning fora and sharing of lessons learnt from CSISA, the Bihar State Department of Agriculture endorsed adopted and direct seeded rice (DSR), rice nursery management, and zero tillage wheat as top priorities for 2016–17.
- ACHIEVING EARLY SOWING AT THE LANDSCAPE SCALE: Early wheat sowing is the most powerful entry point for increasing and stabilizing wheat yields in the heat-prone ecologies of Eastern India. CSISA previous convinced the state government in Bihar to make early sowing an official recommendation and top extension priority. That work has now come to fruition. Based on remotely-sensed information that has been cross-validated through

targeted village surveys, we estimate that some 250,000 hectares of wheat were sown at least 5-days earlier in the 2015-16 cropping season across Bihar and Eastern UP.

- EXPANDING THE SERVICE ECONOMY FOR SUSTAINING IMPACT: Through its partners, CSISA facilitated the emergence of an additional 740 zero-tillage (ZT) service providers for wheat, reflecting an annual growth rate of 34%. Aided by the projects efforts, more than 47,000 households implemented ZT for wheat in Bihar and Eastern UP in 2015-16. For capital-intensive technologies like ZT, purchased services are the only way that cash-constrained smallholders can access the technology. Our 2016 survey of SPs showed that adoption among smallholders in Bihar who are aware of the technology increased from 21% in 2012–13 to 31% in 2015–16, suggesting that equitable access through service providers increases as the market matures.
- CRITICAL MASS OF NEW ADOPTERS: Directly sown rice (DSR) has not gained traction in Eastern India in part because of poor machinery availability in the areas it has been promoted. By specifically targeting ZT drill owners to explore business opportunities in rice, the area under DSR expanded to 2,238 ha in 2016 in Bihar, an increase of 85% over 2015.
- PARTNERSHIPS FOR INCLUSIVE GROWTH: In the tribal belt of Odisha, CSISA has succeeded in developing a strong alliance of partners to support the profitable production of maize at scale. The area under intensified maize production increased from 629 ha in 2015 to 1,681 ha in 2016, with women farmers accounted for 25% of those producing maize for market with a net income increase of $575/ha. There is enormous potential demand among existing Odisha millers for locally-produced maize grain. During high-level consultations at the end of November 2016, CSISA convinced the State Department of the merits of our market-focused and coalition-based approach to maize intensification, and they have committed to expanding the model to more areas in Odisha in partnership with CSISA. Detailed planning for this new partnership is now underway.
- NEW EVIDENCE GENERATION: *Rabi* fallows intensification was the first priority raised by the incoming ICAR Director General (Dr. T. Mohapatra) when the CSISA leadership team met with him in March 2016. The opportunity and apparent need for intensification in these very expansive ecologies is clear, particularly given the diminished yield gaps in the 'bread basket' areas of NW India and the lack of major genetic breakthroughs in the yield potential of the major staple crops. That said, encouraging double cropping in these areas has been a policy imperative in India for the past 20 years and but not much has changed. CSISA has committed itself to learning about how farmers perceive of these opportunities and to determine through decision experiments if 'smarter' support programs are likely to result in an intensification trajectory. Already our work is revealing some surprising results with farmers identifying delayed rice procurement and lack of financial liquidity as binding constraints that preclude winter cropping. These issues are not reflected in any of the on-going or proposed support programs for fallows intensification. The State Department has taken note of our results and has committed to additional evidence generation in collaboration with CSISA.
- TAKING THE LONG-VIEW: CSISA's on-going experimental platform work in collaboration with ICAR (Research Complex for the Eastern Region – Patna, Bihar) affords us the opportunity to assess cumulative and year-wise performance of new technologies. Worrying trends have emerged In 2016, the 7th consecutive rice season with DSR cultivation. Results show that the paddy yields in ZT-DSR were 4.24 t/ha in the scenario 3 (ZT-DSR – ZT-wheat-ZT-moong bean) while in scenario 4 (ZT-DSR – ZT mustard – ZT maize) the paddy yield was reduced to 2.47 t/ha. In contrast, transplanted rice yields in scenarios 1 and 2 ranged from 5.03 to 5.63 t/ha. Modifications of the treatments (split plots) will be implemented to determine if the observed trend is associated with DSR, zero tillage, or a combined effect.

PROGRESS BY INTERVENTION

NOTE: CSISA finalized its extended planning phase with a re-submission of the Phase III proposal in August 2016, receiving final approval from the foundation this past October. Hence the evolved set of priorities, approaches, and project structure described below were not fully in place until the last quarter of 2016. Some interventions did not change remarkably from earlier versions of the proposal, and progress was stronger in those areas. Others areas are newer and just building momentum, particularly those like the precision nutrient and irrigation management interventions that are predicated on forging new partnerships that were not in place in Phase II of the project.

THEME A. INNOVATION TOWARDS IMPACT

Sub-theme A.1: Reducing risk to facilitate the uptake of sustainable intensification practices

Intervention A.1.1: Directly sown rice (DSR) to address labor and energy constraints

Context, approach, and objectives: DSR squarely addresses the major drivers of change in the agricultural systems of the Eastern Indo-Gangetic Plains, namely labor and energy costs that make production increasingly uneconomical. DSR adoption has nonetheless been low due to the perceived risk of poor crop performance among farmers. The future prospectus for DSR depends on combining risk-reducing agronomic practices with technology targeting to environments with less weed pressure, where machinery is available, and where water control can be achieved to avoid stand mortality from inundation by reliably establishing the crop early with irrigation before the chance of heavy monsoon rains increases. For these reasons, CSISA is giving an intermediate level of investment to DSR in Phase III, with a focus on the following work stream elements: (1) development of spatial analytics for technology targeting given biophysical and market constraints, (2) work with NARES partners to evaluate innovative agronomic practices that can reduce risks – including agro-climatology based insights, (3) in areas where DSR holds the most promise, conduct ToTs for service providers on DSR, (4) facilitate market linkages for herbicide dealers operating in areas in which DSR is expected to expand.

Progress in the reporting period:

- TARGETING FAVORABLE PRODUCTION ECOLOGIES: There are vast differences in the performance of direct seeded rice across ecologies. CSISA obtained an average paddy yield of 4.9 t/ha from 32 sites in lowland ecologies compared to 3.6 MT/ha from 33 sites in upland ecologies. Hybrids were better-suited for DSR because of vigorous early growth to out-compete weeds as well as better tolerance to water stress.
- RISK-REDUCING AGRONOMY: On-farm evaluations of 'dust mulching' practices were conducted. Dust mulching is a simple management adjustment that uses pre-sowing irrigation followed by shallow tillage to better control weeds and permit earlier planting by limiting irrigation requirements through reductions in water losses from soil evaporation. With this technique, the newly established crop can survive 2-3 weeks without rains or post-sowing irrigation whereas a crop sown following post-tillage irrigation would fail under similar conditions. In these trials, dust much also reduced weed densities and biomass by half (43 to 65%).
- AGRO-CLIMATOLOGY AND WATER MANAGEMENT: Through dynamic simulation (APSIM-based), low-risk cultivar choices were identified for rainfed DSR systems in the Eastern IGP. In these simulations, transitioning from the most common long-duration varieties to short-duration hybrids resulted in a low probability of crop failure and an associated increase in mean yield from 2.0 t/ha to 4.5 t/ha. Application of supplemental irrigation reduced risk by permitting earlier establishment and avoiding scenarios where either the crop cannot be established due to field access limitations or stand mortality occurs due to inundating water when the crop is just emerging. Supplemental irrigation permits reliable crop establishment before the second week of June, thereby increasing mean crop yields to 6.0 t/ha for both long-duration cultivars and short-duration hybrids.
- MAINSTREAMING WITH PARTNERS: CSISA participated in the planning meetings of Department of Agriculture (DoA) Bihar where priorities for expanding area under DSR were endorsed as a state priority in 2016. CSISA's best-bet agronomic tips for DSR (6,000 distributed to each Bihar and EUP) were extensively used by district-level officers and grassroots extension workers. Tips on DSR were also developed for Odisha and endorsed by the Odisha State Department of Agriculture. In both cases, the tips have been adopted for extending key messages to farmers as well as for internal capacity development purposes.
- JUMPSTARTING THE SERVICE ECONOMY: In Bihar, CSISA-affiliated ZT wheat service providers (i.e. drill owners) were encouraged to expand their business to the direct sowing of rice. In Bihar and EUP, 318 ZT service providers (>15% of total associated with CSISA) were involved in the service provision business for the direct sowing of rice in 2016. In Odisha, all of the service providers (49) were fully engaged in DSR service provision.
- CRITICAL MASS OF NEW ADOPTERS: The area under DSR expanded to 2,238 ha in 2016 in Bihar compared to 1,210 ha in 2015, an increase of 85%. Similarly, with the help of KVKs, the area under DSR in Eastern UP expanded to

2,463 ha, an increase of 65% over the year before.

- TAKING THE LONG-VIEW: CSISA's on-going experimental platform work in collaboration with ICAR (Research Complex for the Eastern Region – Patna, Bihar) affords us the opportunity to assess cumulative and year-wise performance of new technologies. Worrying trends have emerged In 2016, the 7th consecutive rice season with DSR cultivation. Results show that the paddy yields in ZT-DSR were 4.24 t/ha in the scenario 3 (ZT-DSR – ZT-wheat-ZT-moong bean) while in scenario 4 (ZT-DSR – ZT mustard – ZT maize) the paddy yield was reduced to 2.47 t/ha. In contrast, transplanted rice yields in scenarios 1 and 2 ranged from 5.03 to 5.63 t/ha. Modifications of the treatments (split plots) will be implemented to determine if the observed trend is associated with DSR, zero tillage, or a combined effect. Most farmers till their fields in a dry condition before sowing DSR.

Challenges:

- Early pre-monsoon showers (3rd week of May to 2nd week of June 2016) shortened the period that drill-sown DSR could be sown in rainfed systems, highlighting the importance of targeting irrigated areas to reduce risk.
- The pre-emergence herbicide 'pendimethalin' hampered rice germination in locations that encountered heavy early rains. In rainfed systems where early planting cannot be guaranteed, pendimethalin is no longer recommended.

Emerging opportunities:

- One of the causes for the slow adoption of DSR in Odisha is an inadequate number of seed drills; CSISA continues to work with public and private sector partners to bring more drills into the system for service provision and this effort is aligned with significant government programming to support mechanization in the state.
- Bearing in mind that drills availability is likely to continue to constrain adoption, adaptive trials were designed to test the potential of precision broadcasting at lower seed rates combined with early weed control using integrated weed management practices. Initial results suggest a reduction in the cost of cultivation by $59/ha and an increase in yield >1 t/ha compared to beushening with manual seed broadcasting at a high seed rate.

Intervention A.1.2: Realizing the potential of mechanical rice transplanting

Context, approach, and objectives: Mechanical rice transplanting was a technical priority for CSISA in Phase II. Despite considerable yield, energetics, and profitability advantages, adoption remains low largely due to the high cost of the machinery. Nevertheless, there are clear niches where the technology may have a strong business case to aid sustainability and achieving scale, particularly in the double-rice systems of Odisha where the working area and profitability of each machine is double that of single rice system. CSISA has a unique role in developing business diagnostics and analytics in partnership with service providers and machinery dealers and importers, to determine where there is a viable economic case for new technologies independent of subsidy-based support. In Phase III, CSISA is transitioning from a broad-based extension approach and focusing more attention on strategically identifying geographies, business models and other enabling factors that will better inform the public and private sector where MT technology is most likely to be adopted at scale. Those studies and stakeholder engagements are underway and this report mostly conveys some of progress made with service providers and demand generation across CSISA's areas of engagement.

Progress in the reporting period:

- TESTING NEW BUSINESS MODELS: Two types of mechanically transplanted rice (MTR) service provision are being assessed. The first is an integrated model incorporating mat nurseries and mechanical transplanting, and the second, a service provision model only. CSISA is in the process of conducting a business model characterization study across three villages in Odisha: in the first, an established SP with 10 machines in Baniasahi village with an outreach of 550 acres; in the second, a growing SP with 4 machines in Mangarajpur village with an outreach of 195 acres and third, a start up with one machine in Kuanrapur village serving 30 acres of land. A full business diagnostic synoptic study will be conducted after the dry season in the double-rice cropping system of Odisha (March–April 2017).
- PROGRESS IN THE FIELD: CSISA-supported service providers (192) covered 3,265 hectares, a 50% increase from 2015. Yield advantages were confirmed in this broader geography with paddy yields of 5.1 t/ha compared to 4.6

t/ha with manual transplanting in Bihar and similar results in Eastern UP and Odisha.

- PRIVATE SECTOR ENGAGEMENT AND PPP: CSISA developed a new platform for TOT in MTR and nursery development by linking women's groups (Sewa Bharat) and the agriculture wing of ITC (Indian Tobacco Company), with support from the Bihar State Department of Agriculture. In Odisha, CSISA started district-level TOT programs in MTR service provision in collaboration with NGOs and the DoA.

Challenges: Odisha current has one of the lowest rates of agricultural mechanization in India. Given the seasonal labor bottlenecks that are endemic to all parts of the country, the basic incentives are strong for innovations such as mechanical transplanting. Nevertheless, machinery value chains and private sector presence is limited. Progressive steps have been taken by the State Department through subsidy programs, but progress has been incremental.

Emerging opportunities: Mechanization is a top priority for state governments in Eastern India including Odisha and Bihar. CSISA will capitalize on this opportunity by helping the State Departments sharpen support programs by better targeting subsidies that do not 'crowd out' private investments while encouraging the development of markets and machinery value chains.

Sub-theme A.2: Adding value to established and emerging extension and agro-advisory systems

Intervention A.2.1: Timely and actionable advice on yield-enhancing irrigation scheduling for rice and wheat

Context, approach, and objectives: Despite considerable investment in agro-advisory systems at the national, state, and district levels, farmers' use of these recommendations remains limited across India with the ROI on what constitutes a very large investment questioned by many inside and outside the system. The lack of impact associated with current approaches to agro-advisory has antecedents in two areas: (1) information supplied at scales too coarse to permit actionable management decisions, and (2) information not conveyed in simple formats that are readily understood by end users. Irrigation scheduling has an enormous bearing on yield, yield stability, and the economics of staple crop production. It is also the management decision potentially most amenable to support through agro-advisory. By leveraging crop modeling, remote sensing, and weather forecast information, CSISA is working to improve the quality of irrigation scheduling recommendations deployed through established agro-advisory services. This work is predicated on new partnerships with Indian Space Research Organization (ISRO) and the Indian Meteorological Department (IMD), and will ultimately include field testing through the KVK network. Additional work through these same partnerships will focus on in-season adjustments of fertilizer application rates (see next section on precision nutrient management).

Progress in the reporting period:

- FORMALIZING PARTNERSHIPS: CSISA engaged with Space Agriculture Center (SAC), ISRO to determine areas of common interest and opportunity. Based on the discussion, a detailed collaborative work plan on yield-enhancing irrigation scheduling and in-season N-adjustments for rice and wheat has been developed and submitted to ISRO for review. A follow-up meeting with SAC and CSISA scientists will be held in Q1 of 2017 to finalize the work plan.
- DEFINING A SCOPE OF WORK: Collaborative planning with these partners has identified three core workstreams: 1) using time-series remotely sensed information to delineate 'homogenous zones' where management and biophysical factors are relatively uniform that can serve as logical spatial units of analysis for bringing precision agronomy to scale through agro-advisory 2) developing an analytical framework that integrates real-time crop status and remote sensing information and weather information through simulation models to drive adaptive management decisions for irrigation and fertilizer management, 3) strengthen the mechanisms and formats that agro-advisories are communicated with end users in mind through 'rapid prototyping' approaches. The work plan is based on CSISA strengths in crop simulation and ground data collection and ISRO strengths in high spatio-temporal satellite data and their new partnership with Indian Meteorological Department to support agro-advisory.
- FIELD LEVEL COLLABORATIONS: Through our deepening association with ICAR's Extension Division, collaborating KVK's have been identified in Bihar and Odisha to facilitate farmer engagement on decision tool design and *ex post* assessments of adoption and utility after the improved agro-advisories are in place.

- WORKSTREAM PROGRESS: CSISA used 15 years of time-series spatial data (2000–2015) to identify homogenous zones for wheat in the Eastern IGP. Functional typologies are being developed for these zones that couple CSISA's spatial network of crop-cut data and production practices surveys to define unifying attributes of each zone.

Challenges: Too early to report.

Emerging opportunities: Although ISRO has worked at the periphery of agriculture for many years, they have been functionally isolated from the organizations responsible for devising and running agro-advisory systems. Their new tri-partite collaboration with IMD and the KVKs (through ICAR) provides an excellent opportunity to bring world-class spatial datasets and analytics into the agricultural space. CSISA will act as an important 'bridge' in these relationships by understanding both ground realities along with the possibilities and limitations of satellite-derived data. We also bring expert knowledge of the integrating frameworks such as simulation tools that will ultimately drive the most advanced forms of advisory.

Intervention A.2.2: Building precision nutrient management approaches around existing scaling pathways

Context, approach, and objectives: Strong progress has been made over the last 20 years to advance the theory and practice of site-specific nutrient management. Unfortunately, the adoption of decision tools at the field scale is extremely low, despite proven yield and profitability advantages. Rather than continuing to develop tools and then seeking viable pathways to scale them, CSISA is first focusing on opportunities to bring science-based innovation to established and emerging scaling pathways, namely by supporting the Government of India's Soil Health Card (SHC) scheme and by leveraging the power of geo-spatial information to inform agro-advisory for in-season adjustment of fertility recommendations.

Progress during the reporting period:

- DEFINING THE PROBLEM AND THE OPPORTUNITY: CSISA organized a national convening with ICAR, TAAS, BMGF on 'Scaling precision nutrient management (PNM) practices in South Asian cereal systems' in Mussoorie, India from April 27–29, 2016 with a focus on reviewing the present status of PNM in South Asia and brainstorming a pathway forward. This was followed by a policy roundtable convened in Delhi to bridge the divide between technical progress on PNM and the government support programs that are meant to bring new practices to scale.
- A VIEW OF WHERE THE PNM COMMUNITY STANDS FROM MUSSOORIE PARTICIPANTS**:**
    - Significant opportunities exist to increase nutrient use efficiency, productivity and profitability of cereal systems in South Asia through science-based nutrient management solutions.
    - The principles of crop and nutrient management are well understood, but large-scale adoption of PNM remains elusive with few positive examples.
    - Development of impact pathway logic that can help drive technology adoption at scale remains underutilized
    - Advances in spatial data and environmental informatics have not been fully leveraged.
- PRINCIPLES FOR PNM PROGRESS FROM MUSSOORIE PARTICIPANTS**:**
    - Understand user preferences / market niches: customize products based on actual demand of not only farmers but also by potential scaling partners like agro-dealers.
    - Mainstream new analytics: for digital soil mapping, yield prediction, and economics.
    - Test before launch: conduct market research before programs are initiated.
    - Strategic co-investment: in enabling factors that encourage farmers to sustainably adopt and make the most out of precision nutrient management practices.
    - Encourage: open data /open source approaches that broaden ownership and provoke innovation.
    - Support: on-going investments such as the Soil Health Card scheme through digital soil mapping.
- KEY MESSAGES FROM THE PNM TECHNICAL COMMUNITY TO POLICY MAKERS INCLUDED:
    - Create an enabling environment for innovation:
        - 'Big' data investment that will support tool development, policy prioritization, and technology targeting
        - Re-structured subsidies that draw in private investment + innovation (new products and market dev.)

- Recognize that there are few universally-applicable technical solutions; structure policies such that a diversity of approaches emerge that can be matched to end-user preferences and market niches.
- Invest in ML&E for rapid product prototyping and unbiased evidence generation
- Encourage creative science and technology scaling partnerships between public and private sectors
- Promote new institutional arrangements to close gaps and achieve synergies:
    - Collaborations between agro-advisory (IWD) and nutrient recommendations (IISS)
    - Use of KVKs for rigorous evaluations of performance, adoption, decision processes, etc.

- MAINSTREAMING NEW SOIL TESTING METHODS: Soil samples and ancillary data from 460 CSISA sites across Odisha, Bihar and EUP were shared with IISS, Bhopal and ICRAF for spectroscopic analysis. These samples are unique because they included wet chemistry analysis as well as crop response data for nutrient omission, a key consideration for linking spectral-based soil assessments to field management. MIR analysis was completed for all samples at IISS and the results are being processed and compiled.

- PROOF OF CONCEPT FOR WHEAT PNM THROUGH AGRO-ADVISORY: Planting date has more influence on wheat yield potential than any other factor in the Eastern IGP and can be reliably assessed in real-time by satellites in order to drive in-season adjustments of nitrogen fertilizer rates. Proof of concept experiments have been established with KVK partners to identify optimum nitrogen management practices as a function of wheat planting dates. The State Agricultural Universities are also engaged as they must endorse any proposed change in official recommendations.

Challenges: Most government programs in India are highly political in nature, and the soil health card scheme is no different. SHC is doubly difficult because it is jointly administered by the State Departments of Agriculture, ICAR, and the Ministry of Agriculture and Farmers Welfare. Understanding who are the real decision makers that can authorize creative 'experiments' with the SHC scheme is a difficult task. CSISA is working to continue the high-level dialogue that we started in Mussoorie to overcome some of the political and coordination issues that are endemic to work on the SHC. Our national advisor, Dr. Raj Paroda (ex ICAR DG), will be instrumental to this effort.

Emerging opportunities: Scaling considerations have been the downfall of nearly every PNM initiative in South Asia. With a planned GoI investment of $84 m USD, there are ample reasons to rally around the opportunity and 'ready-made' knowledge scaling pathway that this investment creates.

B. SYSTEMIC CHANGE TOWARDS IMPACT

Sub-theme B.1: Partnerships for inclusive growth around commercial pockets and neglected niches

Intervention B.1.1: Deployment of better-bet agronomic messaging

Context, approach, and objectives: Despite growth in the private sector and recent re-investments in extension, many poorer communities in the Eastern IGP are not connected to these sources of agricultural knowledge and the information that is available is often communicated in complex formats that are presented through technical 'jargon'. On the other hand, considerable investments have been made in South Asia through state-based rural livelihoods projects in India. These initiatives have tremendous connectivity with marginalized groups, including women farmers, and can be leveraged to extend better-bet management information to communities that otherwise are disconnected from most formal and informal knowledge sources. CSISA continues to collaborate with formal extension, input dealers, and livelihoods initiatives to provide better-bet guidance for cereal crop management that is demand-driven and presented in accessible formats to farmers.

Progress in the reporting period:

- PRINTED GUIDES: Using results from farmers' participatory research, the ICAR-CSISA research platform, and evidence from partner organizations including ICAR & SAUs, CSISA prepared simple and accessible guides for 'better bet' agronomy for the following topics: directly sown rice, integrated weed management, maize in Odisha, zero-tillage and early sown wheat (see: http://csisa.org/technical-publications/). Materials were translated into local languages and disseminated among through partners including women's SHGs and their federations,

development partners like Pradhan, as well as through the State Departments of Agriculture.

- ICT ALTERNATIVES: Videos on early wheat sowing and zero tillage technology were prepared and distributed through state extension for creating awareness about these technologies. Radio jingles were aired through FM radio to support the widespread adoption of DSR in Eastern UP.
- BASIC MESSAGES FOR MASS CIRCULATION: Tips for nursery management, maize intensification, and integrated weed management (IWM) were published in local newspapers in 20 districts of Odisha.
- ENSURING THE CONTENT 'WORKS' FOR DIFFERENT GROUPS: Focus group discussions were conducted with progressive male and female farmers as well as with less educated male and female farmers in Bihar and Odisha to assess farmer comprehension and perceptions of our printed guides with additions, simplifications, and deletions implemented accordingly.

Challenges: Development partners have their own circumscribed mandates and livelihoods initiatives in India function as massive bureaucracies; both factors contribute to serious inertia in the system that makes partners slow to embrace new opportunities. CSISA has completed very positive dialogues with JEEViKA leadership and expects this livelihoods initiative and several others to mainstream several of our guides before the 2017 *kharif* season.

Intervention B.1.2: Income-generating maize production in neglected hill and plateau ecologies

Opportunities: As above.

Context, approach, and objectives: In Phase II, alternative crops were assessed for production and income generation potential in Odisha's tribal-dominated plateau region. Maize stood out as a potentially remunerative crop with high level of farmer acceptance (including among women) coupled with tremendous growth potential if farmers can be effectively linked to poultry feed mills within Odisha that currently procure maize from outside the state. To capitalize on these opportunities, creative partnerships are essential that draw together a coalition of output market actors and facilitators, development partners that focus on women's empowerment through literacy and numeracy (e.g. Pradan), input providers for seed and fertilizer, and the commitment of the State Department of Agriculture to provide support within a network partners wherever needed – a development that is an innovation unto itself. Within this network of partners, CSISA is playing the dual role of providing technical know-how while facilitating coordination among a disparate set of partners who otherwise would not work together with collaborations driven by a clear and comprehensive Theory of Change. This approach contrasts to the types of *ad hoc* technical interventions such as provision of hybrid seed that dominates much of the agriculture development support programing in India.

Progress in the reporting period:

- CLARIFYING THE TECHNICAL, MARKET, AND COMMUNITY CONTEXT: in part due to the depleted nature of its soils, agriculture in the tribal-dominated plateau region is typically 'written-off' by policy makers as intrinsically unproductive. By emphasizing the power of soil fertility management and other types of best practices, CSISA has demonstrated the very considerable production potential for high-yielding crops such as maize in this region, tripling yields (or more) and transforming profitability over current farmer practices. Perhaps just as importantly, our work has highlighted the multiple end uses for maize (i.e. household consumption, local market as a fresh vegetable, and dry grain sales for food and feed) that can equate to improved HH food security and income generation, with lower levels of risk since all 'eggs' are not in one basket. CSISA's experience engaging with communities also demonstrates that farmers will preferentially cultivate maize in upland fields where extensive grazing is currently practiced, thereby constituting a new more intensive use of the land that doesn't displace other food security crops. Together, progress and learning in these areas have given us a strong platform to engage and mobilize a broad coalition of stakeholders (Department of Agriculture, women's SHGs, development partners, input suppliers, and output market actors).
- ALIGNMENT WITH STATE PRIORITIES: CSISA's maize programming in the plateau is squarely aligned with the state's strategic plan that prioritizes engagement with small and marginal tribal farmers, with a special emphasis on women farmers. This alignment continues to open doors at the district to state level because the State Department is charged with achieving real change and can claim progress as a joint achievement.
- A COMPREHENSIVE APPROACH: One of CSISA's mantras is the concept that change doesn't typically occur on the back of one thing, but rather the orchestration of several. With our range of partners, we conducted 16 pre-

season collaborative planning meetings. The planning meetings helped CSISA and its partners increase the availability of quality inputs, coordinated mechanized service provision, and secured commitments for grain procurement before the crops were sown.

- TRAINING INTERMEDIARIES: Based on participatory research conducted since 2013, CSISA's has produced simple guides to better bet agronomy for maize in the plateau. These guides form the basis for capacity development for agricultural professionals, development workers, and community SHG. More than 50 'master' trainers were supported in 2016 who, in turn, disseminated knowledge on low-risk and profitable maize agronomy through their own networks.
- GENERATING MOMENTUM AND INCLUSIVE GROWTH: CSISA succeeded in developing an informal but strong strategic alliance of concerned stakeholders all working to support the profitable production of maize at scale. The area under intensified maize production increased from 629 ha in 2015 to 1,681 ha in 2016. Women farmers (approximately 700) accounted for 25% of those producing intensified maize with a profitability of $575/ha.
- AMPLE ROOM FOR EXPANSION: Proximate markets in the form of medium to large poultry feed mills are present in northern Odisha were CSISA works; historically these mills have procured grain from other regions of India like Bihar and AP. By sourcing locally, millers can save transportation costs if the supply chains can be consolidated. From a base of zero in the districts where CSISA is working, approximately 700 MT of maize were locally procured by feed mills in 2016. This volume is a good start, but represents less than 1% of the current maize demand of existing mills.

Challenges:

- The availability of quality machinery (e.g. maize planters and shellers) remains a bottleneck. In consultation with the State Department, CSISA has facilitated the purchase of 20 planters by private service providers in the plateau and has helped communities repurpose more than 150 paddy threshers to shell maize. More importantly, we have assisted the private sector establish new machinery dealerships in Odisha.
- An open market for maize seeds has not yet developed in the Odisha plateau. So far, the Department of Agriculture (DoA) is in charge of sourcing and distributing seeds to farmers. The current season's successful production has attracted the attention of the private sector input dealers, and we expect them to his capitalize on this opportunity.
- Feed mills need to make bulk purchases and cannot be overwhelmed by making many smaller transactions for procurement, since this drives up costs and erases much of the profitability gains from reduced transportation costs. Aggregation and market intermediaries are a must and CSISA is working with partners to support this dimension of the value chain.

Opportunities:

- There is enormous potential demand among existing Odisha millers for locally-produced maize grain. Also, state estimates suggest a considerable area is under upland fallow (0.14 million ha) in the tribal belt, much of it suitable for maize cultivation without displacing other uses.
- During high-level consultations at the end of November 2016, CSISA has convinced the State Department of the merits of our market-focused and coalition-based approach to maize intensification, and they have committed to expanding the model to more areas in Odisha in partnership with CSISA. Detailed planning for this new partnership is now underway.

Intervention B.1.3: Rice fallows development in coastal Odisha

Context, approach, and objectives: There are approximately 22 m ha of *rabi* season fallows following *kharif* rice in India. In Phase II, CSISA focused on generating evidence on the yield potential and consolidating technical guidance on crop production technologies in coastal Odisha (Bhadrak, Balasore, and Puri Districts). In Phase III, CSISA is playing a convening role with NARES, private sector, and key livelihoods initiatives in an attempt to create an enabling environment for intensification by identifying a logical sequencing and coordination of technical, market and policy interventions to support intensification. At the center of this effort is an emphasis on decision processes at the farm and community level. Recent history has shown that piecemeal investments in irrigation capacity and output market development in these

environments rarely produce durable results. CSISA's initial efforts are dedicated towards developing evidence for the types of foundational investments that are likely to trigger additional investments by farmers and the private sector, establishing a trajectory for sustainable intensification.

Progress during the reporting period:

- DEMONSTRATING PRODUCTIVITY POTENTIAL: Extension and evidence generation activities carried over from Phase II show clearly that a range of crops can be successfully cultivated in fallowed areas. Service providers with seed drills reached approximately 900 ha, cultivating green gram (714 ha), black gram (28 ha), mustard (96 ha) and sunflower (44 ha). Green gram yielded up to 2.7 t/ha under improved management practices using machines.

- EXPERIMENTAL APPROACH FOR DECISION PROCESSES: CSISA completed field diagnostics of the types of interventions, sequencing, and coordination required to stimulate intensified cropping in the *rabi* fallows areas of coastal Odisha. Participatory cognitive mapping exercises were conducted to characterize perceptions of the opportunities and what support programs or other steps would be essential for promoting intensification. The exercise took place at two levels: First, Fuzzy Cognitive Maps (FCM) were developed based on village-level focus group discussions in Bhadrak, Balasore and Puri Districts. Second, district-level cognitive maps were built with 'expert' groups from the same districts. The experts in this elicitation process represented Department of Water Resources, Registrar of Cooperative Societies (Puri), Department of Agriculture, UCO Bank, district social welfare office, Odisha Lift Irrigation Corporation Ltd, KVKs, OUAT, NABARD, Solidarity, Farmers' Coop Society, and Palli Pragati Krushak Mancha.

- KEY RESULTS: The following insights emerged from the discussions that the team had with different groups during mapping exercise:
  - Delayed rice procurement and insufficient credit heading into the winter season prevent many farmers from investing in winter cropping; this was identified by farmers as perhaps the primary constraint to fallows development, yet policy makers and other 'experts' do not perceive this issue to be a core constraint and do not have programs in place to address it.
  - Not surprisingly, assured access to water resources is also perceived to be a binding constraint to intensification. Access itself is not the only issue. Many farmers are linked to surface water canals, but the reliability of that infrastructure with respect to timing and duration of water flows makes farm-level planning difficult and risky. On the other hand, support schemes for tubewell installation are preferred by farmers but the process of availing to subsidy is considered a cumbersome process and often political in nature. Support programs that are well designed on paper often function less than optimally in practice, and our results suggest that the state government in Odisha needs to take a close look at how support programs that are cross-sectoral in nature (e.g. Water Resources and Agriculture Departments) are administered.
  - Guaranteed water availability alone, however, is unlikely to spur intensification based on the considerable number of tubewell schemes that are now either defunct or only partially utilized.
  - To make support programs effect, it is just important to identify constraints that don't require state investment. Issues that other studies have flagged as important to fallows development such as containing the animal 'menace' posed by open grazing is not perceived by farmers to be a fundamental constraint. If other enabling factors are in place that support intensified cropping, farmers intimate that the community will tackle this issue through their own efforts.

Challenges: *Rabi* fallows intensification was the first priority raised by the incoming ICAR Director General (Dr. T. Mohapatra) when the CSISA leadership team met with him in March 2016. The opportunity and apparent need for intensification in these very expansive ecologies is clear, particularly given the diminished yield gaps in the 'bread basket' areas of NW India and the lack of major genetic breakthroughs in the yield potential of the major staple crops. Future food security will depend on producing two crops per year in these areas. That said, encouraging double cropping has been a policy imperative in India for the past 20 years and but not much has changed. At the end of the day, intensification at scale is the result of private decisions made by millions of small and marginal farmers who have their own perceptions and calculus of the risks and benefits associated with double cropping. CSISA has committed itself to learning about how farmers perceive of these opportunities and to determine if 'smarter' support programs and new knowledge are likely to result in an intensification trajectory. No outcomes are assured, and it may well be that intensification will only happen at scale when commodity prices significantly increase. That itself, however, would be a useful finding that would potentially steer the government away from making unproductive investments that would be better placed elsewhere. At the BMGF-

support policy roundtable in Odisha in September 2016, important voices have called for a > $1.5 billion USD investment in solar pumps to support intensification in the *rabi* fallows areas. The stakes are potentially very large.

Emerging opportunities:

- CSISA's efforts to learn about decision processes will not pay-off if they are decoupled from policy making and investment priority setting at the state level. A strategy meeting was organized between State Department of Agriculture (including Principal Secretary and Commissioner of Agriculture) and CSISA leadership on the 24th of November 2016. Fallows development is a state priority in Odisha and we spoke at length about past development efforts and what our initial work on decision processes is suggesting. We have requested that the Government of Odisha joins us in a joint effort to generate more evidence and a committee has been formed to accelerating planning for this purpose.
- Lower input intensification pathways are possible in coastal Odisha, including those based on better-managed pulses and oilseed crops. CSISA's data suggest that simple steps such as applying a single irrigation to a rainfed crop can increase yields 50% or more. In the forthcoming decision experiments, CSISA will emphasize enabling factors for both 'higher input – higher output' systems, as well 'lower input – lower output' systems.

Sub-theme B.2: Bringing participatory science and tech evaluations to the landscape and back again

Intervention B.2.1: Increasing the capacity of NARES to conduct participatory science and tech evaluations

Context, approach, and objectives: India's KVKs are a tremendous potential asset to help establish district-specific recommendations and investment priorities for agricultural development. However, at present, most only focus on front-line demonstrations, and do not generate quantitative information on technology performance or farmer preferences. In contrast, BARI's On Farm Research Division (OFRD, Bangladesh) conducts on-farm replicated agronomic trials, but with a low level of farmer involvement and without multi-criteria analysis. Neither approach is sufficient nor are companion efforts in all three CSISA countries to conduct surveys to assess management practices in time and space either unrepresentative or not subject to modern multi-variety analytical tools. Responding to these constraints, CSISA will act to implement trainings with the KVKs in India, OFRD in Bangladesh, and the statistical services in all three CSISA countries to improve participatory methods, research design, sampling, and analytical capabilities.

A second objective is to better equip the KVK network in India with the capacity to offer technical guidance and training to extension personnel as other 'change agents' such as input dealers and service providers.

A third objective is to enable the KVK network to conducted rigorous M&E, not only on their own programming, but to quantitatively assess adoption dynamics and technical performance of technologies and support programs implemented by the State Departments of Agriculture.

Progress in the reporting period:

- FORMALIZED AGREEMENT WITH THE INDIAN COUNCIL OF AGRICULTURE RESEARCH (ICAR): In close consultation with Dr. AK Singh (DDG Extension, ICAR) CSISA began a dialogue on making extension in India more participatory and evidence-based in mid-2015. This dialogue culminated in a presentation to the ICAR Director General (Dr. T. Mohapatra) in May 2016 where we presented a vision for the creative utilization of the Krishi Vigyan Kendra (KVK) network to generate adapted and demand-driven extension messages and investment priorities at the district level in India. Dr. Mohapatra was convinced and sanctioned the collaboration with CSISA to move forward with the full commitment of ICAR; a sub-agreement to this effect was signed by CIMMYT and ICAR in July, 2016.
- RESEARCH IMPLEMENTATION: Collaborations with 8 KVKs in Bihar, 2 KVKs in Eastern UP, and 2 KVKs in Odisha have been initiated and field activities in the form of applied on-farm research have been implemented for 2016-17 winter cropping cycle. Key scientists from the State Agricultural Universities (SAUs) are involved to ensure ownership of results at the state level that can be readily mainstreamed through the State Departments of Agriculture. 'Hands on' technical training in on-farm research methods is being incorporated into overall program.
- DEVELOPING CAPACITY: In collaboration with Bihar Agriculture Management and Extension Training Institute

(BAMETI) and the Royal Tropical Institute (KIT), Netherlands, CSISA organized a training program in April 2016 to build the capacities of master trainers from the KVKs and State Department on entrepreneurial and management skills to make service provision more professional. The training was structured around modules that the 'master' trainers can deploy through their own programs for zero tillage, weed management and rice establishment methods.

- INTRODUCTION OF NEW RESEARCH METHODS: A second ToT was organized in April at Bihar Agricultural University for building the capacity of KVK staff in participatory research and extension methods, including the quantification of evidence and how to provide feedback to the policy formulation process in the state extension system. Additional focus was given to methods for monitoring, evaluation and learning through production practice surveys, quantification of end user perceptions, and crop cuts.

Challenges: Many KVKs are accustomed to working not as centers of innovation and rigorous technology testing, but as entities that conduct front line demonstrations in a very limited geography. Not only must most learn how to do something radically new, there must also be performance indicator metrics introduced within the systems that rewards the type of work prioritized in the collaboration with CSISA.

Emerging opportunities: The Modi government is a big proponent of performance metrics and results-oriented programming. The KVK system absorbs around half of the ICAR budget but it's role and contributions to innovation and impact remain a point of contention. By positioning the KVKs to prioritize gaps in the system including participatory research, geographically targeted recommendations and investment prioritization, and rigorous M&E, there is a real window to add value to the agricultural innovation system as a whole – a development that should increase the ROI of the government's investments in agriculture.

THEME C. ACHIEVING IMPACT AT SCALE

Sub-theme C.1: Growing the input and service economy for sustainable intensification technologies

Intervention C.1.1: Integrated weed management to facilitate sustainable intensification transitions in rice

Context, approach, and objectives: In additional to responding to accelerating labor shortages to preserve yield and profitability, integrated weed management (IWM) strategies also are also essential for facilitating the adoption of sustainable intensification technologies such as directly sown rice. CSISA plays a targeted and catalytic role to support initial capacity and market development for IWM through training of trainers for agricultural input dealers and through social marketing campaigns. Consistent monitoring will assess when new weed control products and IWM training activities show signs of ownership and sustained deployment through the private sector and NARES, and we will phase out activities at that time to permit partners to propel IWM forward at scale.

Progress in the reporting period:

- EVIDENCE GENERATION: Based on on-farm adaptive trials conducted in Bihar, integrated weed management (IWM) with a combination of new classes of herbicides [either pre-emergence (pretilachlor or pretilachlor + pyrazosulfuron) or post-emergence application (bispyribac or bispyribac + pyrazosulfuron)] and hand weeding resulted in 14–29% increase in grain yield and a reduction in weed control costs of $28/ha compared to farmers' weed management practices in transplanted rice. In Odisha, rice yields of farmers who deployed IWM practices (herbicide + hand weeding) increased by 25% compared to those farmers who controlled weeds only by manual weeding. IWM options to achieve effective control of diverse and complex weed flora in DSR were developed and disseminated through actionable best-bet agronomy tips. By using IWM approaches in beushening-based rice systems, grain yields were increased by about 1 t/ha while reducing costs ($50/ha) and labor requirement (25–30 person days).
- NEW CULTURAL PRACTICES FOR DSR: Dust mulching (pre-sowing irrigation followed by tillage and then seeding) reduced weed emergence and biomass by 43-65%.
- SERVICE PROVISION: In Odisha: 86 ha were covered by motorized weeders through 20 service providers created in

2016. Service providers are charging $18/ha for mechanical weeding, whereas the cost of manual weeding ranged from $110/ha for DSR and $74/ha for transplanted rice.

- CAPACITY DEVELOPMENT: Experiential training module for IWM is being deployed from *rabi* 2016-17 with the module broadly deployed through partners through ToT. It has already been used by the Odisha State Department for training of input dealers as part of the DAISE program.
- IMPACT AT SCALE THROUGH MARKET DEVELOPMENT: In close collaboration with the private sector, access to new classes of safe and effective herbicides has increased with time. For example, bispyribac sales volume increased from 61,000 liters in 2014 to 98,000 liters in 2016 in CSISA's working domains. This means that new classes of effective and environmental friendly herbicides were used on almost 500,000 ha in 2016; they were not present in the market until CSISA facilitated collaborative testing and product introductions in 2011-12.

Challenges:

- In Odisha, input dealers have very little knowledge of herbicides, including about proper use and safe application. Not surprisingly, timely availability of herbicides, quality sprayers and spray accessories such as flat fan nozzles and multi-nozzle boom is a recurrent problem (and also an opportunity….).
- Pre-emergence herbicide pendimethalin hampered rice germination particularly at those locations which encountered heavy rains and inundation after sowing. Considering possible phyto-toxicity of pendimethalin, we are suspending its recommendation for IWM in DSR pending further evidence generation.

Emerging opportunities:

- Weed management recommendations have been included in Rice Crop Manager for Odisha and in Rice–Wheat Crop Manager for EUP and Bihar. Therefore, the Crop Manager platform can be utilized for the dissemination of weed management recommendations especially in Odisha where the Odisha Government has approved a project with a target to reach 100,000 farmers.

Intervention C.1.2: Zero-till (ZT) wheat to tackle energy and economic constraints and to enhance productivity

Context, approach, and objectives: Zero tillage provides a pragmatic and profitable approach to the problems of mounting energy and production costs in the Eastern IGP without compromising wheat yield potential. Strong momentum was established in Phase II that resulted in > 50,000 ha of ZT wheat in Bihar and EUP planted through service providers; nevertheless, this represents around 1% of the total wheat area and work remains to nurture and accelerate progress. Building on Phase II activities and established partnerships, CSISA is advancing the adoption of zero tillage by: 1) strengthening the project's catalytic role in capacity building through ToT (technical + BDS) for NARES and private sector partners, 2) facilitating consensus among partners regarding the yield and economic value of ZT through on-farm evaluations, and 3) supporting the development of the service provision economy through demand generation (social marketing) and targeting training (and market linkages + finance) towards service providers that are poised for growth. While much of this work stream focuses on expansion of ZT through ToTs, direct training to service providers is conducted in new geographic areas while partner capacity is developing.

Progress in the reporting period:

- VERIFYING THE ADVANTAGES OF ZT: To best document the real-world performance of ZT wheat in Eastern India, we quantified the productivity impact of current ZT practices in the State of Bihar based on a random sample of 1,000 wheat-growing households. In contrast to the global meta-analysis conducted by Pittlekow et al., we found that the prevailing ZT practices without full residue retention led to a robust yield gain over conventional-tillage wheat across different agro-ecological zones, amounting to 498 kg/ha (19%) increase, on average, with significant cost and GHG emissions saving – both associated with burning less diesel.
- TRAINING 'MASTER' TRAINERS: One of CSISA's core objectives is to orient the state extension systems towards supporting intermediaries like service providers rather than only focusing on providing assistance directly to farmers. This is how extension has maintained its relevance and effectiveness in OCD countries even when budgets have fallen. In collaboration with Bihar Agriculture Management and Extension Training Institute

(BAMETI) and the Royal Tropical Institute, Netherlands, CSISA organized a 'training of trainers' program from 12–15 April 2016. This event built the capacities of master trainers from the Bihar State Department to more effectively structure their own internal training programs for ZT, including expanding the curriculum beyond a sole technical focus to encompass entrepreneurial and management skills to make service provision more business oriented.

- NEW PARTNER ENGAGEMENT: In the current year CSISA has signed collaboration agreements with JEEViKA (livelihoods initiative) and ITC, an Indian conglomerate with a diversified business interest in agriculture technologies. Both have an interest in taking ZT to scale and have already started replicating and using CSISA's communication materials like videos, posters and signboards to generate awareness and interest with their own funds and staff.
- IMPACT AT SCALE WITH EXPANSION OF THE SERVICE ECONOMY: In Bihar and EUP, the spread of tractors is limited and land preparation is typically contract from neighbors on a 'fee for service' basis through service provision. By necessity, the spread of ZT must follow the same model. Through its partners, CSISA facilitated the emergence of 572 additional ZT SPs in Bihar, and 169 in EUP, an annual growth rate of 34%, making a total of 2,909 SPs to date. Aided by the projects efforts, more than 47,000 households implemented ZT in 2015-16.
- INCREASING EQUITY: Our 2016 survey of ZT adoption dynamics in Bihar showed that awareness of zero tillage among marginal farmers increased from 31.7% in 2012–13 to 69.8% in 2015–16 and the use of zero tillage by these farmers increased from 20.9% to 31.4%, suggesting that access to capital intensive technologies deployed through service providers increases as the market matures.

Challenges:

- Some studies suggest that ZT may increase the problems with insect pests and perennial weeds. Through long-term experimentation at our 'research platform' housed at ICAR's Eastern Research Complex in Patna, Bihar, we continue to assess the long-term performance of ZT from a cropping systems perspective. Long-term risks and rewards of CA-based technologies are a highlighted concern of ICAR leadership, and the research platform in Patna is the oldest (7th cycle of wheat completed) and arguably best managed set of experiments in Eastern India that addresses these issues.
- In aggregate, adoption of ZT and expansion of the service economy is growing at an impressive rate in Bihar and Eastern UP. That said, district-level progress is uneven and some service providers are much more aggressively growing their small businesses than others. Through additional socio-economic investigations, CSISA is trying to sharpen our targeting of service providers for additional training to those who are poised for growth and also to determine why the technology lags in some districts.

Emerging Opportunities: ZT is on the cusp of becoming a mainstreamed production technology in Bihar and Eastern UP. To consolidate momentum, the private sector, extension, and other development partners need to understand it as 'proven' technology and program accordingly. With support from CSISA, we are seeing this take place with partners such as ITC, JEEViKA, and the State Departments of Agriculture.

Sub-theme C.2: Managing risk by coping with climate extremes

Intervention C.2.1: Coping with a weak and variable monsoon and avoiding *kharif* fallows

Context, approach, and objectives: Farmers in CSISA's target geographies in India rely almost exclusively on rainfall to produce crops during the monsoon (*kharif*) season. In five of the last seven years, monsoon rains have been weak, with uneven distribution, resulting in yield reductions from late planting (or no planting) and drought stress. The consequences of insufficient coping strategies for monsoon variability can be extreme: in 2009, aggregate rice production declined by 38% at the country level. Although the drought experienced in 2014 was not as severe (all-India departure of 12.3% from mean rainfall), estimated losses in India were around $30 billion USD, with national GDP consequently decreasing by about 1.7%. There is saying in India that the monsoon is the real finance minister….

This intervention is multifaceted, and includes the following entry points for coping with monsoon variability:

- Encourage cultivation of shorter-duration and drought-tolerant rice cultivars and hybrids

- Facilitate market-led transitions to less water-demanding crops like soybean in drought-prone areas
- Disseminate information on optimal rice sowing and transplanting dates based on historical rainfall probabilities and weather forecast information
- Highlight the promise of technologies like DSR to establish rice when early rainfall is deficient (see A.1.1)

In contrast to many recent years, the monsoon in 2016 was relatively 'normal' with respect to onset, withdrawal, and total precipitation. Results need to be interpreted from that perspective. Most adaptive measures need to 'work' in all years because they are likely to be deployed independent of monsoon characteristics in any given year.

Progress during the reporting period:

- NEW ANALYTICS: Entry points for increasing rice resilience to monsoon variability are diverse, interactive, and hard to project across years. Dynamic simulation offers an integrating tool for addressing this complexity and distilling generalizable recommendations. We conducted long-term simulations to assess the following management factors: supplemental irrigation, date of planting, appropriately aged seedlings, and rice cultivar duration as independent and layered interventions (Singh *et al*., in review). Simulation results confirm that the prevailing farmer practices of transplanting long-duration cultivars under rainfed conditions results in delayed transplanting and the use of older seedlings, leading to low and variable rice yields (1.6 t/ha, SD 2.2 t/ha). The following insights emerged : 1) adoption of short-duration hybrids with no other changes management practices can double median yields to 3.2 t/ha; 2) supplemental post-establishment irrigation can similarly increase median yields to 3.2 t/ha while significantly reducing inter-annual variability (SD 1.4 t/ha), and 3) when implemented together, supplemental irrigation and short-duration hybrids can further increase rice yields to 4.6 t/ha, while reducing variation by more than half (SD 1.0 t/ha). We also assessed the costs associated with transplanting old seedlings due to asynchrony between the timing of nursery establishment and the onset of heavy rains that permit field preparation. Transplanting appropriately aged seedling as a single intervention increased rice yields to 3.4 t/ha. These results are being shared with partners and will drive programming in 2017.

- RESILIENT RICE: In drier landscape positions in the medium and uplands, CSISA works with seed companies and input dealers to expand the production and sales of medium- and short-duration hybrids as well as varieties like Sahbhagi Dhan, Rajender Bhagwati and Sarju 52. In part due to higher resilience to various forms of drought as well as opportunities for systems intensification that are created by their generally shorter growth duration, adoption is increasing and sales of long-duration cultivars such as MTU 7029 are declining. Binadhan 11 (flood tolerant) and DRR 42 (drought tolerant) were introduced through a CSISA and STRASA collaboration with Binadhan 11 out-performing the traditional variety Lalat by 0.8 to 1.4 MT/ha with increased lodging resistance across Puri, Bhadrak and Balasore Districts in Odisha.

- HYBRID SALES: The market for short- to medium-duration rice hybrids has been increasing at a consistent rate in part due to CSISA engagement with the private sector. Adoption reached 61,229 ha in 2016, representing a 5% increase over 2015.

- ENGAGING WITH DEVELOPMENT PARTNERS: Through gender-focused development partners (e.g; Pradan and DHAN Foundation in Odisha, Creation Welfare Society and Mahilla Samakhya Federation in Bihar, and Betiya Diocesan Social Service Society and Samagar Krishi Vikas, Tharu Mahasangh, and Environmental Action Group in Eastern UP), CSISA has helped facilitate the uptake of stress-tolerant rice varieties. During 2016, almost 3,000 women farmers adopted Sahbhagi Dhan in Odisha.

- CROP DIVERSIFICATION: Drought-prone blocks with consistently low rice yields were identified as prime candidates for diversification, and private sector input and output market actors were enlisted as partners in this effort. Soybean area in Bihar and Eastern UP expanded to almost 800 ha with maize on beds increasing to over 1,500 ha.

Challenges: Coping with monsoon variability is only on the radar of partners during poor years. Attention wanes considerably when the monsoon is reliable.

Emerging opportunities: Development partners who understand the role that risk plays in HH welfare and decision-making are natural allies in our attempts to build more resilience to monsoon variability. CSISA has formalized a new and deepened collaboration with JEEViKA in Bihar that should prove instrumental to moving ahead at scale.

Intervention C.2.2: Early wheat for combatting heat stress

Context, approach, and objectives: Heat stress during the grain filling stage is the most limiting factor for wheat productivity in South Asia (i.e., as reflected in the 50% yield reduction between timely and late-sown wheat in Bihar and Eastern UP). In Phase II, considerable progress was made by encouraging state governments to revise their planting recommendations to encourage early wheat sowing (EWS). This was an important step towards addressing a persistent knowledge gap: most farmers still do not fully understand the yield and economic costs of delaying planting past November 15 (i.e. approximately 50 kg/ha per day of lost yield potential). CSISA's approach in Phase III includes:

- Collaborating with the State Departments of Agriculture in Bihar and UP to devise social marketing campaigns about the importance of early wheat planting.
- Working with seed companies to ensure that farmers who do plant early do so with longer-duration varieties that are adapted to early planting.
- Interfacing with input dealers and agro-advisory services to ensure that basic management adjustments to fertilizer and irrigation management are responsive to earlier planting patterns
- Targeting and articulating the system-level benefits of companion management interventions that facilitate early wheat planting including: shorter duration rice and mechanized harvesting.

Progress during the reporting period:

- THE OPPORTUNITY IN CONTEXT: In collaboration with researchers from Stanford University, smallholder wheat yields were mapped based on micro-satellite data in Bihar. Results confirm that sowing dates are the principal drivers of yield variation at the landscape scale (see Jain *et al*., 2016), with farmers in some districts such as Ara consistently planting after November 30. Within CSISA's working domain, the average date of sowing in the district cluster with the highest yields in Bihar (3.85 t/ha) is 19 November, while in the cluster representing lowest yields (3.15 t/ha) it is 1 December.
- VIEW FROM THE FARM: On-going socio-economic survey work is disentangling drivers of late planting and the first results highlight the importance of management of the rice phase to open an opportunity for earlier sowing. Nearly half the respondents who delay planting state that they cannot plant before November 15th because their rice crop has not yet been harvested. Timely rice establishment with shorter duration varieties or hybrids is a core component of CSISA's work on coping with monsoon variability (*see above*) with system-level benefits that will accrue with earlier wheat planting. Early monsoon recession permitted more farmers to plant early in 2015-16 in relatively poorly-drained areas, and it is important to account for weather variability to appropriately contextualize opportunities for earlier wheat planting.
- STARTING WITH RICE: Medium-duration rice hybrids save time in the cropping calendar while preserving yield potential. At the farm level for sites monitored by CSISA, the average grain yield of wheat following hybrids monitored was 4.1 t/ha compared to 3.0 t/ha where wheat sowing was delayed due to the preceding long-duration rice varieties. Rice yields were unchanged. Strong collaborations are on-going with private sector seed companies to expand the market for rice hybrids.
- NARES ENGAGEMENT: On the back of State Department endorsement of early wheat planting, CSISA is now working to back-stop efforts with district and block level extension personnel to mainstream early sowing messages through print (newspaper), radio, and billboard campaigns. Basic messaging commenced from the *kharif* season with the concept of cropping system optimization (shorter duration rice followed by long duration wheat) emphasized.
- ACHIEVING EARLY SOWING AT THE LANDSCAPE SCALE: Based on remotely-sensed information that has been cross-validated through targeted village surveys, we estimate that some 250,000 hectares of wheat were sown at least 5-days earlier in the 2015-16 cropping season across Bihar and Eastern UP.
- VARIETAL CHANGE: To make the most out of early wheat planting, adoption of longer duration varieties is essential (*parenthetically, these same varieties yield no worse than shorter duration varieties when planted late, suggesting broad adaptability across ecologies and management practices*). CSISA is working with private seed companies

and state seed corporations to encourage production and marketing of long-duration varieties. Progress is evident, especially among famers adopting early sowing practices. Across 400+ sites monitored by CSISA, all fields sown by November 15 were planted to long-duration varieties. The share of long-duration varieties reduced to 50% for late-sown fields.

Challenges:

- Early wheat sowing is difficult to achieve in lowland areas that are poorly drained, which some estimates suggest may constitute 40% of the wheat area in Eastern UP and Bihar where CSISA works. CSISA is endeavoring to characterize the spatial characteristics of these areas to better target opportunities.
- Public research institutions in India are not active in hybrid rice breeding, and this often result in a bias against hybrids with respect to extension recommendations.

Emerging opportunities:

- The Government of India has made climate change adaptation a core policy objective (https://www.adaptation-fund.org/wp-content/uploads/2016/08/National-Adaptation-Fund-for-Climate-Change-India.pdf). Early wheat is one of most promising and low-cost mechanisms for building resilience to contemporary climate extremes as well as progressive climate change.

THEME D. POLICY REFORM

Intervention D.1: Seed systems and markets

- CSISA prepared pre-reading material and participated actively in a BMGF-organized convening on “Policy Options for Varietal Turnover” in London, UK, November 1–2, 2016.
- CSISA is exploring partnerships to advance seed system and market reforms in India and its targeted geographies as part of Phase III.

Intervention D.2: Scale-appropriate mechanization

- CSISA continues to explore mechanisms for incentivizing the development of commercial markets for scale-appropriate machinery and equipment. Part of this includes analyzing heterogeneity in demand for different machines, including, but not limited to, along gender differentials.
- We are also exploring the social and economic impacts of agricultural equipment. In particular, we have been active in assessing the demand for mechanical rice transplanters, which have the short-run potential of relieving drudgery for female laborers engaged in transplanting, but the potential long-run consequence of permanent displacement of female laborers if other employment opportunities do not emerge to absorb these laborers.

Intervention D.3: Soil fertility and fertilizer markets

- Conducted randomized controlled trial to evaluate the effectiveness of site-specific soil health diagnoses and associated fertilizer recommendations. The results of the study suggest that providing such soil test based analyses and recommendations do not have a significant effect on farmers’ subsequent decisions about fertilizer application. Experimental work demonstrates that farmers formulate rigid beliefs about the appropriate application rates for various fertilizers, and external information is either not sufficiently different from prior beliefs or not sufficiently reliable to result in systematic improvements in application balance. The results of this study have been shared at various convenings, within India and abroad.

- We are also keeping tabs on the evolving fertilizer policy landscape in India. In particular, the government's gradual movement toward providing a direct cash payment to farmers to replace the existing subsidies to fertilizer manufacturers. We have prepared and circulated an operational note describing the government's plans for a pilot to test out marginal reforms, but these reforms rely upon infrastructural and institutional capacity that are unlikely to exist in many rural parts of India.

Intervention D.4 Risk management

- We have an ongoing pilot project to test the impacts and market viability of a drought risk management intervention consisting of drought-tolerant rice variety (Sahbhagi dhan) and a specially calibrated, complementary weather index insurance product. As part of the study, we have conducted a stated choice experiment to understand farmer preferences and willingness-to-pay for risk management strategies. Insights from this activity could inform government programs for expanding agricultural insurance under its Pradhan Mantri Fasal Bima Yojana (PMFBY) program or Weather-Based Crop Insurance (WCBIS) program. The PMFBY is particularly ambitious, as it aims to increase insurance coverage nationwide up to 50 percent of total cropped area. Both programs, however, suffer from design issues.

ANNEX 1: PUBLICATIONS

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Additional information on IFPRI’s conferences, workshops and seminars, as well as media coverage and capacity strengthening is available upon request.