TATA-CORNELL INSTITUTE ANNUAL REPORT

2017

TATA-CORNELL INSTITUTE FOR AGRICULTURE AND NUTRITION (TCI)

College of Agriculture and Life Sciences Cornell University

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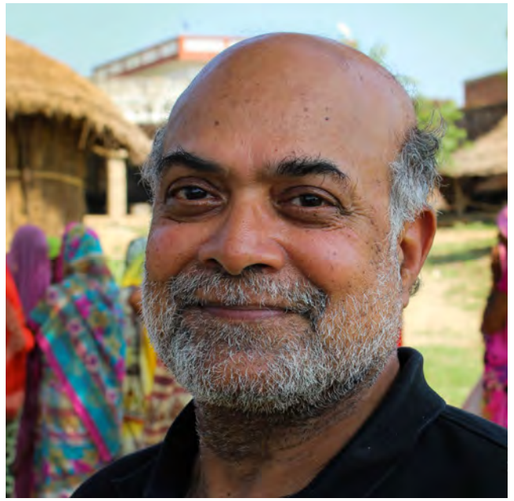
FROM THE DIRECTOR



Since our inception in 2013, the Tata-Cornell Institute for Agriculture and Nutrition (TCI) has grown tremendously in size and in the scope of research and operational work in India. Our work is starting to have an impact on food security and nutrition policy thinking in India and beyond. We are now a multidisciplinary research group of 15 Tata-Cornell Scholars, plus 4 Postdoctoral Fellows and 2 Research Associates. In addition to our Ithaca-based research group, we have a growing presence in our offices in Mumbai, New Delhi, and our field locations. The financial support provided by the generous endowment from the Tata Trusts enables us to think long-term and to conduct field-based research that produces real world solutions to chronic poverty and food insecurity problems faced by rural communities. The four-year grant that we received in 2015 from the Bill & Melinda Gates Foundation allows us to operationalize our research solutions and to take them to scale with an expanded network of academic and NGO partners in India.

I am particularly proud of the multidisciplinary strength of our research group and the rigorous field-based research that is being conducted. Tata-Cornell Scholars come from a variety of disciplines, including: Applied Economics, Nutritional Sciences, Food Science, Animal Science, Plant Pathology, and Soil Science. Intensive fieldwork, including randomized control trials, are currently being conducted in India to address a multitude of problems contributing to the poor nutritional status of its population. Our scholars' field research includes: the promotion of vitamin A rich orange-fleshed sweet potato; the assessment of mycotoxin risk and its mitigation in the food system; the drinking water-health-nutrition nexus; women's empowerment and nutritional outcomes; and behavioral change interventions for promoting toilet use in rural India. We believe that field research, which addresses the problems of the rural poor, can be compatible with the analytical rigor and academic excellence that is expected of Cornell graduate students.

I would like to take this opportunity to acknowledge the enormous support provided to us by the Mumbai-based Tata Institute of Social Sciences (TISS) and its Director Professsor Parasuraman. Our close association with TISS enables the smooth functioning of our research and operations in India. We have also been building academic linkages with TISS, through faculty exchanges, seminars, and joint workshops. This year, we simulcast a course being taught at Cornell University into TISS. Students in Mumbai could participate in real time with students at Cornell and at the Nanjing Agricultural University in China in a course on the Food-Water-Energy nexus. TISS Professor Madhushree Shekar co-taught this course along with myself and three other professors from Cornell and a professor from Nanjing. I look forward to many more such "real-time" joint courses with TISS and Cornell.

We have completed the second year of the Gates Foundation grant: Technical Assistance and Research for Indian Nutrition and Agriculture (TARINA). TARINA promotes a nutrition-sensitive food system in India through a consortium of partners led by TCI. Through this consortium, TARINA merges the evidence-generating capabilities of Cornell University, Emory University, the International Food Policy Research Institute (IFPRI), and TISS with the technical capabilities of leading nongovernmental organizations (NGOs) and development partners—the BAIF Development Research Foundation, CARE India Solutions for Sustainable Development, Grameen Development Services (GDS), and the Tata Trusts. Over the past two years, the TARINA consortium has been promoting the diversification of food production systems in the states of Odisha, Bihar, and Uttar Pradesh. I am optimistic that this strong consortium will make a significant difference in the way future agricultural projects in India are designed and implemented, in order to explicitly incorporate nutrition outcomes.

TATA-CORNELL INSTITUTE RESEARCH TEAM

From left to right: Jocelyn Boiteau, Jessica Ames, Krystal Rampalli, Vidya Bharathi Rajkumar, Payal Seth, Sri Raj, Anna David Thottappilly, Nagesh Gavirneni, Maureen Valentine, Prankur Gupta, Prabhu Pingali, Kiera Crowley, Mathew Abraham, Andaleeb Rahman, Kavya Krishnan, Naveen Sunder, Fjolla Kondirolli, Rohil Bhatnagar, Vanisha Sharma, Anaka Aiyar, Megan Witwer. Not pictured (due to fieldwork): Shiuli Vanaja, Vidya Vemireddy, Anthony Wenndt, Kathryn Merckel.

Through the efforts of TCI and TARINA, we are also starting to influence the nutrition sensitivity of food and agriculture policy in India. A series of seminars and policy dialogues, held in Delhi and in Odisha in the last 12 months, have focused on moving India's food policy beyond its current preoccupation with staple grains to enhancing the availability and access to a diverse set of nutrition-rich foods. Several of our publications have also discussed the policy options for moving beyond staple-grain fundamentalism. Our recent publication, "The Bumpy Road from Food to Nutrition Security—Slow Evolution of India's Food Policy" in *Global Food Security*, has received considerable attention in India.

As we enter our fifth year, I am optimistic that TCI and TARINA are on the cusp of becoming significant forces for new research and policy advocacy for nutrition-sensitive food systems.

I hope you enjoy reading our Annual Report for 2017.

Sincerely,
Dr. Prabhu Pingali
Director

The Tata-Cornell Institute for Agriculture and Nutrition (TCI) is a long-term research initiative based at Cornell University in Ithaca, New York, with offices in Mumbai and New Delhi, India. With a multidisciplinary team consisting of applied economists; nutritionists; food, plant, soil, and animal scientists; sociologists; engineers; and more, we are working to create, test, and scale up sustainable and effective solutions for reducing poverty and improving malnutrition and livelihoods in rural India.

We uniquely combine field-based projects, academic research, and policy analysis to generate and share knowledge relevant to Indian policymakers, research institutions, and development agencies. Our institutional partners have deep field experience and extensive knowledge of the local context; by working together, we share our strengths, mutually build our capacity, and refine the quality of our joint projects. Founded in 2013, with a generous gift from the Tata Trusts, we are well on our way to making meaningful discoveries and developing innovative technologies and policy solutions to address the agriculture-nutrition nexus in India.

PATHWAYS FOR LINKING AGRICULTURE AND NUTRITION

Although there are many approaches to improving health and nutrition outcomes, TCI believes that pathways that link agriculture and nutrition can create the most profound and lasting impacts for good health. As such, we have identified and oriented our applied research along four key pathways:

1. The **income pathway**, where gains in household income can translate to better food affordability and other impacts;
2. The **food access pathway**, including a household's access to sufficient, diverse, and quality food year round;
3. The **positive nutrition behavior pathway**, where interventions attempt to equalize food allocation among individuals within a common household and optimize early childhood care practices; and
4. Nutrient absorption through improvements in the **health–environment pathway**, which links access to clean water and improved sanitation and hygiene practices to better nutritional health.

TCI's research and projects in India consider the factors that influence both a *household's ability to access food*—such as income, employment, and the ability to afford safe, high quality, and diverse foods in sufficient quantities—and *the individual's ability to absorb and utilize* his or her share of the household's total food/nutrient basket, which could differ depending on the individual's age, gender, level of empowerment, household dynamics, cultural practices, or even physiological life stage (e.g., pregnancy and infancy require different diets and care practices).

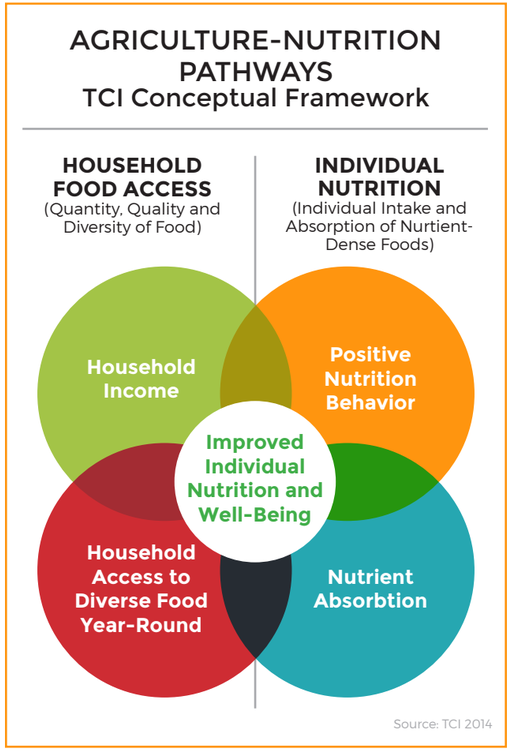


Figure 1: TCI Conceptual Framework

The income pathway and the food access pathway have the most direct connections to agriculture, given the dependency of the poor on these activities for their livelihood. Many TCI projects fall under these pathways and are featured in this year's annual report.

INCOME PATHWAY AND FOOD ACCESS PATHWAY

The Sustainable Flour Fortification Initiative (Sfurti) is designed to provide households with year-round access to micronutrients (food access pathway). TCI partnered with BAIF Development Research Foundation, MS University of Baroda, and DSM to create a solution for micronutrient malnutrition that would be sustainable over the long run. Focusing on tribal communities in southern Gujarat and tapping into the social marketing potential of women's self-help groups (SHGs), this program trains and empowers SHG members to sell sachets of multiple micronutrient powder, generates consumer demand for such sachets, and instructs community members and millers on the proper mixing of the product into flour. Income generated by selling the sachets is used by SHGs to resupply their inventory. In its first year (June 2016–June 2017), this campaign reached 6,500 households, of which 70% voluntarily opted to buy the sachet branded as "Sfurti," which, in the local language, means health. Beyond the food access and income pathways, this program also exemplifies TCI's positive nutrition behavior pathway, as behavior change communication strategies have been essential in raising awareness and creating demand for this important solution to nutrient deficiency.

Tata–Cornell Scholar Maureen Valentine also works to address nutrition deficiencies, but as a PhD candidate in Animal Science, her research with TCI focuses on the feed and fodder for goats. These small ruminants are an important source of family income, and in a country that largely does not eat beef, they are an important animal source food for the population. Mrs. Valentine conducted a field experiment to test the idea that shifting from an extensive, open-grazing system to a semi-intensive, stall-feeding system could increase animal feed efficiency and improve net income for farmers—as animals grow faster and produce better quality milk, which supports the health and development of offspring. Indeed, results from this study showed that goat kid survival improved in the stall-fed treatment group and that risk of death for a goat kid in the control group was three times higher. Furthermore, of the farmers who participated in the study, 25% said that they wanted to provide feeding alternatives to open grazing for their goats in the future. As livestock production rises, management practices such as semi-intensive feeding will be required to increase production efficiency and to cope with diminishing land and forage available. Improvements to agricultural extension networks, however, will be necessary if smallholder farmers are to expand and retain their knowledge of best practices.

Agricultural extension services are also essential for expanding knowledge about soil health. Livelihoods and household nutrition improve when small producers increase production efficiency; if we want to increase crop yield, we should not overlook the basics: a healthy soil grows healthy, productive plants. Unfortunately, most farmers and many agronomists still focus exclusively on adding chemical fertilizers, whereas managing soil health requires thinking holistically about the physical, biological, and chemical attributes of soil. In the TCI Soil Health Project, we are working to give farmers and agricultural extension agents the tools and support they need to be able to measure and track indicators of soil health locally, through the development of a mobile soil health toolkit. This project will facilitate soil health assessment, education, and ultimately, conversation on soil health management practices. We have also been building awareness and capacity among India-based research institutions, universities, and NGOs in Cornell's framework for the Comprehensive Assessment of Soil Health.

Another area of research that explores trends related to the income and food access pathways is Dr. Mathew Abraham's work on the pulse value chain. Nutrient-rich foods like lentils, split peas, and beans are critical to improving nutrition outcomes, and yet, the growing demand for pulses and the low supply response at the farm level has led to uncertain prices and low per capita

availability of pulses in the market. Incentivizing diversification away from staple grains toward more nutrient-rich crops like pulses will depend on a small farm's ability to commercialize. This study looks at the influence that aggregation models (such as farmer producer organizations (FPOs)) and corporate value chains have on commercialization. By examining the nature of FPO and private value chain interventions in the pulses value chain, we assess how they can attempt to rectify the supply–demand mismatch.

POSITIVE NUTRITION BEHAVIOR PATHWAY

Encouraging a more diversified food system will reduce micronutrient malnutrition and improve food and nutrition security. Even as people achieve calorie-adequate diets, they may not attain nutrient-sufficient ones. In fact, micronutrient deficiencies remain highly prevalent throughout India. Beyond fortification, we believe diet-based solutions have great potential for sustainability, while remaining affordable.

As such, TCI is undertaking a groundbreaking project to test the effectiveness of orange-fleshed sweet potato in alleviating vitamin A deficiency (VAD) in villages in rural Uttar Pradesh. This work, led by Tata–Cornell Scholar Kathryn Merckel, will build on the notable successes of similar studies in sub-Saharan Africa, for which the leading research teams were awarded the 2016 World Food Prize. Understanding the potential of the orange-fleshed sweet potato, in the Indian context, to reduce vitamin A deficiency will improve future diet-based solutions for decreasing VAD and influencing food and agriculture policy, and build evidence that promotion of micronutrient-rich vegetables need not be at the expense of calorie density in the Indian diet.

We are also documenting and characterizing existing nutrition behaviors. We have standardized 502 recipes—in terms of ingredients used and the time required to prepare and cook them—as a part of our ongoing research in the Chandrapur district of Maharashtra. Tata–Cornell Scholar Vidya Vemireddy is assessing how a woman's recipe choice may change, depending on how much time she must allocate to agricultural activities. Since this assessment is a 10-round panel survey, we will be able to observe seasonal effects on how women's time allocation patterns in agriculture may affect time-saving food choices and nutrition outcomes. This work is in addition to TCI's data collection effort on the Women's Empowerment in Agriculture Index (WEAI), continuing our work on measuring women's empowerment, dietary diversity, and food choice. Our first graduate, Dr. Soumya Gupta, completed the first WEAI survey in 2014, and Ms. Vemireddy managed the second round, creating a panel, in late 2016–early 2017.

HEALTH–ENVIRONMENT PATHWAY

In Jharkhand, TCI has set out to evaluate the effects of the piped-water systems installed by our partner AguaClara. This year, Tata–Cornell Scholar Shiuli Vanaja completed her year of fieldwork, in which her primary research focused on the potential time-savings for women in these rural areas and how their time might be alternatively allocated (e.g., income-generating activities, improved child care practices, etc.) once piped water was introduced to a household. As suspected, the results of her analysis confirm that women in these houses are saving time after getting access to in-house piped water and spending this saved time on their respective primary occupations. Ms. Vanaja also examined the perception of water quality, relative to actual water quality, in these households. Her research suggests that households with better understanding of good quality in water experience less incidence of diarrhea.

Diarrhea can be a serious illness in small children. In fact, every day in India, nearly 400 children under five perish due to diarrhea that is linked to poor sanitation and hygiene.[1] Open defecation is a major driver of stunting, and its practice is widespread in India. Community-Led Total Sanitation (CLTS) is an effective methodology for reducing—and even eliminating—open defecation. Working closely with our partner Grameen Development Services (GDS) in Uttar Pradesh, TCI is investing in toilet construction and conducting a study to measure the contribution of a behavior change campaign (using the principles of CLTS) on the increased use of toilets. The project involves a total of 15 villages and approximately 1,500 households. TCI's efforts in this area are being led by Tata–Cornell Scholar Payal Seth, as part of her doctoral research.

Under the health–environment pathway, we include food safety issues, as contaminated foods certainly impede nutritional health. TCI has confirmed that there is substantial risk for village-level mycotoxin contamination across several agroecological and cultural contexts in India. Currently in the field, Tata–Cornell Scholar Anthony Wenndt is working to characterize sources of mycotoxin risk in Indian village communities in Uttar Pradesh and leverage local knowledge and resources to develop effective and scalable toxin mitigation strategies for grain storage systems at the household level.

NEW INITIATIVES

Finally, we are thrilled about our burgeoning flagship project TARINA (Technical Assistance and Research for Indian Nutrition and Agriculture). Made possible by a generous grant from the Bill & Melinda Gates Foundation, TCI is leading a consortium of partners to promote a nutrition-sensitive food system approach in Bihar, Odisha, and Uttar Pradesh. The four-year grant uniquely combines the research capacities of TCI, Cornell University, Emory University, the International Food Policy Research Institute (IFPRI), and the Tata Institute of Social Sciences (TISS), with the technical capacities of leading nongovernmental organizations (NGOs) and development partners—BAIF Development Research Foundation, CARE India, Grameen Development Services (GDS), and the Tata Trusts. Together, we are translating our research and deep field knowledge into an actionable policy agenda to tackle the complex problem of malnutrition in India. We are also promoting innovation through cross-institutional collaboration, and we are creating and testing new metrics for the monitoring and evaluation of food systems interventions.

TCI is expanding the scope of our research initiatives. Dr. Sri Raj is a human population geneticist, and she is exploring the genetic and environmental factors contributing to the triple burden of malnutrition in India. Tata–Cornell Scholar Rohil Bhatnagar is a food scientist. For his PhD dissertation, he is developing a diet-based strategy to address iron deficiency, by exploring algae as a potential ingredient to fortify food. Tata–Cornell Scholar Jocelyn Boiteau is a PhD student in International Nutrition. She is creating a new definitional framework for food loss and waste, specific to traditional fruit and vegetable value chains. This can be used to assess the magnitude and causes of quantity and quality losses from farm to retail and will lay the groundwork for future studies on the cost-effectiveness of food loss-reduction interventions within the food system.

We have always endeavored to make meaningful contributions, which are on the cutting edge of applied research. In 2017, we have had more on-the-ground projects; more partners, scholars, and staff; more action research; and more publications coming out in top journals than ever before. As TCI moves into our fifth year of operations, we look forward to the growth, innovation, and discovery that will accompany us in 2018.

OVERVIEW

SUSTAINABLE FLOUR FORTIFICATION INITIATIVE IN GUJARAT: SFURTI FOR A HEALTHIER LIFE

In a world obsessed with caloric consumption, the importance of micronutrients—essential for critical bodily functions—is often underemphasized. Iron is a critical micronutrient for normal bodily functioning and stamina, and its deficiency is found around the world, especially in women and children who live in developing countries. Gujarat, an Indian state experiencing rapid economic growth, also finds itself performing poorly on nutrition indicators and micronutrient adequacy. Data from NFHS-4, a periodically conducted survey by the Government of India, finds 55.1% of women in Gujarat to be anemic (defined as any form of anemia).

In these circumstances, TCI's Sfurti powder—a home food supplement containing iron, folic acid, and vitamins A and B12 to be mixed into flour—seeks to help meet the micronutrient requirements of about 6,500 households in a target of 15 mostly tribal villages located in Songadh Block in the Tapi district of Gujarat. [Note: The number of 6,500 households is based on latest records. This figure is updated from our 2016 report, which stated there were 5,500 households when the project started.] This program is being implemented through the Women's Federation of Self-Help Groups, with technical assistance provided by TCI, BAIF, Maharaja Sayajirao University of Baroda, and Sight and Life (the philanthropic initiative of DSM).

The program was launched in June 2016, and employs women's self-help groups to go door-to-door and sell small sachets at a price determined by the self-help groups (three rupees). TCI's ground team has trained these women—popularly known as Sfurti Bens (Sfurti sisters)—to not just sell the sachets but also create awareness regarding the importance of iron and vitamins through socially interactive events, such as plays, songs, etc.

Throughout Phase 1, the team faced challenges in helping people to understand the importance of Sfurti (and micronutrients, in general) and to start consuming it. However, the assistance of village-level accredited social health activist (ASHA) workers and Anganwadi workers and the testimonies of consumers themselves helped yield results. Despite a gradual start, the program steadily spread and by the end of Phase 1 (in March 2017), Sfurti powder had been used by about 60% of the households (see Figure 2).

Typically, micronutrient programs are free to the consumer, so the fact that 60% of households demonstrated a willingness to pay for this product is a huge success. It is further highlighted by the 25% retention rate (purchased at least five times) (see Figure 3). However, the dropout rate (e.g., buying only once) is 36%, which is what the team wants to address. What differentiates the 25% of retained consumers from the 36% who drop out?

A randomized sample survey of 450 households was thus conducted in June-July 2017 to examine the effect of household demographics, education, the nature of employment, caste, village-level factors, and marketing efforts on the purchasing behavior of the households.

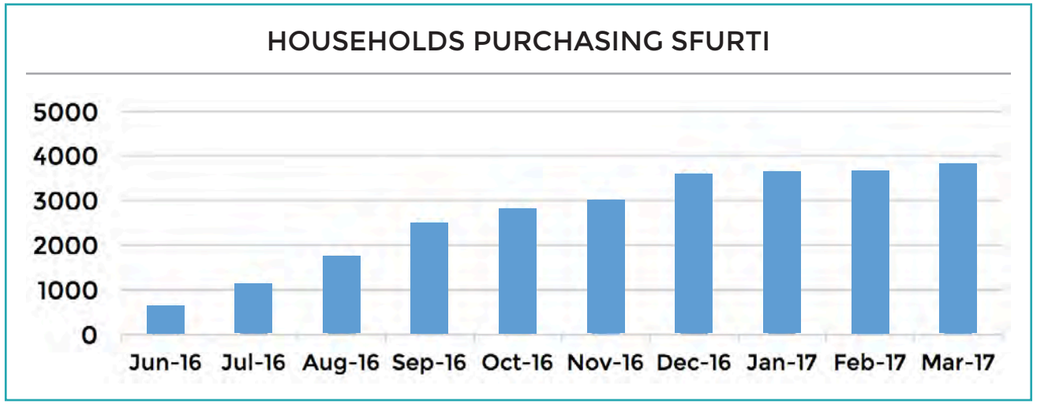


Figure 2. Households Joining the Sfurti Program Over Time

While the survey identified some explanations, such as demographics, education, and (to an extent) income, for which we cannot control, it also found some underlying factors that we can influence, such as the interaction between Sfurti Bens and the household members, as an important reason for retained Sfurti use. The preliminary findings also suggest that the availability of an adult woman in the household sometimes can be a key difference between a regular consumer and a dropout. We also found that it is sometimes a challenge for a Sfurti Ben to frequently visit households situated in remote locations, which in turn affects retention. And finally, we discovered that for the minority of the consumers who bought the sachets but were not consuming them, it was often due to forgetfulness, and in a few cases, lack of time or energy to mix it into the flour.

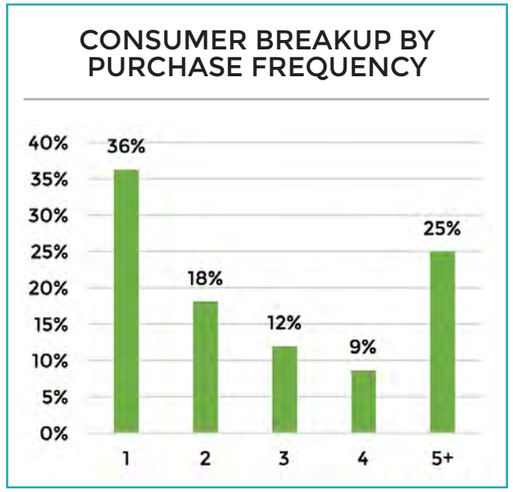


Figure 3. Retention Behavior of Households (as of March 31, 2017)

To robustly test some of these observations and also mitigate the problem, TCI launched Phase 2 of the project in August 2017, which incorporates a variation. In 5 out of the 15 villages, instead of having Sfurti Bens go door-to-door to sell the sachets, they will limit their role to generating awareness, and sales will take place at the millers' level. If successful, this would ensure that those choosing to purchase will also consume the Sfurti, as it minimizes (almost eliminates) the effort required to mix the sachets into the flour, with the flour miller taking care of this step. This is the closest that households using their own produce for consumption can get to the formal market experience (where buying fortified floor or iodized salt off-the-shelf is possible). This phase will also help us to understand if, after almost a year of effort, Sfurti has been transformed from a push product (door-to-door sales) to a pull product (consumers asking the miller to add it).

RESEARCH HIGHLIGHTS

The initial results from Phase 2 are hopeful. Other than improving the nutritional status of the households in the target villages, the program also helps to answer an important question on how social marketing can be used to make an impact in the rural communities across India and other developing countries. Involving the women's self-help groups in the project has been a major success and, unlike a strongly supported government program, this approach ventures into the possibility of a self-sustainable nutrition-oriented product. In the rural economy where most of the consumption occurs through the informal market, consumption of healthier foods has to happen in a voluntary manner for any tangible long-term benefits. That is what the Sfurti team is aiming to achieve.

SUSTAINABLE LIVESTOCK FEEDING SYSTEMS IN THE FACE OF INTENSIFYING GOAT PRODUCTION

India has one of the largest livestock populations in the world with 512 million animals, which is 11.6% of the world's livestock population (GOI 2015).[2] Productivity from this massive livestock population is constrained by feed shortages from limited fodder cultivation, insufficient crop residues, and reliance on common grazing areas that are small in size and increasingly degraded in terms of vegetative and soil quality. Growing human and livestock populations exacerbate feed resource scarcities by reducing the availability and productivity of grazing land. In the goat sector, marginal land or wasteland is commonly utilized for goat feed resources. Policymakers advocate for the intensification of India's goat production systems as a solution to issues caused by open grazing. There are anticipated environmental benefits and increased incomes for farmers who trade openly grazed, underproducing goats with fewer, but more productive stall-fed animals. Little research has been performed on farms to quantify the impact that feeding system changes would have on smallholder farmers.

TCI's research in this area, led by Tata–Cornell Scholar Maureen Valentine, experimented with the recommendation by policymakers and agricultural groups for rural farmers to transition to a more intensive goat production system. Farmers changing from an extensive, open-grazing system to a semi-stall-feeding system have the potential to relieve pressure on common grazing areas and provide beneficial ecosystem services. In the long-term, we expect that goat system intensification will increase animal feed efficiency and improve net income for farmers, as animals grow faster, produce more milk, and are better able to support the health and development of their offspring. Our main objective was to understand better how rural farmers could shift to a more confined feeding system that is less dependent on open grazing of land resources.

Fieldwork was conducted from May to December 2016 in Kandhamal District, Odisha. We selected two tribal villages in the Tikabali Block for the goat feeding study. Sixteen randomly selected farmers were assigned to either the control group or the semi-intensive stall-feeding group. Feed was provided to all goats in each household. We collected data in the three seasons: summer, rainy, and winter. Within each season, we conducted surveys in each of the 16 households, led regular focus groups, took observations of goat feeding behaviors, weighed more than 200 goats monthly, gathered forage samples of commonly consumed forages, had forage samples identified by botanists, analyzed forage samples for nutritional components, and took fecal samples to estimate fecal output and parasite load.

Our survival analysis showed that the risk of death for a goat kid in the control group was 3.35 times (e^(1.2095) = 3.35) greater than the risk of death for a goat kid in the treatment group. Figure 4 shows the relationship between kids that were in the treatment and control groups. We suspect that the mothers eating the treatment diet could provide superior quality milk for their kids, which helped them to survive better than their counterparts. We also found that weights of male adult goats were positively increased with the treatment group ($p \leq 0.05$), though we did not see noteworthy results in the weights of the adult females.

GPS trackers of goats' grazing show the patterns that herders use when grazing livestock around the study villages. Animals tended to transverse over the same tracks daily, which is unfavorable for plant regrowth and tends to cause regular reinfection from parasites. Farmers from both target villages and several nearby villages reported that roughly half of grazing lands had been converted to agricultural lands in the previous 10–20 years, while the livestock population has increased because of market demand. Improved management practices for the diminishing grazing land available is required to salvage forage for the region's expanding livestock population.

Of the 16 farmers that participated in the study, 25% said that they wanted to provide alternative feeds to their goats in the future. Costs mainly determined farmers' hesitations to changes in their livestock system, and to a lesser extent time, labor, and storage facilities. One of the main benefits of providing feed was recognized during the rainy season when torrential downpours sometimes last days, and in the current system, the goats do not eat during heavy rains. If farmers had feed available during rainy or lean periods, they realized that their goats would see great benefits. In comparison, in other regions of India where many farmers already feed cows and buffalo chopped feeds, it would likely be an easier transition for those farmers to feed goats similarly. The study region in Odisha was unique because locals do not consume dairy products and, therefore, cows do not have the same social importance that they do elsewhere and do not receive extra feed or forages in addition to grazing. One of the major takeaways for farmers was that goats could eat feed other than fresh forages, and they learned what types of alternative feeds goats will eat. Considering that farmers were not previously aware that there are alternatives to grazing their goats, their knowledge growth during this project was quite outstanding.

Results will be communicated with local partners in India and abroad. We found that feeding alternatives to open grazing of livestock could have

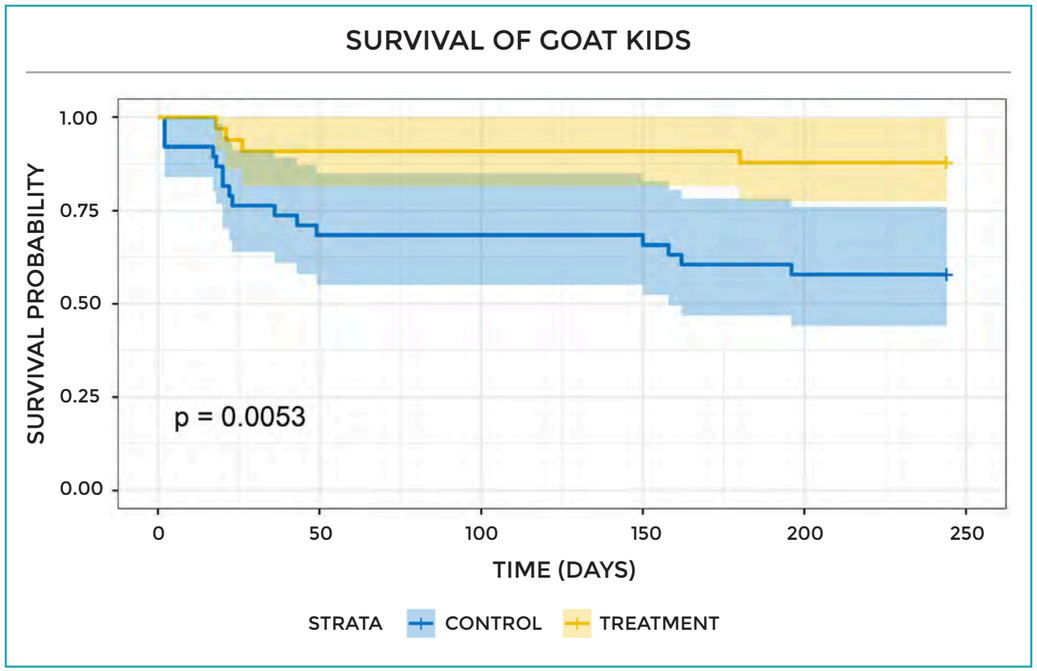


Figure 4. Survival of Goat Kids in the Treatment and Control Groups. Confidence Intervals are 95%

SCHOLAR SPOTLIGHT

Vidya Vemireddy, Tata–Cornell Scholar and Ph.D. candidate, Applied Economics and Management

Vidya Vemireddy is a Tata-Cornell Scholar and Ph.D. Candidate at the Charles H. Dyson School of Applied Economics and Management. Prior to her PhD, Vidya completed her BA (Hons) in Economics at Lady Shri Ram College, New Delhi and MA in Economics from Boston University. Her research interests span across topics in international development, food and agricultural economics. She is passionate about applied research and has been managing TCI's household survey on women in agriculture in the rural Chandrapur district of northeast Maharashtra. Her dissertation research explores the relationship between the amount of time women allocate to their agriculture work and its effects on household and individual nutrition outcomes. More recently, she has been enjoying fieldwork and strongly believes that her student experience has been enriched because of her involvement in field-based research.

an impact, but improvements to current extension networks are essential. More research on topics regarding small ruminants, smallholder farmers, and land use is required, as livestock are pervasive throughout India's agricultural system. Because goat products are high-value commodities, we hope that as the industry develops, smallholder farmers can retain benefits with the continued evolution of their management practices. Adapting to a more intensive production system and prioritizing improvements to grazing lands with rotational grazing will help smallholders compete with larger farms, as agricultural operations become more consolidated.

UNDERSTANDING THE EFFECTS OF TIME ALLOCATION PATTERNS OF WOMEN ON NUTRITION IN RURAL INDIA

Agricultural development has various implications for nutrition. From existing literature, we know that women play a key role in agricultural activities, and this is reflected in their overall time commitments to agriculture. As time commitments in agricultural activities fluctuate, the amount of time a female household member can allocate to food preparation, childcare, and resting is also affected. Time is one of the key resources needed to carry out economic household activities, and yet within the scope of agriculture and nutrition linkages, the direct implications from changes in time allocation of women on nutrition outcomes are not well understood.

For example, given a longer workday in the field, how does a female agricultural worker manage her household duties? Does she adjust her food preparation time? Does this have an implication on food choices within the household? For example, does she choose simpler recipes that require less time? And how do these adjustments affect the nutritional status of household members, in particular, women and children?

Therefore, in order to clarify how time allocation in agriculture might affect nutritional outcomes, TCI has been conducting an ongoing study in the Chandrapur district of Maharashtra. Managed by Tata–Cornell Scholar Vidya Vemireddy, our survey commenced in December 2016, after focus group discussions were held in June–August 2016.

This study spreads across 24 villages located in three blocks of the Chandrapur district—Mul, Korpana, and Gondpipri—each of which have different cropping patterns, allowing for the necessary spread of agricultural activities to study time allocation patterns. Cotton, rice paddy, soybean, and, to an extent, pulses are some of the crops cultivated in this area.

A random sample of 40 households from each of 24 villages was chosen for the study. For each of these 960 households, a woman within the age group of 18–49 years and the male head of household were chosen, thus, totaling the sample of individuals to 1,920. The first survey (December 2016–January 2017) collected information on general household information, dietary diversity, health and sanitation, and empowerment indicators. This data added a panel to a study on the same sample conducted in 2014 by Tata–Cornell's Dr. Soumya Gupta.

Enumerators conducting recipe standardization.

Then, to study the effect of increased time in agricultural activities on the process of food preparation, there was a need for a new conceptualization of time savings with respect to the foods prepared. Based on discussions from the focus groups, women described that they are choosing to prepare food items that take less time whenever there is an increased time burden from agricultural-related activities. In order to determine any potential nutritional consequences, we needed to document and characterize the recipes prepared at home in terms of ingredients used and the time required to prepare and cook them. Through this unique recipe standardization process, TCI has created a one-of-a-kind record of 502 local recipes, which can be used to analyze the time and nutrients that go into preparing each one.

RESEARCH HIGHLIGHTS

PUBLICATION

Gupta, Soumya, Prabhu Pingali, and Per Pinstrup-Andersen. "Women's empowerment in Indian agriculture: does market orientation of farming systems matter?" *Food Security*, November 2017.

Finally, we are also working to address a data gap related to seasonality. One of the main challenges in studying the linkage between women's time allocation and nutrition outcomes is the lack of appropriate time use and dietary intake panel data that spans all agricultural seasons. This makes it almost impossible to analyze the nuances at play. Accordingly, TCI has been conducting a high frequency survey, which involves collecting 10 rounds of data on the same household, where each of the 1,920 individuals are revisited to collect time and diet information spanning agricultural seasons. We capture a detailed 24-hour recall of time use of women and men; a 24-hour dietary intake recall of women, household, and children; dietary diversity; and health information.

Overall, this research contributes to the existing knowledge base in many significant ways. First, it is one of few studies that collects such intensive time use and dietary intake data in India (as it is a 10-round panel covering the whole agricultural season). Second, the standardization of 502 local recipes adds to the available nutrition knowledge base of India.

The richness of the data allows us to relate the effects of women's increased time burdens in agriculture to nutrition outcomes in rural India. Data collection will continue through January 2018, and then statistical analysis will begin. However, based on various observations from time in the field, there are already some visible trends.

First, women are more sensitive to changes in agricultural activities relative to men. They are also involved in more manually intensive labor. Second, observations do suggest that women cut back on food preparation time, childcare, and resting time when agriculture activity is high, though the potential effects on nutrition are still yet to be quantified. Outlining these channels can be helpful in devising a number of gender-sensitive policies in agriculture, childcare arrangements, etc., that could help women to better cope with production seasons that demand more of their time.

ACCESS TO PIPED WATER, TIME SAVINGS, AND DIARRHEA INCIDENCE: RESULTS FROM FIELD SURVEY IN JHARKHAND

There are 748 million people in the world (concentrated mostly in developing countries) who lack access to clean drinking water and 1.8 billion people who use a contaminated water source for drinking purposes (this is based on 2014 reports from WHO and UNICEF, using 2012 data).[3] In Jharkhand, one of the eastern states of India, problems of adequate access to good quality drinking water, especially in the rural areas, are common. According to the state government, only 30% of dwellings have facilities for accessing drinking water, and there is a safety risk for all habitations, as water sources often contain arsenic, fluoride, and iron.

Poor sanitation and hygiene habits, as well as the lack of access to clean piped water expose the population to many deleterious health consequences. For example, drinking unsafe water leads to waterborne illnesses like diarrhea, jaundice, and typhoid fever. This imposes a health cost on affected households and may lead to a diversion of resources (for food, education, etc.) away from certain household members, particularly women and children. Furthermore, in the absence of having a water source at home, the family members must travel a distance to fetch water for household usage. Predictably, the burden of water collection falls predominantly on women. The time spent collecting water is time not spent in other market and home production labor activities.

Therefore, the focus of the TCI project in Jharkhand, which is led by Tata–Cornell Scholar Shiuli Vanaja, is to understand and analyze the time and health costs associated with using water from sources outside the home, compared to sources piped in.

There are two parts of this research project. The first is to find out the time-saving effects for women that result from access to a piped-water system, and the second is to assess the perception of water quality relative to actual water quality in these households.

The piped-water systems used in this study were installed by our partner AguaClara. This technology is low-cost, uses solar energy, and is gravity-based. These systems were constructed in four villages of Jharkhand with the help of TCI and the nongovernmental organization (NGO) PRADAN. On average, AguaClara piped-water systems supply water to 60 households per village. Each household pays 60 rupees (or less than $1) per month for access to piped water at home. To learn more about TCI's collaboration with AguaClara to build these piped-water systems in Jharkhand, please see previous annual reports.

After the installation and operation of the systems for the subsequent two years, we have set out to evaluate the impact of this project. Survey data has been collected from three villages with piped-water systems provided by AguaClara. In the absence of sufficient baseline data for these three villages, a set of three villages with similar socioeconomic structures were chosen in nearby regions to be treated as control villages. From the initial analysis, we find that the average time spent in water collection in the AguaClara villages is less compared to the control villages. The potential time-saving in water collection for women in households with piped water can be used for many alternative activities, like childcare, household chores, market-based labor work, agricultural work on their own farm, and community work.

Analyzing the effect of access to piped water on the time spent in the primary occupation by the female representative of the surveyed household indicates that there is a small but significant positive effect. In other words, the women in these houses are saving time after getting access to in-house piped water and spending this saved time on their respective primary occupations.

The second part of this research is based on understanding the relationship between the perception of water quality, the observed and tested water quality, and resultant diarrheal incidence at the household level. For this analysis, survey data was collected from 1,400 households in 40 villages in the Khunti and Ramgarh districts of Jharkhand. The quality of the drinking water was measured by collecting samples from the drinking water, which was stored in the house, and then testing the samples for presence of E. coli bacteria. We suspect that there could be direct causal relationships between water quality perceptions, water quality test results, and diarrheal incidence.

Perception of drinking water quality may influence the choice of a source of drinking water and affect the water usage and water handling practices inside a house. Households with better understanding of water quality are, perhaps, households with better water usage, storage, and handling practices inside their home. Thus, these are the households that one would expect to be suffering less from diarrhea. Analysis of the final results is in progress, but the initial regressions suggest that the perception of water quality inside the home has a significant negative impact on the probability of diarrhea incidence inside a household. Simply put, households that have a better understanding of good quality water have a lower chance of any member of the family experiencing diarrhea.

RESEARCH HIGHLIGHTS

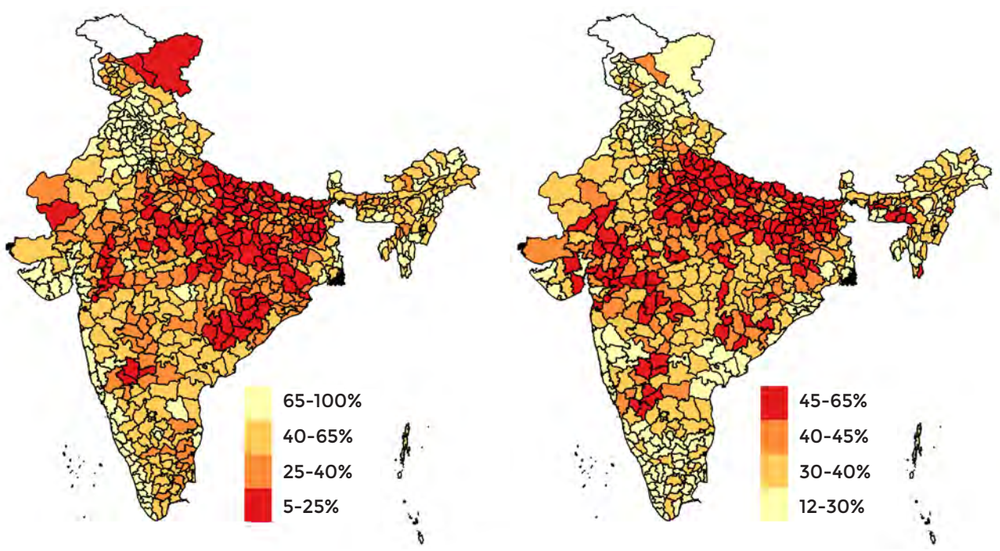
Based on TCI's impact study of the water systems in Jharkhand, we can confirm that having access to in-house piped water significantly reduces the time spent in collecting water in these households. We find that good quality water is associated with better health outcomes. More time and less illness will certainly improve the quality of life and may open up some labor opportunities for women in households with access to piped water.

IGNITING CHANGE IN SANITATION BEHAVIOR THROUGH COMMUNITY-LED TOTAL SANITATION

In India, 564 million people defecate in the open (WHO and UNICEF 2014). This number accounts for 59% of the 1.1 billion people in the world and 90% people in South Asia who practice open defecation (OD). The considerable consequences of OD are endured mainly by children (in the form of diarrhea-related illnesses) and women (with respect to their safety).

Diarrhea can be a serious illness in small children. In fact, every day in India, nearly 400 children under 5 perish due to diarrhea linked to poor sanitation and hygiene.[4] OD is also linked to stunting—in India, 38% of kids under 5 are stunted. Open defecation also has strong gender impacts; women feel constrained to relieve themselves only under the cover of darkness, for reasons of privacy and to protect their dignity. However, rapes and molestation incidents can commonly occur while women are out at night. Furthermore, OD has environmental impacts, such as the contamination of surface water, wells, soil, and food crops, which affects everyone in the community (including those who use a latrine and those who do not).

LINKING SANITATION AND NUTRITION OUTCOMES



Note: Improved sanitation means a household has a flush toilet or latrine that is not shared with any other household. Stunting is measure of chronic malnutrition.

Data source: National Family Health Survey 2015-16

Figure 5. Linking Sanitation and Nutrition Outcomes

Additionally, the effects of OD are greater in dense population areas. Research from India has shown that detrimental health impacts (particularly for health in early life) are even more significant from OD when the population density is high; the same amount of OD is twice as impactful in a place with a high population density average like India, compared to areas with low population density, such as sub-Saharan Africa (Coffey et al. 2014).[5] In a state like Uttar Pradesh, where the population (nearly 200 million) and population density (829 people per square kilometer) are enormous, we see this intensifying effect play out, even in rural areas. Moreover, the rural population in India defecates in the open at greater rates than the urban population (67% and 13%, respectively) (Census 2011).

The gravity of the sanitation problem, particularly, in rural India demands serious attention and must include robust, long-lasting, and replicable solutions. Despite many efforts from the Indian government, the problem of OD stubbornly persists. It has been widely documented that the root cause is not a lack of toilets, but rather unwillingness of the people to change their behavior. Social norms, habits, and sentiments certainly play roles. For example, there is a common belief that defecating in the open is natural and healthy and that building a latrine in the house brings impurity to it.

To end open defecation, we must address long-held traditions and beliefs, discuss what may be taboo, and raise awareness about fecal–oral contamination in a way that will motivate and sustain change at the community level. Simply building more toilets will not do the job.

An approach called Community-Led Total Sanitation (CLTS) has been extremely effective in reducing open defecation. CLTS is a behavior change communication methodology. It not only focuses on the construction of toilets, but also on triggering community self-mobilization to bring about behavior change, so that toilets are used and communities become open defecation free (ODF).

Our partner Grameen Development Services (GDS) has experience with this method. In fact, many villages where they have implemented CLTS are now considered ODF. Therefore, TCI has been working closely with GDS to scale up their CLTS initiative in the Maharajganj district of eastern Uttar Pradesh. TCI is investing in toilet construction and is conducting a study to measure the contribution of a behavior change campaign (using the principles of CLTS) on the increased use of these toilets.

Tata–Cornell Scholar Payal Seth is spearheading TCI's efforts in this area, as part of her doctoral research. She will compare villages that receive only toilets to those that receive toilets and the behavior change campaign (BCC), and to those that have not yet received any intervention (e.g., control villages). Handwashing and toilet maintenance are modules included in the BCC treatment. Through this project, TCI also hopes to estimate the influence that toilet adoption has on child health and nutrition (via diarrheal incidence), women's safety, and basic sanitation and hygiene practices.

By freeing the households of a budget constraint and by igniting a change in sanitation behavior using the CLTS methodology, we hope to see great returns on investment, by way of ending open defecation behaviors and witnessing sustained adoption of toilets. Discerning between the behavioral and/or hardware construction pathways, which may lead to increased adoption of toilets, is not only an empirical question, but also an imperative policy concern.

A PARTICIPATORY APPROACH TO MYCOTOXIN MANAGEMENT IN VILLAGE FOOD SYSTEMS

Fungal toxins, or mycotoxins, are chemical substances that contaminate a range of food commodities in food systems around the world. The presence of these toxins (such as aflatoxins, fumonisins, and trichothecenes) in food and feed has been implicated in a range of adverse health outcomes for humans and livestock, including cancers, growth and nutrition outcomes, and immunological status. Because of these harmful consequences, the burden of mycotoxins in food and feed can limit the marketability of produce and, therefore, be detrimental to smallholder economies, if not properly managed.

Mycotoxin exposure has become an issue of great concern in the global scientific and humanitarian communities, owing to its numerous implications for health, nutrition, and smallholder economies. Even so, substantial regulatory challenges remain at the smallholder level, where knowledge and capacity are generally not sufficient for detecting

and eliminating sources of toxin risk. This global reality holds true in Indian villages, which lack the tools necessary to gauge the mycotoxin burden and take necessary action to address local food safety concerns.

These toxins can accumulate in food and feed prior to harvest in several crops in a host-specific manner, for example, aflatoxins in maize and groundnuts, fumonisins in maize and sorghum, and trichothecenes in wheat. In addition, poor storage conditions after harvest can promote fungal growth and result in further deposition of mycotoxins in a wide range of commodities. In India, limited resources have been leveraged to assess the extent of mycotoxin accumulation in village food systems. Furthermore, little has been done in the Indian context to identify best practices for mycotoxin management at the household level, and of the practices that have been recommended, only a few have been followed through to implementation.

Tata–Cornell Scholar Anthony Wenndt is working to characterize sources of mycotoxin risk in Indian village communities and leverage local knowledge and resources to develop effective and scalable toxin mitigation strategies for grain storage systems at the household level. Focusing his efforts in Unnao District, Uttar Pradesh, our Scholar is currently developing a participatory action research (PAR) approach to profile local toxin risks and identify storage mitigation solutions in village communities.

Unnao District has a range of distinct food systems, including those that are rich in rice paddy and wheat, and others that are enriched with maize, millets, and groundnuts (in addition to rice paddy and wheat). By surveying across these different food systems, TCI aims to elucidate the relationships between food system composition, storage practices and behaviors, and the risk of food spoilage and toxin accumulation. This year of fieldwork will be spent engaging with communities, both in group settings and at the household level, in a process of stakeholder research and collaborative learning designed to characterize grain management behaviors and to assess the magnitude of mycotoxin exposure risk across these diverse local food systems. In addition, participatory programming is being deployed to develop and experimentally test locally relevant toxin mitigation techniques for household grain storage systems.

In the long term, Anthony Wenndt's work will generate a comprehensive profile of mycotoxin risk factors specific to Indian village food systems. Among the outputs of this TCI research will be a set of recommendations for behavior change and systematic improvement of storage infrastructure as well as community-scale toxin monitoring capacity. Moreover, we are developing a novel model for participatory problem-solving in the context of mitigating household grain spoilage, which may eventually be scaled up and operationalized to address mycotoxin management concerns across Indian food systems.

A TASTY TUBER TO TACKLE VITAMIN A DEFICIENCY IN UTTAR PRADESH

TCI is undertaking a groundbreaking project to test the effectiveness of orange-fleshed sweet potato in alleviating vitamin A deficiency (VAD) in villages in rural Uttar Pradesh. This work will build on the notable successes of similar studies in sub-Saharan Africa, for which the leading research teams were awarded the 2016 World Food Prize. Understanding the potential of the orange-fleshed sweet potato, in the Indian context, to reduce vitamin A deficiency will improve future diet-based solutions to decrease VAD and influence food and agriculture policy, building evidence that promotion of micronutrient-rich vegetables need not be at the expense of calorie density.

Micronutrient deficiencies are still rampant throughout India, even as more people achieve calorie-adequate diets. One such micronutrient—critical for child health and healthy pregnancies—is

vitamin A, which plays vital roles in immune function, eye health, and fetal development. VAD exacerbates other forms of malnutrition and increases the risk of death for children, mothers, and babies born to women with VAD. It is estimated that 44% of children in India are vitamin A deficient. This amounts to approximately 70 million children, meaning that India bears the highest burden of childhood VAD of any country in the world. Efforts to reduce this deadly deficiency have been largely unsuccessful, as VAD prevalence among children in South Asia has remained virtually unchanged since 1991, even as the global prevalence has fallen from 39% to 29%.

Promotion of the orange-fleshed sweet potato—often referred to as "OFSP" by the nutrition and development community—has emerged as an extremely promising, diet-based approach to reducing VAD among vulnerable groups. Several large studies have successfully reduced VAD in sub-Saharan Africa by promoting OFSP, combined with nutritional educational messages. These studies found significant and meaningful increases in both the consumption of vitamin-A rich foods and in serum retinol levels in previously deficient children. This success has led to the development of a crop variety of orange-fleshed sweet potato suitable for the climactic conditions of Uttar Pradesh. Working with the TCI partner organization Grameen Development Services (GDS), TCI will be introducing this new vitamin A-rich crop, along with nutrition behavior change messages, to villages in the rural Maharajganj district of Uttar Pradesh, testing the impact of agricultural and behavioral change intervention components on improving the adequacy of vitamin A of the diets of women and children, and changes in vitamin A deficiency

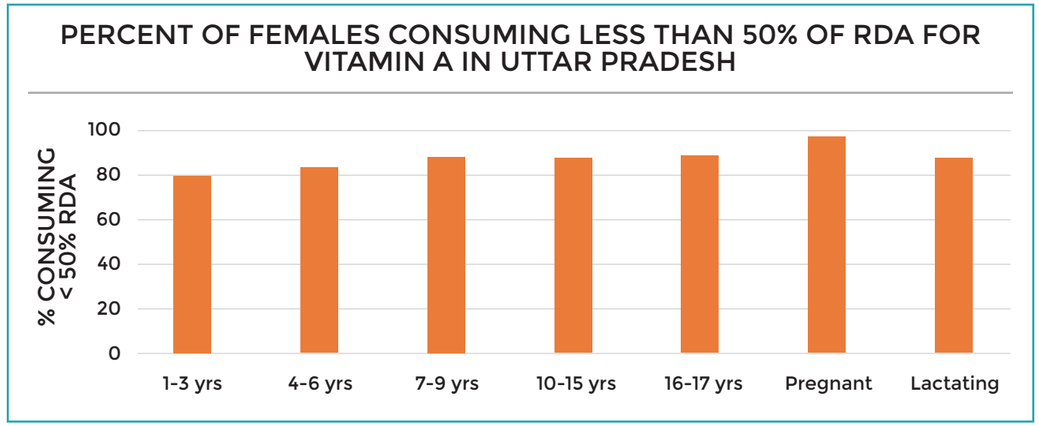


Figure 6. Percent of Females Consuming Less Than 50% of RDA for Vitamin A in Uttar Pradesh

PUBLICATION

Abraham, Mathew, and Prabhu Pingali. "Transforming Smallholder Agriculture to Achieve the SDGs." In *The Role of Small Farms in Food and Nutrition Security*., edited by L. Riesgo, S. Gomez-y-Paloma, and K. Louhichi. New York: Springer, 2017.

among these vulnerable groups. This work is led by Tata–Cornell Scholar Kathryn Merckel, a PhD candidate in International Nutrition.

The success of an OFSP-based dietary approach to vitamin A deficiency requires numerous components. The orange-fleshed sweet potato must be available and affordable, and Indian families must have the desire and knowledge to prepare and serve OFSP to their children. Once the OFSP has been consumed, the vitamin A must be biologically accessible and usable by the body. Previous studies promoting OFSP in sub-Saharan Africa provide a useful framework for the introduction of OFSP to Uttar Pradesh; however, a multitude of contextual differences must be taken into account in order to successfully adapt the project. The interventions must be tailored to the unique constraints of Indian families in Uttar Pradesh, and to food systems that do not already include large amounts of white-fleshed sweet potato, a variety common in Africa that contains no vitamin A.

This research began in the spring of 2017, when Ms. Merckel implemented a nutrition message development methodology, called the Trials of Improved Practices, or "TIPs," in the slated study region. The purpose of TIPs is to discern messages that encourage women to alter their behavior, in this case the foods they prepare for their children, toward healthier practices. Through a series of in-depth interviews with 16 mothers of young children, we were able to identify some of the most common issues with infant and young child feeding, and create messages to encourage change in these behaviors using OFSP and other vitamin A-rich foods.

Our OFSP project will continue through 2018, as farmers are sensitized to the benefits of producing the new crop on their land, and as families learn how consuming the new vegetable can improve the health of their children. Introduction and promotion of the OFSP will be supported through agricultural training and nutrition behavior change messaging activities, developed using participatory methods.

The results of this study will have numerous impacts on the future of OFSP in India and agricultural and nutrition policies. The success of a diet-based VAD reduction program could potentially influence current Indian reliance on ineffectual vitamin A supplementation programs, encouraging policymakers to strengthen diet- and behavior-based strategies to ensure the micronutrient adequacy of diets for mothers and their children. By demonstrating that an easy-to-grow and very tasty tuber can both increase caloric food security and decrease the prevalence of vitamin A deficiency in areas where it is planted, we hope to build evidence that the OFSP is an invaluable crop for future agriculture and nutrition interventions in India.

MARKET–FARM LINKAGES: PRODUCER ORGANIZATIONS AND PRIVATE VALUE CHAINS IN PULSES

In recent years, the growing demand for pulses and the low-supply response at the farm level has led to uncertain prices and low per capita availability of pulses in the market. The value chain response to address this has been twofold. First, to ease the upward price pressure of pulses, in 2015–2016, the Government of India began sourcing pulses through Farmer Producer Organizations (FPOs), which are aggregations of small producers, to create a buffer stock. Second, responding to rising demand, private companies have been actively entering the organized retail space through the branding of pulses. This requires them to link backwards into the market. TCI has been examining the nature of FPO and private value chain interventions in the pulses value chain to assess how they can attempt to rectify the supply–demand mismatch.

We found that FPOs helped small farmers access quality seeds, inputs, and extension services for growing pulses. Farmers were receptive to these initiatives because of assured marketing opportunities (as they were selling to the government), incentivizing them to invest in pulses production. Branding of pulses, in response to changing demand, required interventions in the value chain that provide assurances of quality, quantity, and timely supply. Our study of a private company entering the pulses branding and retail space allowed us to assess how they sourced directly from the agricultural market. Direct procurement reduced the role of intermediaries in value chains, ensured objective price determination on quality parameters, and enabled direct payment to farmers' accounts rather than payment in cash. The limitation for the FPO approach was that, in the absence of government procurement, these groups could find it hard to find buyers or form long-term contracts. The corporate retail segment also has not formed tie-ups with FPOs, as their procurement was limited to select big markets. While FPOs did help with changes at the production level, as Figure 5 illustrates, corporate value chains largely have an impact at the market level.

FPOs and the retail sector linking backwards to the market and farm level is crucial for the commercialization that contributes to agricultural growth and development in all emerging economies. The process of commercialization entails the shift from non-tradable inputs to tradable inputs (seed technology, fertilizer and pesticides, and credit) to improve farm-level production and create marketable surplus. This process enables household income and welfare growth in the agricultural sector. Commercialization in the Indian agricultural sector has been crop specific. Market support, R&D, and the availability of high-yield seeds and quality inputs have made rice and wheat cultivation market-oriented. In certain other crops, such as coarse grains and pulses, where yield improvements over the years have been marginal and R&D limited, the incentives to grow them remain low, despite growing demand. The incentive to diversify away from staple grains to other crops depends on a small farm's ability to commercialize.

Our study on interventions in the marketing of pulses in India sheds light on some general trends of commercialization and challenges of aggregation models and vertical coordination in agricultural markets. Aggregated FPOs may find it difficult to form direct linkages with agricultural commodity markets in the absence of procurement through the state. They, however, can address some of the problems of access to factor markets to improve productivity and production practices. Corporate initiatives to link backwards to producers have proved successful through contract farming initiatives in perishable commodities, such as fresh fruits and vegetables, meat, and milk. In the case of non-perishables such as pulses, the high cost of management, enforcement, and forming linkages with farms limit retailers' participation to agricultural markets, rather than to farms. Linkages between the retail sector and aggregated producers are still uncommon. However, coordination with aggregation models to improve linkages to farms may prove beneficial in the long run, as they may help in reducing management, enforcement, and transaction costs.

INFLUENCE OF AGGREGATION MODELS AND CORPORATE VALUE CHAINS ON COMMERCIALIZATION

	Production Level	Market Level
Producer Organizations	Aids commercialism through improved access to factor markets and information	Poor market access in the absence of government procurment
Corporate Backward integration	Low linkage to farms	Direct procurment, assurance of quality, quantity and good price realization for seller

Figure 7. Influence of Aggregation Models and Corporate Value Chains on Commercialization

RESEARCH HIGHLIGHTS

RESEARCHER SPOTLIGHT

Dr. Sri Raj, Research Associate

Dr. Srilakshmi (Sri) Raj is a Research Associate with the Tata–Cornell Institute. She joined TCI in 2017, after completing a postdoctoral fellowship at the Department of Molecular Biology and Genetics at Cornell. Prior to that, she completed a PhD in Biological Anthropology at the University of Cambridge, and earned BA and MA (Oxon) degrees at the University of Oxford.

As a human population geneticist, she has been interested in understanding inequalities in disease susceptibility among different sectors of the human population. Many common, complex diseases are caused by a combination of genetic and environmental risk factors. Identifying differences in these combinations will help us understand, predict and treat diseases.

Sri has received several honors and awards for her research, including a Gates Cambridge Scholarship for her PhD and a NIH National Research Service Award (NRSA) fellowship for her postdoctoral research. Most recently, she was selected to be on Forbes Magazine's 30 Under 30 list for Healthcare.

She is currently using her expertise on Indian genetic architecture and disease toward understanding how disease risk, particularly diabetes and stunting, is influenced by both genetics and environment.

SOIL HEALTH PROGRAM: DEVELOPING MOBILE AND LABORATORY TESTING PLATFORMS

The TCI Soil Health Project focuses on soil health enhancement to improve agricultural productivity, reduce malnutrition, and enhance the rural environment.

During 2015 and 2016, we worked to establish a baseline for soil health in the Indian state of Jharkhand. In 2015, soil samples were taken from 29 catchments in Jharkhand, including both crop fields and natural areas. Despite a homogeneous agricultural system (mostly paddy rice), our analysis (completed in 2016) revealed higher values of particular soil health indicators in some districts over others. This variance could be due to different soil types, farmer economic capacity and/or heterogeneous management practices—all factors that could influence soil health.

Based on our assessments overall, Jharkhand soil health faces many limitations, including a challenging environment with biologically poor, nutrient-deficient, mono-cropped, anthropogenic soil. However, with management changes, this soil could become more productive and could supply improved health benefits and nutrition to those who farm it.

We believe farmers and agricultural extension agents need tools and support to be able to measure and track indicators of soil health locally. Many farmers report that they have willingly shared soil samples with researchers and governmental or NGO agricultural extension agents to be analyzed in distant laboratories, but they report (1) seldom hearing the results of the assessments, and (2) not knowing the proper actions to take in order to ameliorate their soil health issues.

As such, the TCI Soil Health Project is working along two fronts to improve soil management practices via agricultural extension services and knowledge transfer to farmers. First, we are developing a mobile soil health toolkit, and second, we have been building awareness of and capacity among India-based research institutions and NGOs in Cornell's framework for the Comprehensive Assessment of Soil Health.

The toolkit is intended to function as a basic field tool that can be used by extension and NGO consultants in the field and can provide immediate results for farmers on the most critical metrics to address soil health. This would facilitate soil health assessment, education, and ultimately, conversation on soil health management practices. Operationalizing a simplified and affordable soil health toolkit that can be widely implemented in the Indian agricultural environment and subsequently, developing context-appropriate management advice for soil health improvement are efforts underway with our partners—including partnerships with NGOs (such as PRADAN) and academic institutions (such as Birsa Agricultural University in Ranchi, Jharkhand, and Dr. Rajendra Prasad Central Agricultural University [DRPCAU] in Pusa, Bihar), as well as private-sector partners like Rallis India Limited (a TATA enterprise).

PUBLICATION

Pingali, Prabhu, and Gershon Feder, eds. *Agriculture and Rural Development in a Globalizing World: Challenges and Opportunities*. 1st ed. Earthscan Food and Agriculture. New York: Routledge, 2017.

In terms of knowledge and capacity transfer, the TCI Soil Health Project sponsored its first International Workshop on Soil Health in January 2016. This was organized at Birsa Agricultural University, Ranchi, with over 250 scientists, extension specialists, and agricultural administrators from many parts of India in attendance. The TCI Soil Health Project team and representatives from Cornell University (including Dr. Harold van Es, Dr. Peter Hobbs, Dr. David Rossiter, and Tata–Cornell Scholar Mr. Phil Frost), as well as scientists from the Indian Center of Agricultural Engineering, Indian Institute of Soil Science, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Maize and Wheat Improvement Center (CIMMYT), Borlaug Institute for South Asia, and PRADAN presented on soil health concepts.

Building on that experience, TCI Faculty Fellow Dr. Harold van Es, a foremost expert in soil health and the 2016 President of the Soil Science Society

RESEARCH HIGHLIGHTS

of America, and our newest Tata–Cornell Scholar, Ms. Kavya Krishnan (PhD student in Soil Science) visited DRPCAU in Pusa, Bihar, in August 2017.

Beyond establishing the relationship, we were able to define what a collaborative effort on soil health might look like between our two institutions. As a result, DRPCAU agreed to create a new soil health program. They have committed to providing space for setting up a soil health laboratory in a newly built laboratory building. The university will also allow the Soil Health Program to draw upon existing staff from the university to enable the development of information in a holistic manner. The Chair of the Department of Soil Science also agreed to commit postgraduate students to work on research/theses related to soil health and expressed support to host the soil health laboratory. In general, we expect this initiative to develop over a period of two years, and while these discussions are very recent, we are hopeful that the collaboration with DRPCAU will be a fruitful one. Our interactions have fostered knowledge sharing, partnership development, and capacity building between India-based and Cornell-based soil scientists and research institutes and the NGOs that are in the best position to bring soil health concepts to policymakers, extension service providers, and farmers in India.

EXPLORING THE GENETIC AND ENVIRONMENTAL FACTORS OF THE TRIPLE BURDEN OF MALNUTRITION

Steady economic progress in India has not been concomitant with social and biological indicators of well-being. Most recent estimates (2014–2016) show that nearly 15% of the Indian population is undernourished. While this number represents a 36% decline since 1990, over the same period of time, China had twice the reduction rate. This undernourishment translates to still high levels of stunting and muscle wasting, micronutrient deficiencies, and increasingly, overweight and obesity. The existence of all three conditions simultaneously affecting the Indian population has been called the triple burden of malnutrition.

TCI has been focusing efforts to understand and minimize the influence of the triple burden in India. However, there are special characteristics of the Indian population that may make it more vulnerable to its risk factors, as compared to other populations. These have not been explored previously in India, and there are key features of the Indian population that are important to consider with respect to the triple burden. For instance, why are Indian children more stunted, compared to their African counterparts (where stunting is 30% prevalent), despite better economic status? This phenomenon has been termed the "South Asian enigma." Our Research Associate Dr. Srilakshmi Raj is overlaying genetic and environmental factors to move forward our understanding of the complexity of the triple burden.

First, India holds an extraordinary amount of biological, environmental, and socioeconomic diversity. Indians have four times higher human genetic diversity, compared to European populations. With such diversity spread across the nearly 1.3 billion people in India, exploring its causes and consequences toward health risk can help form health solutions for large sectors of the population.

South Asians, in particular, may be genetically predisposed to short stature. Many South Asian populations are highly consanguineous and branched from larger populations as founders, which can result in genetic predisposition to reduced height. This also places South Asians at high risk for developing recessive disorders, which increase risk of medical pathologies that can result in abnormally short height. It has been hypothesized that South Asians also exhibit a "skinny–fat" phenotype that can influence their risk of diabetes, obesity, and perhaps, also wasting, characterized by high subcutaneous fat deposition, and lower fat-to-muscle ratio in infants. This phenotype is hypothesized to have arisen due to natural selection that would enable survival of feast–famine cycles that accompany periods of monsoon and drought.

Geographically, higher income states in India have higher prevalence of certain burdens, such as overweight and obesity (e.g., Kerala), while low-income states such as Odisha, Bihar, and Uttar Pradesh have higher stunting and micronutrient deficiencies. This geographical variation raises additional questions: is it possible that genetic variation, socioeconomic variation, and phenotypes vary according to geographical location in India? These geographic variations can include different extreme environments, such as the dense forest and desert, but can also include differences between

RESEARCH HIGHLIGHTS

CONSEQUENCES AND CONTRIBUTING FACTORS OF THE TRIPLE BURDEN

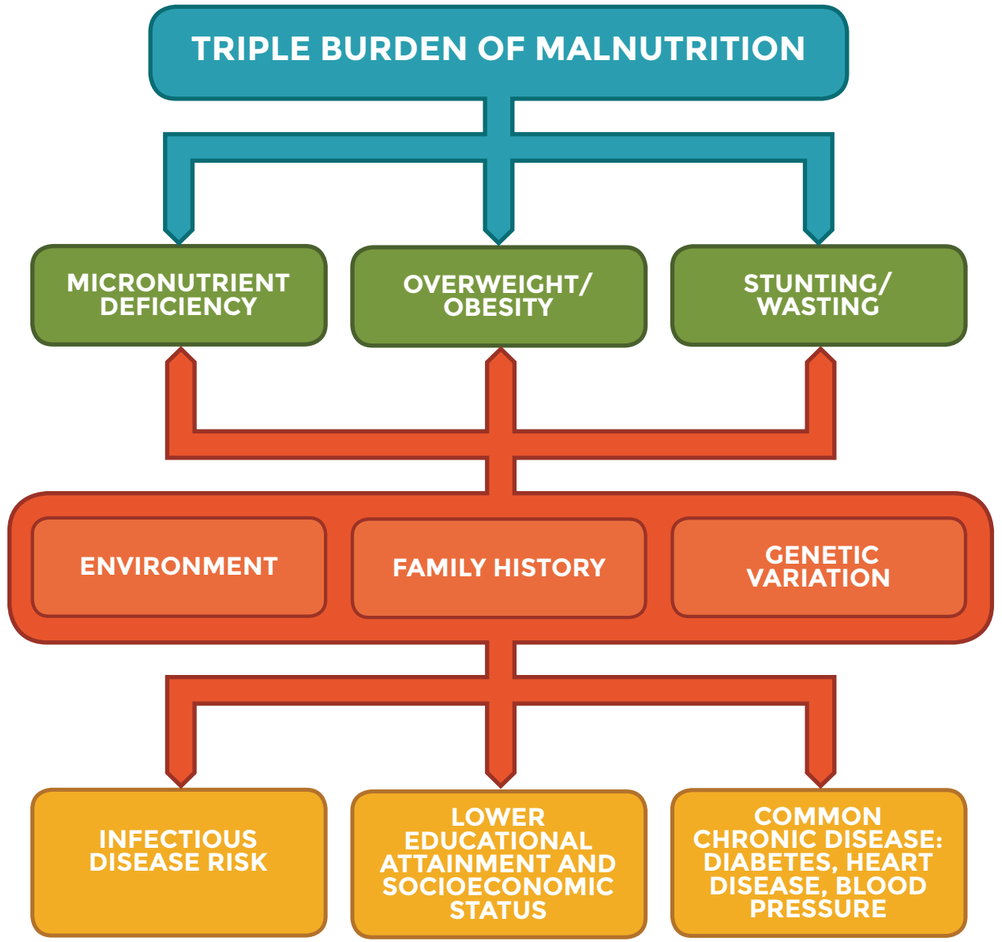


Figure 8. The triple burden of malnutrition is influenced by environment, family history (including birth order preference, cultural practice, family risk, and food preferences), and genetic variation.

urban and rural areas. Environmental differences can include man-made ones like access to good sanitation or toilets, or different micronutrient deficiencies based on agroclimate.

From this perspective, individuals in each family and population show biological variations in height that when interacting with the environment may contribute differently to abnormally short or stunted stature; high risk for diabetes, obesity, and heart disease; and poor health in the face of micronutrient deficiencies. The uniquely severe burden of stunting in South Asia requires careful analysis of all contributing factors—biological, medical, and environmental—to (1) understand the primary causes of stunting in individuals, families, and populations and (2) create optimal prevention and treatment outcomes for stunted growth.

Dr. Raj has expertise in understanding how genetics and environment can contribute to disease. For example, her research shows that type 1 and type 2 diabetes are two genetically distinct traits. She found that there is greater genetic diversity within India than between India and other populations. She also found that India exhibits geographic diversity in genetic variants that encode susceptibility to diabetes and obesity. Lastly, in a forthcoming publication, she provides evidence showing that networks of diabetes-associated genes vary among tissues and among populations (including South Asia, as one of these populations). Therefore, she has demonstrated that the components of the triple burden in India must be evaluated in the context of genetic and environmental factors, and these contributions are likely to vary among populations within the Indian subcontinent.

Dr. Raj will begin fieldwork at the end of 2017. She previously carried out preliminary research to explore aspects of the genetic and environmental variation in India that could contribute to the triple burden. Eventually, this information will be used to develop tools to better predict health outcomes in specific populations in India and to target treatments and policy measures to accurately alleviate the triple burden in India.

DEVELOPING A NOVEL AND SUSTAINABLE FORTIFIED FOOD PRODUCT TO ADDRESS IRON MALNUTRITION IN INDIA

Iron deficiency affects up to 5 billion people worldwide. Even though iron is one of the most abundant elements in the earth's crust, its deficiency, called iron-deficiency anemia (IDA), is also one of the most frequent nutritional disorders. This makes it a highly problematic micronutrient. Dietary iron comes from two sources: non-heme from vegetarian sources, and heme from meat. Humans can only utilize 2–10% of iron ingested through non-heme sources. However, heme iron absorption can be as high as 25%.

Specifically in India, anemia affects over 80% children below the age of 3 years, 58% of expectant mothers, 50% of non-pregnant and non-lactating women, and over 56% of adolescent girls; with IDA accounting for over 60% of the cases of anemia. In pregnant women, iron depletion can cause low birthweights in their newborns and complications caused by intrauterine growth restriction and preterm delivery.[6] In children, it can lead to impaired cognitive function and delayed physical growth, as well as an overall reduced future working capacity. IDA was responsible for 24% of maternal mortality in India, and another 50% of maternal mortality has been indirectly associated with anemia. This has catastrophic consequences for the future generation and can eventually lead to a "dually-burdened society," with both the mother and the child being anemic. The economic implications of IDA in India are also severe, accounting for 5% GDP loss.[7]

National surveys have shown that, except for staples, the consumption of other nutritionally dense commodities, such as pulses, milk, fruits, and vegetables, fall far below the recommended dietary allowance (RDA) (Table 1). With meat consumption among the lowest worldwide, IDA thrives in India. The current government initiatives to control anemia are focused on providing iron and folic acid pills; however, consumer compliance is low.

FOOD CONSUMPTION (G/DAY), BY FOOD GROUP

	INTAKE*		RDA
	CU	PER CAPITA	
CEREALS/ MILLETS	396	345	400
PULSES	28	24	80
MILK	82	71	300
VEGETABLES	49	43	300
OILS	14	12	30

Table 1: Food consumption (g/day), where intake is by consumption units (CU) and by per capita consumption (NIN 2011)[8]

TCI has, therefore, made it a top priority to address the rising issue of IDA in India through fortification. Tata–Cornell Scholar Rohil Bhatnagar is leading TCI's efforts to find a remedial diet-based strategy that can combat iron deficiency. TCI is exploring the utility of biosustainable, marine defatted green microalgae (DGM), inulin (INU), and phytase (PHY) as potential ingredients to fortify food commodities and, in turn, restore healthy iron status in humans.

In cooperation with Cornell University's Department of Food Science, the preliminary work on this project was initiated in September 2016 as a proof-of-concept study using mice models. This study had two phases: first, to establish the efficacy of DGM, INU–PHY in repleting iron status; and secondly, to assess the safety of DGM.

In accordance with our target population, a rice-based, iron-deficient basal rodent diet was formulated. The experimental diets were supplemented with either iron extracted from DGM (Fe-DGM) or INU–PHY. Systemic iron repletion efficiencies were measured across treatments in diet-induced iron-deficient mice. Declining hemoglobin and iron stores, and low body weight are characteristic features of IDA. We showed that Fe-DGM enhanced hemoglobin levels over the control and significantly elevated liver ferritin levels. Additionally, mice consuming Fe-DGM had improved growth performance. Similarly, an INU-PHY diet, providing the same amount of dietary iron as the control, resulted in enhanced body iron stores. This study supports the potential of DGM as a rich source of bioavailable iron. After establishing the safety of DGM in model organisms, our next step will be to develop technology-based DGM/INU/PHY-fortified food products to target IDA.

With this project, we envision translating this novel technology into a safe, viable, and dietary pattern-adherent, fortified food product that optimizes IDA-related health outcomes in the real world, without jeopardizing future resources of nourishment.

QUANTITY AND QUALITY LOSSES ALONG FRUIT AND VEGETABLE VALUE CHAINS IN INDIA

Food loss and waste (FLW) is a decrease in the quantity of food originally intended for human consumption and/or a decrease in quality (e.g., nutrition or other attributes) along the food chain from harvest to consumption. More specifically, food losses occur before consumption, whereas food waste occurs at the consumption level. In developing countries, the majority of FLW exists as food loss. Also important are the foods that are diverted away from human consumption; these have different final destinations and uses, such as animal feed, compost, and landfill.

From a food and nutrition perspective, FLW may impact household food access in terms of quantity, quality, and diversity of food. Diet quality is of concern when diets tend to consist mostly of staple grains and fewer micronutrient-rich foods, such as animal products and fruits and vegetables. Compared to staples, fruits and vegetables are more perishable food groups that are also important sources of micronutrients. Among different

A tomato vendor sorts tomatoes based on appearance attributes. Tomatoes to the right of the divider are sold at a 50% discount. Tomatoes remaining unsold at the end of the day are taken home and fed to cows.

pathways to improving food and nutrition security, the international development organizations have called for reduction of food loss and waste. Therefore, TCI seeks to understand quantity and quality food losses along the fruit and vegetable value chains in India.

We are working to adapt methods to assess the magnitude and causes of fruit and vegetable losses from farm to retail, with the objective of identifying points of quantity and quality loss along the value chain, and final destinations of diverted products. Tata–Cornell Scholar Jocelyn Boiteau has taken the lead on this initiative, and over the summer of 2017, she carried out formative work to understand stakeholder perceptions and influences on fruit and vegetable losses from farm to retail in traditional value chains.

As we continue to build upon this formative work, in combination with literature review, we plan to create a definitional framework for FLW specific to fruit and vegetable value chains. Using this framework, our researcher will adapt existing methods to collect sample data on fruit and vegetable value chain actors, to understand losses at each particular stage of the value chain from farm to retail stages. This data will include assessment of the magnitude and causes of quantity and quality losses, as well as determination of the final destination of diverted products. Focus will be placed on losses in traditional value chains.

Over the long term, this work will advance our ability to accurately assess losses along fruit and vegetable value chains. It will lay the groundwork for future studies on the cost-effectiveness of food loss reduction interventions within the food system. Ultimately, the integration of nutrition and economics plays a key role in aligning food systems to improve nutrition and human health.

DIVERSITY IN DEVELOPMENT: INTERSTATE DIFFERENCES IN THE INDIAN GROWTH STORY

The Indian growth story often appears as if it is riddled in contradictions in the development process. It would seem that within the country, economic growth occurs alongside increasing inequality, stagnant undernutrition coexists with increasing overnutrition, and subsistence agriculture farms operate next to large productive farms. Within the same country, there coexist states like Bihar, which are comparable to countries in sub-Saharan Africa in their development experiences, while other states, such as Goa, have development experiences similar to countries in Latin America. Prior models that have used either geography or income measures to classify the development experiences of the states are not amenable to explaining differences between states that are in similar geographies or have similar income groups. These models cannot explain why some states moved more quickly through the structural transformation than others or what can be done to enable greater structural transformation among the lagging states.

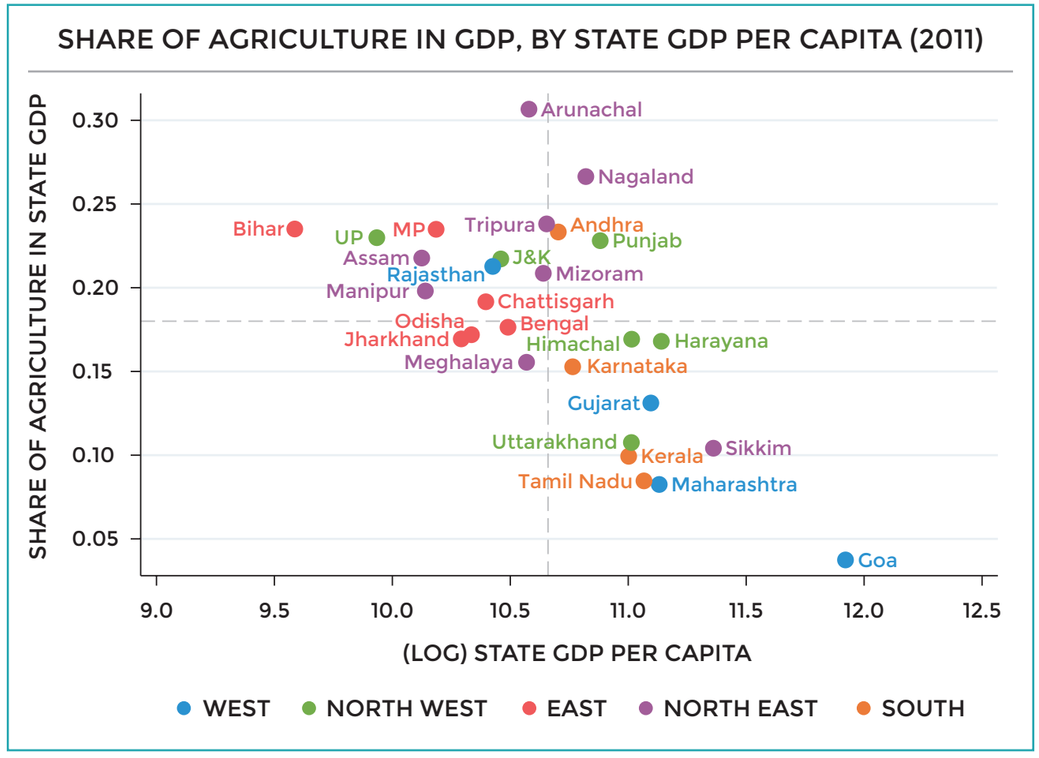
In response, we at TCI have developed a novel way to (re)classify states in India to account for the heterogeneity in growth and development, using the principles of structural transformation (ST). This endeavor has been led by Dr. Anaka Aiyar, a postdoctoral associate, under the guidance of Professor Prabhu Pingali.

By using the share of agriculture in GDP as a proxy for where a state is in the process of ST, along with GDP per capita, as a proxy for productivity, we identify four typologies of states within the country (Figure 9). The first are those for which structural transformation has been stunted by a low-productive agriculture sector. Stunted ST states are characterized by subsistence agriculture, poor urban development indicators, high poverty rates, and incidence of malnutrition. Examples include Bihar, Uttar Pradesh, and Madhya Pradesh.

The second type of states, resource extraction-led growth states, are those with economies that are driven by the natural resource and mining sectors, yet, economic growth processes are weighed down by a low-productive agriculture sector. These states have more urban development but high rural poverty and undernutrition rates. States such as Jharkhand, Odisha, and West Bengal are examples.

The third and fourth groups of states are high-productivity economies. The third group, agriculture-led growth states are those with economies driven by a highly productive agriculture sector. These states have both low rural and urban poverty, but have problems with increasing obesity, driven by increases in income. Punjab and Andhra Pradesh are typical examples of this group.

The fourth group, rapidly transforming states are those with economies that started as high-productive agriculture states but now have economies driven by the non-agricultural sectors. These states are en route to completing the process of ST. Their economies have some of the lowest poverty rates and incidence of undernutrition, but their obesity rates are increasing. Examples of such states are Kerala, Tamil Nadu, and Gujarat.



SHARE OF AGRICULTURE IN GDP, BY STATE GDP PER CAPITA (2011)

Figure 9. Share of Agriculture in GDP, by State GDP Per Capita (2011)

RESEARCHER SPOTLIGHT

Dr. Andaleeb Rahman, Postdoctoral Associate

Dr. Andaleeb Rahman is a Postdoctoral Associate at the Tata–Cornell Institute. His research focuses on the reforms in food and agricultural policy in India and their implications for nutritional outcomes. He wrote his doctoral dissertation on the impacts of consumer food subsidies in rural India. Andaleeb joined TCI in October 2016, and since then, he has been working on the changing nature of food procurement and distribution in India. In his work, he explores these issues at a national level as well as subnational level, given the rising importance of federal governments in shaping the policies. Some of his work has been published in reputed journals, such as Food Policy, Global Food Security, and Economic & Political Weekly. His research has also been cited in print media.

There are three main takeaways from this analysis. One, our model confirms the hypothesis that agriculture led growth is an important catalyst for development and is necessary for rural development, poverty reduction, and reduction in malnutrition. Without a strong non-agriculture sector to absorb surpluses from a productive agriculture sector, economic growth will remain lower than potential. Economic growth is essential for both diet diversification as well as for reduction of poverty and undernutrition. Thus, a focus on developing the agriculture sector while simultaneously creating new non-farm opportunities for the absorption of low-skilled labor is crucial to enabling greater structural transformation.

The second key point of our analysis is that increases in income are associated with increases in obesity, suggesting that there has been a delinking of consumption and food production from the knowledge of what is good nutrition. This problem urgently needs to be remedied.

And finally, a national-level growth strategy is no longer useful if the country intends to create conditions for enabling greater structural transformation.

Using our typology, we argue that it would be more effective to identify the main challenges for each state and to design solutions to enable greater structural transformation. For example, the major policy goal for the stunted ST states would be to jumpstart a new green revolution in order to boost agricultural productivity. In addition, policy in these areas should focus on creating safety nets and increasing nonfarm opportunities to reduce rural poverty and undernutrition. For resource extraction-led growth states, it should be key to increase productivity in the nonfarm sectors of the economy. This would include investing in agriculture, which will help tackle rural poverty and will play a role in increasing access to healthy and diverse diets.

In high-income states, the main goals for development should be to focus on improvements in labor-intensive employment in the non-agricultural sector as a means to reducing poverty and income inequality. Improving quality of food delivered to towns and cities, through investments in food supply chains, will be key to stimulating greater economic growth in agriculture. This can also contribute to improving access to nutritious food for the poor, as well as decreasing risk of overnutrition in these states.

Given that major differences in development currently exist across states in the country, we contend that any national-level development policy, which plans to increase agricultural growth, improve nutrition, and stimulate the economy, has to do so by addressing the unique challenges that each state faces. The previous pan-India models of development that considered the whole country as a single entity in the development process may now be redundant.

PUBLICATION

Pingali, Prabhu. "The Green Revolution and Crop Diversity." In the *Routledge Handbook of Agricultural Biodiversity*. New York: Routledge, 2017.

THE BUMPY ROAD FROM FOOD TO NUTRITION SECURITY

Reducing malnutrition is one of the most important developmental challenges for India. Malnutrition rates in India are significantly higher than even in sub-Saharan African countries, and one of every three malnourished children in the world is from India. At the same time, latest health surveys have shown that obesity and micronutrient deficiencies are increasingly burdensome. This triple burden of malnutrition is a major public health concern, as it seriously undermines a nation's capacity to use its productive labor and benefit from the much-touted demographic dividend.

Such an abysmal performance on nutrition in India begs the very important question—why has the historic success of grain productivity growth, achieved through the Green Revolution, not brought about a reduction in malnutrition? Although there are no easy answers, a retrospective analysis of policy creation and implementation would go a long way in explaining how we arrived at the policies being employed today. We must understand cause and effect—and, in particular, what went wrong—if we are to design a new framework for improving the current state of nutrition.

RESEARCH HIGHLIGHTS

We explored the answers to this conundrum in our recently published paper in the journal Global Food Security, "The Bumpy Road from Food to Nutrition Security—Slow Evolution of India's Food Policy" We provide a comprehensive overview of the evolution of food policy in India, with the aim of elaborating upon the policy objectives and outcomes. A clear narrative emerges from this deliberation that agricultural policies have focused on mitigating hunger but without giving due consideration to nutritional security and dietary transition. Singular focus on national availability of food calories has undermined access to quality diets and a diversified food system. Poor nutritional outcomes, hence, can be partly attributed to the cereal-centered food and agricultural policies of the past.

PUBLICATION

Pingali, Prabhu, Bhaskar Mittra, and Andaleeb Rahman. "The Bumpy Road from Food to Nutrition Security – Slow Evolution of India's Food Policy." *Global Food Security*, May 2017.

The Green Revolution was instrumental in producing adequate quantities of staple foods, such as rice and wheat, thereby increasing food availability and mitigating the specter of famine and hunger. However, it turned out to be detrimental for the production of other non-staple crops, which were less calorie dense but rich in micronutrients, and led to a less diversified production system.

Even when we look at the food assistance programs, there is a clear emphasis on the calorie content of food rather than nutritive value, diet diversity, and/or behavioral changes toward better nutrition. Agricultural policy has tried to ensure stable farm prices through the provision of assured minimum support prices (MSP) to incentivize farming, while poor consumers receive subsidized food through the Public Distribution System (PDS) to improve their welfare. This system has been centered on staple grains, thereby discouraging production, as well as consumption, of other nutritive food items. Political exigencies have also led to the entrenchment of staple grain-based food assistance programs, which potentially limit the scope for dietary diversity. With the National Food Security Act (NFSA) of 2013 in place, it is expected that the PDS will expand. While the NFSA has a provision for including other, more micronutrient-rich coarse cereals and protein-rich pulses, there is not much traction on that front, and staple grains continue to be the main focus of the program.

As an alternative, we argue for a life-cycle approach to nutrition to be at the center of key programmatic interventions, such as nutritional supplements for women during their adolescence, pregnancy and lactation, along with school feeding programs for early childhood nutrition. These provisions do exist in the NFSA, but there is hardly any political initiative in that direction.

We further recommend a "crop-neutral" agricultural policy, which does not incentivize one crop over another, but rather allows farmers to respond to market signals. This would lead to a more diversified production system, which not only benefits farmers through higher income, but also provides consumers with a wider array of product choice. Production of nutritious crops such as fruits and vegetables, livestock intensification, and aquaculture need to be promoted in order to achieve a more diversified food system and improved nutrition outcomes.

In-kind food assistance programs, which have been in place for a long time in India, suffer from serious issues of corruption and inefficiencies. These programs need to be designed better, and more pilot studies should be conducted to evaluate the various other forms of consumer subsidies, such as cash transfers or universal basic income. Adding pulses, millet, and biofortified crops in the PDS would also be a useful way to reduce micronutrient deficiency and improve the current system.

RESEARCH HIGHLIGHTS

TARINA

YEAR 2: GAINING GROUND IN THE FIGHT AGAINST INDIAN MALNUTRITION

Technical Assistance and Research for Indian Nutrition and Agriculture (TARINA) is a consortium that connects policy-focused research partners with impact-focused implementation partners to address the complex problem of malnutrition in India. Led by TCI, TARINA merges the evidence-generating capabilities of Cornell University, Emory University, the International Food Policy Research Institute (IFPRI), and the Tata Institute of Social Sciences (TISS) with the technical capabilities of leading nongovernmental organizations (NGOs) and development partners—BAIF Development Research Foundation, CARE India Solutions for Sustainable Development, Grameen Development Services (GDS), and Tata Trusts (Figure 10). Collectively, the consortium aims to promote a more diversified food system that enhances the availability and affordability of nutrient-rich foods for India's rural poor.

TARINA was founded in December 2015, with a US$13.4 million grant awarded to TCI from the Bill & Melinda Gates Foundation (BMGF). The grant is largely centered on agricultural pathways to improving nutrition outcomes using a food systems approach (Box 1 - see p. 44). Three main objectives and nine intermediate results underwrite the grant's overarching goal to create a more nutrition-sensitive food system in India. Together, these components comprise TARINA's Results Framework. This framework is depicted in Figure 11, which shows the link between each of the components and how they align with the grant's primary goal.

TARINA CONSORTIUM PARTNERS

BAIF DEVELOPMENT RESEARCH FOUNDATION
care
CORNELL UNIVERSITY FOUNDED A.D. 1865
EMORY UNIVERSITY
TCI TATA-CORNELL INSTITUTE
GDS
IFPRI
TATA TRUSTS
RE-IMAGINING FUTURES
TISS

Figure 10. TARINA Consortium Partners

Objective 1 of TARINA's Results Framework focuses on field-based implementation, specifically, on redesigning agricultural projects to ensure positive nutrition outcomes at scale. This is achieved through the integration of nutrition-focused objectives, actions, and metrics into agricultural projects implemented by NGOs and development partners in three Indian states—Bihar, Odisha, and Uttar Pradesh. District locations and lead implementation partners in each state are as follows:

LOCATIONS AND PARTNERS

STATE	DISTRICT(S)	PARTNER(S)
Bihar	Munger	BAIF
Odisha	Kalahandi and Kandhamal	CARE India
Uttar Pradesh	Maharajganj	GDS and Tata Trusts

Table 2. Locations and Implementation Partners

Objectives 2 and 3, in contrast to Objective 1, are more research oriented. Both of these objectives focus on evidence generation, advocacy, and capacity building for the design and implementation of nutrition-sensitive agricultural programs and policies. Research under these objectives is also used to inform field-based initiatives carried out under Objective 1. Each of TARINA's three objectives is realized through a set of intermediate results, which serve as the foundation for planning and focusing grant activities, as well as for monitoring and evaluating progress.

TARINA RESULTS FRAMEWORK

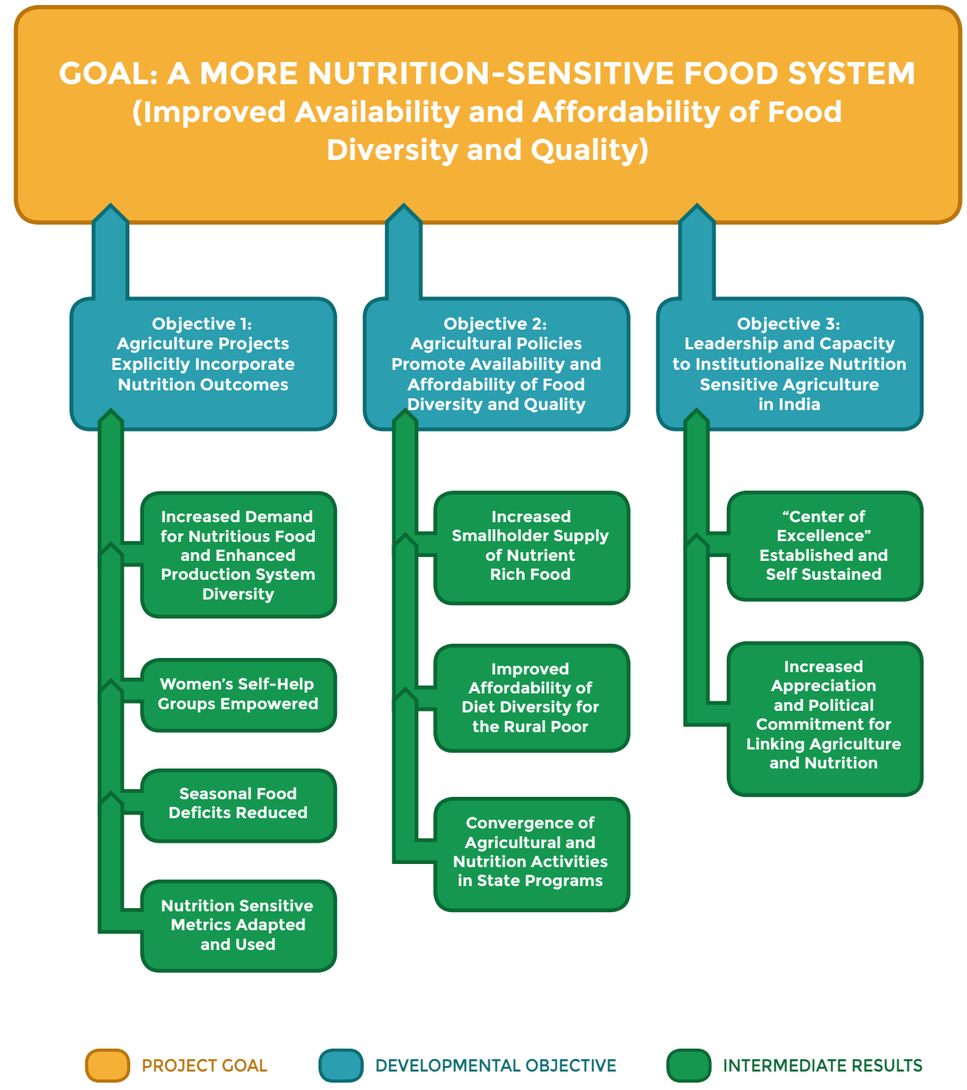


Figure 11. TARINA Results Framework

HOW TARINA TACKLES MALNUTRITION: A FOOD SYSTEMS APPROACH

India's agricultural policy has been slow to respond to persistent problems of malnutrition. Much of the country's rural population suffers from undernutrition and micronutrient deficiencies. Consequently, childhood stunting and wasting, as well as anemia in both women and children, persist at stubbornly high rates.

Over the past several decades, India's policy agenda has focused on improving staple grain productivity to meet national food security requirements and reduce hunger. While significant progress has been made toward this end, the food security challenge has evolved. It is no longer simply a matter of ensuring that sufficient calories are available, but rather an issue of enhancing food diversity and quality to address malnutrition in its many dimensions. Agricultural policies biased toward staple grains have limited ability to achieve positive nutrition outcomes in the context of the need for dietary diversity.

TARINA aims to redirect agricultural policy away from "staple grain fundamentalism" toward a much broader food systems focus, which considers the need to build better connections between agriculture and nutrition. More specifically, it emphasizes agricultural pathways to improving the rural poor's year-round access to affordable, diverse, and high-quality foods that are rich in micronutrients. A food system includes all individuals, enterprises, and institutions that influence the supply, demand, consumption, and absorption of food and micronutrients. The interconnected components of a food system are depicted in Figure 12. TARINA's food systems approach examines factors that influence both agriculture and nutrition within and between stages of the food supply chain, as well as among households, villages, districts, and beyond.

TARINA's food systems approach is twofold. It involves not only ground-level interventions at various stages of the food supply chain, but also policy reforms to support the diversification of agricultural production. Establishing a "crop-neutral" policy environment that ensures a level playing field for the production and marketing of nutritious non-staples, such as fresh fruits, legumes, and livestock products, is critical to creating a more robust and diversified food system.

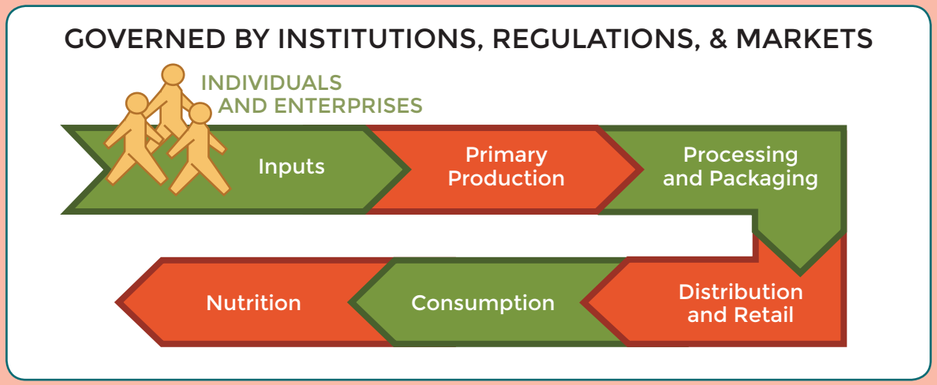


Figure 12. Interconnected Components of a Food System

Box 1. How TARINA Tackles Malnutrition: A Food Systems Approach

The second year of the four-year TARINA grant ended in November 2017. In Year 2, both implementation and research partners successfully broke ground on many of their initiatives planned in Year 1. Ongoing activities and progress achieved by TCI and consortium partners are summarized across key thematic areas of TARINA in the following sections.

THEMATIC AREAS: ONGOING ACTIVITIES AND PROGRESS ACHIEVED

Moving the Dial on Nutritional Status with Innovative Behavior Change Communication Tools and Methods

Implementation partners are working at the village level to increase consumption of nutritious food through behavior change communication (BCC). During the first year of TARINA, CARE's Gender Transformation Toolkit was identified as an effective and potentially scalable approach to empowering women through gender-based dialogue, awareness building, and behavioral change. It was agreed, therefore, that CARE would expand this toolkit to include nutrition BCC tools that aim to improve the diets of women and children. Thus far, CARE has completed five new tools (Figure 13) and is finalizing four more for integration into what is now called the Nutrition-Gender Toolkit (NGTK). In Year 2 of TARINA, these tools have been tested and implemented in 51 villages in Odisha. CARE has also trained BAIF and GDS staff on how to use these tools for BCC in their respective locations.

Meanwhile, in Year 1 of TARINA, BAIF and GDS launched nutrition BCC campaigns, which emphasize the importance of diverse diets and encourage households to improve their diets through the maintenance of kitchen gardens. BAIF's campaign also covers other critical topics related to nutrition, such as Water, Sanitation, and Hygiene (WASH) and Reproductive Child Health (RCH). Similarly, GDS' campaign promotes the cultivation and consumption of pulses. In Year 2 of TARINA, both BAIF and GDS have incorporated elements of CARE's NGTK into their existing BCC campaigns and have reached a total of 15 villages in Bihar and 15 villages in Uttar Pradesh, respectively.

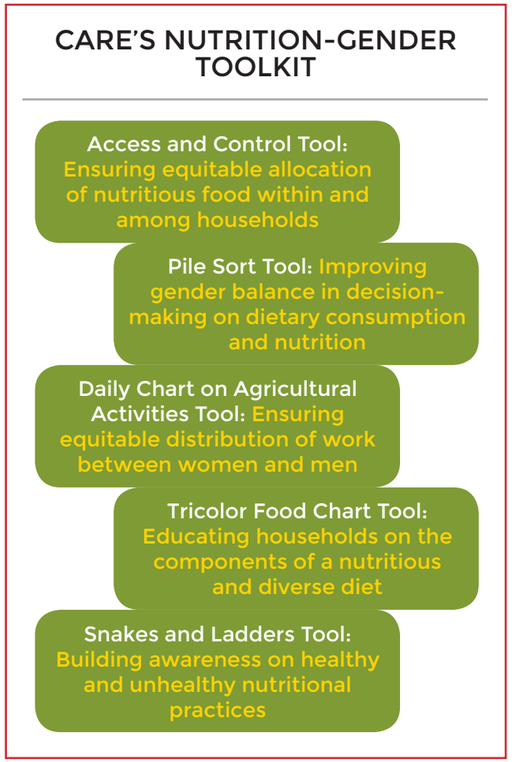


Figure 13. Five New Behavior Change Communication Tools in CARE's Nutrition-Gender Toolkit

Over the past two years, implementation partners have organized regular training sessions and workshops with Self-Help Groups (SHGs) and other women's interest groups, in which nutrition BCC tools are used to build awareness. Handouts and posters have also been used for general educational messaging about nutrition. Furthermore, partners have held mass events to broaden their reach and generate interest among a larger community. For example, GDS held a mass event called Poshan Mela, during which street plays were performed on the themes of kitchen gardens and cultivation of pulses.

Linking Sanitation and Nutrition: Changing Minds and Changing Behavior to Reduce Open Defecation

In Uttar Pradesh, TCI and GDS have joined forces to design and implement a targeted BCC campaign for reducing open defecation. Evidence suggests

that open defecation, which is practiced by one-third of India's population, can lead to diarrhea and other health conditions that limit the body's ability to absorb micronutrients in food. Hence, behavioral change initiatives must also consider sanitation practices to effectively improve an individual's nutritional status.

Despite many efforts by the Government of India (GOI), the problem of open defecation persists. It has been widely documented that the root cause is not a lack of toilets, but rather the unwillingness of people to change their behavior. Thus, social norms, habits, and sentiments need to be altered if open defecation is to be eliminated.

TCI is partnering with GDS to scale up its existing Community-Led Total Sanitation (CLTS) program, which has been extremely effective in reducing open defecation. In fact, many villages where it has been implemented are now considered open defecation free (ODF). The CLTS approach not only focuses on the construction of toilets, but also on bringing about behavioral change in the community to increase their use.

As the CLTS program is being scaled up, TCI is conducting a study to measure the contribution of the program's behavioral component toward the increased use of toilets. Tata–Cornell Scholar, Payal Seth, is spearheading TCI's efforts in this area, as part of her doctoral research. Over the past year, she has worked with GDS to initiate BCC and toilet construction in selected sample villages, following a baseline survey. Next year, she plans to complete a subsequent survey in the same sample villages, after fully implementing both components of the CLTS program.

Increasing Production and Consumption of Orange-Fleshed Sweet Potatoes to Address Micronutrient Deficiencies

In partnership with GDS, TCI is designing and implementing a targeted BCC campaign for increasing the adoption and consumption of orange-fleshed sweet potatoes (OFSP) in Uttar Pradesh. OFSP is rich in nutrients, namely vitamin A, which is essential during late pregnancy and lactation for a child's immunity, eyesight, and lung function. Due to its nutritious properties, OFSP is often considered a strategic crop for addressing vitamin A deficiency, particularly among women of reproductive age.

However, the crop is not traditionally grown in India, and therefore is neither widely nor commonly consumed. In fact, much of the population is unfamiliar with the crop. Lack of knowledge about OFSP, including how to cultivate and prepare it for consumption, can limit its adoption among households. In the first two years of TARINA, GDS has introduced OFSP by providing planting material and extension services to farmers. In addition, TCI and GDS are developing a BCC program that provides educational messaging about OFSP and its health benefits, particularly for women and children. Messages will be delivered via street plays and recipe trials. From February to May 2017, the BCC messages were designed and tested and are now being refined.

Once the BCC program for OFSP is finalized, TCI will conduct a study to assess its impact on consumption and nutrition, particularly for women and children. Tata–Cornell Scholar, Kathyrn Merckel, is leading TCI's study on nutrition BCC for OFSP and will complete this research as part of her doctoral studies in International Nutrition. She plans to implement the BCC program in selected sample villages and households that receive OFSP planting material and extension services from GDS in the coming year, following the completion of a baseline survey.

IFPRI has also undertaken research on sweet potato and has completed an analysis of existing sweet potato value chains in four selected districts of Odisha—Koraput, Kalahandi, Kandhamal, and Ganjam. The purpose was to better understand the role of sweet potato in increasing food security and income for poor farmers. The study assesses the price spread across various actors in the value chain. It also identifies factors constraining both the production and marketing of sweet potatoes. The analysis and findings have been summarized in a paper, entitled "Economic Analysis of Sweet Potato Farming and Marketing in Odisha," which was published in the Journal of Root Crops in December 2016.

PUBLICATION

Prakash, P., Avinash Kishore, Devesh Roy, and Debdutt Behura. "Economic Analysis of Sweet Potato Farming and Marketing in Odisha." *Journal of Root Crops* 42, no. 2 (December 2016): 163-67.

Diversifying Staple Grain Production Systems by Adding Vegetables and Legumes

Implementation partners are promoting the cultivation of vegetables, pulses, and other legumes to diversify staple grain production systems. Although methods used to achieve this objective vary across partners and locations, they all involve the provision of seeds and a recommended Package of Practices (PoP), which include input support, as well as training on relevant technologies and best practices for cultivation.

In Bihar, BAIF is working to diversify agricultural production through the integration of vegetables and pulses into existing cropping systems. Village meetings are held to recruit interested farmers. Participants must have a minimum of 0.25 acres of suitable land and consent to accepting a recommended PoP. Participants must also agree to use their production for household consumption. However, if a surplus is produced, then BAIF assists participants in marketing their surplus through a collective approach to increase their bargaining power.

In Year 1 of TARINA, BAIF promoted the cultivation of lentils and chickpeas during Rabi (winter) season. In Year 2, it introduced green gram as a Zaid (summer) crop and pigeon pea during Kharif (rainy) season. BAIF also initiated vegetable cultivation during Kharif season in Year 2 through the promotion of okra, cucumber, bitter gourd, ridge gourd, and bottle gourd.

Additionally, BAIF is introducing models for cultivating a mixed crop of maize and pulses (pigeon pea or lobia) under its Sustainable Multi-species Agricultural Resource-use Trials (SMART) project. SMART develops mixed, sequential cropping models for intensifying production on small, resource-constrained plots. Cropping models are designed and tested in consultation with farmers on their fields, which are used as demonstrations for dissemination to other farmers. Group action is a key component of SMART. Participants benefit from collective investment in irrigation, procurement of seed and other inputs in bulk, aggregation of produce for marketing, and group management of pests and diseases.

CARE is also working to increase adoption of vegetables and pulses in Odisha. This is achieved through the formation of large demonstration plots in each village, which are comprised of smaller contiguous plots contributed by interested farmers who are willing to participate. Farmer

Field School (FFS) sessions are conducted on the demonstration plots to educate farmers about best practices for cultivation and to attract other farmers in the community. Follow-up extension services

are provided to farmers who express interest in participating. Over the past two years, CARE has used this approach to introduce red and black gram during Kharif season, as well as OFSP. GDS is promoting pigeon pea, mustard, and a new variety of groundnut in its locations in Uttar Pradesh.

Through the combined efforts of BAIF, CARE, and GDS, a total of 5,077 farmers across all locations have diversified their staple grain production systems. In Year 2 of TARINA, 6% of farmers have diversified by adding vegetables (only), 64% by adding pulses (only), 30% by adding other legumes (including oilseeds), and less than 1% by adding both pulses and vegetables, as shown in Figure 14.

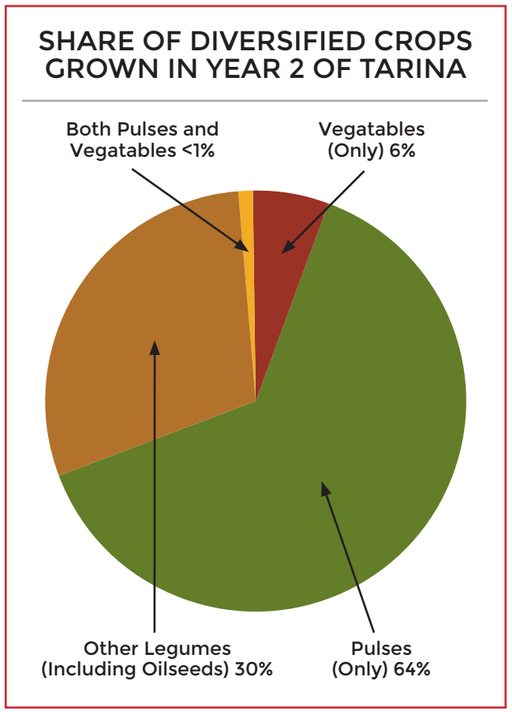


Figure 14. Share of Diversified Crops Grown in Year 2

Catalyzing Producer Supply Response to the Rising Demand for Pulses

TCI has placed pulses at the top of its research agenda, given their important role as a non-animal source of protein, fiber, amino acids, and vitamins for India's population, which is largely vegetarian. India is currently the largest producer, consumer, and importer of pulses in the world. However, pulse yields have stagnated, and the land under pulse production has decreased since the 1960s. At the same time, the demand for pulses continues to increase, due to rapid growth in population and per capita income. This has led to recurring shortages in domestic pulse production.

Tata–Cornell Postdoctoral Associate, Dr. Mathew Abraham, is leading TCI's research on pulses. He aims to better understand why producer response to the rising demand for pulses is so low and how markets can incentivize production. More specifically, he is examining existing aggregation models and private value chains to assess how they can potentially reduce high transaction costs, which result in poor price realization for producers. He is also examining the structure of international trade and import markets for pulses in India to determine their scope and limitations for increasing domestic supply. Dr. Abraham plans to synthesize his findings in various papers over the coming year. His research will be instrumental in devising policy recommendations and scalable initiatives to streamline marketing for pulses and to increase pulse production, thereby enhancing the diversity of food systems.

IFPRI is also contributing to the research on pulses and has undertaken three studies. The first study is an assessment of seed availability for pulses and an evaluation of the GOI's Pulse Seed Hubs Program in the four districts where TARINA is operating. The study aims to provide timely feedback to implementation partners, so that they can improve the efficacy of their field-based initiatives to promote pulse production. As part of this study, a national-level analysis of the pulse seed replacement rate was completed. In the coming year, IFPRI will conduct a survey to collect data on the certified seeds that the government has distributed to the Krishi Vigyan Kendra (KVK, i.e. government agricultural extension centers) within or near TARINA district locations. Scoping and design of the study is being done in consultation with the Indian Institute of Pulse Research (IIPR).

The second and third studies undertaken by IFPRI focus on the impact of the minimum support price (MSP) for pulses on producers and on the supply response of pulse production in India, respectively. Data collection and analysis for these studies are near completion, and IFPRI plans to publish both in the coming year. Preliminary results were shared with the GOI in 2016, as inputs for its report on "Incentivizing Pulses Production through Minimum Support Price and Related Policies." Furthermore, the main findings from both studies have been published in an article in Economic and Political Weekly entitled "Making Pulses Affordable Again: Policy Options from the Farm to Retail in India," on January 7, 2017, and in a policy brief released by TCI in May 2017.

PUBLICATIONS

Joshi, P. K., Avinash Kishore, and Devesh Roy. "Making Pulses Affordable Again: Policy Options from the Farm to Retail in India." *Economic and Political Weekly*, January 7, 2017, 37-44.

Kishore, Avinash, P. K. Joshi, and Devesh Roy. May 2017. "Making Pulses Affordable Again: Policy Options from the Farm to Retail in India." TCI-TARINA Policy Brief No. 8.

Promoting Livestock and Livestock Products to Enhance Food System Diversity

Implementation partners are promoting goat, poultry, and dairy production through the provision of animal health and management services. Partners provide training to livestock producers and producer groups on best practices for breeding, feeding, marketing, and reducing morbidity and mortality. They also provide paraveterinary services, including vaccination and deworming.

In Bihar, BAIF is supporting dairy production by encouraging farmers to cultivate nutritive green fodder. Participants must own at least one cow and 0.25 acres of cultivable land that can be allocated to fodder production without significantly affecting their regular food crop production. Fodder seed and a recommended PoP are provided to selected farmers, along with training and follow-up extension services. In Year 2 of TARINA, BAIF introduced green fodder into the production cycles of 600 farmers.

In addition to dairy, BAIF is promoting backyard poultry farming and goat rearing. In Year 2 of TARINA, it has introduced new breeds of exotic and egg-laying chickens in about 50 households. BAIF has also initiated breeding services for goats. Black Bengals were identified as the most suitable breed for the region, given their large number of offspring (two to three) per gestation. Pure Black Bengal bucks have been procured and provided to selected villages through Buck User Groups. In May 2017, a total of 15 pure bucks were distributed to seven villages for breeding.

In the coming year, BAIF plans to introduce artificial insemination (AI) for goats to eliminate the cost of buck maintenance and service fees for producers. A center for research on goat AI has been established in Pune. Systems for semen collection, freezing, and delivery to households are being developed, building on BAIF's experience with AI for dairy cattle.

CARE is promoting goat rearing, backyard poultry farming, and dairy production in Odisha. Training and support is provided to producers through FFS sessions held at the village level. In Year 2 of TARINA, a total of 60 FFS sessions were held for goats, 25 for poultry, and 30 for dairy.

In Uttar Pradesh, GDS is organizing health camps in villages to teach livestock producers how to improve their feeding and management practices. After the camps, deworming and vaccination services are provided to interested participants for a fee. These services are offered for cows, buffalo, bullocks, and goats.

Collectively, implementation partners have promoted livestock production in a total of 58 villages, across all locations. Goats have been promoted in 47 of these villages, poultry in 13, and dairy production in 55 (Figure 15). Partners have also dewormed and vaccinated 5,141 livestock and 3,797 livestock, respectively (includes cows and goats only).

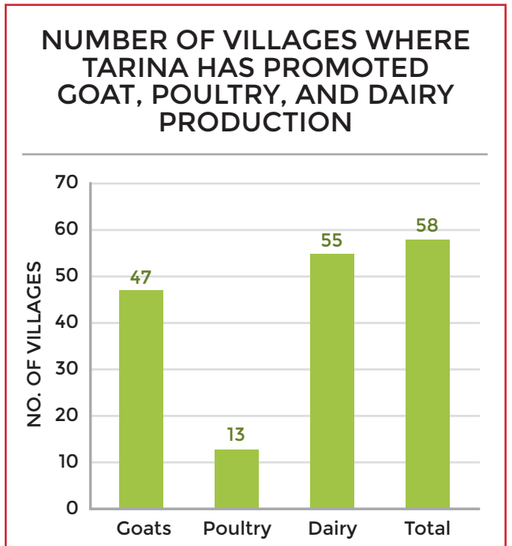


Figure 15. Number of Villages where TARINA Has Promoted Goat, Poultry, and Dairy Production

Intensifying Goat Production through Sustainable Feeding Systems

Goats are a vital source of food and financial security for the resource poor in India, particularly those living in marginal rural areas. Despite their importance, the goat sector is constrained by feed shortages because of limited fodder cultivation, insufficient crop residues, and dependence on common land resources that are becoming increasingly degraded in terms of their vegetative and soil quality. As human and livestock populations continue to grow and put pressure on common property, the availability and productivity of grazing lands are expected to decrease, resulting in fewer feed resources for goats and other animals.

TCI is exploring ways to address the scarcity of feed often faced by goat producers. Maureen Valentine, Tata–Cornell Scholar and PhD candidate in the field of Animal Science, is conducting an experimental study to assess the extent to which transitioning goat producers from extensive, open grazing to semi-intensive, stall-feeding can improve goat health and nutrition while reducing land degradation from grazing. Additionally, she aims to assess the factors that affect producer adoption of semi-intensive, stall-feeding in feed-scarce regions. Ms. Valentine carried out her study on tribal farms in the Kandhamal District of Odisha from May to December 2016, and is currently working to analyze the data collected. She plans to write up her findings and results in the coming year.

Strengthening Women's Leadership in Producer Groups and Access to Agricultural Services

Implementation partners are empowering women through the formation of new and revitalization of existing women's SHGs and interest groups. Given the important role that women play in agriculture and in determining household diets, women's groups are frequently used as platforms for increasing awareness, building capacity, and changing behavior to ensure positive nutrition outcomes. Hence, efforts to educate and mobilize women's groups are critical to the implementation and success of TARINA initiatives in all field locations.

Partners are training women's SHGs and interest groups to increase their understanding of nutrition-sensitive agriculture and practices. CARE and BAIF are also working with these groups to increase women's entrepreneurial skills and access to banks, credit, and working capital. Typically, partners select one individual from each group to be the leader who motivates and teaches others. Leaders are then trained to carry out BCC activities and to set an example for the group. In some cases, they are also taught to do record-keeping, develop business plans, and strengthen group cohesion.

In the first two years of TARINA, partners have mobilized 107 women's SHGs and interest groups across all locations. This includes 29 SHGs, 13 Water User Groups, and 7 Buck User Groups mobilized by BAIF, in addition to 20 SHGs and 38 SHGS mobilized by CARE and GDS, respectively.

Promoting Labor-Saving Technologies for Reducing Women's Drudgery

The purpose of this initiative is not only to reduce women's drudgery in agriculture, but also to reduce their time spent on agricultural activities. Long hours in the field mean that women have less time to spend on personal health and childcare. This trade-off can negatively impact the nutrition of women and their households. To address this challenge, implementation partners are scoping, piloting, and scaling up labor-saving technologies (LSTs) for women in each of their respective locations.

BAIF is engaging with various groups and institutions, such as the International Agricultural Research Institute, the KVK, SHGs, and private companies, for assistance in identifying LSTs that are most suitable for the region and for women. It is also establishing Custom Hiring Centers (CHCs) managed by women's SHGs to handle the maintenance and rental of technologies. In Year 2 of TARINA, BAIF has tested automatic and manual paddy transplanters during Kharif season, with technical support from the DHAN Foundation. It has also started to identify SHGs that are both interested in and capable of managing CHCs. BAIF plans to carry out more demonstrations during the next paddy season and assess the utilization of these technologies.

CARE is developing the overall value chain for LSTs in Odisha by building the capacities of local fabricators, SHGs, and female farmers to customize, use, repair, and maintain LSTs for women. It is identifying suitable LSTs and fabricators to customize these technologies for women. So far, CARE has purchased and tested six LSTs—seed treatment drum, power sprayer, Naveen seed dibbler, sapling transplanter, solar-powered nano pump, and drip irrigation.

In Year 2 of TARINA, CARE has conducted five demonstrations with the seed treatment drum, two with the power sprayer, eight with the Naveen seed dibbler, and two with the sapling transplanter. In addition, it has designed three training modules on low-cost LSTs that are being delivered to female farmers through FFS sessions and have integrated messaging on LSTs into BCC tools developed for its NGTK. A study on LSTs involving various stakeholders is also underway. Potential technologies have been identified, and their suitability is being evaluated against field level requirements.

CARE has also introduced a new gravity-based, micro-irrigation system on collective kitchen gardens in Odisha, which are typically managed by three to four female farmers. Since results have been positive, CARE is generating evidence to promote this technology for integration into existing government schemes.

GDS is promoting direct seeding of rice (DSR) to reduce women's drudgery and time spent on sowing. Drum seeder and zero till machines were introduced in Year 1 of TARINA. Several demonstrations were conducted, and 65 female farmers used the technologies to cultivate paddies. In Year 2, GDS has reached 307 female farmers. Of this total, 298 female farmers are new participants, using the technologies for the first time.

Expanding Homestead Horticulture to Prevent Seasonal Food Deficits

Many Indian farmers cultivate vegetables and other nutrient-rich crops to sell at the market and use a portion of their production for home consumption, but this supply is only available seasonally. Implementation partners are working to bridge the seasonal gap in the supply of micronutrients by promoting household kitchen gardens for growing fruits and vegetables year-round. Having a continuous supply of fresh and nutritious foods available nearby allows households to easily integrate them into their daily diets.

Village and community group meetings are held by partners to recruit households interested in establishing kitchen gardens. Selected participants are then given seeds with a recommended PoP. Field demonstrations are conducted and training on the PoP is provided, along with follow-up extension services. Partners also provide support for fencing to protect gardens from livestock, since open grazing is common in most villages. Through the combined efforts of BAIF, CARE, and GDS, a total of 1,581 households have established kitchen gardens across all locations.

In addition to kitchen gardens, BAIF is promoting year-round cultivation of nutritious foods by intensifying production under its existing WADI project. WADI is a cropping model for tree-based farming that combines several high-value, nutritious, and perennial fruit crops. Selected beneficiaries of the project are given seeds and saplings with a recommended PoP, along with other essential inputs, training, and follow-up extension support. In Year 2 of TARINA, BAIF provided 161 WADI farmers with 13 types of seeds and saplings—papaya, banana, mango, jackfruit, guava, lemon, drumstick, ber, bael, custard apple, aonla, turmeric, and elephant foot yam.

Reducing Postharvest Losses through Improved Practices and Storage Technologies

Postharvest losses can occur within and between stages of crop value chains, from harvest to processing and final consumption. However, a large portion of losses tend to occur during the period between harvest seasons, when seeds are stored for planting in subsequent seasons or when crops are stored for future consumption or sale in the market. This is largely due to a lack of adequate and affordable storage technologies available to farmers. Poor storage facilities can compromise the safety and quality of crops, as well as reduce the productivity of seeds, resulting in health risks and/or economic loss for households.

Implementation partners are addressing this constraint by training farmers on postharvest loss management (PHLM), as well as scoping, piloting, and scaling up improved storage technologies across all locations. In Year 2 of TARINA, BAIF has trained several SHGs on best practices for cleaning, sun-drying, and storing pulse grains. It has also provided 20-piece grain storage drums to SHGs in two villages.

Meanwhile, CARE has designed three training modules on PHLM that are being delivered to farmers through FFS sessions and have integrated messaging on PHLM into BCC tools developed for its NGTK. Additionally, it has piloted hermetic bags for storing grain seed. A total of 15 bags have been distributed to ensure seed quality is preserved for the next season.

Similarly, GDS has piloted superbags to retain seed quality and increase the life of stored grains, mainly for wheat and pulse grains. Superbags have been distributed to 19 households in three villages.

In the coming year, implementation partners plan to identify and pilot storage technologies that are geared more toward perishables. They also plan to scale up storage technologies introduced in Year 2 of TARINA, depending on results achieved during the pilot phase.

Compiling Better Data on Mycotoxin Incidence and Identifying Control Options

TCI has embarked on an intensive research effort to assess the extent of and contributors to mycotoxin contamination in village food systems in India. To date, there has been little effort in the Indian context to profile factors associated with mycotoxin risk at the community level. Anthony Wenndt, Tata–Cornell Scholar and PhD candidate in the field of Plant Pathology and Plant Microbe Biology, has taken on the challenge of addressing this information gap. Through his research, he aims to establish a scalable protocol for food system-wide surveillance of mycotoxin risks, identify tractable mitigation strategies for addressing contributors to mycotoxin risk, and empirically demonstrate the efficacy and scalability of a community-driven model for mycotoxin intervention via experimental trials in selected locations.

In 2016, Mr. Wenndt conducted a survey of aflatoxin and fumonisin contamination in key staple food commodities in nine spatially and socioculturally distinct villages across four Indian States—Uttar Pradesh, Bihar, Odisha, and Telangana. The survey integrated lab results on mycotoxin contamination in household- and market-derived food commodities with data on food management practices and other behavioral risk factors obtained via questionnaire-guided interviews. The survey also included focus group discussions and participatory community resource mapping to elucidate the spatial distribution of food safety risks across villages. It yielded 811 samples of toxin-susceptible food commodities, and established a baseline data set of risk factors that will guide further investigation. Based on findings from this survey, preliminary policy recommendations for promoting safe village food systems have been developed and are highlighted in a policy brief, entitled "Addressing Mycotoxin Exposure across Village Food Systems in Rural India," which was published by TCI in October 2017. Subsequent survey activities are planned to collect longitudinal data that will allow for an analysis of spatiotemporal trends in mycotoxin contamination.

PUBLICATION

Wenndt, Anthony. October 2017. "Addressing Mycotoxin Exposure across Village Food Systems in Rural India." TCI-TARINA Policy Brief No. 10.

In September 2017, Mr. Wenndt initiated a year-long experiment that focuses on reducing mycotoxins in the household grain storage environment. Guided by the hypothesis that promoting proper postharvest storage practices can lead to a reduction in the overall food toxin burden, he aims to demonstrate the effects of a community-based, participatory storage intervention trial on the status of mycotoxin risk indicators. The study is being implemented in the Unnao District of Uttar Pradesh, with logistical support from GDS.

Evaluating and Informing Agri-Marketing Policies to Incentivize Year-Round Production of Nutritious, Non-Staple Foods

IFPRI is conducting a study on the repeal of the Agricultural Produce Market Committee (APMC) Act in Bihar and its impact on farm-gate prices, consumers, and food commodity markets. The APMC Act was passed by the GOI in 1960 to protect smallholder farmers from exploitation by traders and moneylenders. However, research suggests the act had the reverse effect, as it enabled traders to form cartels while prohibiting

farmers from directly doing business with private companies. This limited farmers' options on where and to whom they could sell their produce. It also discouraged private investment in commodity markets and contract farming. To address these challenges, the State Government of Bihar completely abolished the APMC Act in 2006, expecting that deregulation would attract private investment in agri-markets and create more options for farmers, thereby improving prices for both producers and consumers.

IFPRI has completed an assessment of the immediate effects of the APMC Act repeal in Bihar and is currently examining the long-term effects of this reform on all market players, including farmers. Based on initial findings from this study, IFPRI prepared a report entitled "Ease of Doing Agribusiness in Indian States." The report was presented to the National Institute for Transforming India (also referred to as NITI Aayog), which used the key findings to devise and support evidence-based agri-marketing reforms throughout India.

Exploring Feasible Options for Diversifying the Basket of Foods Included in India's Public Distribution System

India's Public Distribution System (PDS) is the world's largest food-based social safety net program. Under the PDS, the GOI procures staple grains (mainly, wheat and rice) and redistributes them to poor households in the form of food rations. In recent years, expansion of the PDS food basket to include more nutritious non-staples, as a means of increasing the production of these foods and diversifying the diets of low-income households, has been widely debated. Pulses have been at the center of this debate, and the government has been exploring their potential for inclusion in the PDS basket.

In light of this trend, IFPRI completed a demand assessment of the PDS, which focused on the three states where TARINA is operating—Bihar, Odisha, and Uttar Pradesh. The aim was to better understand communities' needs and preferences with respect to the PDS food basket. Findings indicate that needs and preferences vary significantly across states and socioeconomic groups. For instance, households in Odisha generally do not want to trade subsidized rice for subsidized pulses, while the opposite is true for a large share of households in Bihar and Uttar Pradesh. Moreover, findings highlight how the PDS could be more effective and sustainable if it is better aligned with the preferences of the intended beneficiaries.

Based on this research, IFPRI has published two op-eds in leading Indian newspapers. The first one, entitled "Policies Based on Demonstration Effect Could Have Suboptimal Outcomes," was published in the Financial Express on August 8, 2017. The second one, entitled "Canteens vs. PDS: The Jury is Still Out on Food Subsidy," was published in the Hindustan Times on August 20, 2017. IFPRI is also working on several reports and a policy brief to outline the main messages and recommendations for policymakers.

PUBLICATIONS

Pradhan, Mamata, Devesh Roy, Avinash Kishore, and Vinay Sonkar. "Policies Based on Demonstration Effect Could Have Suboptimal Outcomes." *Financial Express*, August 8, 2017.

Pradhan, Mamata, and Devesh Roy. "Canteens vs PDS: The Jury is Still Out on food subsidy." *Hindustan Times*, August 20, 2017.

Developing, Adapting, and Using Nutrition Metrics for Food Systems-Level Monitoring and Evaluation

TCI is spearheading the monitoring and evaluation (M&E) component of TARINA. As part of this effort, we are developing overall food systems metrics, which are currently lacking from the body of literature available on metrics for food-, agriculture-, and nutrition-related projects and programs. Much of our work on metrics contributes to bridging this knowledge gap.

From April to September 2017, TCI has implemented a baseline survey across all locations, which was designed with a nutrition lens and included metrics on various aspects of local food systems to assess overall changes in TARINA outcomes during the project period. The survey consisted of three components: a household-level survey, a village-level survey, and measurement of anthropometric outcomes for women and children. Data was collected in 30 (15 control and 15 treatment) villages within each of the 4 districts where TARINA is operating. The village-level component included market-level metrics related to the supply of nutritious foods in the community, such as indicators of market diversity, market access, and seasonal availability. Partners have also undertaken baseline surveys that focus on specific TARINA interventions in their respective locations. Follow-up surveys at the project level and at the intervention level will be conducted in Year 4 of the project. The final panel data set will be used to assess the impact of field-based interventions and the extent to which project objectives are achieved.

In addition, TCI has published two training manuals that focus on how to adapt and implement nutrition metrics and indices within the Indian context. The first manual, entitled Guidelines for Incorporating Dietary Diversity Metrics in Agriculture–Nutrition Surveys, discusses key dietary diversity metrics that are commonly used and how they can be modified for incorporation into a larger household survey in India. The second manual, entitled Guidelines for Assessing Women's Empowerment in Agriculture, discusses how the Women's Empowerment in Agriculture Index (WEAI) can be operationalized in field research, drawing from TCI's experience of adapting and implementing the WEAI via a survey in Maharashtra, India, in 2013–14. This was the first time that the WEAI was used in the Indian context.

PUBLICATIONS

Gupta, Soumya. June 2016. "Guidelines for Incorporating Dietary Diversity Metrics in Agriculture-Nutrition Surveys: Operational Manual for Using Dietary Diversity Indicators in Field Research." TCI-TARINA Training Manual No. 1.

Gupta, Soumya. September 2016. "Guidelines for Assessing Women's Empowerment in Agriculture: Operational Manual for Using the Women's Empowerment in Agriculture Index (WEAI) in Field Research." TCI-TARINA Training Manual No. 2.

Building Capacity and Increasing Political Commitment for Institutionalizing Nutrition-Sensitive Agriculture in India

TCI is actively engaging with the government and other stakeholders to increase awareness and political commitment for linking agriculture and nutrition in India. In collaboration with partners, TCI has held several national- and state-level fora to disseminate evidence and facilitate dialogue on strategic policy issues related to nutrition-sensitive agriculture.

TCI has also held seminars and workshops to strengthen the capacity of institutions to design and implement agricultural projects and programs that ensure positive nutrition outcomes. Events held in Year 2 of TARINA include the following:

Agricultural Economics Research Association 24th Annual Conference: Special Session on Engendering Food Systems for Improved Nutrition • December 16, 2016

TCI and IFPRI jointly organized a special session at the Agricultural Economics Research Association's 24th Annual Conference to discuss linkages between gender, agriculture, and nutrition. The session focused on crop diversification and technological choices for engendering agriculture, as well as behavior change among women for improved nutrition. Panelists included female academics from various national and international research institutes.

India's National Food Security Act and Beyond: Challenges and Opportunities • February 3, 2017

TCI and the Indian Institute of Food Security (IFS) jointly organized a seminar to initiate dialogue on expanding the National Food Security Act's mandate to enhance the availability and affordability of nutrient-rich foods for the poor. Discussions focused on the diversification of agricultural production across India, the diversification of crops included in the PDS, and reforms in agri-marketing. Participants included senior officials from the GOI, academia, donor agencies, and civil society organizations.

Monitoring and Evaluation Systems for Organizational Effectiveness: Why Organizations Should Care and Strategies for Engagement • February 24, 2017

TCI and TISS co-hosted an M&E strategy workshop for senior and mid-level managers of various organizations interested in advancing data-based solutions for development effectiveness. The workshop emphasized the importance of establishing M&E systems for measuring performance, informing decisions, and showcasing results. It also covered the essential components of well-designed M&E systems and the latest technical innovations in evaluation that can improve the efficiency, accuracy, and utility of results.

Toward a Diversified Food System: Emerging Opportunities in Odisha • July 19, 2017

TCI, in partnership with CARE India and the Xavier School of Rural Management, held its first state-level policy forum in Odisha. Deliberations focused on factors that constrain diversification of agricultural production and consumption in the context of local food systems and ways to address these challenges. Recommendations emerging from this event will inform TARINA's ongoing policy advocacy in Odisha.

Redesigning Food Policy for Nutrition Security: Emerging Contours • July 25, 2017

TCI, TISS, and the National Institute of Agricultural Economics and Policy Research (NIAP) co-organized a lecture by Dr. Prabhu Pingali, Director of TCI, based on his publication "The Bumpy Road from Food to Nutrition Security – Slow Evolution of India's Food Policy." This was followed by a detailed discussion on ways to create and promote a crop-neutral policy environment in India. Panelists included Mr. Amaresh Kumar, Director of the IFS, and Dr. Pratap S. Birthal, National Professor at NIAP.

PUBLICATION

Lee, Jenny and Megan Witwer. October 2017. "Crop-neutral Agricultural Policy: Creating a Level Playing Field for More Nutritious, Non-staple Foods in India." TCI-TARINA Policy Brief No. 9.

Green Revolution in Eastern India: Constraints, Opportunities, and the Way Forward • October 9–10, 2017

In collaboration with IFPRI and the Indian Council of Agricultural Research, TCI held a two-day workshop that brought together researchers, policymakers, and practitioners to discuss the constraints and opportunities for promoting a Green Revolution in Eastern India. Deliberations focused on a wide range of interrelated issues, such as production system constraints, technology adoption, climate change and resilience, institutions and their effectiveness, the role of Farmer Producer Organizations (FPOs), agricultural markets and agribusiness, food security, gender and efficiency, and policy reforms. The workshop resulted in a set of clear priorities and strategies for achieving accelerated and sustainable agricultural growth in Eastern India.

LOOKING AHEAD

TCI and consortium partners have made significant progress toward the grant's overall goal and three main objectives (Figure 11 - see p. 43) in Year 2 of TARINA. Field-based interventions and activities implemented by partners will continue into Year 3 of the grant. Additionally, data collected through baseline surveys completed in Year 2 will shed light on various aspects of the local food system in each location. This information will enable partners to strengthen and refine their interventions before scaling up in subsequent years.

Furthermore, many ongoing research studies will be completed in the coming two years. Findings from these studies will help support the efforts of consortium partners, as well as inform the design and implementation of nutrition-sensitive agricultural projects, programs, and policies. TCI and other research partners will translate the findings into concrete policy recommendations and action. Thus, we plan to continue generating policy briefs and initiating dialogue around strategic policy issues, by engaging with the government and other stakeholders at the state and national levels, through various policy fora, seminars, and workshops in the coming year.

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Dr. Andaleeb Rahman, Postdoctoral Associate. Research: Public distribution system.

Dr. Srilakshmi Raj, Research Associate. Research: Genetic and environmental factors contributing to the triple burden of malnutrition.

Dr. Shubh Swain, Gender and Nutrition Specialist & Project Coordinator, TARINA. Research: Empowering women for better nutritional outcomes.

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Ms. Jenny Yoori Lee, M.P.S., candidate, International Agriculture and Rural Development. Research: Crop-neutral agriculture policies; nutrition-sensitive agricultural research & extension in India.

Ms. Tanisha Mohapatra, B.A., candidate, Economics and Government. Research: The challenges of sustaining successful community-led total sanitation.

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ENDNOTES

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