TATA-CORNELL INITIATIVE 2015 ANNUAL REPORT

TATA-CORNELL AGRICULTURE AND NUTRITION INITIATIVE (TCi)

College of Agriculture and Life Sciences
Cornell University

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FROM THE DIRECTOR

The Tata-Cornell Agriculture and Nutrition Initiative (TCi) was established to help us understand why India is such an outlier on maternal and child malnutrition, and to identify technological and policy options for redressing this multidimensional problem. To this end, TCi encourages cross-sectoral collaboration that promotes field-based research focused on identifying and implementing sustainable solutions. I am delighted with the progress we have made over the past three years and excited about the prospects for the future.

The TCi research team at Cornell now has ten Ph.D. students, a multi-disciplinary group whose expertise ranges from soil science to social science. Our students are supervised by an equally diverse team of distinguished Faculty Fellows. Soumya Gupta, the first Ph.D. to graduate through the TCi program, showed effectively that real-life problems are amenable to rigorous, action-oriented applied research. We also completed the second year of our summer internship program. Nine interns spent six weeks to two months collaborating with our partners in India on high-impact projects. ICRISAT, a CGIAR center based in Hyderabad, has been a particularly valuable partner of and host to our summer interns.

Our first action–research pilot project, in which we installed piped clean drinking water systems using AguaClara technologies in four villages in the state of Jharkhand, was completed this year. We are currently examining opportunities for scaling up the AguaClara work in other locations in Jharkhand and other states in India. In January 2016, we will initiate a new project in southern Gujarat that promotes market-based mechanisms for micronutrient fortification of wheat flour.

Over the past three years, TCi has benefited from strong collaborations with several partners based in India, including NGOs such as BAIF, PRADAN, and Digital Green; academic institutions such as the Tata Institute of Social Sciences (TISS) and the Mahatma Gandhi Institute of Medical Sciences; and CGIAR centers such as IFPRI and ICRISAT. We expect the range and depth of our partnerships to grow as we expand our presence in India.

In November this year, TCi was awarded a US$13.4 million grant by the Bill & Melinda Gates Foundation to spearhead a consortium for the purpose of providing "Technical Assistance and Research for Indian Agriculture and Nutrition (TARINA)." TCi looks forward to working with the TARINA consortium to amplify the nutrition impact of agriculture in India. The TARINA grant will also allow TCi to expand its work to the states of Bihar, Odisha, and eastern Uttar Pradesh.

I hope you enjoy reading our 2015 annual report.

Prabhu Pingali, Director

FROM THE ASSOCIATE DIRECTOR

It has been a very exciting, and action-packed year for the TCi and I take great pleasure in updating you on what we have achieved. As you have no doubt gathered from Dr. Pingali's letter, we made considerable progress this year towards consolidating our work on projects and research that we targeted as priorities.

The installation of the AguaClara systems in four villages in Jharkhand, including a stacked rapid sand filter and a chemical doser in two villages and a chemical doser in another two villages, is a significant achievement. We trained members of the community to manage these systems on their own. A quick assessment run by our students during the summer indicated promising outcomes.

This year we organized our annual food security training program for students of the TISS Hyderabad campus at ICRISAT. Twenty-eight very bright students from the bachelor's and master's programs attended. We look forward to organizing more such training opportunities, eventually developing fee-based programs available to anyone who would like to benefit.

Soumya Gupta and Tanvi Rao were our first Ph.D. students to complete their year-long fieldwork in India in 2014-2015. Soumya has since earned her degree, while Tanvi is well on her way to completion. Over the past year, five of our Ph.D. students conducted their summer exploratory fieldwork in India and are now preparing to spend a full year in India collecting data.

As suggested by the advisory board, the TCi is making great strides toward expanding its funding base. As the associate director of TCi, I devote much time to managing our partnerships. From our India-based offices, TCi staff oversee the flour fortification project that works with the BAIF Development Research Foundation, Maharaja Sayajirao University, Sight and Life, and the Tata Trusts to implement the project in several villages in Gujarat. I am also involved in coordinating the launch of the TARINA project born from the support of the Gates Foundation, which in addition to extending our footprint into several states, will also include a Center of Excellence that we are setting up in Delhi.

We at the TCi have been able to build a smart portfolio of activities and projects under the very able leadership of Dr. Pingali, our founding director. We look forward to taking on new challenges as we consolidate our past work. I eagerly look forward to another year of fruitful partnerships, impactful projects, and critical knowledge enrichment.

Dr. Bhaskar Mittra, Associate Director

OVERVIEW

OVERVIEW

The Tata-Cornell Agriculture and Nutrition Initiative (TCi) is a long-term research initiative launched in 2013 with a generous gift from the Tata Trusts. TCi brings together students, visiting scholars and research professionals from fields spanning several disciplines—nutrition, economics, engineering, human ecology, horticulture and resource management—to develop innovative technological and policy solutions capable of improving human health and nutrition in India.

Pathways Linking Agriculture to Nutrition

We believe the road to better health lies at the intersection of several pathways linking agriculture and nutrition. We have identified and oriented our applied research along four such pathways:

1. The **income pathway**, where gains in household income can translate to better food affordability and other impacts
2. The **food supply 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
4. Nutrient absorption through improvements in the **health environment pathway**, which links access to clean water and improved sanitation/hygiene practices to better nutritional health

TCi research in India considers the factors that influence both a household's ability to afford and obtain food—such as relative income and employment activities—as well as the challenges posed to individuals within the household who may not receive the same quality or quantity of food as others, may require alternative foods and care at various life stages (such as pregnancy and infancy), or face conditions that make absorbing and metabolically utilizing nutrients more difficult.

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 income as well as their ability to influence the quality, quantity, and diversity of the overall food supply. However, improvements along some pathways can create ripple effects along others. Enhanced income-earning opportunities for women through investment in agricultural technologies, for example, could promote women as decision-makers within households and lead to more equal access to household resources—including better quality or quantities of food. Similarly, public investments in clean water access can encourage or enable rural communities to comply with food quality and safety regulations that otherwise act as barriers to entering higher-value markets.

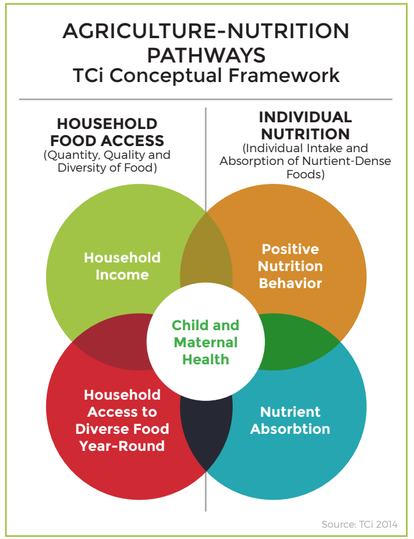


Figure 1: TCi Conceptual Framework

Nutrition is multidimensional and capable of promoting and affecting multiple facets of life, and development across these areas must occur simultaneously. Focusing on agriculture is only one critical dimension of the policy puzzle that must be solved to improve nutrition. Other mediating factors influence household income, micronutrient availability, nutrient absorption and utilization, and household food allocation.

Preview of the 2015 report

While it is well understood that positive maternal and child nutrition outcomes can be achieved through multiple pathways, the sectoral nature of academic research and data limitations have prevented us from being able to identify the relative importance of each of the pathways and the inter-linkages between them. TCi research on the determinants of malnutrition has been able to quantify the relative importance of each of the pathways and the relative returns on investments in each of them for achieving positive nutrition outcomes. This year's report also presents empirical evidence pertaining to the relationship between gender empowerment and the nutritional status of rural women in Southern Maharashtra.

The TCi has been making significant progress in developing and promoting improved nutrition data and metrics. In collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), we have been piloting and testing modules for rapid assessment of diet diversity at the individual and market levels. This work advances our quest for a minimum set of nutrition metrics that could be incorporated into agricultural surveys (such as the Minimum Nutrition Dataset for Agriculture—MNDA). We also report here country-level metrics for assessing the sufficiency of macro- and micronutrients in the Indian food system. Spatial mapping of district-level data on shifts in farming systems has been completed and the maps are now available on our web site. These maps provide

clear and accessible visual representation of long-term changes in the availability of nutrition-rich foods across India.

The TCi takes the link between clean drinking and nutrition and health very seriously; hence, with our very first investment we brought AguaClara technology and expertise to India. In Jharkhand, the AguaClara pilot plants have been set up and tested in four villages. These systems are now operational and pipe clean drinking water to individual houses in the villages. An evaluation of the program villages, which compared their experience with that of control villages, showed a significant drop in water-borne diseases, dramatic time savings for women, and an early indication of increased women's empowerment. We are now exploring opportunities to scale up the AguaClara technologies in Jharkhand and elsewhere. Plans are also underway for further detailed evaluation of the pilot villages to gauge the impact of the technology on nutrition and health.

TCi review and synthesis of existing agricultural policies finds that the historic focus on staple grain productivity and supplies has inadvertently resulted in an undervaluation of food system diversity, especially in terms of access to fresh fruit, vegetables and livestock products. It has also crowded out nutrient-rich millets and pulses in favor of staple grains. Our work calls for a food and agricultural policy that promotes a more balanced food system at the national and local levels. The TCi's statistical crop modeling work is helping quantify climate change risks for the major food crops in India. We will be exploring policies for mitigating climate risks for the food system over the next year.

The 2015 report also provides briefs on numerous other projects carried out by TCi scholars and fellows and a preview of work that will be initiated in 2016.

2015 RESEARCH HIGHLIGHTS

UNDERSTANDING THE MULTIDIMENSIONAL NATURE OF THE MALNUTRITION PROBLEM IN INDIA

Over the past fifty years India has witnessed extraordinary progress in overall agricultural and economic growth, as well as a significant decline in the incidence of hunger. Despite these gains, micronutrient malnutrition ("hidden hunger") persists and is manifested in terms of stubbornly high levels of stunting, underweight, and wasting among both children and adults. Despite having become one of the world's fastest growing economies, India is home to one-third of the world's chronically undernourished (i.e. stunted) children. This unique dichotomy has been an enigma for academics and policymakers since at least the mid-1990's and many have advanced explanations for this puzzle.

The existing malnutrition literature in India, while it illuminates individual factors that determine malnutrition, is ill-poised to provide policymakers with a sense of how the pathways we have identified relate to each other and which have the strongest empirical support for their effectiveness in addressing malnutrition in the country.

To address this critical impediment to translating research into policy-driven action, the TCi brought together several strands of research on malnutrition in India through a comprehensive review and meta-analysis of the existing literature. By focusing exclusively on comparable anthropometric outcomes across studies, we can throw light on the relative strengths of various nutrition determinants that explain improvements in child or adult malnutrition metrics in terms of prevalence rates or z-scores. We organized the existing evidence by mapping the effect-sizes of all the studies we reviewed to one of our four interlocking pathways (shown in Figure 2) that are generally considered to improve child and adult nutrition[1]. To further assist readers in understanding how these effects can be compared with each other, we further organized the studies into three groups—low, medium, and high—based on the extent to which they control for confounders in arriving at their estimates.

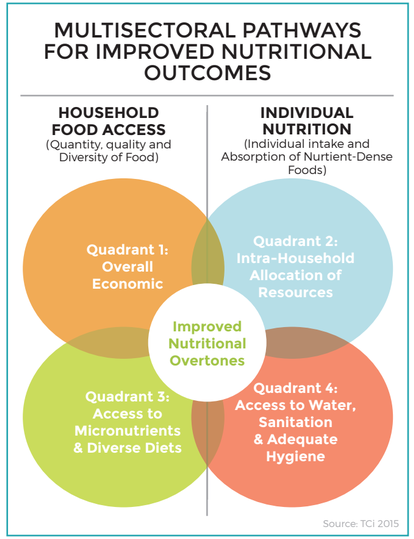


Figure 2

By comparing evidence across quadrants, our analysis establishes many important findings. For instance, we highlight recent research that shows that extending daily supplementation under India's Integrated Child Development Scheme (ICDS) for young children (under 2 years of age) can be among the most effective strategies for combating stunting.[2] This challenges conventional wisdom (based on older data and a coarser outcome measure) that the program is ineffective and wasteful. Currently, very few children in this age group receive daily supplementation and extending the program along this dimension could improve nutrition outcomes.

PUBLICATION ALERT

Pingali, P; Ricketts, K.; and Sahn, D. (2015). Agricultural Pathways to Improved Nutrition: Getting Policies Right (Chapter 7). In D. Sahn (Ed.), *The Fight Against Hunger and Malnutrition: The Role of Food, Agriculture, and Targeted Policies.* Oxford, UK: Oxford University Press.

We also note that studies which measure sanitation by the extent of open defecation find that this practice correlates strongly with poor nutrition outcomes,[3] but at the same time randomized control trials of toilet construction programs have failed to find a comparable effect in the opposite direction.[4] Undoubtedly, this dichotomy is due to low usage of constructed toilets and warrants policy attention on behavior change regarding the use of toilets.

We also highlight the exceptional importance of sibling birth-order effects and the intra-household rank of women as causal pathways in explaining undernutrition.[5,6] While these cultural impediments are less amenable to policy intervention in the short term, they are critical and need to be simultaneously addressed in the long term.

The impending release of India's fourth round of data from the National Family Health Survey (NFHS-4) promises to end a drought of anthropometric data in India, the last of which were collected a decade ago in 2005. Therefore, with this review, we not only hope to draw the attention of policymakers to "low-hanging fruit" in combating the malnutrition crisis but we also will set the stage for further research with up-to-date anthropometric data that are relevant to the new and changed nutritional environment in India.

2015 RESEARCH HIGHLIGHTS

WOMEN'S EMPOWERMENT IN AGRICULTURE, DIETARY DIVERSITY AND IRON OUTCOMES

Very little research has systematically examined the connection between farming systems and the empowerment of women. The Women's Empowerment in Agriculture Index (WEAI), developed by the International Food Policy Research Institute (IFPRI), the Oxford Poverty and Human Development Initiative (OPHI), and the United States Agency for International Development (USAID), takes a first step in analyzing women's empowerment in a multidimensional agriculture-specific framework (see Figure 3). And while women's empowerment influences choices made in agriculture per se, it can also influence nutritional outcomes. Iron deficiency in particular is the most prevalent micronutrient deficiency in the world and a serious public health concern in India.

In this context TCi Scholar Soumya Gupta led our research focused on women's empowerment in agriculture, dietary diversity, and iron outcomes (iron intakes and iron status) in three farming systems of the Chandrapur district in Maharashtra, India. The focus demographic of this research was women (non-pregnant, non-lactating) 15–49 years old, a sub-group of the population that is especially vulnerable to iron deficiency. This is the first time that the WEAI together with multiple measures of dietary diversity and iron outcomes are being applied to an Indian context.

Ms. Gupta collaborated with the Tata Institute for Social Sciences (TISS) and the Mahatma Gandhi Institute of Medical Sciences in India (MGIMS) to design and implement a household survey in 2013-14. Together with TCi Project Coordinator Kasim Saiyyad and a team of 30 enumerators, they surveyed a total of 960 households from 24 villages in the Chandrapur district. The household survey was complemented with anthropometry and blood work to assess women's iron status (see Figure 4). For the latter, a 5ml blood sample

WOMEN'S EMPOWERMENT IN AGRICULTURE INDEX (WEAI)

Respondents: Index male and female from each household

Sub-indices	Component(s)	Details
5-domains of empowerment (5DE)	Production Resources Income Leadership Time	• Each domain: equal weight • 0≤ 5DE ≤1 • Empowered if 5DE ≥ 0.80
Gender Parity Index (GPI)	Gap in 5DE scores of women relative to men	• 0≤ GPI ≤1
WEAI	Weighted sum of 5DE & GPI	• WEAI= 0.9*5DE + 0.1*GPI

Figure 3

was collected from each participant and centrifuged in the field by the team's phlebotomist. Using multiple biochemical assays it was possible to identify prevalence rates of iron deficiency separately from rates of anemia.

Results

Households were classified into one of three groups based on land ownership and the type(s) of crop(s) they chose to cultivate: landless, food crops (such as rice paddy, wheat, sorghum and chickpea/gram) or cash crops (such as cotton and soybeans). We find that characteristics of these farming systems explain the differences in women's empowerment scores, dietary diversity, and prevalence of iron deficiency. Moreover, while cash-crop production results in greater dietary diversity, that diversity does not necessarily translate into better iron outcomes. The results also indicate the importance of home gardens and iron supplementation for improving women's iron status. Detailed results and supporting data will be included in upcoming publications.

AGRICULTURE, NUTRITION AND EMPOWERMENT: HOUSEHOLD SURVEY (2013-14)

Sample size: 960 households, 24 villages
Respondents: 1 Male & 1 female interviewed from each household

Survey activity	Component(s)	Details
Household Survey	Agriculture & allied activities	
	Empowerment in agriculture	• Male & female
	Maternal dietary intake	• 24-hour dietary diversity score • 30-day semi-quantitative food-frequency questionnaire
	Socioeconomic status	
	Household food security	
	Maternal health history	
Anthropometry	Height & weight	• Male & female • Children if any (2–5 years)
Iron-study	5ml blood sample	• Iron assays:[1] SF, sTfR, Hb • Inflammation assays:2CRP, AGP • Non-response rate: 1.25%

1. Serum ferritin (SF), serum transferrin receptor (sTfR), hemoglobin (Hb). 2. C-reactive protein (CRP), Alpha-1-glycoprotein (AGP).

Figure 4

IMPROVED NUTRITION METRICS: THE MINIMUM NUTRITION DATASET FOR AGRICULTURE (MNDA) WITH MARKET-LEVEL DIETARY DIVERSITY (MLDD)

The TCi began its work with the MNDA in response to the need for improved metrics. Of particular interest are metrics that can help researchers and policymakers better understand linkages between agriculture and nutrition. For example, for decades agricultural surveys effectively tracked important indicators such as household income and food supply as well as prices, but they have not adequately captured how agriculture policies and interventions affect nutrition outcomes.

The intention of the MNDA is to achieve consensus on the most essential nutrition metrics and ultimately develop a short module for current and future longitudinal agriculture surveys. The first module we developed focused on dietary diversity.

Lack of dietary diversity is a particularly severe problem among poor populations in the developing world, as starchy staples and grains dominate diets, with little or no animal products and few fresh fruits and vegetables. There is strong evidence linking low dietary diversity to a number of micronutrient inadequacies. By targeting women 18–45 years of age (women in their childbearing years) and asking them to recall three days of food intake, the MNDA dietary diversity module was designed to yield dietary score results similar to those a more intensive nutrition survey would yield, but in less than 30 minutes.

The pilot for the dietary diversity module of the MNDA was completed in June and July of 2014 by a team comprised of TCi staff, interns, and ICRISAT researchers. Four villages in Andhra Pradesh and Maharashtra were surveyed and more than 140 households participated. Our participants, women 18–45 years of age, were randomly drawn from a larger group that had previously taken part in an ICRISAT-administered intensive nutrition survey. Findings from this MNDA pilot survey showed that the mean and distribution of dietary diversity scores were not significantly different from those found in the intensive ICRISAT survey, but the results were achieved in less time—an average of 27 minutes—and with fewer questions. In other words, the MNDA was validated as an efficacious and efficient tool for capturing dietary diversity scores.

Seeking to verify through replication, TCi and ICRISAT re-ran the pilot exercise in the summer of 2015. A new team of TCi interns was paired with experienced ICRISAT field enumerators, and data were collected from the same villages, using the same household selection criteria that were used the previous year. Importantly, meaningful additions were made to the module: questions about eating-out behavior and the consumption of processed and packaged foods were added to reflect the dietary shift that is becoming increasingly pronounced in Indian society and yet is not fully understood. Comparing survey results from the 2014 and 2015 data collections periods should not only verify the dietary diversity module of the MNDA, but also provide insights into whether the additional probing into eating-out and packaged/processed foods leads to differences in dietary diversity scores. This analysis is ongoing.

Finally, the TCi piloted survey instruments to assess Market-level Dietary Diversity (MLDD). We are exploring the linkages between what is available at primary marketplaces and village shops and what households consume. This is innovative and important work that a) will help us to understand nutrition

RIGHT: TCi Intern Michaela Brown, accompanied by an ICRISAT field enumerator, conducts a household survey on dietary diversity.

2015 RESEARCH HIGHLIGHTS

security from the market perspective and b) represent an original approach (scoring the dietary diversity of what's available at a marketplace has not yet been tried). Our researchers assessed the very markets that MNDA survey participants utilize. In the fall of 2015, further analysis has been performed to explore the association between the MLDD score and the household and individual dietary diversity scores obtained from the MNDA module.

SUFFICIENCY OF MACRONUTRIENTS AND MICRONUTRIENTS IN THE INDIAN FOOD SUPPLY

Addressing widespread malnutrition in India is a complex endeavor, in part because of the wide range of factors that determine malnutrition and its consequences. The nutrient status of an individual person is the cumulative result of a cascade of events (Figure 5). Any number of events that occur at any point in the food supply system may diminish both what is available to consumers and its nutrient density. Nutrient absorption can also be affected by health and micronutrient status, the cleanliness of water, and the mix of foods consumed.

Thus a stream of nutrients travels from their source, the national food supply, to the consumers who are the target of public health recommendations. This stream from source to consumer includes a number of "canals" through which foods and their constituent nutrients must pass, including adequate infrastructure for transportation, accessible markets/affordable prices, adequate and safe equipment, electricity, and water for storage and preparation. When micronutrients face obstacles in the stream, they are diverted or lost. Consequently, some consumers receive too few micronutrients.

To investigate this process of nutrient loss, we must begin by examining the source of the micronutrient stream, which raises two questions: Are there enough macro- and micronutrients in the Indian food supply to begin with? Has the sufficiency of nutrients in the Indian national food supply changed over time? This latter question, which Dr. Julia Felice explored while a postdoctoral associate at the TCi, responds to the relatively recent Green Revolution in India, which changed both the size and composition of its food supply.

To determine whether there are enough nutrients in the food supply involves estimating both the nutrient needs of a population and the nutrient content of the food supply. Estimating the macro- and micronutrient needs of the Indian population involved collecting population demographic data and determining the nutrient requirements of population subgroups defined by age, sex, and reproductive status. Estimating the macro- and micronutrient content of the food supply involved collecting data on how much of each of a range of foods are in the food supply and on the nutrient content of each food.

Recently, the National Institute of Nutrition provided a welcome update of available data on the macro- and micronutrient content of foods (The Nutritive Value of Indian Foods, Gopalan et al., 2010). This publication provided a comprehensive list of plant- and animal-sourced foods native to India. We used the list of foods provided by Gopalan and colleagues as a starting point, then incorporated nutrient content data from the Bangladesh Food Composition Tables and the United States Department of Agriculture Nutrient Database to complement and support data from India.

Key results, an interpretation, and potential implications

Macronutrients

- Our findings suggest that there is likely enough energy and protein in the Indian food supply to meet the needs of its population, but that there may not be adequate fat available. These findings raise specific concerns for some population subgroups—e.g., infants, children, and pregnant and lactating women—for whom adequate fat intake is particularly important.

The minerals: iron and zinc

- Our findings suggest that the iron and zinc content of the food supply remained adequate throughout the 1990–2011 period. (Figure 5) It must be noted, however, that absorption of these micronutrients was not accounted for in these analyses. It remains possible that the iron and zinc content of the food supply may need to be still higher to account for low bioavailability of iron and zinc.

- Our findings suggest that cereals, vegetables, and pulses provide most of the iron contained in the national food supply and, consequently, that the vast majority of iron in the food supply is plant-sourced, non-heme iron. Our findings also suggest

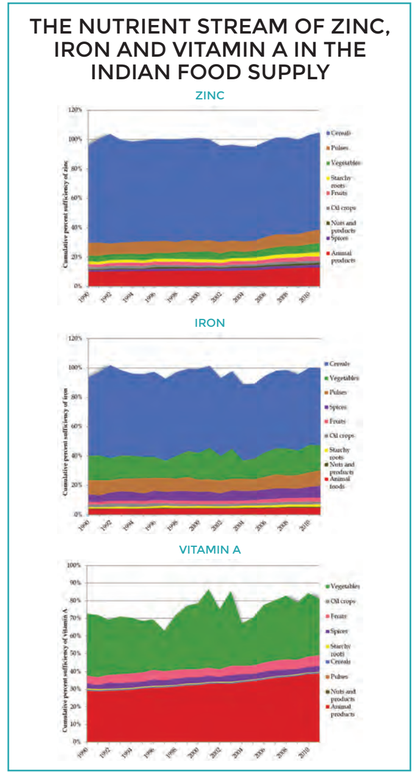


Figure 5

that cereals provide the vast majority of the zinc contained in the national food supply.

- This finding both supports and raises further questions about the potential causes of widespread iron and zinc deficiencies and their adverse consequences in India. For example, the absorption of zinc and non-heme iron is hindered by phytic acid, and phytic acid is found in high quantity in the grains and legumes that constitute the bulk of most diets in India. However, our findings also support the importance of dietary diversity: including fruits and vegetables high in ascorbic acid (vitamin C) in the diet could facilitate the absorption of available non-heme iron.

Vitamin A

- Our findings may explain, in part, the widespread risk of vitamin A deficiency in India: we found that the vitamin A content in the national food supply remained inadequate to meet population needs in 1990–2011. (Figure 5) However, across this time period the vitamin A content of the national food supply increased faster than the content of iron or zinc. We believe this difference indicates that a large proportion of vitamin A in the food supply was provided by animal-sourced foods and that there was a notable increase in the production of animal-sourced foods between 1990 and 2011.

- In contrast, because a small proportion of iron and zinc in the food supply came from animal-sourced foods, this increase in production has not translated to substantial increases in iron or zinc availability. Moreover, vegetables were as significant a contributor to the vitamin A content of the food supply as animal-sourced foods.

Open questions and future directions

Creating our database necessitated using data from other countries, as available Indian data were limited in both their content and the description of their methods. Thus, to get a more complete picture of the nourishment available to Indians, Indian data must be further updated.

Furthermore, our analyses do not and cannot account for the contribution that home gardens and livestock make to individual, house, or community food supplies. For some Indians, these unaccounted-for sources of food may compensate for the gap between needs and the nutrient availability suggested here.

As illustrated in Figure 5, the "stream" of macronutrients and micronutrients could be further investigated by connecting the data to consumer expenditure and dietary intake data.

The nutrient database created for this work provides a convenient means of identifying the most nutrient-rich foods available in the Indian food supply. In turn, the production analyses described here and the purchase and intake analyses described might translate to field research that chronicles household food storage, preparation, and consumption practices.

Translational research projects such as these may strengthen the work conducted by the TCi in the effort to reduce malnutrition and its adverse consequences.

SPATIAL ANALYSIS: VISUALIZING SHIFTS IN AGRICULTURE IN INDIA

India's narrative of the Green Revolution is familiar to agricultural development practitioners. High-yield varieties of wheat and rice introduced in the 1960s, along with access to modern inputs, such as fertilizer and irrigation, doubled cereal production.[7] A country that was plagued by famine in the first half of the 1900s became self-sufficient in calorie production by the end of the century.

Using almost half a century of data on area and production of major crops at the district level from ICRISAT's VDSA database (http://vdsa.icrisat. ac.in), the TCi has mapped this evolution in farming. This effort was organized by our research assistant Hilary Byerly.

A three-year average of data from 1967–1969 shows the status of agriculture in the late 1960s, which is juxtaposed against an average of data from 2007–2009 (late 2000s). Comparing the landscape across time illuminates changing agricultural patterns in India, perhaps enabling more targeted interventions to address the shortcomings of the last fifty years.

Statistics—the number of people in poverty, the percentage of households suffering from malnutrition, the tonnage of rice lost to drought—can highlight need, but their spatial distribution can be far more illuminating. Mapping this data indicates where need is greatest, which regions suffer more than others, and exceptions that buck the trend their neighbors exhibit. Insights into the spatial patterns of food production can inspire research, advocacy and policymaking for more targeted interventions against malnutrition in the parts of India that need them most.

Example of Mapping to Show (not Tell) the story: The Evolving Relative Importance of Nutritious Crops

Cropping patterns have changed significantly over the last half century in India. The rural landscape in the mid-1900s supported mostly subsistence agriculture, as farmers cultivated coarse cereals, rice, and pulses with limited inputs.

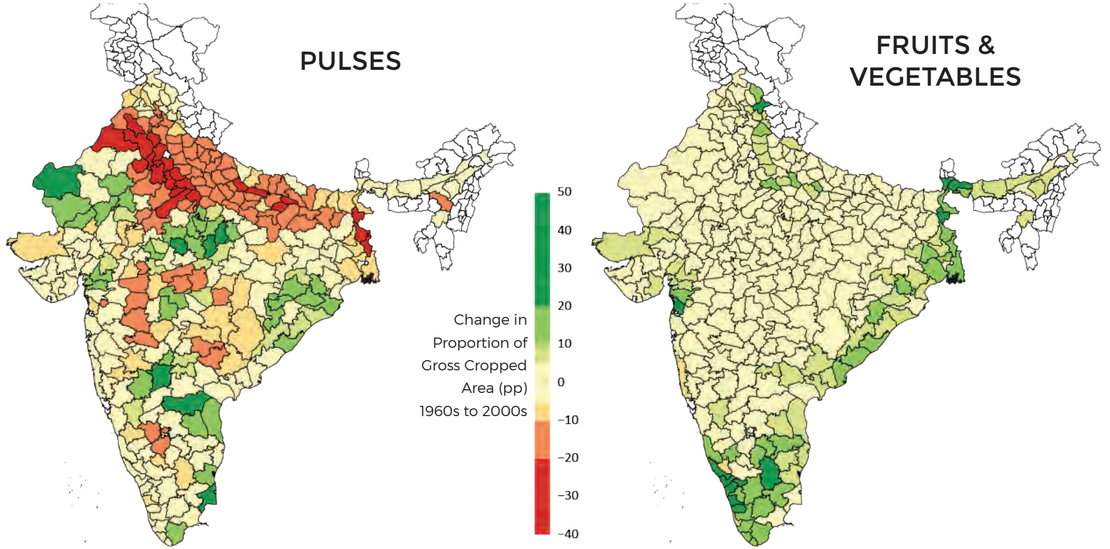
Intensive investment in rice and wheat during the Green Revolution focused production of these crops on areas endowed with certain resources and infrastructure, primarily across the plains of northern India. By the late 2000s, cereal production was clearly concentrated in the north, but continued to be a focus for much of the rest of the country.

Considering changes in nutritious crops, northern India's shifting cultivation patterns are evident in the decline of pulses in the region. Pulses seem to have moved southward, as the country-wide area under pulses has remained nearly constant—decreasing just 650,000 hectares, or 3%, from the 1960s to the 2000s.

Rising incomes and changing diets in India over the last few decades have increased demand for fresh produce, dairy, and meat.[8] Consequently, production of fruits and vegetables has expanded (albeit slowly) in southern and eastern regions.

CHANGING AGRICULTURAL LANDSCAPES IN INDIA

Dominant cropping systems over the last 40 years



NET CHANGE IN AREA UNDER PULSES
650,000 HECTARES

NET CHANGE IN AREA UNDER FRUITS & VEGETABLES
5,140,000 HECTARES

Data source: Govt of India - Agricultural Statistics;
(From ICRISAT's VDSA Database) 1970 district boundaries

INNOVATIONS IN CLEAN DRINKING WATER SYSTEMS: AGUACLARA

Solving water, sanitation, and hygiene problems is fundamental to addressing the problem of public health in India. Water-borne diseases can not only make a person ill and unfit to work or learn in school, but they can also affect that individual's ability to absorb

nutrients. This can have long-term and pernicious outcomes. For example, without clean water and a hygienic environment, individuals are repeatedly exposed to infection, which can lead to enteropathy (intestinal inflammation) and the complete or partial malabsorption of calories and nutrients, both of which are associated with stunting. Drinking water contaminated with worms, parasites, viruses or bacteria can also lead to diarrhea and dehydration, conditions which are life-threatening, especially among young children. Therefore, access to clean drinking water protects against malnutrition, and can even prevent death.

Gaining access to affordable, piped, clean water may have other benefits as well. The TCi is investigating the economic and community-empowerment potential of clean drinking water—as well as the perceived health improvements—through our AguaClara project in Jharkhand.

Successful Pilots in Jharkhand

AguaClara is a clean drinking water technology system developed at Cornell University and supported by the TCi for pilots in Jharkhand. There have been two pilots in Koderma district (in the villages of Johlakarma and Durgunia) and two pilots in Khunti district (in the villages of Ronhe and Gufu). The entire system is gravity- and solar-powered, requiring zero fossil fuel energy inputs. All pilot sites use a chemical dosing unit that maintains safe chlorine and coagulant doses for purification and flocculation, respectively. In the latest pilots, a Stacked Rapid Sand (StaRs) filtration technology was developed by AguaClara engineers. This specialized filter is found only in the villages of Ronhe and Gufu. When tested in December 2014, water quality in Ronhe was found to meet 99% of U.S. EPA standards.

Currently, the TCi is evaluating the efficacy of these two models: the Koderma model, which features only

SCHOLAR SPOTLIGHT

Shiuli Vanaja, TCi Scholar and Applied Economics and Management PhD candidate

Access to and availability of clean water for household use is limited in India, and the burden of water collection typically falls on women. Improving water systems can change the lives of rural women in innumerable ways. Having piped water at home can free up labor time that a woman can use for other productive activities. Reduced incidence of water-borne diseases would also reduce the time spent taking care of sick people at home.

My research interests lie in analyzing the effect of access to clean piped water on disease incidence and time savings at the household level in rural India. In summer 2015, I conducted exploratory field work in Khunti and Koderma districts of Jharkhand, where the AguaClara piped water system is operating.

It was a challenging yet enriching experience to design and administer surveys in two socially diverse sets of villages, especially during monsoon. This initial experience studying the effects of piped water has shaped the trajectory of my Ph.D. research. For my thesis, I look forward to understanding the interworking of health, time, and women's empowerment as it relates to intra-household behavior change and quality of life for the rural people of Jharkhand.

the chemical dosing unit, and the Khunti model, which combines the chemical dosing unit with the filter. We are interested in comparing the outcomes of the two models, using time-saving, health, and women's empowerment as indicators. This evaluation was conducted in June and July of 2015.

Our analysis found that, in both models, the piped water connection led to significantly greater time-savings in treatment villages than in control villages. It also preceded a significant decrease in the incidence of water-borne diseases including diarrhea, stomach disorders, skin lesions, jaundice, and typhoid. Further research needs to be conducted with a larger sample to establish causality. However, initial findings offer associational evidence of the time-savings and health impact (in terms of disease incidence) of both models of AguaClara's water system in Jharkhand.

Inside the water tower with Cornell-trained AguaClara engineers Maysoon Sharif and Sarah Long (top row) with TCi intern Tara Gadde and TCi Scholar Shiuli Vanaja (bottom row).

With our pilot efforts now complete, we expect that what we have learned from this project will inform policy decisions and approaches not only for our implementation partner Professional Assistance for Development Action (PRADAN) (a respected Indian non-governmental development organization) but also for all those working on water, sanitation and hygiene in Jharkhand.

In particular, as toilet construction projects are implemented across India (a stated policy priority of the Modi government), TCi recommends that toilet installation be accompanied by piped water connections. According to our analysis, piped water connections offer powerful incentives for actually using toilets and are likely associated with women's empowerment and reduced malnutrition. We will continue to examine, in particular, potential women's empowerment outcomes when they have access to the piped water.

REFOCUSING AGRICULTURAL POLICY FOR BETTER NUTRITION OUTCOMES

Due to the historic success of agricultural policy in ensuring adequate quantities of staple cereal grain and thereby managing the problem of famine, the food security challenge has evolved in much of the developing world. It is no longer about making enough calories available, but rather about enhancing food diversity to addressing malnutrition in its multiple dimensions. For the poor, it's about having access to adequate amounts of protein, vitamins, and minerals. For the middle class, it's about addressing emerging health concerns associated with overweight and obesity through higher quality diets.

TCi's review reveals a growing disconnect between agricultural policy and contemporary nutritional challenges. Agricultural policy is still heavily biased towards improving staple grain productivity, especially for the big three cereal crops—rice, wheat and maize—while the diet diversity needs of the middle class and the poor alike are not adequately addressed. Policy actions taken after the 2008 food price crisis make it clear that most countries, including India, continue to interpret food security as equivalent to staple grain self-sufficiency. Staple grain fundamentalism has constrained the ability of agricultural policies to achieve positive nutritional outcomes.

PUBLICATION ALERT

Pingali, P. (2015). Agricultural Policy and Nutrition Outcomes—Getting Beyond the Preoccupation with Staple Grains. *Food Security*, Vol 7(3), 583–591.

The persistence of Green Revolution–era policies and structural impediments, combined with a weak private sector, limit the supply responsiveness for vegetables and other non-staple foods. Creating a "level policy playing field" that corrects the historical bias in favor of staple crops would improve incentives for diversification of production into non-staple foods. In today's world and into the future, we need a "crop-neutral" policy that removes distortions and allows farmers to respond to market signals when making crop production choices.

In addition to correcting this incentives bias, enhancing farmers' ability to diversify production systems would also require high levels of public and private sector investment in transportation, storage, and market development. Investments are also required to reduce transactions costs for smallholder integration into non-staple food markets. Diversifying diets to include protein- and micronutrient-rich food could provide new opportunities for agriculture-led growth for smallholder farmers.

Given the connection between market linkages, economic growth, and dietary diversity, investments that can equip a diverse socioeconomic group of farmers (including smallholders) to participate in relevant markets are essential. Public policies aimed at creating an "enabling environment" that includes institutions that encourage private sector investment lead to new market opportunities for farmers and thereby promote diversification. Market development investments include both connective infrastructure (paved roads, telecommunication networks, distribution networks) and mediating infrastructure (credit sources, credit rating agencies, property titles, and other legal and regulatory institutions that can depersonalize exchange transactions and make assets fungible).

Moreover, policies that succeed in creating such an enabling environment for agriculture may improve equity by including those among the rural poor who are less likely to have access to nonfarm employment, such as women farmers, the uneducated, and recent immigrants, in active markets and distribution chains. Finally, policy investments in market information technologies, product standardization, and food safety regulations can build consumer trust, identify new market demands, and provide meaningful opportunities for farmer response.

EFFECTS OF CLIMATE VARIABILITY ON AGRICULTURE

For as long as agriculture has been practiced it has been subject to the vagaries of climate. Yet until fairly recently, knowledge of climate behavior and its effects was localized and often passed down from generation to generation of farmers. In recent decades, as governmental and non-governmental entities across the world have launched concerted efforts to improve food and nutrition security, we have gained access to more climate and crop data than ever.

This allows us to vastly improve our understanding of how climate variability and trends affect agriculture at larger spatial scales and complement traditional farming knowledge. TCi is using statistical models to quantify past and potential future effects of climate on crop yields in India. This work is conducted by Dr. Asha Sharma, postdoctoral associate.

The single most important climatic phenomenon for Indian agriculture is the summer monsoon, which accounts for three-quarters of the total annual precipitation received in most of the country. The importance of the monsoons to the economy, and indeed to the national psyche, is obvious to anyone who has happened across Indian news media in the summer months. Yet surprisingly few studies have quantified its effect on crop yields.

TCi's work shows that the onset of the rainy season has complex effects on agricultural production. For example, in districts with extensive irrigation the monsoon has had much less, if any impact on rice yields. In districts with limited irrigation, later onsets of monsoon are associated with both less area cultivated and lower yield. Future research will address the relative importance of onset dates and rainfall amounts as well as the effects on many crops in addition to rice.

TCi's statistical crop modeling work also seeks to better define risks related to climate change for many of the major food crops in India. While many studies report a single crop yield decline (or increase) due to a given climate projection, TCi's work emphasizes the potential range of yield outcomes that reflects both the variability of potential climatic conditions as well as uncertainty in the climate and crop models.

Moreover, our work extends the focus beyond rice and wheat to include pulses, oilseeds, and so-called "coarse" grains, which will provide a more comprehensive picture of future climate effects on nutrition.

We are also looking at the effects of extreme events on crop yields, a little understood problem that the science and development communities acknowledge to be important. These studies together will help prioritize crops and regions in terms of their need for adaptation to climate shocks. Please check the TCi website for updates on these studies, including links to publications.

NURTURING HEALTHY SOIL

Healthy soils filter and store ground water, sequester carbon, host considerable biodiversity, and provide the nutrients that crops need to grow into healthy and productive plants. Healthy soils lead to healthy crops, healthy livestock, and healthy people. This holistic view of soil that incorporates its physical, biological, and chemical attributes is fundamental as we face the task of feeding 9 billion people with a diminishing resource.

Many agricultural soils in India are degraded due to non-holistic and non-sustainable soil management. Consequently, crop yields decline even as farmers must apply more chemical fertilizers to maintain productivity. Traditionally, in India and elsewhere, greater attention has been paid to the chemical and nutrient balances of soils (e.g. nitrogen, phosphorous, potassium, etc.)

RESEARCHER SPOTLIGHT

Dr. Asha Sharma, Postdoctoral Fellow

The future of nutrition security hinges critically on understanding climate risks to agriculture. My research aims to improve our understanding of climate risks as I address questions such as: Which crops are most heavily affected by climate variability and change? Which regions in India are more vulnerable to the effects of climate change? Should we be more concerned about rainfall changes or temperature changes? What are the differential effects of mean climate change versus those of extreme events?

My analysis incorporates three areas of focus that have rarely been studied. First, I am interested not only in the main crops of rice and wheat but also in pulses, oilseeds, and "coarse" cereals. Second, I plan to examine the effects of climate at a district level across India, whereas most research so far has focused on smaller regions or coarser resolutions. Finally, I seek to understand the effects of climate extremes rather than just those of the average seasonal climatic conditions.

An unintended outcome of my research is that I have become especially interested in issues involving data—from collection and availability to quality and the usability of the format in which they are provided. I hope to highlight these issues even as I pursue our main objectives because I believe good data are essential to research and policy. In 2016, I expect to share my findings more widely with practitioners, academics, and policymakers, sensitizing them to these important issues and challenges.

without paying similar attention to the physical and biological attributes.

The first step in protecting soil resources is quantitatively measuring soil functions that indicate soil health. Therefore, the TCi is establishing baseline values for physical, biological, and chemical soil attributes and characterizing the current health status of the soils in Jharkhand. Leveraging the technical expertise of the Crop and Soil Sciences department at Cornell University's School of Integrative Plant Science and the agricultural extension experience of PRADAN, this TCi project will seek to establish a soil assessment framework which can be used to assess critical soil functions, identify constraints, and develop appropriate management practices based on measurable conditions of the soil.

TCi Scholar Phil Frost and TCi Regional Coordinator Lal Thangsing collect first soil sample.

Initial field visits to Jharkhand were completed in February 2015 when it was agreed that TCi Scholar Phil Frost would collaborate with PRADAN extension agents to complete the extensive baseline soil analysis in strategic locations across the state. Since that time, the TCi has collected approximately 120 soil samples from 27 micro-watersheds in order to quantify distinct soil health features. Samples have been shipped to Cornell laboratories in Ithaca, New York for analysis. These data will be used to establish the baseline measurement of soil health characteristics in Jharkhand assessed on four main descriptors of soil (undisturbed soil, upland, middle-upland, lowland soils). With this baseline in hand, the Cornell Soil Health Test scoring curves will be calibrated for the Jharkhand context to yield insights into intervention priorities—areas that offer the greatest "bang for the buck" potential and can be defined and applied to soil management strategies offered to farmers.

TCi will continue to focus on developing such new tools for optimizing soil health in the India context. For example, we are creating digital soil maps using GIS and GPS markers. We are also developing a mobile, rapid in-field assessment "soil lab in a box" for direct testing in remote, infrastructure-poor regions (modeled after the SoilDoc kit created by researchers at the University of Maryland and Columbia University). Here NGOs such as PRADAN, who have the essential role of transferring this soil testing and management know-how to farmers, will be implementing the technology.

To build capacity for monitoring and improving soil health among our partners in Jharkhand, two agriculture extension officers from PRADAN and one academic researcher (a professor at Birsa Agriculture University in Ranchi) participated in a Soil Health training workshop at the Cornell campus in August 2015 to see first-hand the Cornell Soil Health technology and approach in practice.

These practitioners and several Cornell soil scientists with extensive backgrounds in South Asia participated in an additional day-long workshop. Overall, this exchange strengthened the TCi–PRADAN–Cornell Crop and Soil Science Department partnership. The knowledge shared will improve the efficacy of our future interactions to serve farmers, achieve buy-in, and increase awareness of soil health among farmers, institutions, and policymakers alike.

MARKED-BASED, VILLAGE-LEVEL FLOUR FORTIFICATION PROJECT IN GUJARAT

Micronutrient malnutrition—especially iron deficiency anemia (IDA)—is a severe public health problem for the Indian population. As such, the TCi is leading a partnership coalition to pilot a flour fortification project in Gujarat. Our partners for this work include: the Tata Institute of Social Sciences (TISS, the BAIF Development Research Foundation, Maharaja Sayajirao University (MSU), Sight and Life, and a federation of women's self-help groups (SHGs).

The project involves piloting a supply chain for making micronutrient sachets available to women through a network of federation SHGs formed by BAIF in 16 villages in Tapi district of Gujarat. This approach is unique in that it applies market-based principals (e.g., demand generation, social marketing, small enterprise development, and consumer behavior) to create a self-sustained model for flour fortification.

The micronutrients sachets will comprise 1.25 grams of fortificant consisting of iron, folic acid, Vitamin B12, and Vitamin A, adequate for up to 5 kg of wheat, rice, or jowar flour. The micronutrients will be manufactured and supplied by DSM, a well-known manufacturer of micronutrients in India and globally, from their Baroda unit and Sight and Life (the nutrition think tank of DSM).

A field team comprising TISS-TCi and BAIF field staff will implement the project. MSU Baroda will be involved in tracking the changes in the nutritional status of communities in the project location.

The project involves four main phases—an awareness phase, a capacity-building phase, a core implementation or business phase, and a consolidation phase. The awareness and capacity-building phases will be used to build awareness among community members regarding nutrition-related issues and the possibility of using micronutrient powders to reduce malnutrition levels as well as carrying out the baseline.

The micronutrient sachet will be introduced in the business phase. The women's federation will work with SHGs to sell the fortificant sachets to community members. During the consolidation phase the business plan for the women's federation will be finalized and the results of the work in terms of changed health status will be assessed.

While this project is still in its early stages, the TCi continues to advance the project by securing the necessary approvals through the ethical review process, guiding the development and refinement of monitoring and evaluation indicators, and nurturing collaborative relationships and building trust between partnership stakeholders.

ASSESSING WOMEN'S SELF HELP GROUPS AS CONDUITS OF CHANGE

Women's Self Help Groups (SHGs) are increasingly being leveraged as agents of social change in development policy, both in India and around the world. Initially set up to facilitate microfinancing through a big policy push in the early 2000s, SHGs have matured over the past decade into strong community assets with training experience, access to the formal financial system, and a capacity for self-governance. SHGs have also formed federations that provide a stronger voice for women in local governance.

Development organizations and governments are tapping into their role as "common interest groups" to enhance local delivery, monitoring, and take-up of public provision programs, especially in areas of agriculture and nutrition, where women are the primary target audience. The rapid recruitment of SHGs has, however, been met with a fair share of skepticism regarding not only their ability to create sustainable economic benefit but also group cohesiveness, lifespan, and sufficient interest and capacity to move beyond their economic function to adopt a larger role in the community.

Such skepticism is not unfounded. In India today you will find SHGs involved in a range of community activities, from cleaning of village public property to inspection of mid-day meals to campaigning against open defecation, alcoholism, and domestic violence. As TCi researchers observed in the field, there is remarkable diversity in group dynamics, characteristics, and goals, and stories of both successes disappointments can be found. We recognize a need to thoroughly study the participation of SHGs in community mobilization programs in agriculture and nutrition and identify characteristics that make some SHGs more effective than others in undertaking this role.

In the summer of 2015, TCi placed an intern, Ms. Samyuktha Kannan, in the field to study SHGs involved in the Shakti Varta program of the State Government of Odisha, focused on generating community awareness of mother and child health, nutrition, and WASH practices. Women's SHGs conducted meetings in their local communities, made young mothers aware of their rights and entitlements, and encouraged women to participate in state-sponsored programs. The study creates the framework for conducting a systematic assessment of SHGs, identifying determinants of SHG involvement in community action, and recording the best practices for performing fieldwork in this area.

The TCi is taking steps towards creating a well-defined set of metrics with which to assess the potential of SHGs to undertake community development responsibilities, complement widely used ratings and gradation systems that focus only on SHG credit scoring, and financial discipline. We expect this area of research to have vast policy relevance as more and more practitioners tap into this huge pool of local institutions to ensure better last-mile delivery of agriculture and nutrition programs.

PROMOTING BEHAVIOR CHANGE FOR IMPROVED NUTRITION

A vital part of the TCi's mission is studying the effects of changes in agriculture and nutrition practices among the most vulnerable and poor of India's population. We work on research that can aid policies and interventions to bring about positive change. However, we realize that no change can be simply imposed from on high, and that real change will be found only when people are encouraged to change their behavior in the interest of their health and well-being. The best of policies are of no use without proper implementation, and this often comes about when people are convinced to use such policies.

To achieve this, the TCi is working with its partner Digital Green to understand how using technology to communicate can affect people's choices and behaviors in agriculture and health. Digital Green leverages communication to motivate changes in attitudes, capacity, and behaviors regarding mother and child health and nutrition practices using a unique Information Communication Technology for Development (ICT4D) model.

Since 2008, they have popularized important elements of their approach: community-led creating and sharing of videos, and monitoring video-watch and adoption of new practices to increase farm productivity. The model works through already-established women's SHGs in the villages. Over the years, they have also expanded into the health and nutrition arena.

This summer TCi intern Amruta Byatnal assessed health and nutrition interventions in the states of Bihar and Odisha that are targeted at young mothers and their children and suggested recommendations for scaling up the initiative. While the model is successful in its present form, qualitative research showed that

collaborating with the existing social infrastructure of frontline health workers in rural areas will work well to promote behavior change among women. We are now trying to understand which metrics will make it possible to evaluate the model more effectively and thus ensure that the videos are working as they were meant to work, and identify limitations and challenges that remain.

Unarguably, the intervention is also bringing about change in perceived gender roles, and is empowering women as they now become their own decision-makers. TCi believes that these lessons learned are transferable to its many field projects and we look forward to future collaborations and consultations with Digital Green as our field presence grows.

OUTREACH AND CAPACITY BUILDING

Engaging with Students in India: Joint Courses Held between TCi, TISS, and ICRISAT

As a follow-up to the first joint course held with the TISS in Mumbai in January 2014, the "Sustainable Global Food Systems: Food Policy for Developing Countries" course was held on 20–23 July 2015 at the ICRISAT campus near Hyderabad. The course was jointly organized by the TCi, the TISS, and the ICRISAT as a training program for TISS Hyderabad campus students; 28 students studying for their BA/MA programs from TISS Hyderabad attended.

Course instruction covered a wide range of topics from the global food situation and price changes to the Indian scenario covering production and the Public Distribution System (PDS). The training program also covered elements of the global and domestic trade regime, issues that threaten global food production (such as climate change) and issues pertaining to nutrition.

The sessions resulted in a very lively discussion between students and resource persons (faculty members from Cornell University), TISS Hyderabad and Mumbai, and experts on the topics that were covered during the training program.

Building Capacity: Soil Health Training Workshop

In August, representatives from PRADAN and the agricultural university in Jharkhand attended a week-long training on Cornell Soil Health Testing methodology. Co-organized by the TCi in collaboration with the Department of Soil and Crop Sciences at Cornell University, the week culminated with the TCI Soil Health Training Workshop in which practitioners and academics discussed solutions to key soil health constraints for resource-poor farmers with very limited agronomic inputs.

Attendees included Mr. Mannan Choudhury (PRADAN - Patna), Mr. Ashook Kumar (PRADAN - Ranchi), Dr. B. K. Agarwal (BIRSA University Ranchi); Drs. Harold van Es, Peter Hobbs, David Rossiter, and Julie Lauren (Cornell University Department of Soil and Crop Sciences); Mr. Phil Frost (Soil and Crop Sciences /TCi); and Ms. Jessica Ames (TCi).

Bringing Indian Voices to a Global Conference: The TCi Supports Young Indian Scholars' Attendance at the Second International Conference on Global Food Security at Cornell

With the Global Food Security Conference hosted at Cornell and held from October 11–14, 2015, the TCi worked behind the scenes to organize thematic group 11 (The Agriculture–Nutrition–Health Nexus), coordinate conference volunteers, and provide support for TCi Scholars and Fellows to attend. The TCi also offered funding to bring Young Indian Scholars (Indian citizens based in India) who had papers or posters accepted to participate in the proceedings of the conference. These highly competitive awards were granted to seven scholars from distinguished institutions across India.

2015 RESEARCH HIGHLIGHTS

BEYOND 2015: PLANNED RESEARCH AND ACTIVITIES

GATES FOUNDATION AND TCI JOIN HANDS TO LAUNCH TARINA

The Bill & Melinda Gates Foundation has awarded a US$13.4 million grant to the TCi to help amplify the nutrition profile of agriculture in India. This new funding will allow the TCi to scale up its work on promoting a more nutrition-sensitive food system. We aim to enhance the rural poor's year-round access to affordable food diversity and quality by influencing the design of ongoing and future agricultural projects, programs, and policies. More specifically, we will integrate nutrition objectives, nutrition-focused actions, and nutrition-focused metrics and measurement into agricultural projects and programs that are currently committed to delivering adequate food to local populations. We propose to do this

by connecting a leading group of pragmatic and policy-focused academics from diverse disciplinary perspectives with scale, quality, and impact-focused Indian implementation partners and policy influencers in an open consortium, called Technical Assistance and Research for Indian Nutrition and Agriculture (TARINA). The TARINA project will be launched on December 1, 2015 and run through November 2019.

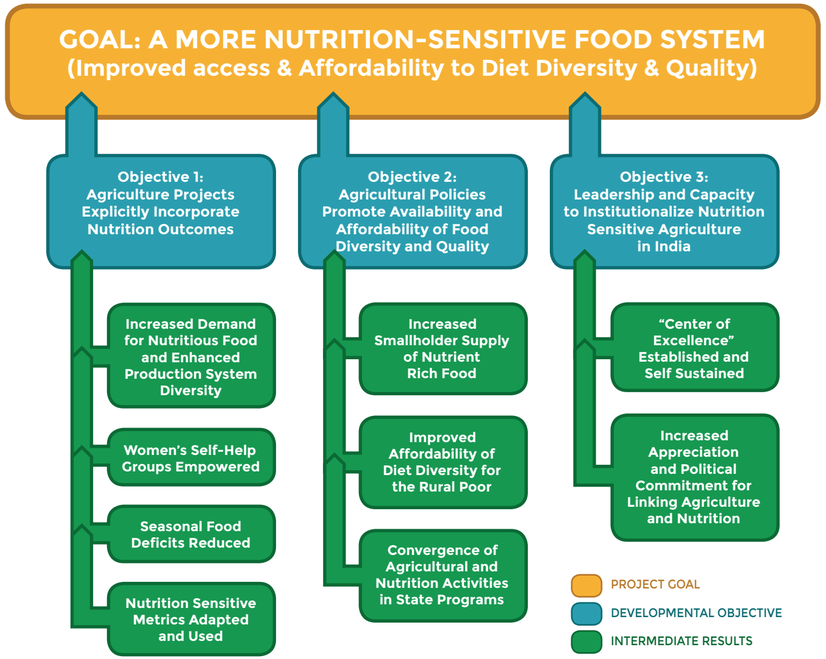
Collectively, the TARINA consortium will be able to provide the kind of leadership that is today essential to tackling the problem of hunger and malnutrition in India. Led by the TCi, TARINA links the evidence-generating capabilities of the International Food Policy Research Institute (IFPRI), the Tata Institute of Social Sciences (TISS), Emory University, and Cornell University with the highly competent implementation and technical capacity and experience of leading NGO partners—BAIF and CARE. The Tata Trusts, India's largest philanthropy, will support the consortium through their convening power and influence with policymakers at the national and state levels and by being a frontrunner in generating demand for technical assistance to proactively integrate a "nutrition lens" into the agricultural projects that they fund.

The broad objectives of the project are to:

1. Provide technical assistance in redesigning agricultural projects to ensure nutrition outcomes at scale.
2. Provide assistance and evidence for policy reform that enhances diet quality at affordable prices.
3. Build capacity to design and implement nutrition-sensitive agricultural programs and policies.

As part of this initiative to support the three objectives we will also develop and implement metrics for food systems, agricultural policies, and programs. The TARINA consortium will focus its field-based work for objective 1 on current agricultural and rural development projects being implemented by our NGO partners in Bihar, Eastern Uttar Pradesh, and Odisha. We will also engage with the government, at both the national and state levels, on strategic policy issues. Finally, we plan to set up a "center of excellence" for the generation and dissemination of evidence to make the

TECHNICAL ASSISTANCE AND RESEARCH FOR INDIAN NUTRITION AND AGRICULTURE (TARINA): RESULTS FRAMEWORK



case for nutrition-sensitive agriculture and to provide technical assistance for redesigning agricultural and rural development projects and programs.

PULSE INNOVATION PRIZE

India is the largest producer of pulses in the world. In India, pulses are grown on approximately 24–26 million hectares, producing 18–20 million tons annually, accounting for over one-third of the total world area under pulse production and over 20 percent of the world's total pulse production. For the majority of the vegetarian population in India, pulses are the major source of protein. In spite of common knowledge of their nutritional value, pulse consumption in India has been dropping in recent years. Along with efforts to understand why this drop has occurred, policymakers are trying to increase consumption of pulses in raw and/or value-added form.

The TCi along with McGill University and players from industry and civil society are discussing a collaborative venture called the Convergent Innovation (CI) approach. Three possible activities have been proposed for operationalizing this food CI accelerator—mapping the food demand/innovation landscape in India, crystallizing the CI accelerator operations by choosing three food products to promote for commercialization, and documenting the theory of change for all concerned actors.

So far, the TCi is playing the lead role in mapping the food innovation landscape in India pertaining to pulses. With our partners, we are exploring the possibility of creating an innovation competition called the Pulse Innovation Prize.

Using our CI approach, a systematic review would be conducted to identify and shortlist innovations in pulse-based products. These new products would be evaluated for their replicability and scalability. The competition would be followed by the creation of an incubation support ecosystem for those pulse-based products that have the greatest potential for being scaled up and rolled out across sectors.

If the competition goes forward, it could be an important step in reaching out to players in the pulse products value chain. It should help to map the pulse innovation landscape and push forward the innovations that have been tested and therefore have strong chances for market success. Discussions are currently underway with the Tata Trusts to provide support for the Pulse Innovation Prize.

OFF-FARM EMPLOYMENT AND GENDERED PATTERNS OF LABOR MOBILITY

From 1993-94 through 2009-10, employment in rural construction in India experienced an average annual growth rate of about 10%[9]. Similar employment patterns are gaining prominence with respect to economic activity (or occupation), and reflect the spatial and temporal mobility of individuals within rural India. For instance, male farm workers in many villages commute daily to nearby towns for off-farm work or seek seasonal off-farm employment opportunities in cities. What does this increasing diversity in employment patterns tell us about broader changes in the Indian rural economy?

Motivated by this central theme, The TCi is examining the determinants of men's off-farm employment on women's changing economic roles in rural India. This work is being led by TCi Scholar Amit Anshumali.

Using aggregate data from six villages compiled by ICRISAT in Hyderabad, one of the preliminary findings from this study shows that the share of women cultivators grew from 29% to 45% between 1975 and 2010. More specifically, women in these six villages are increasingly serving as farm managers or own-farm workers. This trend is important and warrants further examination of the effects of women's changing economic roles on their relative autonomy in the household.

This research has possible implications for understanding the following:

1. The re-organization of cropping patterns and the farm labor market in the Indian countryside.
2. Comparing the direct effects of off-farm employment on farm workers and their households with the effects of spillovers to the rural economy.
3. The relationship between livelihood diversification and the changing social structure of rural India.

This research should yield a detailed picture of the shifting social and economic contributions of off-farm and farm employment in the rural Indian economy, which also has implications for food systems and household gender dynamics. TCi will continue to examine these linkages between rural livelihoods, evolving food consumption patterns (e.g., eating-out behaviors) and nutrition outcomes.

INFORMATION AND CREDIT CONSTRAINTS IN HIGHER EDUCATION CHOICE

Even though the monetary returns on completing post-secondary education in India are high, with graduates earning 50%–100% more than individuals completing only high school, overall enrollment in the country is low and socioeconomically uneven.

In Jharkhand, as per recent National Sample Survey (NSS) data, less than 6% of all working-age individuals have completed some form of higher education. Moreover, rural individuals were found to be at least 20 percentage points less likely to have attained a degree or diploma when compared with their urban counterparts.

In an India where youth are increasingly moving out of farming occupations, it is critical in invest in training to help them overcome impediments to finding

BEYOND 2015

employment in a changing economy. As an additional challenge, public support of the agricultural sector is limited. Most of the growth in education degrees with an occupational focus is occurring in the private sector, where poor individuals must expend their own resources to obtain higher education.

Without doubt, the poor face multiple constraints on enrolling in higher education. These constraints are impossible to identify and isolate with a standard survey. To address this gap, TCi Scholar Tanvi Rao is leading a research project which aims to (a) identify demand for various types of higher education among Indian youth (among alternatives ranging from technical/professional degrees to general academic degrees to vocational diplomas/skill-based certificate courses) and (b) identify specific roles of information in (regarding returns on various education tracks) and short-term borrowing constraints on mediating the higher-education decisions of students.

Between August 2014 and February 2015, the TCi survey team, co-headed by Ms. Rao and TCi Regional Coordinator Thangkhanlal "Lal" Thangsing, collected unique baseline and experimental data from high-school students regarding their decisions to enroll in post-secondary education.

A student completing a tablet-based survey.

Apart from relevant socioeconomic details, the baseline of the survey collected probabilistic data on expected student enrollment and a wide set of questions on the pecuniary and non-pecuniary beliefs that students associate with each higher education alternative available in their choice-set. The survey also identifies short-term borrowing constraints by measuring the willingness of students to accept higher education loans. Outcomes of this work will also throw light on whether students make sub-optimal enrollment and borrowing decisions because they are uninformed about the true rate of return associated with distinct education tracks.

This survey of over 1,500 students spanned urban and rural areas and covered nine intermediate colleges (equivalent to the 11th and 12th grades in the US) across four administrative districts of Jharkhand. The data-collection process was administered entirely digitally on Android tablets and created using Open Data Kit (ODK) software. This has ensured that the data are high in quality, consistent, and complete. Currently, Ms. Rao is analyzing the collected data. When her analysis is complete, the TCi expects to report on the ways in which higher education and the acquisition of employable skills can be made more accessible to a larger segment of Indian youth.

ALTERNATIVE LIVESTOCK SYSTEMS

Livestock play an integral role in the crop–livestock systems that predominate in Indian agriculture, yet agricultural research largely overlooks the importance of livestock in terms of fertilizer, nutrition, and financial security for smallholder farmers in developing

countries. Without livestock, there would be no manure to enrich the cornfield, milk to consume in the home, or emergency "insurance policy" for when someone in the family unexpectedly falls ill.

Considering that livestock contributes 25.6% to agricultural GDP in India (2012 census), the TCi recognizes the value of livestock within the overall food system, and seeks to better understand how livestock—particularly small ruminants such as sheep and goats—affect the environment and smallholder livelihoods. Research also shows that women perform more than 77% of animal care work (FAO, 2012), which provides additional income in a gender-biased system in which few other sources of income are available to women.

In many sheep-and-goat-populated regions, animal foraging on common lands is a contentious issue for neighbors who do not own livestock. Other stakeholders typically believe that livestock foraging degrades common areas. To address this perception, TCi is in the development stage of a project that will compare alternative livestock systems with the traditional extensive grazing systems that are common in many areas of India.

PUBLICATION ALERT

Valentine, M.E; McRoberts, K.C.; and Cherney D.J. (2015). Foraging and Body Condition Characterization of Goats in Northwestern India. *The Indian Journal for Small Ruminants* 21(2), 245–252.

We will research changes in animal health, household labor, household income, and variations in income expenditures. Additionally, we are looking to fine-tune technologies that can help livestock extension workers suggest meaningful recommendations for improving livestock feed systems based on input parameters.

Research on this topic will be conducted in collaboration with the International Livestock Research Institute (ILRI) and will be spearheaded by TCi Scholar Maureen Valentine in 2016.

Through this research, we can potentially identify alternative livestock feed systems that can offer win-win scenarios for livestock holders and their non-livestock-holding neighbors. This will help us better understand relationships between small ruminants and the environment, small ruminants and household income, and the willingness of farmers to adopt technologies that could improve their livestock productivity.

Results from this research will inform organizations that use goats as a tool for poverty reduction about how these animals influence households, and how development projects that involve goats can be augmented to yield more tangible results for smallholder farmers. This project will take a whole-farm approach to providing information about how livestock relate to smallholder crop production and income generation, which aligns with the TCi's larger mission of creating more linkages between agriculture and household improvements.

EXPLORING THE DYNAMICS OF FARMER PRODUCER ORGANIZATIONS

The relevance of Farmer Producer Organizations (FPOs) in an agricultural sector comprising largely of small and marginal farmers is high. Small farms have an inherent disadvantage when accessing inputs, credit,

information, and commodity markets due to weak bargaining power and low operating scales. Addressing these issues is crucial to enabling small and marginal farming households to adapt to changing food systems in the context of urbanization, rising incomes, and changing quality needs. Development of the agricultural sector in India depends on the ability of smallholders to adapt to these changes.

In the past, cooperatives that were set up to enable greater small and marginal farm viability have not met their expected goals, except in the case of the dairy sector. This poses a number of questions with regards to the role of FPOs: What is their likelihood of succeeding where traditional cooperatives have failed? What factors influence their performance as institutions coordinating collective initiatives? How can one measure the performance of FPOs?

Answering these questions will enable us to identify factors that influence optimal outcomes in cooperation with FPOs, meet the various challenges of small farm production they address, and theorize ex ante about some of the factors that influence the performance of these initiatives.

At the TCi, our research focuses on some of these questions and aims to understand the dynamics of FPOs and the role they play in agricultural development. Dr. Mathew Abraham, postdoctoral associate, shall lead this research.

Recently, the Government of India has been aggressively promoting FPOs. The Small Farmers Agribusiness Consortium (SFAC) under the Department of Agriculture, Cooperation and Farmers Welfare has been set up specifically to promote FPOs. The government has earmarked subsidies and support to promote around 2,000 FPOs (with about 1,000 members each) in 2015-16. Considering the economic importance of FPOs to the agricultural sector and the resources allocated to promote them, understanding how they function, perform, and enable growth and development is crucial.

TCI PERSONNEL AND PARTNERS

TCI SCHOLARS

Mr. Amit Anshumali, Ph.D. candidate, Development Sociology. Research: The effect of off-farm employment on women's relative autonomy in rural India.

Mr. Phil Frost, Ph.D. student, Crop and Soil Sciences. Research: Developing a soil health assessment framework for Indian agriculture.

Ms. Soumya Gupta, Ph.D. graduate, Applied Economics and Management. Research: Cropping patterns and women's iron status in Chandrapur.

Ms. Katy Merckel, Ph.D. student, Division of Nutritional Sciences. Research: TBD.

Ms. Vidya Bharathi Rajkumar, Ph.D. student, Applied Economics and Management. Research: TBD.

Ms. Tanvi Rao, Ph.D. candidate, Applied Economics and Management. Research: Youth employment and employment aspirations in Jharkhand.

Ms. Payal Seth, Ph.D. student, Applied Economics and Management. Research: TBD.

Ms. Maureen Valentine, Ph.D. student, Animal Science. Research: Trade-offs with the intensification of goat systems in India.

Ms. Shiuli Vanaja, Ph.D. student, Applied Economics and Management. Research: Household level effects of AguaClara piped water system in Jharkhand.

Ms. Vidya Vemireddy, Ph.D. student, Applied Economics and Management. Research: TBD.

Ms. Gargi Wable, Ph.D. student, Division of Nutritional Sciences. Research: TBD..

TCI INTERNS (SUMMER 2015)

Ms. Michaela Brown, B.S. candidate, Food Science

Ms. Amruta Byatnal, M.P.A. candidate, Cornell Institute for Public Affairs

Ms. Rebecca Chew Min Ting, B.S., Chemical Engineering

Ms. Uttara "Tara" Gadde, B.S., Human Biology, Health & Society

Ms. Dora Heng, B.A., Economics

Ms. Samyuktha Kannan, M.S. candidate, Applied Economics and Management

Mr. John Lowry, B.S. candidate, Biology; B.A. candidate, Government

Ms. Olivia Obodoagha, B.S., Applied Economics and Management

Mr. Wenhai Yang, B.A., Economics & Computer Science & Mathematics

TCI POST-DOCTORAL FELLOWS

Dr. Mathew Abraham, Post-Doctoral Associate. Research: Understanding farmer oroducer organizations in India.

Dr. Julia Felice, Post-Doctoral Associate. Research: Nutrient availability and accessibility.

Dr. Asha Narayan Sharma, Post-Doctoral Associate. Research: Agricultural impacts of climate change.

TCI VISITING FELLOWS

Dr. Yanping "Roger" Liu, Associate Professor from NanKai University, China

Dr. Ravula Padmaja, Senior Scientist-Gender Research, ICRISAT, India

Dr. Shoba Shetty, Practice Manager - Agriculture and Rural Development, South Asia Region, World Bank

Dr. Jeena Srinivasan, Fulbright Scholar and Associate Professor, Centre for Economic and Social Studies, India

TCI FACULTY FELLOWS

Dr. Debbie Cherney, Department of Animal Science

Dr. Mark Constas, Dyson School of Applied Economics and Management

Dr. Jere Haas, Division of Nutritional Sciences

Dr. Bruce Lewenstein, Department of Science & Technology Studies | Department of Communication

Dr. Harold van Es, Soil and Crop Sciences, School of Integrative Plant Science

Dr. Michael Walter, Department of Biological and Environmental Engineering

Dr. Monroe Weber-Shirk, School of Civil and Environmental Engineering

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- Design: **Bill Akunevicz Jr.**
  DragonFish Studio - www.dragonfishstudio.com

ENDNOTES

1. A detailed description of Figure 1 can be found in Pingali, Ricketts and Sahn (2015).
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9. Chand and Srivastava (2014): "Changes in the Rural Labour Market and Their Implications for Agriculture", Economic and Political Weekly, Vol. XLIX (10), pp. 47–54.

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