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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 collaboration through programs that promote 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 from our program, is making major contributions to our understanding of the microworld of India. In November this year, TCi was awarded a US$1.4 million grant by the Bill & Melinda Gates Foundation to spearhead the 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.

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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 prioritized our applied research along four such pathways:

1. **The income pathway,** where gains in household income can translate to better food affordability and overall impact.
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 stabilize food allocation among individuals within a common household, as well as improve early childhood care practices.
4. **Nutrient absorption through improvements in the health environment pathway,** which links access to clean water and improved sanitation/hygienic 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 employment and income—and challenges faced by 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 with the ability to influence food supply pathways, and encourage nutrient absorption and positive nutrition behavior. Other mediating factors influence household income, micronutrient availability, nutrient absorption and utilization, and household food allocation.

### Nutrition

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 vitamin and micronutrient availability, nutrient absorption, and household food allocation. 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

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**Figure 1: TCi Conceptual Framework**

[Map of TCi Conceptual Framework with pathways and stakeholders]
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
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-1990s and many have advanced explanations for this puzzle.

The existing malnutrition literature in India, while confounders in arriving at their estimates. By comparing evidence across quadrants, our analysis relates to each other and which have the strongest with a sense of how the pathways we have identified it illuminates individual factors that determine to our four interlocking pathways (shown in Figure 2) that are generally considered to are less amenable to policy intervention in the short term, they are critical and need to be simultaneously addressed in the long term.

We also highlight the exceptional importance of sibling birth-order effects and the intra-household the use of toilets. 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 2010. 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 highlight recent research that shows that extending daily supplementary undernutrition. 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.

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Multi-sectoral pathways for improved nutritional outcomes

**HOUSEHOLD FOOD ACCESS (Quantity, quality and diversity of foods)**

Quadrant 1: Overall Economic

Quadrant 2: Intra-Household allocation of resources

Quadrant 3: Access to Micronutrients & diverse data

Quadrant 4: Access to Water, Sanitation, & Hygiene

**INIVIDUAL NUTRITION OUTCOMES**

Improved Nutritional Outcomes

**MULTISECTORAL PATHWAYS FOR IMPROVED NUTRITIONAL OUTCOMES**

**QUADRANT 1:**

- Overall Economic

**QUADRANT 2:**

- Intra-Household allocation of resources

**QUADRANT 3:**

- Access to Micronutrients & diverse data

**QUADRANT 4:**

- Access to Water, Sanitation, & Hygiene

By comparing evidence across quadrants, our analysis establishes important findings. For instance, we highlight recent research that shows that extending daily supplementary 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 2015. 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 highlight recent research that shows that extending daily supplementary undernutrition. 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.

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

**REFERENCES**

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 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 TCG Scholar Soumya Gupta led our research focused on women’s empowerment in agriculture dietary diversity, and iron outcomes (iron intake 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 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 grain) 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.

Women’s Empowerment in Agriculture Index (WEAI)

Respondents: Index male and female from each household

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<th>Sub-indices</th>
<th>Component(s)</th>
<th>Details</th>
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<td>5-domains of empowerment (SDE)</td>
<td>Production Resource Income Leadership Time</td>
<td>Each domain, equal weight – 0.5 SDE; 0.4 – Empowered if SDE 0.80</td>
</tr>
<tr>
<td>Gender Parity Index (GPI)</td>
<td>Gap in SDE scores of women relative to men</td>
<td>0.5 GPI</td>
</tr>
<tr>
<td>WEAI</td>
<td>Weighted sum of SDE &amp; GPI</td>
<td>WEAI = 0.9<em>SDE + 0.1</em>GPI</td>
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The WEAI has five sub-indices: 1. Land ownership (in order of importance: landless, food crops, cash crops); 2. Inland and household income (including cash crops and non-cash crops); 3. Status (of women, in order of importance: landless, food crops, cash crops); 4. Leadership (in order of importance: landless, food crops, cash crops); and 5. Gender Parity Index (GPI) (in order of importance: landless, food crops, cash crops). The final composite score is calculated as follows: WEAI = 0.9*SDE + 0.1*GPI, where SDE is the sum of the scores of the four sub-indices.

Household Survey

Survey activity: Agriculture & allied activities

Component(s): Agriculture & allied activities

Details: Male & female

Maternal dietary intake

Survey activity: 24-hour dietary diversity score

Component(s): 24-hour semi-quantitative food-frequency questionnaire

Details: Female

Socioeconomic status

Survey activity: Socioeconomic status

Component(s): Male & female

Details: Children if any (≤ 5 years)

Household food security

Survey activity: Iron study

Component(s): 5ml blood sample

Details: Female

Maternal health history

Survey activity: Iron-status

Component(s): Hemoglobin

Details: Female

Anthropometry

Survey activity: Weight & height

Component(s): Weight & height

Details: Female

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

Sample size: 960 households, 24 villages

Respondents: 1 Male & 1 female interviewed from each household

Survey activity: Anthropometry

Component(s): Iron-status

Details: Female

Figure 3

Figure 4

See Table 1 for a listing of the sub-indices and their details.
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 the 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 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.
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 assumed 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). To gain an understanding of whether nutrient deficiencies exist in the Indian food supply, it is necessary to evaluate the nutrient content of foods 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 its 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.

The minerals: iron and zinc

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—e.g., infants, children, and pregnant and lactating women—for whom adequate fat intake is particularly important.

**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 lower 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...
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.
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. 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-1960s 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. Consequently, production of fruits and vegetables has expanded (albeit slowly) in southern and eastern regions.
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...
Development Action (PRADAN) (a respected Indian non-governmental development organization) but also our implementation partner Professional Assistance for Rural Development (PARD) (a stated policy priority of the Modi government), TCi recommends that implementing agencies continue to examine, in particular, potential women’s empowerment outcomes when they have access to the piped water.

Inside the water tower with Cornell-trained AguaClara engineers Maysoon Sharo and Sarah Long (top row) with TCi’sorious Koderma model (bottom row).

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. Farmers also require payment for non-market transactions costs for smallholder integration into non-staple grain markets. Disequilibrium pricing in input and output markets is therefore promoting diversification. Market development investments can equip a diverse socioeconomic group of farmers (including smallholders) to participate in relevant markets and thereby manage the problem of famine, the diet diversity needs of the middle class and the poor alike are not adequately addressed. Policy action taken after the 2008 food price crisis makes 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.

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Due to the historic success of agricultural policy in ensuring adequate quantities of staple grains 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.

In particular, as toilet construction projects are constrained by financial resources and regulatory institutions that can equip a diverse socioeconomic group of farmers (including smallholders) to participate in relevant markets and thereby promote diversification. Market development investments can equip a diverse socioeconomic group of farmers (including smallholders) to participate in relevant markets and thereby manage the problem of famine.

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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 investments are needed at creating an “enabling environment” that includes institutions that encourage private sector investment in infrastructure 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 equip a diverse socioeconomic group of farmers (including smallholders) to participate in relevant markets and thereby manage the problem of famine).
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’s work 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 provides 80% of the country’s rainfall and is indeed to the national psyche, is obvious to anyone who happens across Indian news media in the summer months: Y et surprisingly few studies have quantified its importance to the economy, and the nutrients that crops need to grow into healthy and nutrition security hinges critically on 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. 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, whereas most research so far has focused on smaller regions or cousin subnational studies, 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 formats in which they are presented. 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.

Effects of climate variability on agriculture

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 would 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.
The first step in protecting soil resources is quantifying and 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 that can be used to assess critical soil functions, identify constraints, and develop appropriate management practices based on measurable conditions of the soil.

Initial field visits to Jharkhand were completed in 2015 to see first-hand the Cornell Soil Health training workshop at the Cornell campus in August 2015, and increase awareness of soil health among farmers, as PRADAN, who have the essential role of transferring knowledge shared will improve the efficacy of our 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.

The TCi will continue to focus on developing 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 scaling up our soil health 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 agricultural extension officers from PRADAN and one academic researcher (a professor at Birla Institute of Technology and Science, Pilani) 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. The 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 Sciences 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.

The TCi Scholar Phil Frost and TCi Regional Coordinator Lal Thangchol taking first soil sample.

Final 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 partnered with 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 soil types (upland, middle upland, lowland, and wetland). 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.

The project involves four main phases—an awareness or business 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 microminute 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 select women’s self-help groups (SHGs) for implementing the technology. MSU Baroda will be involved in tracking the changes in the nutritional status of communities in the project location. The project involves piloting a supply chain for making micronutrient sachets available to women that will be assessed.

The TCi Scholar Phil Frost and TCi Regional Coordinator Lal Thangchol taking first soil sample.

The TCi project involves piloting a supply chain for making micronutrient sachets available to women. The women’s federation will be assessed and 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.

The TCi Scholar Phil Frost and TCi Regional Coordinator Lal Thangchol taking first soil sample.
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 are also federated organizations 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 actors. 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 mobilization, 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 graduation 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.

In the summer of 2015, TCi placed an intern, Ms. Samyuktha Kannan, in the field to study SHGs involved in community mobilization programs in agriculture and nutrition and identify characteristics that make some SHGs more effective than others in undertaking this role.

As TCi researchers observed in the field, there is skepticism is not unfounded. In India today you will find SHGs involved in a range of community activities, from cleaning of village property 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 success and 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 economic function to adopt a larger role in the community.

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PROMOTING BEHAVIOR CHANGE FOR IMPROVED NUTRITION

A vital part of the TCG’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 the impact of SHGs 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 methods 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. Ashok 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.
BEYOND 2015: PLANNED RESEARCH AND ACTIVITIES
The Bill & Melinda Gates Foundation has awarded a US$13.4 million grant to the TC to help amplify the nutrition profile of agriculture in India. This new funding will allow the TC 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 programs, policies, and projects. 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 funding will allow the TC 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 programs, policies, and projects. 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 Foundation (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 TC, 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 and rural development 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 agricultural projects that they fund.

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

GOAL: A MORE NUTRITION-SENSITIVE FOOD SYSTEM (Improved access & Affordability to Diet Diversity & Quality)

Objective 1: Agriculture Projects Explicitly Incorporate Nutrition Outcomes

- Increased Demand for Nutritional and Enhanced Production System Diversity
- Women’s Self-Help Groups Empowered
- Seasonal Food Deficits Reduced
- Nutrition Sensitive Metrics Adopted and Used

Objective 2: Agricultural Policies Promote Availability and Affordability of Food Diversity and Quality

- Increased Smallholder Supply of Nutrient-Rich Food
- Improved Affordability of Diet Diversity for the Rural Poor
- Convergence of Agricultural and Nutrition Efforts in State Programs

Objective 3: Leadership and Capacity to Institutionalize Nutrition-Sensitive Agriculture in India

- Increased Appreciation and Political Commitment for Linking Agriculture and Nutrition
- ‘Center of Excellence’ Established and Self-Sustained
- ‘New Framework’ on Access & Affordability to Diet Diversity & Quality
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.

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%. 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 or housewives 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 and 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. Moreover, 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 work 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 to invest in training to help them overcome impediments to finding work.
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. 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.
countries. Without livestock, there would be no manure to enrich the cornfield, milk to consume in the home, or additional income in a gender-biased system in which replacement of livestock is a contentious issue for 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 TGs 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, 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 that arise, and thereby evaluate some of the factors that influence the performance of these initiatives. At the TCG, 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 some 2,000 FPOs (with about 1,000 members each) in 2015-16. Considering the common areas. To address this perception, TCG 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.

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 TCG 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 the role 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.

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, and the willingness of farmers to adopt technologies that can help livestock extension workers suggest meaningful recommendations for improving livestock feed systems based on input parameters.
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Dr. Mathew Abraham, Post-Doctoral Associates. Research: Understanding farmerproducer organizations in India.

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

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