



# ANNUAL REPORT 2020-21

TATA-CORNELL INSTITUTE  
FOR AGRICULTURE AND NUTRITION



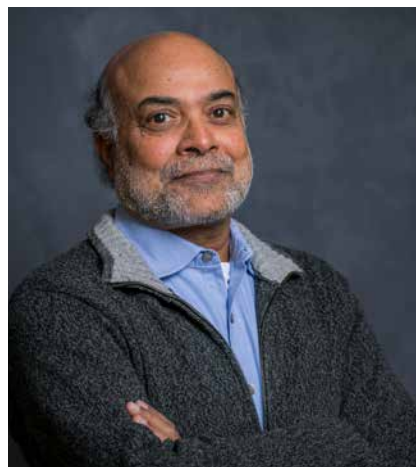


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# DIRECTOR'S NOTE



The last eighteen months have been challenging due to the enormous and unprecedented effects that COVID-19 has had on all our lives. TCI offices at Cornell University in Ithaca and in India were closed in March 2020, with staff working

remotely and meeting regularly on Zoom. Our staff in India had to face a horrific second wave of the pandemic this year. We are fortunate that we are coming out of this crisis without any loss of life among the TCI family. Our students and staff have shown incredible resilience and an uncanny ability to stay focused on their work despite all odds.

We have been actively monitoring the impacts of the pandemic on food systems, food prices, and food security. A dedicated section of our website catalogs our pandemic-related studies and blog posts, which have been widely read and cited. Our report on the impact of public health lockdowns on food prices in Indian metros was one of the most popular on our website over the past year and a half.

We had a record number of graduates during the 2020 and 2021 graduation cycles: seven PhDs and four master's degrees across the two years. These graduates represent the broad reach of the TCI program across the Cornell campus, with three from applied economics; two from international nutrition; one from soil science; one from plant pathology and plant-microbe biology; one from food science and technology; and three from international development.

Several of our students had to reimagine their work given the restrictions on travel and field research. I am happy to

report that they are all on track to finish their academic work on schedule. They are continuing in the TCI tradition of producing research outputs that are outstanding in terms of scientific rigor while providing solutions to problems faced by rural communities across India.

TCI has also seen record publications in the 2020-21 time period. We published twelve articles in leading peer-reviewed journals such as *PNAS*, *PLOS One*, *World Development*, *Food Policy*, *Agricultural Systems*, and others. Our 2019 book, *Transforming Food Systems for a Rising India*, has been downloaded more than 120,000 times as of June 1, 2021, and is helping reshape the discussion on food, agriculture, and nutrition policy in India.

TCI has been fortunate to have strong partners and collaborators in the donor community and among the academic and NGO communities in India. The TARINA consortium, which has been supported by the Bill and Melinda Gates Foundation for the past six years, has helped scale our efforts promoting a nutrition-sensitive food system in India. I would like to thank our consortium partners—BAIF, CARE-India, GDS, and IFPRI-South Asia—for their collaboration and commitment to enhancing nutrition security. TCI has also been fortunate to build new partnerships with the Walmart Foundation for studying the efficacy of farmer producer organizations and with the Government of Denmark for identifying technology priorities for Indian agriculture.

As we come out of the COVID-19 crisis, I am excited to get back on the ground and to focus TCI's research, extension, and policy advocacy on long-term solutions to the chronic problems of rural poverty and food and nutrition security in India. I hope you enjoy reading our 2020-21 Annual Report.

A handwritten signature in black ink, reading "Prabhu Pingali".

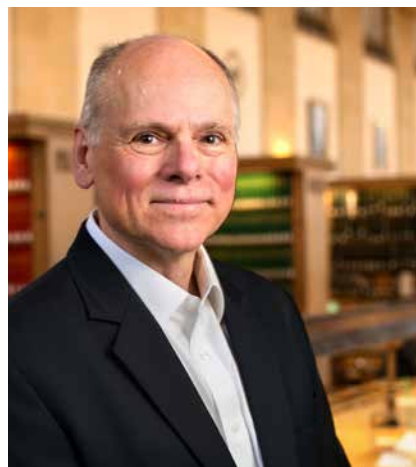
Prabhu Pingali  
Founding Director, TCI





# MESSAGE

## FROM FORMER GALS EXECUTIVE DEAN MAX PFEFFER



It is with great satisfaction that I reflect on the extensive accomplishments of the Tata–Cornell Institute for Agriculture and Nutrition after just seven years. Key to this level of success is Professor Prabhu Pingali, who

has provided excellent leadership. Of course, he depends on the strong support of his excellent staff, and we must acknowledge their steadfast commitment to TCI and its programming.

TCI's work is important and supports the overall mission of Cornell University and the College of Agriculture and Life Sciences in creating and disseminating knowledge with public purpose. TCI reflects this mission in its efforts to secure a bright future for the world's children by reducing food insecurity, and in doing so, inspires optimism throughout the university.

Key to TCI's success is its interdisciplinary approach to addressing problems of poverty, malnutrition, and rural development in India, and this mission aligns with efforts across the university to successfully feed the world's growing population in the 21st century. With TCI's support, our faculty, staff, and students address global challenges such as food security. TCI's initiatives build on more than a century of Cornell partnerships to improve food systems around the world. And as we look to a future in which food security and development-related issues in the era of climate change are at the forefront of the global agenda, I believe TCI's role will only grow more prominent.

I am confident that TCI and all those associated with it will contribute significantly to improving the lives of some of the world's neediest people. I commend TCI for its growth and continuing success, and I congratulate all those associated with TCI for what you have accomplished. I wish you all the very best for continued success.

Professor Max J. Pfeffer  
College of Agriculture and Life Sciences  
Cornell University

# BY THE NUMBERS

As of June 2021

9  
Researchers

3  
Postdoctoral  
Associates

13  
TCI  
Scholars

6  
Faculty  
Fellows

19  
Alumni

13  
PhDs  
Earned

5  
Master's  
Degrees Earned

10  
Academic  
Disciplines

3  
Reports

3  
Books

28  
Journal  
Articles

12  
Book  
Chapters

15  
Policy  
Briefs

2  
Training  
Manuals



# OUR WORK

**TCI is a long-term, multidisciplinary research initiative focused on creating and assessing innovative, food systems-based approaches to improving nutrition and livelihoods in India and other developing countries.**

## **Agriculture Transformation, Food Systems & Nutrition Transition**

India's ongoing transformation from low-productivity agriculture to an advanced economy has profound implications for nutrition in the country. TCI research explores the impact of these changes to help India's food systems adapt and adequately provide for the shifting needs of its people.

## **Markets & Value Chains**

Rising demand for diverse agricultural products presents an opportunity for smallholder farmers to improve their livelihoods. TCI research aims to identify and address barriers that limit small farmers from accessing value chains and markets, empowering them to enhance their incomes and welfare.

## **Gender & Nutrition**

In India, 80 percent of economically active women are employed in the agricultural sector, with many performing unpaid household labor. TCI seeks to improve nutrition outcomes by understanding how women's empowerment at the community and household levels helps to bolster positive nutritional behaviors and improved intrahousehold access to food.

## **Food Safety, Water & Sanitation**

Nutrient absorption is significantly impacted by interrelated factors involving food contamination, access to safe water, and hygiene. TCI research in these areas aims to inform effective interventions that ensure that families and individuals can enjoy the full nutritional benefits of the foods they eat.

## **Food & Ag-Science Innovations ICTs, Data Systems & Ag-Tech**

Building food systems that prioritize nutrition requires leveraging the latest scientific advancements in areas like soil health and fortification. TCI researchers and scholars bridge the gaps between research and implementation through awareness-building, technology, and knowledge transfer.

Information and communication technologies and other technological inventions can boost agricultural productivity and improve livelihoods, while strong, comprehensive data systems help ensure that policies and strategies are built on a foundation of solid evidence. TCI explores how new technologies can enhance food systems while working to build and improve databases and platforms.



*TCI Scholar Anna David Thottappilly conducts a group interview with participants in a goat-rearing program in Munger, Bihar. The TCI Scholar Program places an emphasis on field-based research. (Photo courtesy of Anna David Thottappilly).*



# COVID-19

## TCI's Work Continues throughout the Pandemic

The year 2020 was anything but normal. As it did with all aspects of life, COVID-19 disrupted the work of TCI. Yet, despite the lockdowns, travel bans, and quarantines, the Institute continued to advance its research, finding new ways to operate in abnormal times.

“While we are putting the safety and health of our staff and scholars first, we are changing the way we do things in order to continue doing our important work in support of nutrition-sensitive food systems,” TCI Director Prabhu Pingali said.

### Research Shifts to Coronavirus Impact

As COVID-19 struck India and the government implemented a strict lockdown, TCI researchers took actions to analyze the impact of public health measures on the country's food systems and the workers they employ.

TCI published a study of the effects of lockdown measures on food prices, entitled “Pandemic Prices: Price Shocks from COVID-19 and Their Implications on Nutrition Security in India.” The study showed that India's rigorous lockdown drove up the price of produce, potentially limiting people's ability to afford a nutritionally diverse diet.

TCI analyzed the average weekly prices of cereal grains, vegetables, pulses (the edible seeds of plants in the legume family, such as beans and peas), and eggs in eleven major metropolitan cities across India, between March 1 and May 31, comparing them to the 2019 prices and the weeks before the lockdown.

Supply chain disruptions caused the prices of vegetables, pulses, and eggs to rise, but the price of cereals remained

relatively stable, in large part due to government policies that support their production and supply chains. While prices eventually stabilized, the price of pulses remained stubbornly high, even twelve weeks after the lockdown.

While lockdowns disrupted agriculture, TCI researchers also assessed potential opportunities for farmers brought about by pandemic-related disturbances. Supply chain interruptions, for example, gave a boost to digital agriculture supply chain ecosystems. Start-ups that directly connect food producers with business and consumers fared well after the lockdown, as did online grocery shopping outfits. Farmers also increased direct sales during the pandemic by selling their products at farmers' markets or at housing society gates.

Researchers also reviewed the impact of mass reverse migration on India's agricultural economies. The nationwide lockdown led to a sudden mass exodus of millions of migrant workers from cities back to rural areas, depressing the remittance economy and flooding rural labor markets with out-of-work laborers. While the government took steps to help these migrants, TCI researchers warned that marginalized, impoverished populations could be adversely affected.

With the wide-ranging impacts of COVID-19 bringing the importance of agriculture, food, and nutrition into sharp focus, TCI called on Indian policymakers to reboot the country's agricultural policy in favor of nutritious, sustainable crops.

### Zoom PhDs

Aside from redirecting some of TCI's research focus, COVID-19 also impacted the TCI scholars working toward



*A woman shops for produce at the Shyambazar Market in Kolkata, India, during the nationwide COVID-19 lockdown. (Photo by Indrajit Das CC-BY-SA-4.0).*

their doctorates. With the Cornell University campus shut down during the spring 2020 semester and social distancing measures in place long after, classes moved online. Scholars in the United States were unable to travel to India to conduct research, and those in India were unable to be in the field.

For scholars with established, ongoing studies in India, data were disrupted for a time and slow to be collected. Some who had been in the planning stages of their research projects elected to use existing data sets collected by past scholars. Still others are using technology to conduct fieldwork from afar. TCI Scholar Vanisha Sharma, for example, is conducting phone surveys of farmers in rural Telangana to study the role of social media in agricultural technology adoption.

Even scholars who had completed their field research were affected. Some defended their dissertations over Zoom.

Shiuli Vanaja was the first to do so. While she intended to be in Ithaca to take her final exam in person, she instead presented years of work over the spotty Internet connection in her Delhi apartment.

“I wanted to present my thesis in person, to explain it in detail and answer questions while looking at the faces and expressions of my committee members, so, participating in my exam remotely was quite a different experience,” Vanaja said. “But I am happy to say that it went well, and I was able to interact with my committee members and answer their questions satisfactorily.”

Since the start of the pandemic, seven TCI scholars have earned their PhDs, demonstrating the resilience with which the Institute has met this unprecedented challenge.



# AGRICULTURE

## TRANSFORMATION, FOOD SYSTEMS & NUTRITION TRANSITION

### Achieving Zero Hunger through Food System Diversity

In August 2020, TCI published *Food, Agriculture, and Nutrition in India 2020: Leveraging Agriculture to Achieve Zero Hunger*, a report mapping opportunities for India to reduce hunger and improve overall nutrition by reorienting its agricultural policies in favor of more nutritious foods. The report also assessed the prospects for enhancing productivity and increasing farm income across India and emphasized the need for continued investment in agricultural infrastructure.

Since the late 1960s, India has made considerable progress in reducing hunger in terms of calories, but many people remain undernourished, and now, the country is also facing rising rates of obesity. The report noted that this is due to government policies that have boosted staple grains, like wheat and rice, to help meet people's caloric needs, but are now inhibiting the production of more diverse and nutritious foods.

*[G]overnment policies...boosted staple grains, like wheat and rice, to help meet people's caloric needs, but are now inhibiting the production of more diverse and nutritious foods*

Using data from the District-Level Database for Indian Agriculture and Allied Sectors, a comprehensive data platform jointly developed by TCI and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the report showed that undernutrition is concentrated in the economically lagging and less agriculturally productive states in central and eastern India, while obesity is

mostly an issue in the more developed and agriculturally productive states in the northwest and south.

The report also featured detailed maps showing the dominant crops grown in different areas and offered advice for increasing productivity and diversifying local food systems.



*Eating a diverse diet is associated with improved nutritional outcomes. (Photo by Mayur Deshpande/Unsplash).*

For example, for the cropping systems of eastern India—which are less productive due to poor infrastructure and agroclimatic conditions—the report recommended adopting less water-intensive crops, such as pulses, coarse cereals, and oilseeds.

Enhancing agricultural productivity is particularly important in the lagging states. As the report detailed, states that failed to invest in agriculture during the Green Revolution of the 1960s were left with weak agricultural sectors and high levels of poverty.

Since the lagging states are unlikely to match the productivity of staple-grain agriculture in developed states, the report recommended focusing efforts on adding

more diverse crops like pulses, coarse grains, fruits, and vegetables. With investment from the public and private sectors, farmers could take advantage of the growing demand for these crops, which can be sold at higher prices than staple crops.

TCI launched the report with a special virtual panel event, which was viewed by nearly 1,000 people, including academics, researchers, government officials, and development experts. To date, the report has been downloaded more than 350 times.

The report is the first in an anticipated series from TCI. Future reports will provide updates on progress toward a hunger-free India.

### Urbanization Increases the Risk of Rural Obesity

For developing countries like India, the transition from subsistence agriculture to modernized economies brings



*Aspects of urban lifestyles, including eating unhealthy fast food, increase the risk of obesity. (Photo by Paul Prescott/Shutterstock).*

economic opportunities but also precipitates a nutrition transition, which can exacerbate overnutrition even as it alleviates undernutrition. According to a TCI study published in *World Development*, the urbanization of rural areas in India is closely associated with a rise in rural obesity rates, which disproportionately impacts lower socioeconomic classes.

*Women who live in villages near cities with populations of 50,000 or more are four times more likely to be at risk for obesity.*

Urbanization is a primary driver of economic development in rural areas. However, cities typically provide greater access to processed foods, and fast-paced urban lifestyles place a premium on time, which make people more likely to eat out or choose unhealthy, precooked foods. These changes in consumption patterns contribute to an increased risk for obesity, thus raising the incidence of noncommunicable diseases like diabetes.

Using India's 2015–16 National and Family Health Survey, TCI alumna Anaka Aiyar, Postdoctoral Associate Andaleeb Rahman, and Director Prabhu Pingali calculated body mass index scores for women living in rural areas and estimated the distance between towns and village clusters where the women live. They found that when the distance between cities and rural villages decreases by one kilometer, the risk of obesity among women increases by 0.06 percent. At the national level, approximately 3,000 rural women become at-risk for obesity for each kilometer of reduction in rural–urban distance.

The size of the urban center in question is particularly consequential. Women who live in villages near cities with populations of 50,000 or more are four times more likely to be at risk for obesity.



Socioeconomic status also plays an important role. Lower income groups and those with lower levels of education are increasingly vulnerable to obesity.

One bright spot is that high dietary diversity—the number of different food groups from which a person eats—appears to mitigate the impact of proximity to cities. As India's rural areas continue to be transformed and its cities grow, ensuring access to affordable, healthy foods will be key to keeping obesity in check.

“India's Rural Transformation and Rising Obesity Burden,” Anaka Aiyar, Andaleeb Rahman, and Prabhu Pingali, *World Development*, Volume 138, 2021

## Food Systems Book Has 120,000 Downloads

*Transforming Food Systems for a Rising India*, TCI's 2019 book, which explored the various challenges and opportunities to achieve a nutrition-secure future for India, has been downloaded more than 120,000 times.

Published by Palgrave Macmillan and written by TCI Director Prabhu Pingali, Postdoctoral Associate Anaka Aiyar, Assistant Director Mathew Abraham, and Postdoctoral Associate Andaleeb Rahman, the book explored various challenges and opportunities to achieving a nutrition-secure future through diversified production systems, improved health and hygiene environments, and greater individual capability to accessing a balanced diet, all contributing to an increase in overall productivity.

The authors brought together the latest data and scientific evidence to map out the current state of food systems and nutrition outcomes in India. They placed India within the context of other developing country experiences and highlighted India's status as an outlier in terms of the persistence of high levels of stunting while following global trends in obesity.

This book discusses the policy and institutional interventions needed for promoting a nutrition-sensitive food system and the multisectoral strategies needed for simultaneously addressing the triple burden of malnutrition in India.

*Transforming Food Systems for a Rising India* can be downloaded for free at: [tci.cornell.edu/?publications=transforming-food-systems-for-a-rising-india](https://tci.cornell.edu/?publications=transforming-food-systems-for-a-rising-india)

## Other Publications

As of June 2021, TCI researchers published twelve journal articles and four book chapters in 2020-21, in addition to two self-published reports.

To view all TCI publications, visit: [tci.cornell.edu/publications/](https://tci.cornell.edu/publications/)



## STAFF SPOTLIGHT



### Bhaskar Mittra

TCI Director Prabhu Pingali calls Bhaskar Mittra “our anchor in India.” Without him, it would be difficult for TCI to work in the country.

TCI's associate director, Mittra played a central role in the Institute's early formation. In

2013, he and Pingali traveled nearly 2,000 km by road—across the breadth of India—to understand the country's various communities, the challenges that they faced, and which issues TCI should prioritize.

To prepare the ground for TCI's work in India, Mittra built partnerships with local organizations to assist with fieldwork. He also set up systems to hire support staff and procure equipment and space for research projects.

“Setting up those initial systems took a bit of time,” Mittra said. “Those were not easy days.”

Today, Mittra oversees all of TCI's research work in India, from TCI scholars conducting field studies to the Institute's ambitious TARINA project. The Tata Institute for Social Sciences in Mumbai, which houses the TCI Secretariat in India and where Mittra is a faculty member, provides important administrative and management support for many of the activities.

Mittra is in regular contact with researchers in the field to learn about what problems they may be facing and figure out how they can be overcome. “I've been on my toes, because new challenges evolve, and you have to find ways out of those problems,” he said.

Mittra balances his problem-solving duties with his own research, which focuses on agricultural production systems and markets. During the COVID-19 lockdown in the summer of 2020, he studied the impact that lockdowns had on agricultural arrivals and commodity prices.



# MARKETS & VALUE CHAINS

## Promoting Successful Farmer Producer Organizations

With demand for agricultural products on the rise, small farms have an opportunity to benefit from the growing opportunities. However, due to their size, small farms have an inherent disadvantage in accessing product markets, credit, management inputs, and technology. Aggregation models such as farmer producer organizations (FPOs), in which smallholders collectively access technology, agricultural inputs, and markets, can aid agricultural development and poverty reduction by rectifying disadvantages in economies of scale.

TCI sees FPOs as essential to smallholder agricultural development and food security. With funding and support from the Walmart Foundation, TCI is increasing its research focus on their promotion, with a focus on the aggregation model experience in India and Mexico. As part of this effort, TCI plans to expand the ambit of its Center of Excellence in New Delhi to support FPO promotion. The Center will serve as a repository of learning, information, and knowledge for the advancement of FPOs in India.

*The Center of Excellence [for Indian FPOs] will play a role as a much-needed platform to aid the development and promotion of aggregation models in the Indian context.*

A central part of the Center of Excellence for Indian FPOs is a comprehensive FPO database containing collated and visualized information from various sources on a single interactive platform. With data on more than 4,400 FPOs promoted in India since 2003—including location, activities, strength, and financial performance—the database will be

an invaluable resource for information related to FPOs in India.

The Center of Excellence will play a role as a much-needed platform to aid the development and promotion of aggregation models in the Indian context, ultimately helping smallholder farmers become more productive and improve their livelihoods.

## Preventing Food Loss to Boost Fruit and Vegetable Availability

As India struggles to produce enough fruits and vegetables to meet its population's dietary needs, food loss is an urgent issue. Globally, an estimated 14 percent of food is lost as it moves from the farm to wholesale markets. Led by TCI alumna Jocelyn Boiteau, TCI is working to address knowledge gaps in estimating food loss along perishable vegetable supply chains in India to inform effective loss prevention strategies.



*Crates of tomatoes are auctioned at the Madanapalle wholesale market. (Photo by Jocelyn Boiteau/TCI).*

Using data collected from surveys with smallholder farmers and tomato traders in Chittoor district, Andhra Pradesh, and with vegetable traders and vegetable retailers in Hyderabad, Telangana, Boiteau studied the extent and stages of food loss along tomato supply chains. Novel to this study, surveys were completed at the time of harvest, auction, and day-of-sale, providing detailed and context-specific information on factors that affect food loss.

*At the Madanapalle tomato wholesale market, where most farmers sell their tomatoes, farmers lose an average of 2 percent of tomatoes after grading and sorting.*

Boiteau found that farmers incur the most loss, particularly at the farm level. Forty-six percent of harvests observed in the study involved postharvest food loss. Among these harvests, farmers lost an average of 11 percent of their harvested tomatoes, most often due to quality deterioration from pests or disease. At the Madanapalle tomato wholesale market, where most farmers sell their tomatoes, farmers lose an average of 2 percent of tomatoes after grading and sorting.

In contrast, tomato and vegetable traders lose less than 1 percent of the tomatoes that they trade. Vegetable retailers lose an average of 2 percent of tomatoes after sorting out those that will not be sold.

Boiteau's findings provide important insights that will enable further analysis of the determinants of food loss, particularly at the farm level. A clearer picture of where and why food loss occurs will help develop food loss prevention strategies to increase fruit and vegetable availability.

## Improving Diets through Market Access and Production Diversity

Dietary diversity—the number of different food groups from which foods are eaten on a regular basis—is an important marker for nutrient adequacy and improved health



*Having access to a diverse array of foods at local markets enables households to eat more diverse diets. (Photo by Kiera Crowley/TCI).*

outcomes, especially in developing countries like India, where people in rural areas often subsist on diets of mostly cereal grains that lack important micronutrients.

TCI researchers are investigating how dietary diversity can be improved in the Indian context. In a study published in the *Food and Nutrition Bulletin*, they showed that market access—the ability of households to buy nonstaple foods at local markets—is associated with improved dietary diversity.



The study also revealed that on-farm production diversity, as measured by conventional markers like the number of crops or food groups grown at the field level, had no significant effect on diet diversity. However, an expanded measure of on-farm production diversity, which includes field-level production of pulses, livestock management, and kitchen gardens, had a positive impact, though not as big an effect as market access.

*[M]arket access—the ability of households to buy nonstaple foods at local markets—is associated with improved dietary diversity.*

The expanded definition of production diversity was meant to account for the rice–wheat cropping system prevalent where the study was conducted. This reflects the importance of nonstaples in improving both individual and household dietary diversity in cereal-centric cropping systems.

Other significant determinants of dietary diversity include women’s literacy and awareness of nutrition.

“Market Access, Production Diversity, and Diet Diversity: Evidence From India,” Soumya Gupta, Naveen Sunder, and Prabhu Pingali, *Food and Nutrition Bulletin*, Volume 41, Issue 2, 2020

Based on these results, TCI researchers recommend that the Indian government should implement policies to ensure the availability and affordability of nonstaple foods at local markets and develop transportation infrastructure in rural areas to improve access to markets. They also recommend that the government implement policies to promote and support livestock rearing, in addition to developing programs to educate rural households about nutrition.



While not as significant as market access, TCI research shows that an expanded conception of on-farm production diversity that includes the production of pulses, kitchen gardens, and livestock management has a positive impact on dietary diversity. (Photo by Maureen Valentine).

The study used data from TCI’s Technical Assistance and Research for Indian Nutrition and Agriculture baseline survey, which collected data from 3,600 households in Bihar, Uttar Pradesh, and Odisha.



# ALUMNI SPOTLIGHT



## Vidya Vemireddy

Since graduating with her PhD in applied economics and management, Vidya Vemireddy has continued her research at one of India’s top universities. Vemireddy is an assistant professor at the Indian Institute of Management Ahmedabad (IIMA), where she teaches MBA- and PhD-level courses on food and agribusiness.

As a TCI scholar, Vemireddy’s research focused on how women’s time allocation in agricultural work affected their nutritional outcomes. Vemireddy conducted multiple surveys across seasons in the Chandrapur district of Maharashtra, India, and standardized 502 local recipes to calculate nutrient intake. Her analysis revealed that during peak seasons, when women are most involved in agricultural work, their nutrient intake decreased.

At IIMA, Vemireddy is continuing to work with the data she collected at TCI. She is currently examining how women’s workloads affect their body mass index. She is also working on a research project focused on women’s perceptions and use of labor-saving agricultural technologies.

The experience of doing fieldwork with TCI has proven to be extremely useful for Vemireddy’s career and ongoing research, teaching her valuable project management skills and providing her with insight into the issues facing people in rural areas.

In fact, Vemireddy’s research focus on women’s time use came directly from her experience in the field.

“When I did my formative fieldwork, I visited villages, and as I was talking to people, I realized that time was a constraint,” she said. “I started looking and found that this was a serious research gap that had not been addressed.”

The opportunity to do fieldwork was an important factor in her decision to join TCI, as was the interdisciplinary make-up of the TCI team, which she said creates a synergy that helped advance her own research.

“It’s a multidisciplinary group, where scholars from different backgrounds come together for a common objective, which is broadly addressing agricultural and nutritional linkages,” she said.



# GENDER & NUTRITION

## Indian Women Eat Less Diverse Diets

It is widely accepted among researchers and policymakers that women in India eat less diverse diets than other members of their households. As a result, they often fail to meet their nutritional needs, negatively affecting not only their own health, but the health of their children.

In a study in the *Food & Nutrition Bulletin*, TCI Research Economist Soumya Gupta, alumnus Naveen Sunder, and Director Prabhu Pingali provided empirical evidence of the dietary diversity gap faced by Indian women. Strikingly, the gap is due to women not eating foods from some of the most nutrient-rich food groups.

Using survey data collected from three states, the researchers showed that women eat fewer foods from different food groups than their family members. In nearly a quarter of the households surveyed, women consumed foods from at least one fewer food group than their household. Crucially, the differences in dietary diversity are concentrated in micronutrient-dense food groups, like dairy, meat/fish/poultry, green leafy vegetables, and vitamin A-rich fruits and vegetables. In other words, while households may have access to some nutritious foods, many women are not eating them.

*In nearly a quarter of the households surveyed, women consumed foods from at least one fewer food group than their household.*

By providing evidence of the female nutrition gap, this research underscores the importance of considering gender when formulating nutrition strategies. By targeting policies toward key populations, like women, programs can



Data collected by TCI researchers shows that Indian women eat less diverse diets than their households. (Photo by Evgeny Nelmin/Unsplash).

yield the biggest “bang for the buck.” Focusing nutrition policies on women multiplies their impact, because advantages accrued by women of childbearing age have intergenerational benefits through improved child health.

“Are Women in Rural India Really Consuming a Less Diverse Diet?” Soumya Gupta, Naveen Sunder, and Prabhu Pingali, *Food and Nutrition Bulletin*, Volume 41, Issue 3, 2020

## Birth Spacing Decreases Stunting

Stunting, or low height-for-age, afflicts more than 141 million children around the world, forty million of whom are in India. The nutrition-related condition has significant and long-lasting implications for children’s well-being, leaving them vulnerable to disease and at risk of impaired cognitive ability.

Although there is considerable evidence showing that birth order influences stunting, new research from TCI reveals that the time between births may be more consequential.

In a study published in the *Proceedings of the National Academy of Sciences of the United States of America*, TCI Postdoctoral Associate Sunaina Dhingra and Director Prabhu Pingali found that children born after the first child are typically shorter for their age, but when children are born at least three years after their older siblings, the height gap between them disappears.

*[W]hen children are born at least three years after their older siblings, the height gap between them disappears.*

A mothers’ body needs time after birth to replenish key micronutrients, so getting pregnant again too quickly may reduce the nutrients available to the fetus and limit milk production. Having children too close together also makes it more difficult for parents to devote adequate time and resources to each child.



According to TCI research, waiting at least three years between births can reduce the likelihood of stunting. (Photo by Kreative Studios/Shutterstock).

India’s family planning policies have focused on lowering population growth and postponing pregnancy to improve maternal health outcomes. While the overall fertility rate has fallen as low as 2.1, there has been little progress increasing the period between births. In 2015, approximately 60 percent of women surveyed waited less than the recommended period of three years between children.

The TCI study, which was reported by news outlets, including the *Times of India*, shows that placing a greater focus on sufficient birth spacing in maternal and child nutritional policies and public health programs could help to prevent stunting.

“Effects of Short Birth Spacing on Birth-Order Differences in Child Stunting: Evidence from India,” Sunaina Dhingra and Prabhu Pingali, *Proceedings of the National Academy of Sciences of the United States of America*, Volume 118, Issue 8, February 2021

## Migration’s Impact on Rural Households

Across India, as many as 450 million people migrate from their homes in search of work. Most of these migrants are men from rural areas who send remittances back to their families. TCI alumna Vidya Bharathi Rajkumar worked to understand how male labor migration affects the families left behind and women’s roles in agriculture in rural India.

Often, male migration leaves women to take on more work on the farm, with implications for productivity. Using data from a nationally representative household survey, Rajkumar found that, following male migration, women are increasingly likely to report taking on the role of farm manager. This change is concentrated among women in migrants’ nuclear families and among women in North India, a region with relatively strict gender norms.



Because these women typically have less control over production assets and limited access to technical know-how and credit opportunities, the increase of female farm managers could have a negative impact on farm productivity. Rajkumar found that about a third of the reduction in profits can be attributed to having a female farm manager.

*[F]ollowing male migration, women are increasingly likely to report taking on the role of farm manager.*

Rajkumar’s research also examined the effect of parental migration and remittances on the education and health of children left behind. She found that a father’s migration and remittances improve child-specific educational expenditures and time spent on schooling. Remittances, by serving as an additional source of income, also have a positive bearing on child health and are specifically associated with improvements in children’s weight and reductions in the prevalence of diarrhea.

Given the scale and importance of migration in a country like India, Rajkumar’s research demonstrates the need for policies to better understand and account for migration’s impacts on farm productivity, gender equity, and child well-being.

### Dowry Prohibition Increases Educational Investments

Education has long been shown to positively impact nutritional outcomes, rendering household investments in schooling an important piece of India’s malnutrition puzzle.

TCI Scholar Natasha Jha’s research explores the influence of social norms and gender bias on household investments

in human capital. Specifically, she is studying the impact that dowries have on educational attainment of siblings in a household.

Using data from the 1999 Rural Economic and Development Survey, Jha finds that the decrease in dowry payments after the 1985–86 amendments to the Dowry Prohibition Act—which increased the severity of punishments under the law—corresponded with an increase in household investment in education.

Jha’s research has implications for understanding the impacts of human capital investment of similar magnitude and timing, such as investment in tertiary education, which could ultimately inform policies that improve long-term nutritional outcomes through enhanced educational attainment.

## ALUMNI SPOTLIGHT



### Vidya Bharathi Rajkumar

Vidya Bharathi Rajkumar earned her PhD in applied economics and management in 2021. Her research focuses on the impact of male migration on agriculture and children’s welfare.

Fascinated by human behavior and driven by a desire to improve people’s lives, Rajkumar decided to specialize in development economics.

“I am inspired by the idea of applying economic principles to conduct research that will improve the lives of the underprivileged,” she said.

This inspiration also led Rajkumar to study migration, a significant but understudied phenomenon in India.

“Migration can affect the migrant-sending households in several ways,” she said, “including farm production and profitability, food security, human capital investments in health and education, gender equity, and so on.”

Like many TCI scholars, she joined the Institute because of the breadth of the research that it is involved in.

“It has been a rewarding experience to work with and learn from a motivated and diverse network of scholars,” Rajkumar said.



# FOOD SAFETY

## WATER & SANITATION

### Mitigating Mycotoxin Exposure

Dietary exposure to mycotoxins—harmful chemicals produced by fungi—is associated with cancers, cirrhosis, immune deficiencies, and growth impairment, but smallholder farmers in India and elsewhere typically lack the capacity to detect and eliminate sources of the risk. As a TCI scholar, Anthony Wenndt researched mycotoxin contamination in food systems throughout India, identifying key risk factors that can be used to develop effective mitigation efforts.

In a study published in *PLOS One*, Wenndt and coauthors from Cornell University and ICRISAT developed a novel approach to modeling mycotoxin exposure risk using household-level risk factors surveyed in Uttar Pradesh, Bihar, Odisha, and Telangana. They determined that food system composition, storage technology, food hygiene, and a household's farming status all contributed substantially to the risk of exposure. Compared to more conventional models, which largely focus on landscape-scale agroclimatic variables, Wenndt's model demonstrates potential to inform practical, local solutions more effectively.

Wenndt's fieldwork in Unnao, Uttar Pradesh, revealed that mycotoxin contamination is pervasive across villages, crop species, and seasons. As expected, highly susceptible commodities, such as maize and groundnut, yielded the highest toxin loads, both in terms of toxin levels and the frequency of toxin contamination. Rice and sorghum had lower levels of contamination, but the frequency of high contamination levels was significant enough to warrant substantial public health concern.

In response to these concerns, Wenndt established a farmer research network that successfully mobilized more than 200 smallholder households in participatory

intervention programs. Installation of hermetic (airtight) grain storage systems yielded a 99 percent success rate in preserving participants' grain against spoilage and pest infestation. As a result of capacity-building efforts spearheaded by the network in Unnao, participants are



Storing crops like groundnuts in burlap sacks leaves them at risk of mycotoxin contamination. (Photo by Anthony Wenndt/TCI).

now familiar with principles of collective action, are better equipped to undertake food safety diagnostics, have better access to technology via local markets, and continue to monitor grain spoilage in their communities.

Wenndt also investigated the risk of dietary and breast milk mycotoxin exposure among infants and lactating women. A study, which he coauthored and published in *Maternal & Child Nutrition*, revealed that 41 percent and 93 percent of human breast milk and animal milk samples, respectively, collected in Haryana, India, were contaminated with aflatoxin M1, a potent mycotoxin. All lactating mothers and a substantial fraction (41 percent) of infants exceeded tolerable daily intake levels for aflatoxin, corresponding to observed high levels of aflatoxin contamination in key staple foods.

Wenndt's revelations of the dynamics of exposure risk have set the stage for continued work toward identifying effective strategies for ameliorating the mycotoxin burden.

### Clean Water Is Key to Nutrition

Providing people with access to affordable, nutritious food is only one step in improving nutrition outcomes. In countries like India, where the majority of people lack access to piped water in the home, waterborne diseases often interfere with people's ability to absorb nutrients from the food they eat.

TCI is working to improve access to clean drinking water in rural India. Led by TCI alumna Shiuli Vanaja, TCI research examines how rural Indians choose water sources and the impact of piped water in the home.

Using data that she collected in thirty villages from two districts of Jharkhand, Vanaja's research shows that when objective information about water quality is lacking, perceptions of quality based on the color and taste play a significant role in the choice of a water source. Households in her study were willing to pay, on average, \$4–\$68 per month for improvements to perceived quality based on taste and \$2–\$40 per month for improvements based on the color of the water.

Vanaja also found that while choosing safe water sources improves the quality of water that a household consumes, contamination can still happen at home. Households that use water filters and practice frequent handwashing have significantly better water quality and are at a lower risk of diarrhea.

In addition to her study of water sources and quality, Vanaja conducted a yearlong field survey to measure the time spent in water collection across seasons. The survey

included six villages, three of which were provided with solar-powered, piped-water systems from TCI partner AguaClara. She found that households with piped water saved roughly 60 minutes per day on water collection, which increased the time women spent in their primary occupation by 20 percent per day.

This research reveals that providing access to clean drinking water can have important effects beyond nutrition and general health, but that development projects aimed at providing clean water must account for people's perceptions of water quality and promote good hygiene practices like handwashing.

*[D]evelopment projects aimed at providing clean water must account for people's perceptions of water quality and promote good hygiene practices like handwashing.*

### Delivering Safe Water to Rural India

The partnership between TCI and AguaClara Reach continues to bear fruit in India, where water disinfection systems were installed in two villages in Odisha. The new Hydrodoser systems were inaugurated in the villages of Patimul and Majhi Ukhura in spring 2020, providing safe drinking water to approximately 260 people.

The Hydrodoser is a hydraulic chemical-dosing system, developed by AguaClara Cornell, which delivers an accurate amount of chemicals to raw water, without using electronics, sensors, or pumps. The systems are designed to be sustainable for the villages, costing around \$1–2 per household per month.



AguaClara Reach partners with development organization Gram Vikas to install the Hydrososers in Odisha.



AguaClara water disinfection systems installed with the support of TCI provide safe drinking water to more than 2,000 people in India. (Photo by Shiuli Vanaja/TCI).

Community members are intimately involved in the process from the start. Local masons build concrete stands that allow the systems to function using gravity, and community members help to install some of the plumbing that connects the disinfection system to the existing water systems. Gram Vikas also works with village water and sanitation committees to establish tariffs that will pay for the maintenance of the systems.

According to AguaClara Reach India Program Project Manager Fletcher Chapin, bringing the community into the process is crucial for long-term success.

“You can build the technology anywhere, but you really need a community that’s supportive and wants to maintain and operate the water treatment system afterward,” Chapin said.

TCI began its partnership with AguaClara Reach in 2014 to bring their safe water technology to Jharkhand, India, providing safe water to more than 2,000 people there and facilitating TCI research on water, sanitation, and hygiene. To date, AguaClara Reach has built systems in three villages in Odisha, serving about 460 people in total.



# ALUMNI SPOTLIGHT



**Naveen Sunder**  
Naveen Sunder, who received his PhD in economics from Cornell University in May 2019, did not join TCI until midway through his graduate studies, but even after graduating, he is still contributing to TCI’s research. Now an assistant professor of economics at Bentley University, Sunder has coauthored several papers in collaboration with other TCI researchers.

Since graduating from Cornell, Sunder has been working with TCI Research Economist Soumya Gupta and Director Prabhu Pingali on a series of papers. One such analysis explored the relative nutritional impacts of on-farm production and market purchases and was published in the *Food and Nutrition Bulletin* in June 2020. Two additional papers, for which he partnered with Gupta and Pingali, explore the gender gaps in diet diversity and the role of women’s education in improving the quality of diets in rural India.

“These papers build upon work I did as a TCI scholar,” Sunder said. “Using detailed information on diets of people in four Indian districts, we explore various aspects of diet diversity in rural India and produce evidence-based learning that can inform future policies.”

While most scholars join TCI from the first day of graduate school, Sunder took a different path. As a PhD student in the economics department, he attended some TCI events and later worked as a research assistant with Pingali before becoming a scholar. As a scholar, he worked on a diverse set of topics, including the intergenerational effects of enhanced education opportunities, the long-term effects of early marriage, and the determinants of diet diversity.

“TCI provides an amazing and unique platform for researchers from disciplines as diverse as economics, plant science, soil sciences, and nutrition to come together and critically discuss various approaches to strengthening food systems in India and across the world,” Sunder said. “This allows young researchers like me to develop a holistic understanding of food systems and fosters dialogue and cooperation between academics from different domains.”



# FOOD

## & AG-SCIENCE INNOVATIONS

### Curbing Vitamin A Deficiency through Biofortification

Orange-fleshed sweet potato has shown great promise toward reducing vitamin A insufficiency in the diet when introduced to rural communities in developing regions, as an easy-to-cultivate crop and a tasty, affordable, healthy food. Although it has been successfully introduced in East Africa, where white-fleshed varieties of sweet potato are regularly consumed, Indian consumers have little to no experience with the tubers.

From 2017 to 2019, TCI alumna Kathryn Merckel conducted a randomized controlled trial in North India—where vitamin A deficiency is a well-documented public health concern—to determine if agricultural promotion alone of orange-fleshed sweet potatoes is sufficient to build knowledge of and demand for them, or if nutritional education is required as well.

Merckel's research reveals that the promotion of the sweet potatoes, both with and without integrated nutrition messaging, holds promise for improving the diets of North Indian rural communities. Relative to control villages, all intervention villages in the study were observed to have significantly increased knowledge about vitamin A, orange-fleshed sweet potato, and proper infant and young child feeding practices. These increases led to a significant and meaningful increase in demand for the sweet potatoes, with 85 percent of households in intervention villages reporting that they would buy them if they were available in their market.

Despite this market opportunity, farmers faced serious agricultural constraints, especially the availability of land and pressure from pests.

These findings reveal a tremendous opportunity to introduce orange-fleshed sweet potatoes in the South



Children taste orange-fleshed sweet potato at an event organized as part of Kathryn Merckel's study in North India. (Photo by Kathryn Merckel/TCI).

Asian context. Investment in agricultural markets—particularly, access to appropriate inputs and solutions to land constraints—can facilitate meeting the high demand for sweet potatoes, especially vitamin-A rich orange-fleshed varieties. Continued work to build consumer demand for such micronutrient-rich crops through nutrient-sensitive agriculture interventions is pivotal to ensuring food systems are enabling healthy diets for all

### Using Microalgae to Address Iron Deficiency

With around 600 million people suffering from iron deficiency, India pays a steep price in terms of mortality, disability, and lost productivity. Fortifying staples like wheat has long been considered a cost-effective public health approach to reducing iron deficiency, but ideal sources of iron that can be effectively utilized in food products have proven elusive.

TCI is exploring an innovative approach to curbing iron deficiency by fortifying wheat flour using a byproduct

of the biofuel industry. Widely consumed and available through India's Public Distribution System, wheat flour is an ideal vehicle for fortification.

Research conducted by TCI alumnus Rohil Bhatnagar focused on using defatted green microalgae called *Nannochloropsis oceanica* as a source of iron. With 3,530 mg of iron per kg, the microalgae compares favorably to other iron sources in terms of bioavailability, which means more of it can be absorbed and used by the body.

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The bioavailability of iron from the microalgae was confirmed in a lab study conducted with iron-deficient mice. Mice that were fed a diet that included microalgae-extracted iron had improved hemoglobin levels and a twofold increase in iron storage in the liver, compared to an iron-deficient control group.

Bhatnagar also conducted a safety assessment of continuous microalgae consumption, since having excess iron in the body adversely affects health. In the study, mice fed high levels of microalgae did not experience any negative effects, such as oxidative stress, iron bioaccumulation, or inflammation.

While the microalgae has an unpleasant fishy aroma and off-putting green color, in-home sensory tests, using algae-fortified flour to make flatbreads, show that encapsulating the microalgae in emulsions sufficiently masks both color and taste.

This work provides a novel approach to combatting iron malnutrition and exhibits the vast potential of microalgae as an effective and safe source for fortification.

### Improving Nutrition during Weaning

Ensuring good nutrition during weaning can help set a child on the path of good health and development. Yet, when it comes time to wean babies from breast milk or formula, many parents reach for puffed cereal snacks that, while convenient, offer little nutritional benefit at a time when children's protein requirement is at its peak.

TCI Scholar Bindvi Arora is developing an alternative puffed snack that can offer all the conveniences of puffed cereals with the added benefit of protein. Using supercritical fluid extrusion technology, Arora is turning milk protein into easily handled puffs that dissolve in the mouth, similarly to the traditional starch-based variety.

Extrusion-based cooking involves exposing food mixtures, typically starches, to high pressure and temperature, causing them to puff and crisp up. Traditional steam-based methods require high temperatures that can damage sensitive nutrients. Supercritical fluid extrusion occurs at lower temperatures, allowing the puffs to retain their nutritional value.

*Using supercritical fluid extrusion technology, Arora is turning milk protein into easily handled puffs that dissolve in the mouth.*

This research is making significant steps toward developing nutritious, easily eaten foods for toddlers who may be at risk for undernutrition during the weaning process.



# Improving Farm Yields through Comprehensive Soil Health

Soil degradation, resulting from poor land management practices such as the overuse of fertilizers, can worsen farm productivity. Yet, across India, efforts to improve soil quality have focused almost exclusively on chemical properties, ignoring the physical and biological processes that make soils dynamic and complex living systems.

To improve productivity in Bihar, where rice and wheat yields are well below the national average, TCI is spearheading the use of a comprehensive assessment of soil health that measures 15 properties, representing physical, biological, and chemical processes. A more complete understanding of soil health is vital, as rising demand places India's farmlands under pressure to bear increasing yields, especially in areas where low-input farming is the norm.

*A more complete understanding of soil health is vital, as rising demand places India's farmlands under pressure to bear increasing yields, especially in areas where low-input farming is the norm.*

TCI Scholar Kavya Krishnan is examining how soil health, land management, and cropping systems interact with each other to affect yield. Her study of long-term, controlled agricultural trials gives greater insight into the impact of soil health in building diverse, resilient cropping systems.

Preliminary results suggest that differences in fertilizer application do not appear to influence any of the soil health indicators, but additions of crop residue and organic

amendments appear to increase labile carbon and soil protein. Labile carbon is an energy source for microbes that help maintain a healthy soil food web, and protein plays an important role in the storage and release of organic nitrogen.



*TCI's Soil Health Project promotes a holistic conception of soil health that considers chemical, physical, and biological properties. (Photo by Talukdar David/Shutterstock).*

Krishnan is also exploring low-cost, quick methods for predicting soil health using mid-infrared spectroscopy. This can improve the speed and efficiency of data collection in India, where the need for complete and accurate information to drive policy is crucial.

## Understanding the Soil-Human Health Connection

Soil health impacts farm productivity, but it can also play a role in human health.

In 2020, TCI alumna Fatma Rekik completed a study to help understand how soil health affects human health through nutrition. She specifically examined soil-to-human mineral

transmission through rice by collecting and analyzing samples of soil, rice, and human hair (a bioindicator of long-term nutrition) in Jharkhand, India.

Soil-to-human nutrient transmission has rarely been studied on a household level, and when it has, studies have looked at only one or two minerals.

Rekik's study included the analysis of twenty-two minerals and utilized TCI's comprehensive approach to soil health, which addresses its physical, biological, and chemical attributes.

Her research reveals that soil health is reflected nutritionally in both rice and in humans. The associated benefits of physical and biological soil health for humans includes increased availability of essential nutrients, like manganese, calcium, and cobalt, as well as decreased presence of potentially toxic elements such as lead.

By demonstrating that healthy soil yields important nutritional benefits to humans, this research provides important insights for efforts to reduce micronutrient deficiencies.

## Research Shows Extended Impact of Soil Health Project

Investments in soil health infrastructure have boosted TCI's efforts to improve soil health in India, as evidenced by the work of two doctoral candidates at the Dr. Rajendra Prasad Central Agricultural University (DRPCA) in Bihar, who presented studies using the comprehensive assessment developed as part of Institute's Soil Health Project.

Developed for use on Indian lands by TCI and researchers in the Soil and Crop Sciences Section at Cornell University, the comprehensive assessment tests the physical, biological, and chemical properties of soil.

The students were trained to use the assessment at a DRPCA soil health lab created as part of TCI's efforts to build infrastructure for soil health testing.

TCI Scholar Kavya Krishnan led a series of workshops to teach students, faculty, and other researchers how to use specialized lab equipment to conduct the fifteen tests that comprise the assessment.

The students used the assessment to study the impact on soil health of different agroforestry systems and the effects of organic and inorganic amendments on rice productivity and nutrient uptake.

TCI's Soil Health Project endeavors to increase agricultural productivity, reduce malnutrition, and improve the environment in rural India through soil health enhancement.

## Turning Farm Waste into Furniture

Every fall in northern India, farmers burn the stubble or straw that remains in the field after paddy is harvested, contributing significantly to air pollution in the region. TCI is supporting an effort to upcycle rice stubble into inexpensive, green composite panels that can replace commonly used wood products like particleboard and plywood.

A team led by Cornell University Professor Anil Netravali is developing a process through which chemically treated rice straw is blended with jute or nonwoven fabrics to form mats. The mats are then layered with plant-based resins and hot-pressed into desired shapes.

The composite panels can be engineered to meet a variety of properties for different uses.





A member of Professor Anil Netravali's team operates the needle-punching machine that helps form mats out of rice straw and jute fabrics. (Photo by Abdullah Alkandary).

The entire process is water-based, uses relatively little energy, and can be easily transferred to India for large-scale production. In addition to creating technical and manufacturing jobs, production would also create demand for rice stubble, providing farmers with an additional revenue source.

Netravali's process also eliminates the formaldehyde-based resins used to make particleboard and wood-based products, which release carcinogenic off-gases.

By creating a profitable alternative to stubble burning, this innovative product has the potential to significantly improve air quality while improving the livelihoods of smallholder farmers.

## Measuring Capacity for Crop Innovation

As part of the Feed the Future Innovation Lab for Crop Improvement, a United States Agency for International

Development project spearheaded by researchers at Cornell University, TCI is evaluating the capacity of national breeding programs to deliver genetic gains to improve productivity and nutrition in East and West Africa, South Asia, and Latin America.

The Innovation Lab is designed to uplift breeding programs by increasing their capacity to access and utilize innovative tools, technologies, and methods. The program aims to enhance the potential of national programs to develop improved crops that are marketable, resilient to stresses and environmental conditions, and are aligned with the needs and preferences of stakeholders across the value chain.

TCI's role is to understand how various institutional factors influence the setting and achievement of crop-improvement goals, as well as how the implementation of innovative tools, technologies, and methods translates into the potential for genetic gains.

Institutional capacity in breeding programs comprises diverse resources and skills tied to human capital, technological access, and institutional management. TCI is working to characterize the roles played by these various drivers in executing sound, sustainable, and effective breeding activities across a range of crops and product profiles.

TCI will work closely with breeding programs to develop specific indices to conceptualize institutional capacity opportunities and gaps.

## SCHOLAR SPOTLIGHT



### Bindvi Arora

A PhD candidate in food science, TCI Scholar Bindvi Arora's research centers on the development of a milk-based, protein-packed puffed snack for weaning babies.

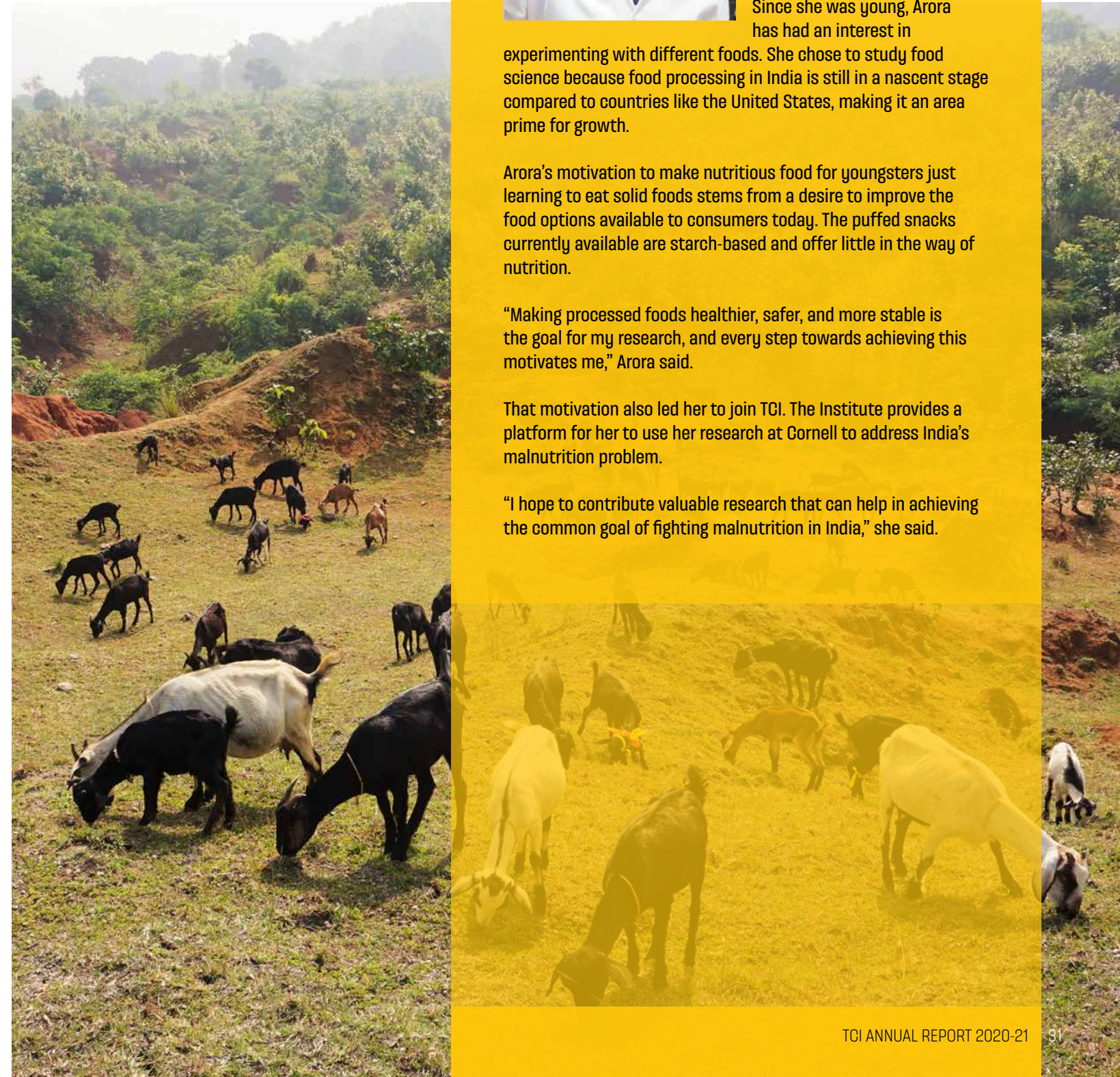
Since she was young, Arora has had an interest in experimenting with different foods. She chose to study food science because food processing in India is still in a nascent stage compared to countries like the United States, making it an area prime for growth.

Arora's motivation to make nutritious food for youngsters just learning to eat solid foods stems from a desire to improve the food options available to consumers today. The puffed snacks currently available are starch-based and offer little in the way of nutrition.

"Making processed foods healthier, safer, and more stable is the goal for my research, and every step towards achieving this motivates me," Arora said.

That motivation also led her to join TCI. The Institute provides a platform for her to use her research at Cornell to address India's malnutrition problem.

"I hope to contribute valuable research that can help in achieving the common goal of fighting malnutrition in India," she said.





# ICTS, DATA SYSTEMS & AG TECH

## Databases Enable Greater Food Systems Research

To design the most effective interventions and policies to improve nutrition, good data are paramount.

As an institute focused on long-term research, TCI is dedicated to making data accessible that are needed by researchers, policymakers, and others interested in advancing agriculture and nutrition. In addition to the data collected as part of its field-based research studies, TCI is also invested in developing data platforms that facilitate further research.

In 2019, TCI and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) unveiled an improved and expanded District-Level Database for Indian Agriculture and Allied Sectors.

*[T]hese two platforms will empower researchers and policymakers alike to dig deeper into India's food systems to gain a better understanding of the factors driving trends in nutrition and agriculture.*

Researchers and policymakers have long struggled to find geographically disaggregated data on a host of indicators related to India's food systems and growth patterns. ICRISAT had collected disaggregated agricultural data but only from 1966–2011 and based on 1961 district boundaries that have since changed. The TCI–ICRISAT project helped to collect data from 2011–2015 and expanded the data to include a more comprehensive set of variables related to food and agriculture systems, including impacts on consumption, nutrition, income, and poverty reduction.

The new database brings together data for 571 districts in twenty states. Crucially, the data have been “apportioned” to control for the creation of new districts and changes to district boundaries, empowering researchers to look at the diversity in growth patterns across India from a historical perspective.

The database was vital in the creation of one of TCI's newest reports, *Food, Agriculture, and Nutrition in India 2020: Leveraging Agriculture to Achieve Zero Hunger*. The database allowed TCI researchers to show differences in malnutrition from district to district and to create maps of the dominant cropping systems in each district.

With support from the Walmart Foundation, TCI is also creating a new database for Indian farmer producer organizations (FPOs). While FPOs are an important tool for increasing agricultural productivity and enhancing smallholder farmers' livelihoods, stories of FPO success are rare, and data on the thousands of FPOs in India are not centrally available.

TCI's Database for Indian FPOs brings together data on thousands of FPOs on an accessible platform to facilitate greater research on small-farm aggregation models. The database includes variables related crops grown, compliance, revenue, sponsoring agencies, and more.

By making important data centrally available and easily accessible, these two platforms will empower researchers and policymakers alike to dig deeper into India's food systems to gain a better understanding of the factors driving trends in nutrition and agriculture.

## Can Social Media Influence Digital Ag-Tech Adoption?

India's internet revolution is a potential boon to the country's agricultural communities. An increasing number



*Smartphone apps that offer agriculture-related tools and services can help farmers improve productivity. (Photo by Dipak Shelare/Shutterstock).*

of mobile phone apps now perform a wide gamut of productivity-boosting functions, from satellite-based weather forecasting and yield estimation to machine-learning-derived agricultural advisory services.

However, awareness and adoption of these applications is still relatively low and concentrated in certain geographic regions, such as urban and suburban areas. This is due to several factors, including the availability of mobile phone network towers, internet accessibility, and mobile phone literacy.

TCI seeks to understand the drivers of app usage to expand their uptake by farmers. TCI Scholar Vanisha Sharma is studying how social media networks, such as the messenger service WhatsApp, influence the adoption of agricultural phone apps. Sharma's research could reveal a pathway for increasing agricultural productivity through web-based technology.

## Moving Ag-Tech beyond Yield Enhancement

With India poised to become the most populous country in the world by 2030, increasing agricultural productivity to end hunger and malnutrition poses a major challenge. In the 1960s, agricultural technology in the form of high-yielding varieties of wheat and rice were instrumental in helping India achieve food security in terms of calories. Technology will again play a critical role in achieving nutrition security, but the approach will be different from the Green Revolution.

In a study funded by the Royal Embassy of Denmark in New Delhi, TCI is exploring how agricultural technology can be moved beyond increasing yield to address important factors like environmental challenges posed by climate change; the shifting focus of food systems to focus on consumer demands, with an emphasis on food quality; the disadvantages that smallholder farmers face in accessing and implementing technology; and the changing role of the private and public sectors in delivering these technologies.

The study focuses on developing a technological approach to the supply side of the food system that involves activities related to plant breeding, farm management, marketing systems, and harvest and postharvest storage and preservation practices.



# TARINA

## Cementing TARINA's Legacy

Technical Assistance and Research for Indian Nutrition and Agriculture (TARINA) is a TCI-led consortium that connects policy-focused researchers with impact-focused nongovernmental organizations and development partners to address malnutrition by promoting a diversified food system, which enhances the availability and affordability of nutrient-rich foods in India. TARINA has built a wealth of evidence from interventions carried out in Bihar, Odisha, and Uttar Pradesh, such as encouraging the creation of kitchen gardens and empowering women through self-help groups. Now in its fifth year, TARINA aims to use that experience to build larger, sustainable programs and influence national and state policy.



TARINA's kitchen garden program is being adopted by a number of government offices in Odisha. (Photo by Mathew Abraham/TCI).

## Scaling Up Initiatives

In Odisha, where a TARINA initiative successfully promoted the growth of kitchen gardens to provide nutritious foods to households, the Department of Women and Child Welfare

is implementing its own program based on that project to ensure affordable, year-round access to nutrient-rich food groups like fruits and vegetables.

*In Bihar, TARINA is collaborating with the JEEViKA platform and forty-four Krishi Vigyan Kendra operating statewide to expand its crop diversification initiative beyond the initial intervention district.*

With technical support and capacity building from TARINA, the department established gardens at 10 Anganwadi centers in Kandhamal district. The initiative complements the hot-cooked meals served at the centers to enhance children's diets in a cost-effective manner.

TARINA has developed and shared with the department a strategy to take the initiative statewide.

TARINA is also helping the Department of Scheduled Caste and Scheduled Tribe Welfare to implement a garden initiative in residential schools to provide nutrient-rich foods to vulnerable populations.

Also, in Odisha, TARINA is working with the Department of Women and Child Welfare and Mission Shakti to implement a program based on TARINA's Nutrition Gender Toolkit, which uses social behavior change communications to improve age- and gender-specific nutrition outcomes. An effort will also be made to include nutrition within the overall framework of Odisha Livelihood Mission, which aims to create economic opportunities for impoverished rural communities.

In Bihar, TARINA is collaborating with the JEEViKA platform (the local name given to the Bihar Rural Livelihoods Project) and forty-four Krishi Vigyan Kendra (government-sponsored agriculture research and extension centers) operating statewide to expand its crop diversification initiative beyond the initial intervention district, where it has resulted in a considerable increase in the number of farmers who have diversified production to include nonstaple crops like pulses, vegetables, oilseeds, and biofortified crops. TARINA is providing technical assistance to improve the capacity of the Krishi Vigyan Kendra and JEEViKA platforms, share best practices, and help devise strategies to overcome contextual constraints at district and village levels. TARINA is also using its experience with food and nutrition metrics to improve the monitoring and evaluation systems of the Krishi Vigyan Kendra and JEEViKA platforms.

## Making Efforts Sustainable

Elsewhere, TARINA aims to turn its successful trial interventions into sustainable programs. One such intervention is TARINA's introduction of vitamin-A-rich, orange-fleshed sweet potatoes in the Maharajganj District of eastern Uttar Pradesh. TARINA is now working with the State Rural Livelihood Mission to integrate that initiative into its programs and activities to promote further production of the nutritious tuber as both a field and kitchen garden crop.

*Across Bihar, Odisha, and Uttar Pradesh, TARINA created nearly 500 self-help groups to empower women in a range of agricultural activities, such as water use and goat rearing.*



TARINA's women's self-help groups help empower women in a range of agricultural activities, such as goat rearing. (Photo by Maureen Valentine/TCI).

TARINA will share its cumulative knowledge from the intervention and provide technical support in the form of agricultural best practices, training modules for farmers, awareness- building modules, recipe books, and sweet potato vines for initiating cultivation. TARINA will also provide capacity building for field-level staff and extension workers.

Across Bihar, Odisha, and Uttar Pradesh, TARINA created nearly 500 self-help groups to empower women in a range of agricultural activities, such as water use and goat rearing. TARINA is now working to integrate these groups into long-term programs operated by various private and public stakeholders, including government-sponsored





TARINA is working with government bodies in Bihar to expand its successful crop diversification efforts. (Photo by Mathew Abraham/TCI).

programs, like the Odisha Livelihood Mission, Uttar Pradesh State Rural Livelihood Mission, and JEEViKA.

For example, in Bihar, TARINA is working closely with the Krishi Vigyan Kendra and JEEViKA platforms to expand the cultivation of kitchen gardens to improve food availability and increase the self-reliance of community-based women's collectives.

## Building Bodies of Evidence

To support more informed policymaking, TARINA invests in surveys to understand underlying trends related to nutrition and agriculture.

One such survey conducted in Bihar and Maharashtra aimed to understand the benefits of farmer producer organizations (FPOs) for smallholder farmers, as well as the

factors that contribute to FPO success. The interim findings suggest that there are very few successful FPOs in Bihar, compared to Maharashtra. This is true, even after the state government and federal agencies have promoted hundreds of them over the last few years.

In collaboration with the Indian Council of Agricultural Research, TARINA is analyzing the survey data to inform national- and state-level policy discussions.

TARINA also commissioned a survey to identify constraints to and entry points for interventions to encourage behavioral change related to cropping system diversification in Odisha. The survey includes individual- and group-based behavioral constraints to adoption of production diversification, particularly, moving from rice-fallow cultivation to post-paddy pulse and vegetable farming.

The study results will be used to make policy recommendations for minimizing constraints on crop diversification in the state.

*With the expertise and research products of its Center of Excellence, TARINA has worked toward building the capacities of stakeholders—including partner development agencies and grassroots organizations—in the areas of program implementation, behavior change, and technical inputs for better program delivery*

capacities of stakeholders—including partner development agencies and grassroots organizations—in the areas of program implementation, behavior change, and technical inputs for better program delivery.

TARINA is particularly focused on building capacity for monitoring and evaluating food, agriculture, and nutrition programs. The consortium has conducted nine different trainings, aimed at empowering staff from government departments, corporate social responsibility units, and nongovernmental organizations, to better utilize metrics for monitoring and evaluation in agriculture and food systems.

In Uttar Pradesh, TARINA evaluated the government's Million Farmer's Scheme, which aims to empower a million farmers to grow more high-value crops and engage in related activities to increase their incomes. Based on its evaluation, TARINA suggested a number of policy-relevant action points for inclusion in the training modules used by extension workers involved in the program, such as using simple but innovative approaches to information dissemination and the provision of technical knowledge about new crops. The state government is working toward incorporating the TARINA's suggestions into the state program.

## Increasing Stakeholder Capacity

One of TARINA's core objectives is to build a cadre of leadership and improve the capacity of key players in nutrition-sensitive agriculture.

With the expertise and research products of its Center of Excellence, TARINA has worked toward building the



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