



# ANNUAL REPORT 2022-23

TATA-CORNELL INSTITUTE  
FOR AGRICULTURE AND NUTRITION



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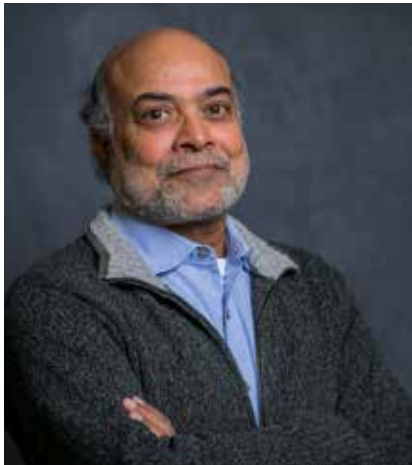
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# DIRECTOR'S NOTE



The 2022–23 academic year was auspicious for the Tata–Cornell Institute (TCI), as we marked the 10th anniversary of our founding. Throughout the year, we brought guest speakers to Cornell University and celebrated the

accomplishments of the previous decade, culminating in a two-day academic conference. The conference reminded us of the innovative food systems research being done across the world and its capacity to effect change. I am proud that TCI is doing its part in this regard to improve food systems in India.

While we spent the last year celebrating past accomplishments, our current work has continued apace. In 2022–23, two TCI scholars earned PhDs and one earned an MS. Three new students joined the program. There are 13 scholars currently in the program. This interdisciplinary group of young researchers is doing impressive work, as you will read about in the pages of this report.

Our researchers and alumni network continue to add to the vast academic literature related to food systems. TCI-affiliated researchers published five journal articles and two book chapters in the past year. TCI also self-published one report and one special policy briefing.

Our work on environmental sustainability in particular has progressed considerably. The Zero-Hunger, Zero-Carbon Food Systems project is well on its way to producing recommendations for reducing greenhouse-gas emissions associated with agriculture in Bihar. Meanwhile, a new

project, Transformation of Agricultural Systems for Climate Resilience, promises to highlight pathways for diversifying Chhattisgarh's agricultural system in favor of more nutritious, climate-sensitive alternatives to rice. We hope that these two projects will help to shape the future of sustainable Indian food systems.

We also embarked on a new research project on the True Cost of Food Subsidies in India. The project utilizes true cost accounting to reveal the hidden impacts of India's Public Distribution System (PDS). The project is already bearing fruit, with a policy briefing detailing preliminary estimates of the environmental and health costs associated with the PDS.

In the past year, we also made critical improvements to the TCI–International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) District-Level Database for Indian Agriculture and Allied Sectors, as well as the TCI FPO Platform for India. Both data platforms are now even stronger tools for researchers and other stakeholders interested in Indian food systems.

As our 10th anniversary year draws to a close, I am filled with excitement and hope for the future of TCI. We will continue to build on our first 10 years of research and educate the next generation of food systems researchers and practitioners in pursuit of nutrition-sensitive, sustainable food systems in India and the developing world. We will also institute some changes designed to increase the impact of our program. I look forward to sharing more information about those improvements in the future, but for now, I present this report of research and activities from the past year. I hope that you enjoy reading it and thank you for supporting TCI.

A handwritten signature in black ink that reads "Prabhakar Pingali".

Prabhakar Pingali  
Founding Director, TCI

# BY THE NUMBERS

As of August 2023

16

Researchers

3

Postdoctoral  
Associates

13

TCI  
Scholars

6

Faculty  
Fellows

27

Alumni

17

PhDs  
Earned

6

Master's  
Degrees Earned

16

Academic  
Disciplines

6

Reports

3

Books

45

Journal  
Articles

14

Book  
Chapters

21

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.

## **Climate Change & Sustainable Agriculture**

As climate change continues, the agricultural sector must grapple with its effects and adopt more resource-conscious, sustainable practices. TCI's research focuses on building resilient food systems capable of weathering climate change while meeting the nutritional needs of growing populations.

## **Food & Ag-Science Innovations**

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

## **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.



*TCI researchers meet with farmers in Bihar to discuss the relationship between agriculture and climate change. (Photo by TCI)*

## 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.

## ICTs, Data Systems & Ag-Tech

Information and communication technologies (ICTs) 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.

## 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 in accessing value chains and markets, and empower them to enhance their incomes and welfare.

# TCI AT 10

## Celebrating 10 Years of TCI

The 2022–23 academic year was an auspicious one for TCI, as it celebrated its 10th anniversary with a variety of events, culminating in a two-day academic conference.

The celebration began with a kick-off event in September 2022, featuring speeches from TCI Director Prabhu Pingali and Beth Ahner, Senior Associate Dean of the College of Agriculture and Life Sciences (CALS) at Cornell University. The event also included a series of presentations by TCI scholars, staff, and faculty fellows showcasing different sides of the Institute's research.

TCI also hosted several seminars during the year. Ashok Gulati, Distinguished Professor at the Indian Council for Research on International Economic Relations, delivered a lecture titled "India: Repurposing Support for Sustainable Food Systems." Another lecture was given by Digital Green Co-Founder Rikin Gandhi, whose talk was titled "Elevating Farmer Voices by Digitizing Rural Networks."

In May 2023, researchers from universities and research institutions across the world traveled to Cornell for TCI's 10th Anniversary Conference. The theme of the conference was "Food, Environment, and Health—Global Evidence."

A total of 30 scholars presented their research during the two-day conference. The presentations were grouped into eight thematic sessions: Environment–Nutrition Linkages;

Externalities in the Food System; Food Prices and Household Diets; Global Food Systems; Child Nutrition; Resilience and Welfare Transfers; Agricultural Markets and Food Security; and Risks, Investments, and Social Networks.

The keynote presentation was delivered by Ruth DeFries, Professor of Ecology and Sustainable Development at Columbia University, New York, and co-founding Dean of the Columbia Climate School. In her presentation, DeFries used the revival of millets in India as a case study for discussing

how scientists can use their research to effect change in deeply entrenched food systems.

The conference was an opportunity to compare TCI's India-focused work on the nexus between agriculture and nutrition with

research happening elsewhere, with the diverse set of presentations showing significant parallels across countries and across the development spectrum.

The conference featured a mix of experienced researchers, such as Ben Davis, Food and Agriculture Organization Director for Inclusive Rural Transformation and Gender Equality Division, as well as young professionals, including graduate students from Cornell and other universities around the world.

Read TCI's 10th anniversary magazine at [tci.cornell.edu/10th-anniversary/tci-at-10-magazine/](https://tci.cornell.edu/10th-anniversary/tci-at-10-magazine/)







*TCI held a two-day conference in May 2023 to conclude its 10th anniversary celebration. (Photos by Dan Verderosa/TCI)*

# AGRICULTURE

## TRANSFORMATION, FOOD SYSTEMS & NUTRITION TRANSITION

### Calculating the True Cost of India's PDS

Each year, India spends tens of billions of dollars on the Public Distribution System (PDS), a food subsidy program that helps to ensure the food security of more than 800 million people. The largest such program in the world, the PDS is a monumental achievement for food security. With high transaction costs and a reliance on resource-intensive crops such as rice and wheat, however, the actual cost of these subsidies is likely much higher.

TGI's project on the True Cost of Food Subsidies in India uses a "true cost accounting" approach to measure the costs and societal impacts, which are not accounted for in the PDS budget, to provide policymakers with a clearer picture of the program's costs and benefits. True cost

accounting provides a holistic assessment of the food system, essentially, measuring, valuing, and describing the processes from farm to plate by accounting for all direct and indirect costs and values.

*Preliminary estimates from the project show that the production of food grain for the PDS increased the overall cost of the program by about 40% in 2019–20.*

Preliminary estimates from the project show that the production of food grain for the PDS increased the overall cost of the program by about 40% in 2019–20. The Indian government spent approximately US\$13.8 billion to procure, store, transport, and distribute food grain through the PDS.



TGI Postdoctoral Associate Raghav Puri interviews a pair of PDS beneficiaries. (Photo by TGI)

TCI's research indicates that greenhouse gas emissions and water use tied to the production of wheat and rice for the PDS cost an additional US\$5.1 billion. Increased respiratory infections due to crop residue burning during rice production cost another US\$1 billion.

TCI's research also shows that the environmental and health costs of PDS production are concentrated in a just handful of states from which the majority of PDS grain is procured, namely Punjab and Haryana.

A special policy brief presenting these preliminary estimates was shared at the 2022 United Nations Climate Change Conference in Sharm El Sheikh, Egypt, as well as the 2023 World Sustainable Development Summit in New Delhi, India.

The project is also modeling the costs of PDS alternatives that feature locally sourced grains and more nutritious options. Modeling the costs of these baskets will provide policymakers with additional information for making the PDS more efficient and nutrition-sensitive.

## Evaluating Food Security in Forest-Proximate Communities

Although the discourse on food and nutrition insecurity has focused mainly on agriculture as the solution, millions of people live in proximity to forests and depend on forests as a food source. Considering the importance of forests to food security, it is imperative that they be adequately researched.

TCI research on this subject seeks to understand the different pathways through which forests contribute to the nutritional quality of diets and how seasonal variation impacts access to food. Led by TCI Scholar Amrutha Jose Pampackal, this research pays particular attention to

how the food and nutritional security of forest-proximate communities can be strengthened without increasing the socioeconomic and ecological pressures that threaten to deplete forest resources.



*TCI Scholar Amrutha Jose Pampackal spent a year in the field as part of her PhD research. (Photo by TCI)*

Pampackal spent a year studying these issues in Thuamul Rampur—a remote, forested region in the Kalahandi district of Odisha, India. In partnership with the NGO Gram Vikas,

*Pampackal found that dietary diversity is higher for those who collected non-firewood forest produce, suggesting that better access to forests has the potential to improve food security.*

she surveyed 440 households and 12 weekly food markets across the winter, summer, and rainy seasons.

Preliminary results from her research indicate very low dietary diversity in women across all three seasons, due in part to poor market access, which makes it difficult to both earn income from the sale of local produce and purchase diverse foods. However, Pampackal found that dietary diversity is higher for those who collected non-firewood forest produce, suggesting that better access to forests has the potential to improve food security.

Pampackal's research carries the potential to inform policies improving the food security of impoverished, forest-proximate tribal communities. The evidence she has accrued points to the vesting of community forest rights under the 2006 Forest Rights Act as an important pathway to further strengthen forests' role as a contributor to sustainable food security.

## Understanding the Politics of Food Pricing

Set by the Indian government to promote the production of crops like rice and wheat, Minimum Support Prices

(MSP) play an important role in influencing which crops farmers grow. Decisions to raise or lower MSP directly impact farmers' livelihoods and, as such, can also play a role in how they vote, creating an incentive for politicians to intervene in the agricultural markets to gain an electoral edge.

TGI alumna Natasha Jha explored this issue in a study of MSP price changes, finding that the MSP is typically higher during state government election years. This suggests that the incumbent central government may use the MSP as a make-do instrument for improving its electoral chances at the state level.

The study underlines the danger of this type of decision-making around price-setting, as Jha found that increases in the MSP are correlated with increased price volatility across India's retail food markets.

Jha's research reveals the real-world impact of MSP changes and their potential misuse for political ends, demonstrating the importance of considering the political implications of food system reforms.



Laborers carry sacks of wheat in Haryana, India. (Photo by PradeepGaur/Shutterstock)

# SCHOLAR SPOTLIGHT



## Amrutha Jose Pampackal

TCI Scholar Amrutha Jose Pampackal is a PhD candidate in development studies, a field that appeals to her because of its interdisciplinary nature. The research interests lie at the interface of environmental

governance and rural food security.

For her doctoral research, Pampackal spent over a year in Thuamul Rampur, a remote area in Odisha, in India's Kalahandi district. There, she conducted surveys designed to reveal the impact of forests on the diets of forest-proximate tribes. Though she was concerned about the relative lack of phone connectivity and access to health care in the area, she was motivated to undertake her study because it addressed several issues that were unexplored in the current academic literature.

The support of TCI and other TCI scholars also buoyed her self-confidence. "The confidence to undertake a study of such scope came only after interacting with and receiving the guidance of former TCI scholars who had conducted research fieldwork as part of their PhDs," Pampackal said. "At all stages of my research, I have also benefited from the guidance of the strong body of food security scholars that TCI has."

After she completes her PhD, Pampackal hopes to make a career conducting research on food system sustainability, which adds value to both the academic literature and the lives of communities struggling with food insecurity.

Although she once viewed working in Thuamul Rampur with some trepidation, she wants to return there to continue her work.

"I deeply care about forest access and food security of the communities that I worked with in Odisha, and hence, wish to conduct many more years of research in Odisha, building on the foundation I laid during my PhD research," she said.

# FOOD & AG-SCIENCE INNOVATIONS

## Creating Disease-Resistant Rice Varieties

Every year, 20–40% of crops are lost to pests and diseases worldwide. In developing countries like India, these losses exacerbate existing food and nutritional security issues.

TGI is working to reduce crop losses through research aimed at achieving a better understanding of the molecular mechanisms behind two common diseases afflicting rice crops: bacterial leaf streak and bacterial blight. Led by TGI Scholar Shivranjani Baruah, TGI has helped to identify potentially important features of the bacterial leaf streak pathogen, in addition to a natural source of resistance against select strains. There are currently very few known broad-spectrum genetic sources of resistance against bacterial leaf streak, and none that are effective against Asian strains of the pathogen.

Through a collaboration with ICRISAT and the Indian Institute of Rice Research (IIRR), Baruah's research also aims to build a high-output phenotyping pipeline for the identification of bacterial blight susceptibility and resistance in rice using proximal spectrographic sensing. This proof-of-concept study could open doors for rapid screening of rice hereditary lines in disease-resistance breeding programs in India.

## Improving Public Sector Plant Breeding Capacity

Across the world, improved crop varieties are needed more than ever to tackle issues like poverty, climate change, and malnutrition.

TGI is part of a multidisciplinary team within the Innovation Lab for Crop Improvement (ILCI), a USAID-funded venture that aims to empower national breeding programs to set targeted goals to enhance genetic improvement in

crops, which will address the specific needs of vulnerable populations to advance economic growth, crop resilience, and food security.

While a global network of researchers makes scientific discoveries in plant breeding, the capacities of the plant breeding programs that enable the development of crops must be strengthened. National breeding programs perform a unique, context-specific role by developing locally important crop varieties adapted to diverse agroecological zones and the particular needs of their country's population.

Leading ILCI's institutional capacity team, TGI works with programs in Africa, Latin America, and the Caribbean to reveal bottlenecks to technology diffusion and improve their ability to innovate and implement sustained crop improvement research effectively and efficiently.

Measuring baseline capacity is essential to define a starting point for change and provide a benchmark against which progress is assessed overtime. Following a scoping literature review, the development of a conceptual framework, and the construction of a survey tool, TGI is measuring and tracking breeding institutions' capacities to achieve their desired outputs.

To better understand the process of capacity building, TGI conducted field visits to participating breeding programs in Senegal, Kenya, Uganda, and Tanzania to assess the status of institutional capacity building, understand the future aspirations of breeding programs, and determine the progress of project implementation and collaboration.

Future analyses will assess the success of breeding program interventions and measure progress over time. TGI will continue to work closely with partner breeding programs to better understand the major factors that influence institutional capacity building and how it can be sustained after the completion of the ILCI project.

# STAFF SPOTLIGHT



## Pallavi Rajkhowa

With more than a decade of research experience, Postdoctoral Research Fellow Pallavi Rajkhowa is an integral part of TCI's Center of Excellence in New Delhi, India.

Rajkhowa received her PhD from the Bonn International Graduate School for Development Research at the University of Bonn, where she studied the impact of personalized digital extension services, electronic marketplaces, and mobile phones on various development outcomes in India. As part of her research, she conducted fieldwork in Odisha, Assam, West Bengal, and Tamil Nadu.

Prior to earning her doctorate, Rajkhowa spent seven years performing agricultural research for organizations, including the International Food Policy Research Institute (IFPRI) and the Indian Council for Research on International Economic Relations (ICRIER).

At TCI, Rajkhowa contributes to two projects: Transformation of Agricultural Systems for Climate Resilience and FPO-Led Small Farm Market Access Models. As part of the FPO project, she is analyzing how proximity to urban hubs affects FPO performance, in addition to undertaking a study to understand alternative marketing channels for FPOs and the role of warehouses and derivatives markets in managing price risks and improving the bargaining power of smallholder farmers.

Several factors drew Rajkhowa to TCI, including its focus on climate change, agriculture, and nutrition in India; young, dynamic research staff; multidisciplinary research approach; and impact on policy.

"Working with TCI provides me with an engaging and challenging environment that allows me to participate in meaningful research while expanding my skills and knowledge," she said.

# MARKETS & VALUE CHAINS

## Reducing Food Loss and Waste

Fresh fruits and vegetables are an important source of micronutrients, but access to them is limited in developing countries like India because of several factors, including food loss and waste. New TCI research on tomato supply chains sheds light on where and when most loss occurs and how it can be reduced.

In a study published in the *American Journal of Clinical Nutrition*, TCI researchers show that most food loss in South India's tomato supply chain occurs on the farm and demonstrate a link between quality loss and the number of tomatoes eventually lost.



Wasted vegetables rot on the ground. (Photo by Janosch Kunze/ Shutterstock)

The majority of loss occurs after tomatoes are harvested but before they leave the farm. Lower levels of loss were

found to be associated with harvesting during peak season, indicating the potential importance of seasonal supply and demand factors.

The researchers also discovered a link between preharvest quality loss and postharvest quantity loss, with a 1% increase in preharvest damage corresponding to a 2% rise in postharvest loss. According to the study, 13.9% of tomatoes suffer preharvest quality loss due to damage from pests and disease, as well as from receiving too much sun or rain, or a lack of rain. Harvesting during peak season was found to reduce the odds of quality loss by 88%, compared to off-season harvests.

The study was based on field research performed by postdoctoral associate Jocelyn Boiteau as part of her doctoral studies with TCI. From January 2019 to March 2020, Boiteau and her research team surveyed 75 farm households and 83 tomato traders in the Chittoor district of Andhra Pradesh, in addition to 52 vegetable traders and 50 vegetable retailers in Hyderabad, Telangana, on harvest and market days.

TCI's research suggests that strategies for reducing food loss and waste in perishable supply chains should focus on the underlying reasons for loss, namely postharvest handling, seasonality, and market structures.

"Food loss of perishable produce from farm to retail: evidence from tomato supply chains in South India,"  
Jocelyn Boiteau and Prabhu Pingali, *The American Journal of Clinical Nutrition*, Volume 115, Issue 6, June 2022

## Defining Food Loss and Waste

As it makes its journey from the farm to consumers' plates, about a third of the total food produced in the world is lost or wasted. Reducing such waste is key to achieving sustainable food systems. However, before significant



progress can be made, researchers must first agree on exactly what they mean by “food loss and waste.”

TCI research published in the journal *Global Food Security* shows that databases tracking food loss and waste use definitions that differ in important ways. For example, while some databases may count losses that occur during harvest or slaughter operations, others only count losses that occur after harvesting.

TCI researchers determined that a 2014 definition of food loss and waste put forth by the Food and Agriculture Organization of the United Nations (FAO) is both comprehensive and globally applicable and should be the standard going forward. That definition describes food loss and waste as “a reduction in the quantity or quality of the edible portion of food intended for human consumption when food is redirected to nonfood uses or when there is a decrease in the nutritional value, food safety, or other quality aspects from the time food is ready for harvest or slaughter to consumption.”

The adoption of a harmonized definition of food loss and waste can help to improve the interpretation and comparison of data, the evaluation of loss and waste management efficiencies, and the identification of evidence gaps, ultimately benefiting mitigation efforts.

“Can We Agree on a Food Loss and Waste Definition? An Assessment of Definitional Elements for a Globally Applicable Framework,” Jocelyn Boiteau and Prabhu Pingali, *Global Food Security*, Volume 37, June 2023

## Assessing Farm Aggregation Models

As demand for high-value, diverse agricultural products rises throughout the developing world, smallholder farmers face pressure to either commercialize or exit the

farm sector altogether. By joining together with other smallholders, farmers can reap the benefits of scale and realize increased income.

According to a scoping review of the global academic literature on farm aggregation models completed by TCI and published in the journal *Food Policy*, a new generation of farm aggregation models, such as farmer producer organizations (FPOs), can help such smallholders by improving their access to credit, technology, and extension services.



A farmer works on a field of blue agave in Jalisco, Mexico. (Photo by javarman/Shutterstock)

While FPOs and other models were found to improve access to factor markets for extension services, credit, information, technical assistance, technology access, and marketing services, the review revealed that joint selling was relatively low. By granting farmers greater bargaining power, joint selling can reduce transaction costs. It can also help farmers to identify buyers and lower transportation costs.

Based on the studies reviewed by TCI, cooperatives remain the leading aggregation model in the developing world. However, newer models have taken hold in India, Mexico, Kenya, and South Africa. FPOs are the dominant form of aggregation in India.

TCI published an annotated bibliography of the research it reviewed, providing researchers with insights into 84 studies from around the world. *Aggregation Models and Small Farm Commercialization: An Annotated Bibliography of Relevant Literature* summarizes each study's research questions, methods, main findings, strengths and weaknesses, and relevance to the literature on aggregation models.

The studies cover agricultural produce ranging from staple crops to fruits and vegetables, cash crops, livestock, and raw textile materials, in addition to livestock and fisheries. Geographical areas covered in the report include countries from Asia, Africa, Europe, North America, and South America, with extensive coverage of India, China, Mexico, Nicaragua, Tanzania, and Ethiopia.

"Aggregation models and small farm commercialization — A scoping review of the global literature," Mathew Abraham, Leslie Verteramo Chiu, Ekta Joshi, Muhammad Ali Ilahi, and Prabhu Pingali, *Food Policy*, Volume 110, July 2022

*Aggregation Models and Small Farm Commercialization: An Annotated Bibliography of Relevant Literature*, Tata-Cornell Institute, 2022.

## Measuring the FPO Impact on Farmer Incomes

For the past 10 years, the Indian government has pinned its efforts for boosting smallholder productivity and improving livelihoods on the promotion of farmer producer organizations (FPOs), through which farmers can better

access markets and sell their products at better prices. The number of FPOs has risen dramatically as a result, but are farmers seeing the benefits?

As part of TCI's project on FPO-Led Small Farm Market Access Models, TCI Scholar Ekta Joshi is analyzing the effectiveness of FPOs to commercialize smallholders and enhance their agricultural performance.

For her research, Joshi conducted field surveys of 1,800 farmers in five districts in Maharashtra, the home of the most FPOs in India. Preliminary results indicate that FPO membership is positively associated with crop incomes and profits, mainly driven by improved bargaining power in terms of price premiums received for certain crops.

Joshi also administered surveys for the boards of directors of 100 FPOs in Maharashtra to explore whether a board's gender diversity leads to systematic differences in the financial performance of an FPO.

Joshi's study is one of the first large-scale studies of the individual-level impacts of FPOs in India. With more than 33,000 FPOs in the country and massive investments in FPO promotion, this research is poised to reveal vital evidence of the livelihood improvements that FPOs can help farmers to attain.

## Publications

In 2022-23, TCI researchers authored 5 journal articles, 2 book chapters, 1 report, and 1 policy brief.

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

\*As of August 2023

# SCHOLAR SPOTLIGHT



## Ekta Joshi

For TCI Scholar Ekta Joshi, applied economics is a tool for understanding and solving some of the developing world's most challenging socioeconomic problems, some of which she witnessed firsthand working in the field early in her career. Her long-term goal is

to perform policy-relevant research, tackling issues facing the underprivileged in developing countries.

Before joining TCI, Joshi worked for the International Rice Research Institute, where she conducted differential impact assessments associated with the adoption of modern agricultural technologies. At the Centre for Policy Research, she helped to evaluate the governance systems and intergovernmental budgetary flows underpinning the implementation of social programs in Chhattisgarh.

At Cornell University, Joshi is pursuing a PhD in applied economics and management. Her research is focused on the scope and ability of farmer producer organizations (FPOs) to promote smallholder commercialization and aid agricultural development in India. In keeping with TCI's commitment to field-based research, Joshi conducted extensive surveys of farmers and FPOs to analyze the implications of FPO membership on farming outcomes. She was inspired to carry out this work after exploratory fieldwork revealed the challenges and underlying dynamics at play in India's FPO ecosystem.

"Ultimately, I hope that my research helps foster inclusive economic growth of smallholder farmers by enabling them to capture a higher share of the food value chains," Joshi said.

Joshi holds a master's degree from Madras School of Economics and a bachelor's degree from Delhi University's Hindu College.

# GENDER & NUTRITION

## Men's Education Key to Household Nutrition

Among development practitioners and policymakers, women's education is a crucial tool for improving household nutrition. However, TCI research shows that men's education also plays an important role in improving the nutritional outcomes of both women and households.

In a study published in the journal *PLOS One*, TCI researchers establish a causal link between men's education and dietary diversity. For every additional year of men's schooling, household dietary diversity increases by 0.2 food groups, while women's dietary diversity increases by 0.16 food groups. Dietary diversity is a commonly used indicator of nutrition, as a greater number of food groups eaten increases the likelihood of adequate nutrient consumption.

Men's education level can impact dietary diversity through a variety of pathways. For example, men in India are typically the primary income earners and key decision-makers in their households, and thus play a major role in deciding what foods are grown or purchased and how that food is allocated among members of the household.

The researchers arrived at their findings using survey data from 3,600 households from four districts in three states in India: Bihar, Uttar Pradesh, and Odisha. The data were collected as part of the TCI project, Technical Assistance and Research for Indian Nutrition and Agriculture (TARINA), which ran from 2015-2019.

The study shows that men's education can be leveraged by policymakers as a primary driver of household nutrition outcomes. Many policies and programs in India focus on educating and empowering women to make better nutrition-related decisions for their households. Including men in those efforts could amplify their impact.

"Leveraging Men's Education as an Effective Pathway for Improving Diet Quality: Evidence from Rural India," By Naveen Sunder, Soumya Gupta, and Prabhu Pingali, *PLOS One*, Volume 18(1), 2023

## Exposing An Anomaly in India's Anemia Figures

Although anemia declined in India from 2005–2015, the latest round of the National Family Health Survey (NFHS-5) shows that it is now on the rise, increasing from 53% to 57% in women and 58% to 67% in children over the past five years. In an op-ed published in *The Indian Express* in September 2022, TCI researchers Soumya Gupta and Payal Seth showed that the increase cannot be explained by the traditional drivers of anemia and urgently called for further investigation.

In the article, the researchers detailed how many of the factors typically associated with anemia have been lessened with improvements in diet since 2015. For example, the percentages of children and women eating iron-rich foods increased from NFHS-4 to NFHS-5, as did the percentage of children consuming an adequate diet. High levels of anemia are often linked with poor water quality and sanitation conditions, but these factors also improved.

Gupta and Seth questioned whether this discrepancy could result from differences in data between NFHS-4 and NFHS-5, or from other measurement issues. They proposed using alternative iron-specific biomarkers, like serum ferritin, as well as markers of inflammation, to identify the specific role of iron deficiency as a driver of anemia.

With rates on the rise, India is off course in achieving both its national and global targets for anemia reduction. To reverse the trend, TCI calls for further rigorous research and informed policymaking that includes all stakeholders.

# STAFF SPOTLIGHT



## Soumya Gupta

Soumya Gupta has a long history with TCI. One of the first TCI scholars, she earned her PhD in applied economics and management in 2015, and remained with the Institute—first, as a postdoctoral associate, and now, as a research economist. In that

capacity, Gupta has published an abundance of research related to gender and nutrition.

Gupta was called to pursue economic research on women's nutrition during a UNICEF internship in rural Rajasthan, where she witnessed women eating diets inadequate in nutrition due to gender-based social conventions. As a TCI scholar, she conducted a field study examining women's empowerment in agriculture and its association with their iron deficiency status. The research showed that women's control over income, food purchases, and farming decisions translated into better nutritional outcomes.

"Field work comes with its own set of challenges, but I received a lot of support from my dissertation committee when designing the survey and the questionnaire," Gupta said. "While it was a little intimidating to start with, at the end of the one and a half years of fieldwork, I learned so much... it was so enriching and rewarding."

After receiving her doctorate, Gupta designed and led the surveys for TCI's Technical Assistance and Research in Indian Nutrition and Agriculture (TARINA) program and analyzed the survey data to better understand the drivers behind women's food intake and diet quality. She has since published studies on a range of topics, such as the affordability of the EAT-Lancet diet and the impact of COVID-19 lockdowns on women's nutrition.

From her start as a PhD student to her ongoing work today, Gupta continues to advance research on gender and nutrition at TCI.

# FOOD SAFETY

## WATER & SANITATION

### Understanding Farming and Arsenic Contamination

As climate change limits the surface-level supply of fresh water, farmers are increasingly reliant on groundwater resources for irrigation. However, in South Asia, arsenic contamination limits such aquifers' usefulness as a source of both irrigation and drinking water. TCI alumna Natasha Jha's doctoral research is helping to uncover whether arsenic contamination in India might actually be caused by the intensification of agriculture and the overutilization of groundwater.

Researchers have found evidence that people can be exposed to arsenic, a known carcinogen, by eating crops irrigated with contaminated water. Rehabilitating contaminated water sources is costly, as is adaptation. Water purification methods are limited and often

unaffordable for developing countries, and it can be difficult to identify contaminated water sources. Coupled with limited surveillance and testing, arsenic contamination of groundwater is a worrying prospect in countries like India.

Whereas previous research has focused on geochemical processes causing arsenic contamination, Jha's research tests what role anthropogenic factors might play. Using data from districts across India, Jha is testing whether changes in exposure to arsenic contamination are linked with varying levels of usage of agricultural inputs, such as fertilizers, pesticides, and groundwater extraction.

Research like Jha's is crucial to informing groundwater usage strategies to minimize the risk of arsenic contamination rendering some sources unusable for the foreseeable future.



*Water flows from an irrigation pipe onto a rice field. (Photo by Venkatesa Perumal/Shutterstock)*

# ALUMNI SPOTLIGHT



## Anthony Wenndt

TCI alumnus Anthony Wenndt is making a difference in the lives of the poor. In Africa and in other parts of the world where malnutrition is a public health concern, he works to improve the nutrition outcomes of the programs of the Global Alliance for Improved Nutrition (GAIN).

Wenndt credits his experience performing fieldwork, while at TCI, for helping him to be responsive to the needs and constraints faced by marginalized people.

Wenndt earned his PhD in plant pathology and plant-microbe biology from Cornell University in 2020. While performing field-based research on mycotoxin contamination in Uttar Pradesh, India, he mobilized more than 400 smallholder farmers and their families in a farmer research network, leveraging their common interest in grain preservation and mycotoxin management to develop and implement locally meaningful mitigation solutions.

At GAIN, Wenndt works as the technical officer for reaching the very poor, supporting the organization's cross-cutting priority of increasing the impact of programs on people living in poverty. Wenndt builds resources, strategies, and standards of practice that can help guide GAIN's work. He also leads the social protection program, which seeks to ensure that the organization's social protection offerings (programs that reduce social and economic risk and vulnerability) are nutrition-sensitive, responding to the nutritional needs of beneficiaries, particularly, the poorest of the poor and, among them, women and children.

"I credit TCI with exposing me to the tools I required to examine the needs of communities from the perspective of vulnerable people themselves, using human-centered and participatory approaches," Wenndt said. "I believe that impacting communities necessarily means including them and prioritizing their own perspectives. This is something that continues to inform and drive my approach to social protection and reaching the very poor at GAIN."

# ICTS, DATA SYSTEMS & AG TECH

## Improving Crucial Data Platforms

High quality research and policymaking are impossible without access to timely, accurate data. In the past several years, TCI has contributed significantly to the data available for studying Indian food systems through the creation of the FPO Platform for India and the revitalization of the District-Level Database for Indian Agriculture and Allied Sectors.

TCI's FPO Platform for India offers users a one-stop shop for information on India's FPO ecosystem. Created with the support of the Walmart Foundation, as part of the FPO Hub within TCI's Center of Excellence, the FPO Platform is the only centralized source of data on Indian FPOs currently available.



*The FPO Platform for India features comprehensive information on more than 33,000 FPOs. (Photo by TCI Digital composite by DragonFish Studio)*

Through the interactive, web-based dashboard, researchers and other stakeholders can access a wealth of data on FPOs, such as crops produced, founding years, and sponsoring agencies. The flexible dashboard allows users to take a wide view of FPOs across states or dig deep into the attributes of individual FPOs.

After a major overhaul in 2023, the platform now has data on more than 33,000 FPOs. A new portal feature empowers FPOs to validate and update their own data and can facilitate connections between FPOs, businesses, and other stakeholders.

Efforts are now underway to establish a data-sharing pipeline with major FPO stakeholders in India to ensure that all data on the platform are as current and comprehensive as possible.

TCI is also in the process of improving the District-Level Database, one of the most used and most consequential databases for research related to food systems in India. In partnership with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), TCI previously updated the database with apportioned data that accounts for changes in district boundaries, allowing researchers to look at the diversity in growth patterns across India from a historical perspective. The database currently features socioeconomic, environmental, and nutrition- and health-related data for 571 districts in 20 Indian states from 1966 to 2017.

For the next iteration of the database, TCI and ICRISAT researchers will update its data through 2019–20 and create national-level and state-level datasets. They will also create apportioned datasets using 1991 and 2001 district boundaries, allowing users to perform time series analyses with more districts.

New variables will be considered for inclusion in the database, such as fisheries, plantation crops, social safety net programs, and agro-processing industries.

By maintaining and improving these platforms, TCI is helping to ensure that researchers can perform high quality research on Indian food systems for the foreseeable future.



## Assessing WhatsApp's Potential as Ag-Tech

With the recent expansion of Internet access in India, social communication has overflowed into messaging apps like WhatsApp. The expansion of both technology and connectivity could hold tremendous promise for agriculture.



*Mobile phones can be useful tools for farmers. (Photo by PhotoBankIndia/Shutterstock)*

TCI research on the use of new information communication technologies (ICTs) for agricultural purposes is led by TCI Scholar Vanisha Sharma, who conducted a field experiment with 1,083 Indian farmers to understand whether the existing online infrastructure provided by WhatsApp could be used to provide agricultural education. Sharma created 24 moderated, multi-village WhatsApp groups, where she shared posters and invited farmer discussion on topics, such as inputs, prices, and pest prevention. Farmers from half of the groups were also invited to monthly, in-person

lunch meetings and poster presentations on the same topics.

The results of the study show that farmers in the WhatsApp groups were significantly more likely to use WhatsApp for agricultural decision-making. These farmers were also significantly more likely to invest more in their farms through inputs like pesticide. Farmers who participated in in-person meetings were more likely to use WhatsApp to share market-relevant information.

Sharma's research demonstrates that messaging apps like WhatsApp can be of use to smallholder farmers, improving our understanding of how to best utilize ICTs and other digital agriculture tools .

## Spurring Digital Innovation

Digital tools are increasingly important to farmers and food systems as a whole, with new technologies emerging rapidly. To spur the creation of innovative, new digital agriculture applications, TCI cosponsored a Digital Ag Hackathon at Cornell University in spring 2023, organized by the Cornell Institute for Digital Agriculture.

The Digital Ag Hackathon drew 150 undergraduate and graduate participants from most of Cornell's schools and colleges, who spent two days crafting ideas and prototypes.

Several TCI researchers volunteered as mentors at the event, and Chandra S. Nuthalapati, a visiting professor at TCI, served as a judge for the competition.

TCI Scholar Shree Saha and her team took home the award for market readiness for developing a platform, called TransportX, which would help smallholder farmers in India bring their products to market. The app connects farmers with potential buyers, then uses a series of algorithms to match requests with available transportation.

# CLIMATE CHANGE & SUSTAINABLE AGRICULTURE

## Building Zero-Hunger, Zero-Carbon Food Systems

As the impacts of climate change are felt more strongly and frequently, researchers and policymakers dedicated to ending hunger must reckon with the agricultural sector's contribution to greenhouse gas emissions. TCI's Zero-Hunger, Zero-Carbon Food Systems project aims to create a menu of policy options for policymakers in Bihar, India, to curb emissions while increasing agricultural productivity.

TCI has convened expert workshops and technical consultations aimed at identifying the primary production, nutrition, and emissions challenges facing the agricultural sector in Bihar, in addition to identifying potential greenhouse gas mitigation strategies for each production system in the state. The mitigation strategies identified through these meetings include zero or reduced tillage in wheat systems, direct seeding in rice systems, and improved feeding practices for livestock systems, in addition to technologies like agrivoltaics.



*Solar panels provide electricity for irrigation on a field in Bihar, India. (Photo by TCI)*

Researchers conducted site visits to each of Bihar's agroclimatic zones to confirm the ideas discussed during the expert workshops, better understand current agricultural practices, and hear farmers' opinions on the link between climate change and agriculture. The field assessments highlighted significant variations in agricultural practices among farmers and agroclimatic zones, emphasizing the need for tailored interventions that address the specific needs of each region.

Following the field visits, TCI organized a scenario-building workshop to think through several different paths that Bihar could take in relation to agriculture and climate change. The frequency of extreme weather events and the capacity of the state government were determined to be the two main drivers shaping Bihar's food systems over the next 20 years.

TCI researchers are now modeling the impacts of different policy interventions and climate-smart farming practices to determine their potential effects on productivity and net emissions.

Efforts to reach zero hunger must be undertaken in balance with efforts to limit climate change and mitigate its effects on agricultural systems. Through its research in Bihar, TCI aims to show that a zero-hunger, zero-carbon food system is possible, offering a model to other Indian states and countries throughout South Asia.

## Diversifying Agriculture for Climate Resilience

Rice is perhaps the most important crop grown in India, accounting for roughly a third of all cultivated land. The relatively high greenhouse gas emissions associated with rice production, however, contribute significantly to climate change, while the disproportionate share of starchy rice in Indian diets increases the risk of noncommunicable

diseases. Moving away from rice production and increasing the cultivation of more nutritious, climate-friendly crops could help address both issues.

TGI is partnering with Professional Assistance for Development Action (PRADAN) on a project in the state of Chhattisgarh that aims to diversify agriculture away from rice in order to improve climate resiliency, increase farm income, and encourage healthy dietary practices.

Transformation of the Agriculture System for Climate Resilience explores pathways to promote the diversification of Chhattisgarh's agricultural system away from rice and toward pulses, oilseeds, and millets, which are more agroclimatically suited to the state. Although systemic barriers to diversification are generally understood, the triggers and policies that could catalyze large-scale adoption are not as well-known.

The evidence generated by the project can be used to create tools and policies supporting a shift to a more diversified agricultural system. The project reinforces TGI's commitment to research aimed at ensuring that future food systems are environmentally sustainable.

## Turning Farm Waste into Furniture

For decades, the people of northern India have suffered from breathing dangerous air pollution caused by farmers burning rice stubble—the straw left on the field after harvest—to quickly clear their fields for the next growing season. The smoke is attributable to 20% of deaths nationwide and has lowered the life expectancy of people in New Delhi and surrounding areas by as many as 9 years.

Research supported by TGI aims to curb this pollution by creating demand for the rice straw. Led by Cornell University Professor Emeritus Anil Netravali, the Farm



*A graduate student tests the mechanical properties of the stubble-based composite panels. (Photo by Anil Netravali)*

Waste to Furniture project developed a process through which rice stubble is upcycled into inexpensive, environmentally friendly, composite panels that can replace wood and wood-based products that are currently used for everything from housing to furniture.

Netravali's process combines mild-chemical-treated rice straw with jute fabrics to form bilayer mats. The mats are then infused with plant-based resins and hot molded into the desired shape. The process is water-based, generates almost zero waste, and does not use the formaldehyde-based resins typically utilized to make wood-based products.

Lab testing has shown that the composite panels are two to three times stronger and more durable than wood-based products and can be easily engineered to fit a wide variety of applications.

Efforts are currently being made to transfer this technology to India for large-scale production. When implemented at scale, the production of stubble-based composite panels has the potential to create thousands of jobs and provide farmers with an additional source of income by creating a market for rice stubble.

## Avoiding Trade-offs Between Productivity and Sustainability

United Nations Sustainable Development Goal (SDG2) aims to eradicate hunger, but could efforts to do so interfere with SDGs supporting environmental sustainability and conservation?

TGI research published in the journal *Environmental Challenges* examines Target 2.3 of SDG2, which aims to double the productivity and incomes of small farmers. The study shows that when productivity increases are pursued without regard to environmental externalities, it can result in increased land degradation, water and air pollution, loss of biodiversity, and other ill effects that negatively impact environmental goals.

TGI researchers mapped out the relationship between SDG2.3 and the other SDGs in South Asia, showing that boosting farm productivity supports some goals and undermines others. For example, while SDG2.3 has a negative impact on SDG6, which intends to ensure clean water and sanitation for all, it has a positive effect on SDG1's aim to end poverty.

The study shows the need for clearly defined metrics and high quality data for measuring the impact that the SDGs have on each other. There is currently no global monitoring for 37 percent of SDG indicators, and 25 percent of indicators rely on data that is incomplete or outdated. Until that is fixed, the smart approach to the SDGs would be

to enact policies that have as many synergies with other goals as possible.

For SDG2.3, TGI proposes two high-payoff interventions for minimizing the environmental trade-offs in South Asia: one, a high-level structural change and the other, a low-level change in cultivation practices. First, reorient agricultural production away from rice and wheat in favor of a more diverse, environmentally sustainable mix of crops. Second, promote minimum or zero tillage production, which has been shown to increase productivity, decrease costs, and improve soil health.

“Hunger and Environmental Goals for Asia: Synergies and Trade-Offs Among the SDGs,” Prabhu Pingali and Milorad Plavsic, *Environmental Challenges*, Volume 7, April 2022

## Promoting Sustainable, Excreta-Derived Fertilizers

If agriculture is ever to be truly sustainable, all nutrients removed from the soil through the production of crops and animals must be returned to the farm. The return of human waste—feces and urine—to the soil has historically been a major component of maintaining agricultural productivity, though excreta reuse declined considerably with the introduction of inorganic fertilizers, the production of which is energy intensive, environmentally harmful, and expensive.

Understanding the current use of soil amendments derived from human waste by farmers in India may help to guide policy and programming to promote the reuse of human waste and improve agricultural sustainability.

TGI Scholar Whitman Barrett is investigating the use of soil amendments derived from human feces and urine by farmers in Tamil Nadu, India. Through partnerships with local NGOs that have provided farmers with composting

toilets, he is working to evaluate the effects of human excreta-derived fertilizers on soil health and crop production. He conducted preliminary fieldwork in Tamil Nadu during the summer of 2022, interviewing farmers about the ways that they integrate composted human feces into their soil fertility management strategies. Barrett's interdisciplinary research will combine extensive farmer interviews with participatory agronomic experimentation and soil testing.

TCI's research in this area has the potential to empower smallholder farmers to save money on agricultural inputs, improve the health of their soils, and make their agricultural practices more environmentally sustainable.

## Understanding Atmospheric Carbon's Effect on Farm Yields

Carbon dioxide is a key component in the photosynthetic process that plants use to convert sunlight into energy, which makes it an essential input for agriculture. With greenhouse gas emissions increasing levels of atmospheric carbon around the world, understanding the resulting impact is crucial to estimating future crop yields.



Anna David Thottappilly's research uses data from NASA's Orbiting Carbon Observatory. (Image by NASA)

Anna David Thottappilly, a recent alumna of the TCI Scholar Program, conducted a pioneering study confirming lab-based findings that showed that heightened carbon dioxide increases yields. Using atmospheric carbon dioxide data from NASA's Orbiting Carbon Observatory (OCO-2) and comprehensive data on crop yields and input usage from the TCI-ICRISAT District-Level Database on Indian Agriculture and Allied Sectors, she charted the impact that increased atmospheric carbon has had on rice and wheat yields in India from 2014–2017.

*Thottappilly's research confirms the positive effect that atmospheric carbon has on crop yields.*

In those three years, global carbon dioxide levels rose 2.5 parts per million annually. In India, the increase was even greater at 3 parts per million.

Thottappilly's study reveals a 0.8% increase in wheat yield for every parts-per-million rise in atmospheric carbon dioxide. The impact on rice yield varies depending on the crop variety employed. In the regions along the western side of the Indo-Gangetic plain, where the finest rice crop variety is cultivated, a significant 0.9% yield increase is observed.

Thoroughly assessing the various factors that influence agricultural production and yield holds great importance in safeguarding future food security. Thottappilly's research confirms the positive effect that atmospheric carbon has on crop yields. As the world seeks to curb climate change by limiting emissions like carbon dioxide, these findings have important implications for efforts to boost agricultural productivity.

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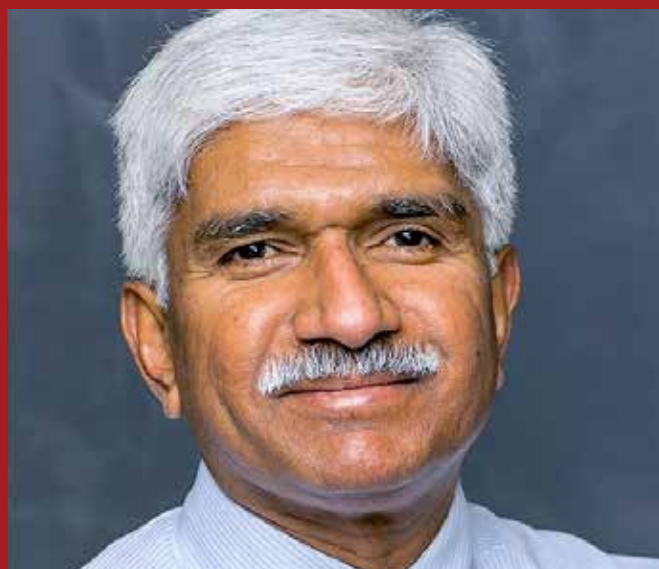
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## **Remembering Nagesh Gavirneni**

Dr. Nagesh Gavirneni, a TCI faculty fellow and professor of operations management in the Johnson Graduate School of Management at Cornell University, died in Ithaca, New York, this past year at the age of 56.

Gavirneni was a frequent fixture at TCI events. As a faculty fellow, he played a candidate advisory role in TCI's research agenda and helped to mentor TCI scholars.

"Nagesh was a valued member of the TCI family," TCI Director Prabhu Pingali said. "He was always eager to participate in TCI activities and provide support for our scholars and fellows. TCI has lost a close friend; his warmth and good humor will be sorely missed."

A respected researcher, Gavirneni used models and methodologies from the areas of supply chain management, inventory control, production scheduling, simulation, and optimization to solve problems in health care, agriculture, and humanitarian logistics in developing countries. He made seminal academic contributions to supply chain information sharing.



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