



# ANNUAL REPORT 2023-24

TATA-CORNELL INSTITUTE  
FOR AGRICULTURE AND NUTRITION



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# DIRECTOR'S NOTE



India and around the world.

In May, four TCI scholars graduated. Vanisha Sharma earned her PhD in applied economics, Chanchal Pramanik received his PhD in regional science, and management and Whitman Barrett earned his MS in crop and soil sciences, while Naveen Sridhar Kottayil received his MPS in global development. I am proud of the work that these scholars completed during their time at TCI and see great things in their futures.

With the departures of Vanisha, Whitman, Chanchal, and Naveen, we now have 10 scholars pursuing graduate degrees. These scholars are studying a diverse array of topics, all focused on improving food systems in India. Some of our current scholars' research includes the use of spectral imaging to assist with crop improvement, an assessment of the impact of farmer producer organizations on farm outcomes, and an analysis of the barriers to the use of digital farm management tools by smallholder shrimp farmers. You can read about their work in this report.

Recent years have seen a steady production of publications by TCI researchers, and in 2023–24, this productivity continued. TCI researchers had a total of 7 studies published in peer-reviewed journals like *Environmental Research Letters*, *PLOS One*, and *World Development*. Research Associate Andaleeb Rahman and I collaborated on a new book that sets forth a framework for the future of India's social safety net programs, a book that has been downloaded more than 18,000 times. We also published the latest in our series

The 2023–24 academic year was a productive time for the Tata-Cornell Institute for Agriculture and Nutrition (TCI), with the release of a new book, a report, and several policy briefs, plus ongoing field-based research in

of reports on food, agriculture, and nutrition—an in-depth analysis of food systems trends across South Asia.

In 2023–24, we also published two special policy briefs. One featured preliminary results from our project examining the true cost of India's national food subsidy program. It showed that substituting some of the rice provided through the program with millets could reduce its environmental impact. Another policy brief shared insights from our project on Zero-Hunger, Zero-Carbon Food Systems, recommending a trio of technological interventions with the potential to decrease greenhouse gas emissions associated with agriculture in the state of Bihar. This project is now moving into a second phase in which researchers will assess the viability of several climate-smart agricultural interventions and generate evidence to support implementing them at scale throughout the state.

The work that I have described here and that you will read about in this report would not be possible without the generous support of our funders, including grants from the Walmart Foundation and the Rockefeller Foundation, as well as the founding endowment given to Cornell by the Tata Education and Development Trust.

As ever, I am immensely proud of the work we are doing at TCI and its potential to positively impact the lives of millions of people in India and elsewhere in the world. I hope that you enjoy reading about that work in this report and thank you for supporting TCI.

A handwritten signature in black ink that reads "Prabhu Pingali". The signature is written in a cursive, slightly slanted style.

Prabhu Pingali  
Founding Director, TCI.

# BY THE NUMBERS

As of July 2024

18

Researchers

1

Postdoctoral Associate

10

TCI Scholars

5

Faculty Fellows

31

Alumni

19

PhDs Earned

7

Master's Degrees Earned

16

Academic Disciplines

7

Reports

4

Books

50

Journal Articles

14

Book Chapters

25

Policy Briefs

3

Fact Sheets

2

Training Manuals

# OVERVIEW

**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 staff assess different crops during a field visit in Bihar, India. (Photo by Milorad Plavsic/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.

# AGRICULTURE

## TRANSFORMATION, FOOD SYSTEMS & NUTRITION TRANSITION

### Millets Reduce True Cost of PDS

India's Public Distribution System (PDS) plays an important role in maintaining food security in the country by providing subsidized food grain to 800 million people. The program typically accounts for roughly 5% of India's annual budget, but TCI research shows that the true cost of the PDS is significantly higher when environmental and health impacts are taken into account.

TCI's project on the True Cost of Food Subsidies in India, led by Research Associate Raghav Puri, uses "true cost accounting" to reveal the hidden impacts of the PDS and models possible strategies to reduce their cost. In a study published in the journal *Environmental Research Letters*, TCI demonstrated that the true cost of the program was US\$45.3 billion when the economic and environmental



Millets are more nutritious than rice and can be grown more sustainably. (Photo by Raghav Puri/TCI)

impacts of rice and wheat production were considered, compared with US\$16.5 billion budgeted by the federal government and US\$900 million spent by PDS beneficiaries to buy subsidized grain.

The study showed that replacing 1 kg of rice with 1 kg of millets for a quarter of PDS beneficiaries would save US\$1.37 billion in environmental and economic costs each year. Production of millets is associated with significantly lower greenhouse gas emissions and water use than rice and wheat. When these factors are considered, the cost of producing 1 kg of rice and wheat is 2 and 1.8 times that of 1 kg of millets, respectively.

Millets also offer greater health benefits, compared to rice and wheat. Millets have more iron, a lower glycemic index, and are a rich source of calcium. Adding them to the PDS food basket could help to address India's high rates of anemia and rising obesity in the country.

The promotion of millets in the PDS could also help to decentralize procurement for the program, which is concentrated in a handful of rice- and wheat-producing states, thus reducing acquisition and transportation costs by as much as US\$110 million. Decentralized procurement would also economically benefit farmers in millet-producing states and reduce the environmental stresses felt by the northwestern states that are growing the bulk of the rice procured for the PDS.

By providing policymakers with a clearer picture of the costs and benefits of the PDS and different food basket outcomes, TCI is paving the way for a food subsidy program that is more cost-effective, environmentally friendly, and nutrition-sensitive.

Puri, Raghav and Prabhu Pingali. 2024. "Reducing the True Cost of Food-Based Safety Nets: Evidence from India's Subsidized Food Program." *Environmental Research Letters*, Vol. 19, No. 6, May 24.



## Reimagining India's Social Safety Nets

With a growing economy and increasing clout on the world stage, India is a success story among developing countries, but persistently high poverty and malnutrition rates threaten to leave millions of lives behind. A new book, authored by TCI researchers in 2024, argued that India needs to rethink its social safety nets to better address issues of poverty and malnutrition and to realize its full potential.

In *The Future of India's Social Safety Nets: Focus, Form, and Scope*, Research Associate Andaleeb Rahman and Director Prabhu Pingali explored India's array of social welfare programs and contended that the country should replace its piecemeal efforts with a systemic approach aimed at achieving a resilience that lifts families out of poverty and keeps others from falling into hardship.

In their analysis, Rahman and Pingali focused on three aspects of welfare policy design: focus, or intended beneficiaries; form, or the manner through which assistance is provided; and scope, or the developmental objective of a policy. They argued that India would benefit from a progressively universal social protection system that balances the trade-offs between fiscal prudence and the minimizing of targeting errors, which have left deserving beneficiaries in the wind. They advocated for adaptability for the form of assistance provided, arguing that social programs must be attuned to the economic and demographic changes occurring throughout the country, especially as different regions experience different levels of economic development.

To launch the book, TCI held a special workshop on India's social safety nets in New Delhi in August 2024. Researchers, practitioners, and other stakeholders analyzed the country's current programs and discussed



*The Future of India's Social Safety Nets* coauthor Andaleeb Rahman speaks during the launch event for the book in New Delhi. (Photo provided)

ideas for the development of a more inclusive, equitable, and efficient social protection system.

*The Future of India's Social Safety Nets* was published by Palgrave Macmillan as part of the Palgrave Studies in Agricultural Economics and Food Policy book series. It is available for download through open access at [tcu.cornell.edu/?publications=the-future-of-indias-social-safety-nets-focus-form-and-scope](https://tcu.cornell.edu/?publications=the-future-of-indias-social-safety-nets-focus-form-and-scope).

## Examining Food Systems Across South Asia

South Asia is a region of diverse cultures and political systems, but each country faces similar challenges with high rates of undernutrition and micronutrient malnutrition, in addition to rising levels of obesity. The latest report in TCI's series on food, agriculture, and

nutrition examines these and related trends across South Asia, offering a range of policy instruments for improving nutritional outcomes.

As detailed in the report, *Food, Agriculture, and Nutrition in South Asia: Building Healthy, Sustainable Food Systems*, hunger rates in South Asia declined for over a decade, but in recent years there has been a notable uptick. From 2018 to 2021, undernourishment increased from 12% to 17%. Around one-third of South Asian children under 5 are stunted, 15% are wasted, and more than half are anemic. Simultaneously, obesity is also on the rise in the region. Among adults, 20% of the population are overweight.

To address these issues, the report outlines a suite of policy options that could be considered along different parts of food supply chains in South Asia. For example, at the production stage, access to high-quality seeds and breeds, as well as changing cropping structures, could improve productivity.

The report presents three key messages for policymakers and researchers working on food systems in the region. First, policy interventions developed in isolation from other areas often lead to trade-offs and unintended consequences. Second, robust policy interventions are only possible in the presence of knowledge, credible data, and capable institutions. Third, current food systems challenges are too complex for any one entity—be it a country, institution, or field of research—to tackle alone.

TGI launched the report in April 2024, with a panel discussion featuring experts on South Asian food systems from across Cornell University.

*Food, Agriculture, and Nutrition in South Asia: Building Healthy, Sustainable Food Systems* is available for download at [tci.cornell.edu/food-agriculture-nutrition/](https://tci.cornell.edu/food-agriculture-nutrition/)

## Taking Stock of Plant-Based Meats

As efforts to stop climate change ramp up, increased attention is being given to swapping out meats and dairy items for plant-based alternatives designed to replicate the real thing. However, TGI research casts some doubt on plant-based meat and dairy analogs' ability to meet the nutritional needs of people in the developing world.

Published in the journal *World Development*, the study assessed the potential for plant-based meat and dairy products to be part of sustainable diets, as meat consumption rises in low- and middle-income countries and falls in high-income countries. According to the study, the greenhouse gas emissions associated with beef, pork, and poultry production are 13, 3, and 2 times greater than plant-based meats, respectively.

Although plant-based meat and dairy products are more environmentally friendly than the products they mimic, they do not always offer the same nutritional benefits. Plant-based meats often have a similar protein content as traditional meat, but plant-based milks frequently do not have as much protein as dairy milk and may not always contain the complete amino acid profile needed by the human body. Micronutrients found in animal-sourced foods, such as iron, are artificially added to plant-based analogs, but the study revealed insufficient evidence that they are absorbed as readily by the human body as the animal-sourced foods.

Pingali, Prabhu, Jocelyn Boiteau, Abhinav Choudhry, and Aaron Hall. 2023. "Making Meat and Milk from Plants: A Review of Plant-Based Food for Human and Planetary Health." *World Development*, Vol. 170, October.

# SCHOLAR SPOTLIGHT



## Kasim Saiyyad

Most TCI scholars start their journeys in the classroom before heading out into the field, but Kasim Saiyyad flipped that script. A PhD student studying applied economics and management, Saiyyad began his time with TCI as a staff member, helping scholars coordinate their fieldwork across India.

Saiyyad also played a leading role in one of TCI's first field-based research projects—the Sustainable Flour Fortification Initiative, or Sfurti. In that role, Saiyyad worked with development organizations, academic institutions, and women's self-help groups to pilot a program providing micronutrient sachets for households to mix into their flour.

“This project exposed me to the severe and widespread problem of malnutrition and its profound impact on family well-being,” Saiyyad says.

After the Sfurti project concluded, Saiyyad moved to Ithaca, New York, to pursue a master's degree and eventually a doctorate at Cornell University.

“During my time coordinating fieldwork and leading the flour fortification program, I gained invaluable practical insights into the intricacies of implementing development initiatives,” he says. “However, I also recognized the need for a more comprehensive understanding of the underlying economic principles, theoretical frameworks, and analytical tools that inform effective policymaking and sustainable solutions.”

Now undertaking his own field-based research, Saiyyad has come full circle. It's a privilege that influences his decisions as a PhD student. “Fieldwork has instilled in me a profound sense of humility and empathy, reminding me of the privilege inherent in my position as a researcher and deepening my commitment to using research as a tool for positive change and amplifying the voices of those I seek to support,” he says.

In the future, Saiyyad hopes to use his skills and knowledge to create interventions that enhance efficiency and equity in the delivery of essential social services, like health care and education.

# FOOD & AG-SCIENCE INNOVATIONS

## Raising Capacity to Improve “Orphan” Crops

In agricultural research and development, staple grains like rice and wheat loom large, while coarse grains, roots, tubers, and pulses are overshadowed. But these “orphan” crops are cultivated by smallholder farmers across developing countries for the essential nutrients they provide. Crops like millets, cassava, and cowpea often boast rich nutritional profiles and are adaptable to diverse agroecological landscapes.

Despite their importance, the “orphan” crops have not received adequate attention from agricultural research institutions. With little investment in plant breeding, these crops present challenges, including suboptimal yields and vulnerability to pests and disease, disincentivizing farmers from farming them. Because they are consumed mostly locally, what crop development activities exist are undertaken by public sector breeding programs.



*An improved variety of cowpea grows at an ILCI research institute in Senegal. (Photo by Kelly Merchan)*

To help advance these vital crops, TCI is part of the Feed the Future Innovation Lab for Crop Improvement (ILCI), an initiative that partners with national agricultural research institutes in Africa, Latin America, and the Caribbean to co-develop tools, technologies, and methods to assist with the improvement of orphan crops and build institutional capacity. TCI leads the lab’s institutional capacity evaluation component by assessing, understanding, and tracking how the capacities of partner institutions are built.

In this role, TCI researchers conducted surveys and field visits to measure changes in institutional capacity and understand the capacity-building process and its challenges. Preliminary survey results indicate that, since the start of the project, programs have consulted more diverse stakeholder groups to identify needs, adopted genomic services, increased the use of digital data collection, and utilized breeding management software for more efficient, accurate, and transparent breeding processes. Field visits helped to reveal the challenges faced by public research institutions, including funding constraints and infrastructure gaps that limit the institutions’ ability to carry out basic research.

TCI’s research shows that ILCI has helped public research institutions to overcome obstacles to breeding better varieties of orphan crops by prioritizing breeding initiatives aligned with local communities’ needs, fostering inclusive stakeholder engagement, and nurturing regional collaborations. Sustaining this momentum requires continued investment in capacity-building initiatives and robust partnerships.

## Accelerating Crop Breeding for Disease-Resistance

Genetic resistance to disease is one of the keys of sustainable agriculture, as 20–40% of crops across the



*Shivranjani Baruah and an ICRISAT researcher use drone-based spectral sensors to assess physiological changes to plants. (Photo courtesy of ICRISAT)*

world are lost to pests and diseases each year. Such losses fall particularly hard on developing countries like India, where they exacerbate existing food and nutritional insecurity.

Breeding disease-resistant crops can help overcome this problem. However, the process of large-scale screening for disease resistance during the breeding process remains a bottleneck in the developing world, where breeders use time-consuming and difficult-to-standardize manual phenotyping techniques.

To address this issue, TCI is supporting a proof-of-concept study, led by TCI Scholar Shivranjani Baruah, to evaluate whether spectral imaging can be used as a high-output

method to detect and quantify bacterial blight in rice crops. The process being tested by Baruah uses canopy-mounted, multispectral sensors, combined with drone-based multispectral and hyperspectral sensors, that together provide wide spectral resolution to identify disease-dependent changes in plant physiology, which cannot be detected by human eyesight. Baruah is also testing how this process could be scaled up to operate under natural field conditions.

Baruah's experiments are being conducted at the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) in Hyderabad, India.

The framework for this study can be easily adapted for spectral characterization of other diseases in rice, and in other cereals, potentially paving the way for rapid crop phenotyping for a wide range of breeding applications in India.

## Improving Goat Breeding

Goat breeding is a valuable activity for smallholder farmers in India, providing a means of income generation even during crop failures. However, a reliance on natural breeding techniques limits their productivity because of issues like inbreeding and disease transmission. Farmers could benefit from using artificial insemination to breed goats with superior genetic material, but few have adopted the practice due to perceived costs and underdeveloped markets.

In partnership with BAIF Development Research Foundation, TCI is leading a study to assess the benefits of artificial insemination for goat breeding, as well as the factors affecting farmers' decisions to adopt the practice. As part of the study, researchers are providing artificial insemination and other healthcare services to goat-rearing households across Rajasthan, Bihar, Maharashtra, and Odisha.



Using artificial insemination to breed goats can improve their productivity and increase farmer incomes. (Photo by Maureen Valentine/TCI)

Preliminary results indicate that the impact of artificial insemination on birthweight and kidding rates varies across different regions. Participating farmers report satisfaction with using artificial insemination, noting that it saves time and yields healthier offspring.

This study can pave the way for more effective and sustainable goat breeding practices, positively impacting the livelihoods of small and marginal farmers.

## GM Regulations and Farmer Incomes

Genetically modified (GM) crops have vast potential to increase yields and improve nutrition outcomes. However, such crops are tightly regulated in India, with cotton the only GM crop currently approved for commercial cultivation.

A TCI study published in *Economic & Political Weekly* examined the costs of India's stringent regulatory system using GM mustard—which received government approval for environmental release in 2022—as a case study. The study showed that GM technology enables mustard hybrids with higher yields, poses no risk to food and the environment, and benefits both farmers and consumers through higher farm incomes and lower vegetable oil prices. Over the nine-year period that the GM variety was ready for use but not yet approved, the Indian farming community lost potential additional income gains worth US\$16 billion, while the country lost 15–20 million tons of potential mustard seeds.

Though it is nearing commercial use, GM mustard must still pass additional hurdles, including seed multiplication and post-release monitoring tests. TCI's research shows that this burdensome process has real costs for farmers and consumers alike.



The prolonged approval process for genetically modified mustard has cost Indian farmers US\$16 billion in potential earnings. (Photo by Abhi Verma/Unsplash)

Nuthalapati, Chandra S., David Zilberman, Matin Qaim, and Prabhu Pingali. 2023. "Hybrid Mustard and Biotechnology: Pathways for Doubling Farmers' Incomes and Nutritional Security." *Economic & Political Weekly*, Vol. 58, No. 43, October 28.

# STAFF SPOTLIGHT



## Sage Grasso-Monroe

After volunteering with the Peace Corps in Ethiopia and earning an MPS in global development at Cornell, Sage Grasso-Monroe has become an indispensable member of the TCI research staff. As a

research support specialist, she assists with TCI's work for the Feed the Future Innovation Lab for Crop Improvement (see page 10), Grasso-Monroe helps to evaluate the institutional capacities that contribute to the success of national agricultural research institutes. In that role, she conducts literature reviews, develops metrics, administers surveys, and analyzes data, among a variety of other responsibilities.

"My involvement in these diverse tasks allows me to contribute significantly to our team's efforts in evaluating and enhancing institutional capacities within agricultural research programs," she says.

Grasso-Monroe's own research interests revolve around cultural agricultural practices, such as crop varieties and land management, and how they influence nutrition and soil health. The topic is closely related to the work of ILCI.

"What initially attracted me to this project was its focus on enhancing food security through addressing the specific needs of food-insecure populations and improving crops that hold cultural and nutritional significance for local communities," she says. "The ultimate goal is to develop and release crop varieties that address farmers' needs and enhance food security, a powerful and motivating mission driving my research endeavors."

Grasso-Monroe says that working for TCI has afforded her the opportunity to advance as a researcher while learning from leading experts on food-security-related issues and broadening her knowledge and skill set.

"I am privileged to be part of a dynamic and motivated group of students and staff whom I proudly call my colleagues," she says. "I am continually inspired by their innovative and diverse approaches to addressing and understanding food systems."

# MARKETS & VALUE CHAINS

## Understanding the Income-Increasing Power of FPOs

With growing urban markets and evolving food preferences, India's farmers have a tremendous chance to increase their profits in the coming years. Yet, Indian agriculture is dominated by smallholders, whose diminutively sized farms make it difficult for them to access the markets needed to take advantage of this opportunity.

Farmer producer organizations (FPOs) have emerged as a favored vehicle for smallholder commercialization in India's development strategy. By joining together in FPOs, farmers can potentially achieve economies of scale and increased

bargaining power, leading to enhanced productivity and higher incomes.

As part of TCI's project on FPO-Led Small Farm Market Access Models, TCI Scholar Ekta Joshi is analyzing the impact of FPO membership on farm outcomes, including crop income, farm profits, and household income. As part of her study, Joshi conducted field surveys of 1,800 farmers in five districts in Maharashtra, the state with the most FPOs in India.

Preliminary results from Joshi's study show significant, positive associations between FPOs and farm outcomes, mainly driven by improved bargaining power on price premiums. The impact of FPO membership is greater among



A post-harvest facility and warehouse owned and operated by an FPO in Maharashtra helps soybean farmers sell their crops at higher prices. (Photo by Leslie Verteramo Chui/TCI).





*Discarded crops are eaten by a pig at the Madanapalle tomato market in Andhra Pradesh, India. (Photo by Jocelyn Boiteau/TCI)*

well-established FPOs and those with large memberships. FPOs with CEOs that assist in business plan development and operationalization also yield better outcomes for members.

With more than 33,000 FPOs in the country and massive investments in FPO promotion by the government and other actors, this research provides new and timely empirical evidence on the impact of one of India's largest agricultural interventions and its potential to significantly improve the livelihoods of smallholder farmers.

## Combating Food Loss and Waste Across Transforming Food Systems

As part of the UN Sustainable Development Goals (SDGs), reducing and preventing food loss and waste is recognized

as an urgent issue under SDG Target 12.3. Reducing food loss and waste can yield potentially significant environmental, economic, and food security benefits—each of which are highly context-specific. Achieving global food loss and waste reduction goals requires understanding of the nature of the problem within a given context and accounting for the structural transformation of economies and transformation of food systems.

TCI Postdoctoral Associate Jocelyn Boiteau and Director Prabhu Pingali are co-authoring a forthcoming book on this topic: *Food Loss and Waste Across Transforming Food Systems: Frameworks, Pathways, and Approaches*. In the book, they examine how reforms of food systems can support food loss and waste reduction efforts to promote sustainable, safe, and nutritious diets in countries at different points of structural transformation. Using a food systems lens, they focus on low- and middle-income countries to explore entry points for food loss and waste investment and intervention priorities.

This book adds to the existing literature by presenting, for the first time, a comprehensive framework of food loss and waste pathways to describe the links between food quality loss and physical food loss and waste that directly impact diets and food diverted for nonfood uses. Food loss and waste is complex and has many dimensions, requiring a variety of approaches to estimate the extent of losses and identify the layered causes across food products, value chain stages, and geographies.

Based on their review of the evidence, Boiteau and Pingali identify promising and inclusive policy agendas that align food loss and waste prevention with sustainable food systems goals. This book will appeal both to professionals interested in food loss and waste prevention and to academic researchers studying the issue.

# GENDER & NUTRITION

## Pandemic Linked to Child Undernutrition

From extreme weather events to disease outbreaks, food systems disruptions can negatively impact nutritional outcomes, especially among the most vulnerable populations. TCI research on the COVID-19 pandemic in India underscores the issue and highlights the importance galvanizing food systems to minimize the impact of disturbances when they occur.

In a study published in *Economic & Political Weekly*, TCI used pre- and post-pandemic survey data on children's health and nutrition to show that the number of children

deemed underweight increased by 14% as a result of disruptions caused by the pandemic, including supply chain problems, price inflation, loss of work, and the interruption of government food safety net programs.

Researchers examined survey data collected from 511 households in Bihar and Odisha in June 2017 and July 2021, about 18 months after the pandemic-related lockdowns in India. The survey data included a wide range of information about food consumption and nutrition, including height and weight measurements of children under the age of 5.

The percentage of underweight children increased from 31% in 2017 to 45% in 2021, with children under the age of 2



Children in New Delhi wait in line to receive food from aid workers during the COVID-19 pandemic. (Photo by PradeepGaur/Shutterstock)

disproportionately impacted. Most of the shift occurred in children who already had low weights for their ages in 2017.

A number of factors were found particularly determinative of whether a child's weight-for-age worsened, namely reduced access to food safety net programs like Integrated Child Development Services (ICDS) and the Partnerships and Opportunities to Strengthen and Harmonize Actions for Nutrition in India (POSHAN), or the Mid-Day Meal Scheme.

Some of the children surveyed experienced an improvement in weight during the pandemic. Those children had higher access to ICDS and their families cultivated more pulses and vegetables in 2021, than they did in 2017. A higher maternal body mass index (BMI) was also associated with improved child weight.

The study builds on previous TCI research showing that women's dietary diversity suffered during the pandemic. Taken together, the studies demonstrate that policymakers should work to minimize potential disruptions to programs that ensure supplementary nutrition for vulnerable groups, with priority given to basic maternal and childcare services.

Seth, Payal, Soumya Gupta, and Prabhu Pingali. 2024. "Did the COVID-19 Lockdown Reverse the Nutritional Gains in Children? Evidence from Rural India." *Economic & Political Weekly*, Vol. 59, No. 5, February 3.

## Men's Education Elevates Household Nutrition

Among development practitioners and policymakers, women's education is a key tool for improving household nutrition. Research from TCI 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



*For each additional year of schooling men receive, the dietary diversity score of their household increases by 0.2 food groups. (Photo by Rj Stocks/Shutterstock)*

researchers established 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 nutritional status, as a greater number of food groups eaten increases the likelihood of adequate nutrient consumption.

The researchers arrived at their findings using survey data from 3,600 households from 4 districts in 3 states in India: Bihar, Uttar Pradesh, and Odisha. The data were collected as part of a past TCI project, Technical Assistance and Research for Indian Nutrition and Agriculture (TARINA).

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 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.

Sunder, Naveen, Soumya Gupta, and Prabhu Pingali. 2023. "Leveraging Men's Education as an Effective Pathway for Improving Diet Quality: Evidence from Rural India." *PLOS One*, Vol. 18, No. 11, November.

## Understanding Alcohol Prohibition and Women's Empowerment

Could prohibiting alcohol empower women? In 2016, the state of Bihar imposed a comprehensive ban on alcohol

to address domestic violence and crime within the state. Previous studies by TCI researchers found that a prohibition resulted in a reduction in violent crime. Now, TCI Scholar Apurva Borar is assessing its impact on women.

To evaluate the effects of prohibition, Borar conducted interviews with women in the state and analyzed data from India's National Family Health Survey to measure how the ban changed women's attitudes toward domestic and intimate partner violence.

Preliminary analysis shows that alcohol prohibition led to a significant reduction in women's excusal of domestic violence. By reducing domestic violence, the reduction in the availability of alcohol appears to have influenced how women perceive and rationalize such violence. Notably, this change is partially attributed to police vigilance and grassroots awareness campaigns that promote women's rights and equal gender norms.

By establishing a link between alcohol consumption and women's empowerment, this research reveals a potentially important pathway for empowering women in states with high alcohol consumption.



TCI Scholar Apurva Borar interviewed a group of women in Bihar about their thoughts on alcohol prohibition and domestic violence. (Photo provided)

# STAFF SPOTLIGHT



## Bharath Chandran C

TCI would not be able to undertake its ambitious research projects without the support of researchers like Bharath Chandran C. An associate researcher, Chandran contributes to several projects,

including Zero-Hunger, Zero-Carbon Food Systems (see page 24) and a field-based study on goat breeding through artificial insemination (see page 11).

Chandran is interested in studying how long-term social and climatic trends impact food systems in developing countries. He is motivated to do so by the real impacts that food systems have on people's lives. "Improving the system is essential for addressing equitable access to nutritious food and improved agricultural practices," he says.

Chandran's responsibilities at TCI take him to multiple field locations, like smallholder farms in Bihar as part of the Zero-Hunger, Zero-Carbon Food Systems project, and to TCI's Center for Excellence in New Delhi, where he assists with data analysis. He finds working for TCI to be a rewarding experience, due to the impactful nature of the work and the diverse set of researchers, policymakers, and academics with whom he interacts.

"The work we do here can play a bigger role in the policy environment, helping to better inform decision-makers at the national and global levels," he says. "Finally, the work we do has a larger purpose of addressing sustainable development issues. Contributing to this cause is the biggest reward for a researcher like me."

Chandran previously served as a research intern at TCI from January 2020 to June 2021. He holds a master's degree in studies and resource management from the TERI School of Advanced Studies in New Delhi.

# FOOD SAFETY

## WATER & SANITATION

### Promoting Excreta-Derived Fertilizers

The prevalent use of inorganic fertilizers, which are subsidized in India, has been a boon for agricultural productivity, but they are not without costs. Producing such fertilizers is energy intensive, environmentally harmful, and expensive. When used excessively, they can damage soil health.

Creating circular economies that return nutrients removed from the soil through agricultural activity can help to make farming more sustainable. One way to do this is through the use of fertilizers derived from human feces and urine, which contain carbon, nitrogen, and other useful nutrients.

Excreta-derived soil amendments may be particularly important for smallholder farmers who do not have access to adequate quantities of animal manure to maintain organic matter levels on their farms. Declining organic matter levels can cause the inorganic fertilizers purchased

by farmers to leach out of the soil, rendering them unavailable to crops and leading to lower yields.

TCI is working to understand the current use of soil amendments made from human waste in rural India to better guide policies and programming promoting excreta-derived fertilizers. As part of this effort, TCI alumnus Whitman Barrett investigated the use of such fertilizers by farmers in Tamil Nadu. Through partnerships with local NGOs that have provided farmers with composting toilets and interviews with the farmers themselves, Barrett evaluated how human excreta-derived fertilizers are integrated into smallholder farmers' soil fertility management strategies. Barrett returned to Tamil Nadu in 2024, to report his findings to project stakeholders.

By providing a better understanding of how farmers think about and use excreta-derived fertilizers, 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 and productive.



*Composted human waste offers farmers a cheaper, more sustainable means to improve soil fertility than chemical fertilizers. (Photo by Whitman Barrett/TCI)*

# ALUMNI SPOTLIGHT



## Whitman Barrett

Given his area of study, it's safe to say that Whitman Barrett knows his... stuff. Barrett, who earned a master's degree in soil and crop sciences, spent his time as a TCI scholar studying the use of human excreta as a soil amendment among smallholder farmers in India.

Barrett's interest in the agronomic potential of human waste was sparked while he was living in Togo as a Peace Corps volunteer. There, he was involved in several projects related to soil fertility management and agroforestry. When he came to Cornell for a master of professional studies in global development, he worked with Professor Johannes Lehmann to estimate the potential agricultural benefits of human excreta in Togo.

"I got to thinking about the role of human excreta as a soil amendment and as a critical link in closing these nutrient cycles from a farm to a human who consumes food, and then eventually returning those nutrients back to the soil," Barrett says.

Interacting with the academically diverse TCI research group had an important impact on Barrett's research, as he came to see where his work fit within the broader food systems landscape. "The kinds of questions that occur to them about my work and the kinds of questions that occur to me about their work—I think there's a really useful exchange of ideas that happens because we're all interacting on a regular basis," he says.

Barrett said that TCI's emphasis on field-based study also benefited his research, as he had an opportunity to see the broader context in which farmers make decisions and the constraints that they face with regard to soil management.

In the future, Barrett plans to work in agricultural extension. "I'm interested in working with farmers to collaboratively solve agricultural problems and ensure that farmers have the tools and information they need to adapt to a changing climate and adapt to changing realities facing food systems throughout the world," Barrett says.

# ICTS, DATA SYSTEMS & AG TECH

## Improving Access to FPO Data

Without accurate, timely data, sound policymaking is largely impossible. Yet, despite the Indian government's and development agencies' robust support of farmer producer organizations (FPOs) as a pathway for boosting agricultural productivity and farmer incomes, there is little data available to stakeholders interested in India's FPO ecosystem. TCI is working to change that by developing the FPO Platform for India, the only centralized source of data on Indian FPOs that is currently available.

Supported by a grant from the Walmart Foundation, the database features data on more than 33,000 FPOs. Since it was created in 2021, more than 12,000 users have visited the platform, including researchers, FPO members, and prospective buyers and sellers of agricultural products.

Through the interactive, web-based dashboard, users can access a wealth of information on FPOs, including crops produced, founding years, and sponsoring agencies. The flexible dashboard also allows users to take a wide view of FPOs across states, or dig deep into the cropping, legal, and basic financial information of individual organizations.

Ongoing updates in 2024 are set to improve user experiences on the platform, making it more readily accessible for its largest group of users—Indian farmers. Since nearly 100% of Indian farmers in rural areas access the Internet with mobile devices, the platform will be optimized for smartphones. It will also be made available in several local and regional languages spoken by the majority of users, including Hindi, Marathi, Kannada, and Telegu.

Other updates will make it easier for FPOs to claim its business profile pages and update information highly sought after by policymakers and market actors, including crops, sponsoring agency, and resource institution. By claiming its profile page, an FPO can use it as a website representing the organization, get increased search engine

views, and receive notifications for contact requests from potential product buyers or service providers.

## Improving Adoption of Digital Ag Tech

Digital farm management technologies can potentially enhance productivity across India's agricultural sector, increasing farmer incomes and improving the availability and affordability of agricultural products. However, farmers may fear that such technology is too complex for them to utilize, limiting its adoption.

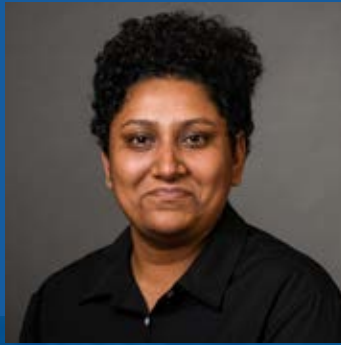
TCI is spearheading research to better understand the barriers blocking the adoption of digital agricultural technology. TCI Scholar Shree Saha has undertaken a field-based study of shrimp aquaculture to discover how the perceived complexity of technology hinders uptake even when resources, human capital, and availability are no longer roadblocks. Based on field interviews, she found that farmers often chose not to use digital technology because of preconceived notions about the technology's complexity and the inherent complexity of farming itself.

Saha also conducted a randomized control trial with 611 shrimp farmers in the coastal districts of Odisha, India, providing them with hands-on training about a specific piece of farm management technology. Preliminary results show that individualized training significantly reduces overall perceptions of complexity and encourages adoption of digital farm management tools.

When completed, Saha's research will help policymakers to create more effective interventions promoting technology adoption by farmers, to enhance productivity. By integrating the framework of supply and demand with behavioral economics, this research has the potential to transform the way technology adoption is studied, helping to improve overall agricultural practices.



# SCHOLAR SPOTLIGHT



## Shree Saha

For TCI Scholar Shree Saha, research is more than a job—it's a passion. She decided to pursue a PhD in applied economics and management because she is passionate about advanced quantitative economic analysis and wants to use it to study Indian

experiences. Her doctoral research focuses on the barriers to technology adoption among Indian shrimp farmers.

Saha credits TCI with giving her the freedom to explore different ideas and topics for her research. "This freedom has been incredibly beneficial for me in uncovering my passion as a researcher," she says.

She describes fieldwork—one of the pillars of the TCI Scholar Program—as a crucial part of her PhD journey, helping her to develop essential skills, such as planning, training, and team building. It has also helped her to bridge the gap between the theoretical knowledge gained in the classroom and on-the-ground reality.

"I find immense satisfaction of viewing the data through the lens of reality," Saha says. "My research predominantly centers around primary data collection, driven by the desire to ensure that the voices of those I interview are authentically reflected in my work."

With her enthusiasm for economic analysis and field-based study, Saha intends to remain actively engaged in research after completing her doctoral dissertation.

# CLIMATE CHANGE & SUSTAINABLE AGRICULTURE

## Achieving Net-Zero Agriculture

With the climate rapidly changing, countries like India are beginning to take action to reduce greenhouse gas emissions, including those associated with agricultural production. As India continues to struggle with undernutrition, it is crucial that policies are designed to mitigate emissions without hurting efforts to reduce hunger. Through its project on Zero-Hunger, Zero-Carbon Food Systems, TCI is working to identify interventions that will move the agricultural sector in Bihar closer to net-zero emissions while maintaining or even improving productivity.

After a series of workshops and field visits, project researchers identified three transformative, climate-smart interventions for further study—alternate wetting and drying in paddy cultivation, and for livestock production, advanced artificial insemination and anti-methanogenic feed supplements. In a special policy brief, TCI demonstrated these technologies' potential impacts on both emissions and productivity.

TCI research shows that alternate wetting and drying, a controlled irrigation technology, can reduce emissions from paddy cultivation by 4 MT annually, as compared to continuous flooding. A reduction of 5.4–7.2 MT can be achieved in the livestock sector through advanced artificial



*Agrivoltaics utilizes solar panels to use the same land to generate electricity and grow crops. (Photo by Milorad Plavsic/TCI)*

insemination and anti-methanogenic feed. The use of sex-sorted semen for artificial insemination holds the potential to improve milk productivity of cattle, allowing farmers to maintain smaller herds, thus lowering total methane emissions.

The policy brief presents an assessment of these technologies' impacts across Bihar's four agroecological zones, providing policymakers with the information necessary to allocate their resources effectively and target interventions based on suitability to local contexts.

In the next stage of the project, TCI researchers are working with partners in Bihar to assess the viability of several interventions and generate evidence to support their scaling up through existing state programs. Researchers are focusing on reducing cattle herd size and emissions through the use of sex-sorted semen and anti-methanogenic feed supplements; achieving optimal water and nutrient usage in rice production through integrated management practices, including alternate wetting and drying; and using agrivoltaics to produce both solar power and food on the same farmland.

## Diversifying Agriculture for Climate Resiliency

Images of lush green paddy fields are evocative of food security and agricultural prosperity. However, accounting for a third of all cultivated land in India, paddy is a major source of greenhouse gas (GHG) emissions. To achieve the global goal of net-zero emissions, reducing the environmental footprint of paddy cultivation is now a policy priority. Aside from reducing emissions, moving away from rice could also improve Indian diets by reducing carbohydrate consumption, which contributes to the upswing of lifestyle-based noncommunicable diseases in the country.

TCI is partnering with Professional Assistance for Development Action (PRADAN) on the project, Transformation of Agriculture Systems for Climate Resilience, which aims to diversify agriculture in the central Indian state of Chhattisgarh away from a paddy-based system toward the production of more nutritious and climate-resilient crops, like pulses, oilseeds, and millets.

During multiple field visits to the state, TCI researchers found that agricultural diversification in Chhattisgarh is inhibited by a variety of factors, such as a lack of information, absence of markets, antiquated agricultural practices, underdeveloped irrigation systems, and the expansion of government support to paddy production through minimum support prices. Rice is the state's primary crop, covering 76% of its total gross cropped area. The influence of paddy has reduced the production of other nutritious crops. Pulses, oilseeds, and millets occupy only 12%, 3%, and 0.1% of the total gross cropped area, respectively.

Utilizing an experimental design to inform the right policy plan, TCI and PRADAN are investigating whether information dissemination regarding agricultural sustainability, farmer training, the availability of seeds for non-paddy crops, and access to community-based lift irrigation can create a cycle of climate-resilient agricultural practices, putting Chhattisgarh on the path to sustainable agricultural development.

This project exemplifies TCI's commitment to and expertise in promoting environmentally sustainable food systems in India. The evidence that it generates will help create tools and policies supporting a shift to a more diversified, climate-conscious agricultural sector.

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