

Reducing Methane Emissions from Livestock in Bihar

Raising awareness of advanced artificial insemination is a key pathway to increasing its adoption

As the Indian government works to promote climate-smart agricultural practices and make its food systems more environmentally sustainable, livestock production is a key focus area. Improving herd efficiency serves not only to reduce these emissions, but can also improve farmers' incomes.

Research from the Tata–Cornell Institute for Agriculture and Nutrition's (TCI) Zero-Hunger, Zero-Carbon Food Systems project shows that livestock breeding, using advanced artificial insemination with sex-sorted semen, is a promising method for reducing emissions. As the role of power animals has diminished due to mechanization, and the beef industry faces significant social and legal challenges, male calves pose economic burdens for farmers, whereas female calves present economic opportunity. Sex-sorted semen has the potential to increase the proportion of productive female animals, with the likelihood of obtaining a female calf reaching nearly 90%, compared to 50% with conventional artificial insemination or natural breeding. However, the higher market price for advanced artificial insemination with sex-sorted semen (800-1,100 rupees, compared to 150-300 rupees for traditional artificial insemination) poses a significant challenge for scaling adoption.

To address this challenge, TCI partnered with BAIF Development Research Foundation to examine how raising awareness can improve uptake and willingness to pay for sex-sorted semen, with the aim of formulating a potential plan to encourage its use among livestock farmers in Bihar.

TCI research shows that raising awareness of advanced artificial insemination with sex-sorted semen increases farmers' willingness to adopt and pay for the service.

Livestock Production in India

With one of the largest cattle populations in the world, India's livestock sector serves as a major source of livelihood for over 70% of rural households and contributes around 30% of farm income. Bihar is a key livestock-producing region. However, its mostly smallholder and marginal farmers struggle with lower milk productivity, at 4.6 kg/day/animal against the national average milk yield of 6 kg/day/animal. This disparity is largely due to Bihar's higher proportion of unproductive, non-descript cattle varieties.

In this context, sex-sorted semen has emerged as an especially relevant technology supported by existing government policies, like the Rashtriya

Gokul Mission, which aims to improve milk production by developing and improving the genetic quality of indigenous cattle, as well as recent infrastructure investments, including the establishment of a large sex-sorted semen facility in Bihar's Purnea district.



Raising Awareness of Advanced Artificial Insemination

To test the impact of awareness on adoption of advanced artificial insemination, TCI researchers, in coordination with Digital Green and with technical inputs from BAIF, designed an awareness campaign consisting of videos and pamphlets. These were distributed through community meetings by artificial insemination technicians in eight cattle development clusters (CDCs), typically consisting of 11–15 villages, spanning 7 districts across 4 agro-ecological zones in Bihar. The objective of the campaign videos was to educate farmers on sex-sorted semen technology, its benefits, and related environmental impacts. Awareness campaigns were administered in two rounds to groups of 15–20 farmers in public spaces at the village-level. Additionally, sex-sorted semen doses were made available for purchase at two price points (300 rupees and 500 rupees) that were randomly assigned to different CDCs. The artificial insemination technicians administered these doses at the farm gate.

To assess the impact of the awareness campaign and understand the drivers of farmers' purchase decisions, TCI conducted two rounds of surveys,

Prices for Sex-Sorted Semen Doses

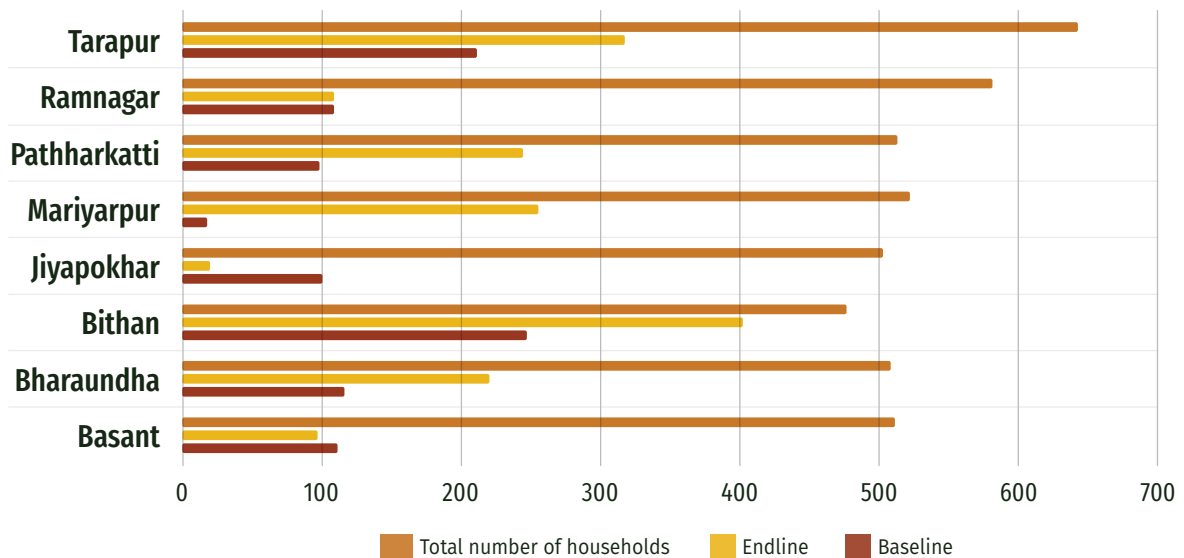
CDC Name	District	Number of households	Price (rupees)
Basant	Darbhanga	582	300
Bharaundha	Gaya	503	300
Jiyapokhar	Kisanganj	523	300
Mariyarpur	Banka	509	300
Bithan	Samastipur	643	500
Pathharkatti	Gaya	477	500
Ramnagar	Khagariya	513	500
Tarapur	Munger	512	500

one before and one after the rollout of the intervention. In addition to farmers' stated preference regarding sex-sorted semen (captured through willingness to pay for it), researchers also tracked purchase decisions of survey households (that is, their revealed preference).

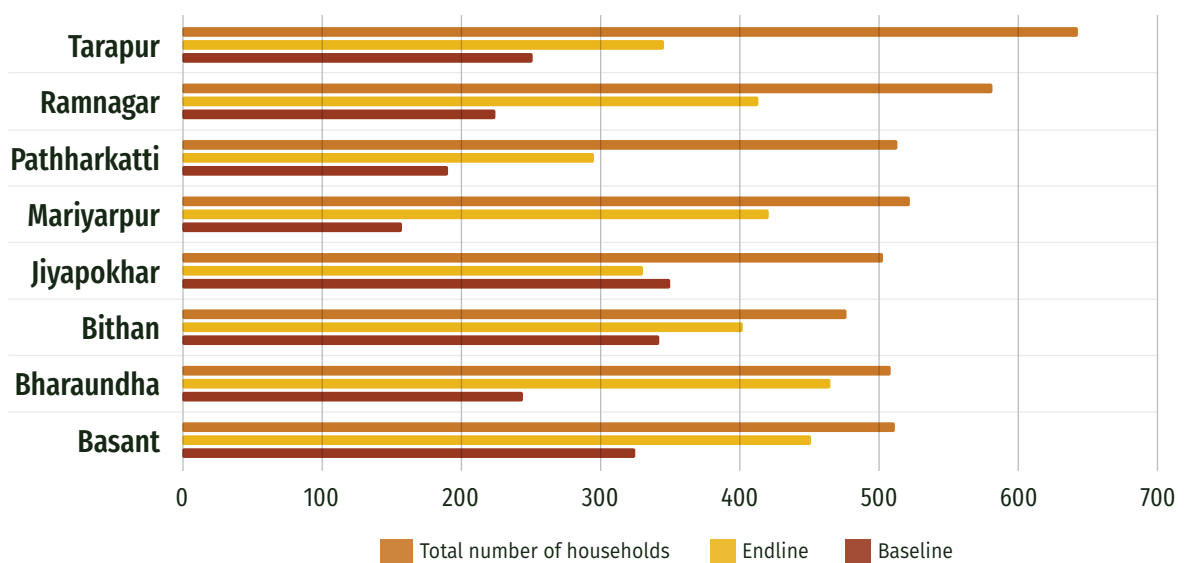
Awareness Increases Adoption

Our baseline survey revealed that prior exposure to artificial insemination

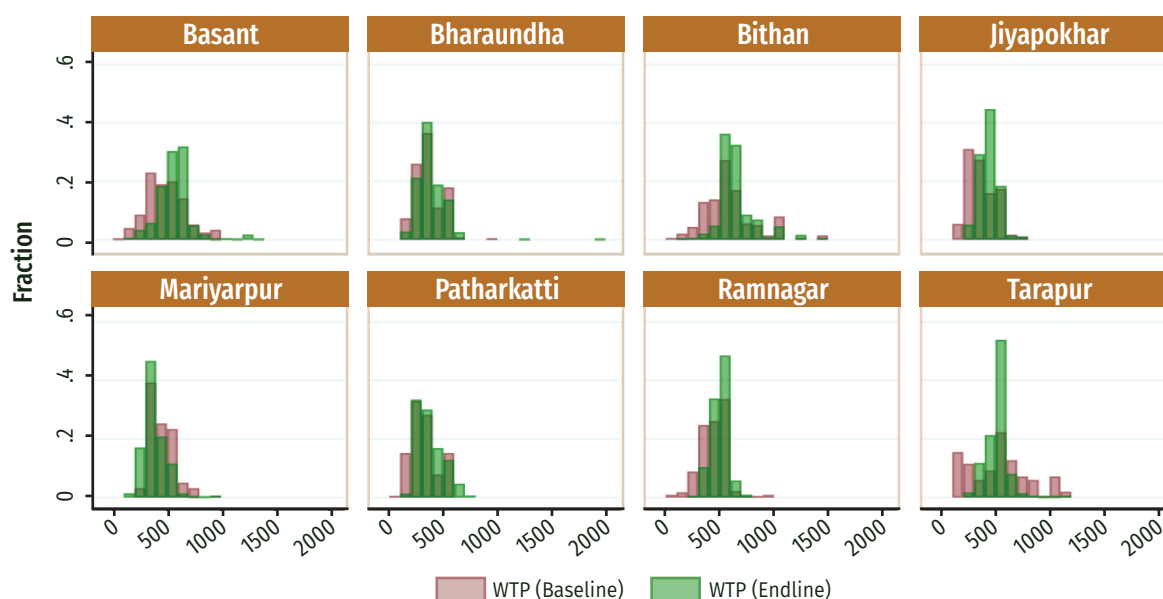
Households that Have Heard of Artificial Insemination with Sex-Sorted Semen



Households that are Willing to Adopt Artificial Insemination with Sex-Sorted Semen



Willingness to Pay for Sex-Sorted Semen Doses in Rupees (Baseline Versus Endline)



using sex-sorted semen—specifically, having heard about it—significantly increased the likelihood of adoption by approximately eight times. In contrast, prior sex-sorted semen use, on average, lowered the willingness to pay by about 10 rupees per dose. The endline survey revealed that post-intervention, the number of households that had heard about sex-sorted semen increased on average by 15.6%. Similarly, the willingness to adopt sex-sorted semen increased by around 27%, while the reported willingness to pay increased by around 7%, suggesting that information

Willingness to Pay for Sex-Sorted Semen Doses

CDC Name	Price Offered (rupees)	Average WTP Baseline (rupees)	Average WTP Post Awareness (rupees)
Basant	300	448	537
Bharaundha	300	323	344
Jiyapokhar	300	332	390
Mariyarpur	300	413	345
Bithan	500	559	603
Pathharkatti	500	293	333
Ramnagar	500	402	457
Tarapur	500	491	474

from trusted sources can improve adoption of new technologies once the price barrier is crossed.

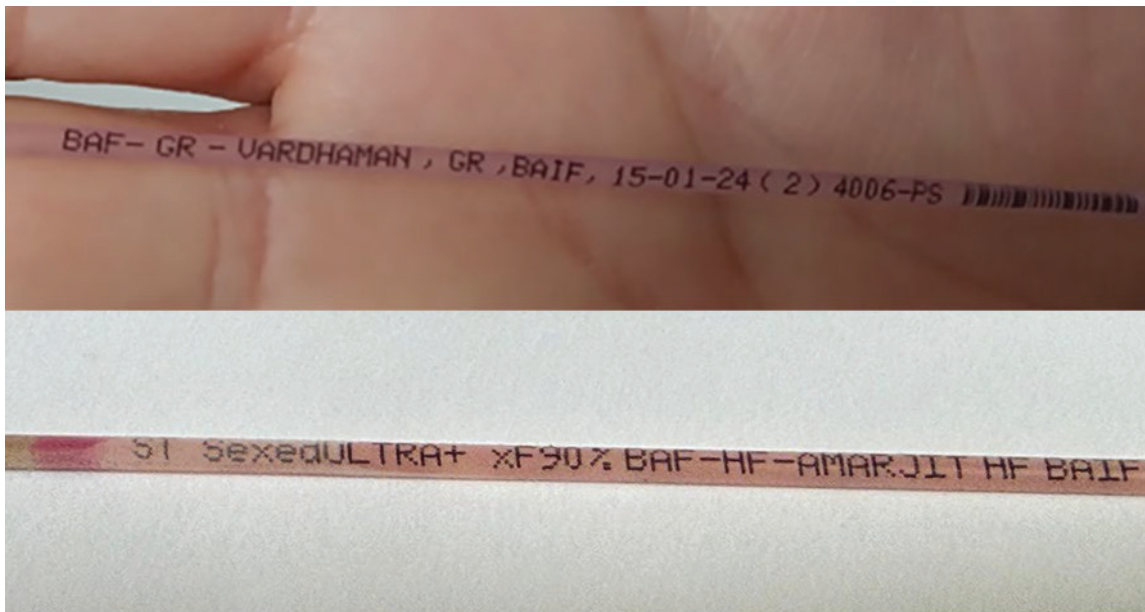
A comparison of the average willingness to pay by CDC reveals that the households exposed to the awareness campaign generally report a higher willingness to pay, except in one instance (Mariyarpur). This could be driven by the relatively higher prior use of sex-sorted semen technology in this CDC, which can lower the willingness to pay for sex-sorted semen. The difference in the average willingness to pay between the endline (466 rupees) and the baseline (434 rupees) is 32 rupees. This can be benchmarked against the market price for a sex-sorted semen dose (800–1100 rupees) and the subsidized price (250 rupees under the Rashtriya Gokul Mission).

Preliminary results show that participants in the awareness campaign were about 1.1 times more likely to purchase sex-sorted semen than nonparticipants, who had already reported a willingness to pay above the offered price. Although the increase may appear modest, it is noteworthy since the comparison group already had strong purchase intent, suggesting even larger effects for other groups.

Policy Infrastructure Supporting Advanced Artificial Insemination

Based on TCI research, including surveys and field interviews, scaling the adoption of artificial insemination using sex-sorted semen relies on the following factors:

1. **Time sensitivity of demand:** Upon reaching heat, a dose of sex-sorted semen should be administered to the animal within 24 hours. Hence, timely supply is critical, especially, given that the next heat cycle occurs only after a minimum of 21 days.
2. **Reliable supply and cold storage:** Given that demand for sex-sorted semen is highly time-sensitive, a widespread network of semen centers, staffed with artificial insemination technicians trained to administer doses of sex-sorted semen, is critical. Sex-sorted semen doses are costlier and will not be purchased in bulk upfront by technicians. This necessitates quick procurement and delivery, requiring reliable transportation and cold storage, as sex-sorted semen is preserved in straws stored within a liquid-nitrogen-cooled tank.
3. **Trust in agencies and partners:** The lack of clear visual identifiers to distinguish sex-sorted-semen straws from conventional straws, as well as the slightly lower conception rates with this technology (relative to conventional artificial insemination) creates distrust that can hinder adoption. The credibility of the agency supplying sex-sorted semen and trust in the skill of the technician administering the dose are both integral to adoption.



A conventional semen straw (top) and a straw of sex-sorted semen (bottom) can be difficult to distinguish.

Maximizing Livestock Efficiency and Productivity

This study underscores the critical role of awareness in shaping farmers' adoption behavior and willingness to pay for advanced artificial insemination with sex-sorted semen in Bihar. The evidence suggests that informed households demonstrate a significantly higher propensity to adopt and invest in sex-sorted semen, with the willingness to adopt increasing by 27% and the willingness to pay rising by approximately 7%. However, the high market price of sex-sorted semen (800–1,100 rupees) presents a significant challenge to adoption, with the average farmer's willingness to pay standing at around 450 rupees.

At any price, the expansion of advanced artificial insemination is contingent on addressing systemic supply-side challenges. The inherent time sensitivity of demand necessitates timely procurement and last-mile delivery aligned with the reproductive cycle of the animal, while the requirement of cold storage infrastructure emphasizes the need for robust supply chain systems and greater coordination among semen stations, delivery agents, and government programs. Furthermore, farmers' skepticism regarding conception rates and product authenticity illustrates the importance of fostering trust—both in the technology itself and in the institutional actors facilitating its delivery.

In this context, sex-sorted semen represents not only a pathway to reducing the methane emissions of India's livestock sector by increasing the proportion of productive female cattle, but also an instrument that can enhance farm incomes by reducing the economic burden posed by

male calves. The results from Bihar demonstrate the value of awareness campaigns as a cost-effective policy lever that, when coupled with investments in supply logistics and institutional credibility, can contribute to scaling climate-smart agricultural practices. Strengthening the enabling environment for adoption, therefore, can support India's broader sustainability objectives, linking livestock development with climate mitigation and rural livelihood improvement.

Zero-Hunger, Zero-Carbon Food Systems

This policy brief was produced as a part of TCI's project on Zero-Hunger, Zero-Carbon Food Systems. The project aims to support the reduction of GHG emissions associated with agriculture while improving productivity and benefiting farmer livelihoods.

Learn More

To learn more about the Zero-Hunger, Zero-Carbon Food Systems project, visit:

tci.cornell.edu/?projects=zero-hunger-zero-carbon-food-systems





TATA-CORNELL INSTITUTE FOR AGRICULTURE AND NUTRITION • 375 Warren Hall • College of Agriculture and Life Sciences
Cornell University • Ithaca, NY 14853-7801 • Phone: 607-255-4416 • Email: tc.cals@cornell.edu
Website: tci.cornell.edu • Twitter: [@TataCornell](https://twitter.com/TataCornell) • Facebook: [@tatacornellinstitute](https://facebook.com/tatacornellinstitute) • Instagram: [@tatacornellinstitute](https://instagram.com/tatacornellinstitute)