Agenda Item 10
For [Information]
Issued: 25 November 2025

Report from the Standing Panel on Impact Assessment (SPIA)

Purpose

This document provides information on the System Council-commissioned Return on Investment (ROI) study led by SPIA and the main evidence/dissemination products produced.

Action Requested

The System Council is requested to read and reflect on the ROI evidence products ahead of the SPIA Chair's presentation. To support efficiency, SPIA would recommend viewing the products in the following order: *Infographic*, followed by the 2-page *Policy Brief*, followed by the (draft) *Technical Report*. A **video explainer** is also available.

The SC-23 SPIA session will center around how results can be leveraged to nuance the CGIAR investment case.

Document category: Working document of the System Council.
There is no restriction on the circulation of this document.

Prepared by: SPIA supported by SPIA Professional Team.

The Returns on Investment (ROI) for Select CGIAR Innovations

Background

SPIA has consistently documented the reach and impacts of CGIAR innovations in priority countries. Within the previous SPIA workplan for 2019-2024, eight innovations (Flood-Tolerant Rice, Salt-Tolerant Rice, Drought-Tolerant Maize, Axial Flow Pumps, GIF Tilapia, Poultry, Forages, Index-Based Livestock Insurance) emerged particularly promising within country contexts. As a first step, SPIA provided high-level summaries about these “showcase successes”, and upon further consultation with System Council, a need to estimate ROI for these innovations was identified.

Given the novelty for SPIA to engage in ROI work and expansion from the planned 2025 activities, SPIA engaged an External Expert/Consultant to develop and implement an approach to estimate the ROI of select “showcase successes”. The Consultant worked closely with the SPIA team and panel members to generate ROIs for four innovations where the estimation was deemed both *appropriate* (with a clear R&D pathway) and *feasible* (with the availability of relevant cost, reach and impact data). The four innovations include Index-Based Livestock Insurance, Drought-Tolerant Maize, Axial Flow Pumps, and Flood-Tolerant Rice. The results produced by the Consultant were further tested in-house for sensitivity and robustness.

The SPIA Chair presented the ROI results to SIMEC on 22 October 2025. Based on SIMEC feedback, the SPIA team worked to improve the narrative and technical nuances. The Chair then presented the results to the System Council through two drop-in calls on 3 and 4 November 2025. The feedback from these discussions fed into the curation of the evidence products. The SPIA Chair was also invited to present SPIA’s ongoing work and the ROI study during their September 2025 meetings.

ROI Evidence Products and Dissemination

SPIA curated a range of evidence products to disseminate the results from this study, each catering to different audiences, levels of technicality and detail. Ranking from the least to the most technical, the evidence products include:

- **Infographic** – One-page visual summary of the ROI estimates
- **2-Page Policy Brief** – Executive summary of methods, key findings and learnings
- **Video Explainer** – Short video (04:24 minutes) highlighting main concepts and findings
- **(Draft) Technical Report** – Detailed methods, measures, sensitivity analyses, and deep-dive for each innovation

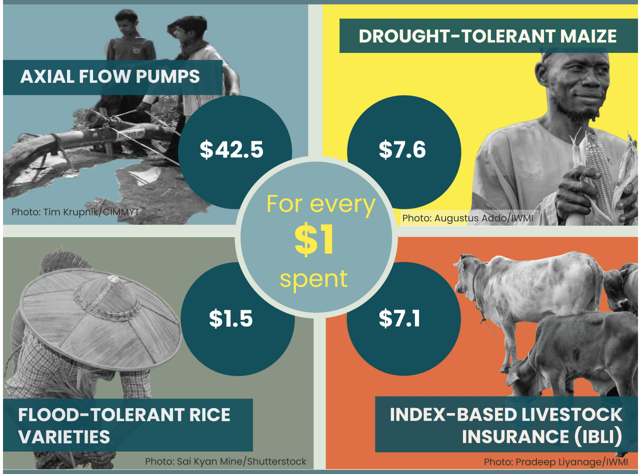
The technical report is still in the draft stages and will be finalized following the System Council meeting in December 2025, to allow for incorporation of any further feedback emerging from the discussions. This will ensure that the System Council has a final opportunity to weigh in with any feedback on the overall framing/narrative or clarifying the methodology.

To ensure broad uptake and engagement, SPIA will actively disseminate these evidence products through CGIAR Centers (especially those involved with the ROI innovations), Chief Scientist’s Office, the Impact Assessment Focal Point Community, the Impact Assessment Community of Practice under MELIAF, and the CGIAR System Organization (Relevant Accelerators/Science Programs, PPU, Business Development Unit and Communications Team). The goal is to foster CGIAR-wide learning about key methodological concerns that emerge while generating rigorous ROI estimates and advancing nuanced interpretation of the study findings to build CGIAR’s investment case.

From Evidence to ROI

Measuring Returns on CGIAR's Investments

ROI FOR FOUR INNOVATIONS



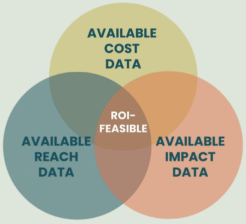
SELECTION CRITERIA

The innovations were selected from a group of 14 "Showcase Successes", designated as **ROI-Appropriate** by the CGIAR Standing Panel on Impact Assessment.

What makes an innovation ROI-Appropriate?

- A clear R&D path to a distinct innovation
- The possibility of tracking dissemination
- Evaluation of potential complications with regard to attribution, benefit, and accountability

Selected innovations also had to be **ROI-Feasible,** meaning there is sufficient data on cost, reach, and impact to enable an ROI estimation.



ROI-APPROPRIATE (# Innovations)	ROI-FEASIBLE (# Innovations)
8	4

RESULTS

	COSTS (USD)	REACH	KEY IMPACTS
Axial Flow Pumps	$4.9 million	1.6 million households	• Fuel cost savings
Drought-Tolerant Maize	$21 million	2.6 million households	• Yield loss avoided • Higher farm income
Flood-Tolerant Rice Varieties	$5.7 million	607,000 households	• Rice production in flood years
Index-Based Livestock Insurance	$17.7 million	43,931 policies sold	• Higher income • Education gains

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To learn more, read the full report.

The Returns on Investment (ROI) for Select CGIAR Innovations

CGIAR
Standing Panel on Impact Assessment

November, 2025

	Index-Based Livestock Insurance Kenya and Ethiopia	Axial Flow Pumps Bangladesh	Flood-Tolerant Rice Varieties Bangladesh	Drought-Tolerant Maize Ethiopia
For every $1, median* ROI =	**$7.1**	**$42.5**	**$1.5**	**$7.6**

Key Findings:

- To calculate ROI of CGIAR innovations, they must be both **'ROI-Appropriate'** and **'ROI-Feasible'** (i.e., reliable cost, reach and impact data available)
- This study finds that 4 CGIAR 'successes' likely generated positive returns, even under conservative assumptions
- Three of the four qualify as 'Big Wins', which are rare in Agricultural Research for Development (AR4D) but justify investment in the portfolio as a whole

Background

Stakeholders and funders increasingly demand evidence of CGIAR's economic returns. Building on SPIA's mandate to document the reach and impact of CGIAR innovations, the System Council requested SPIA to conduct a ROI analysis for select "emerging successes", i.e., innovations with strong evidence of reach and causal effects. This policy brief presents results for four such innovations which lend themselves to ROI estimation relatively easily: they are "ROI-appropriate", and comprehensive cost data, rigorous impact evidence, and documented reach/adoption numbers make ROI estimation feasible. They demonstrate an approach to estimate ROI when the right data exists but also highlight key challenges.

Methods

SPIA used a harmonized benefit–cost analysis (BCA) framework to estimate the ROI of the four CGIAR innovations. ROI is defined as the ratio of total monetized benefits generated by an innovation to the CGIAR costs for research and dissemination activities. It is computed as follows:

$$\mathrm{ROI} = \frac{\text{Total Benefits}}{\text{CGIAR Costs}}$$

Reported ROI values therefore represent the realized economic return over the period covered by available data. To account for parameter uncertainty and to assess the robustness of estimated returns, we present results in the form of Monte Carlo-based distributions of the ROI for each case. Each simulation run involved 100,000 random draws over the distributions of the underlying parameters. In this way we hope to communicate the uncertainty inherent in such an exercise, that is amplified by the multiple assumptions needed to plug information gaps at different points. We also see the likelihood that the investment does better than break-even (i.e., ROI>1). This is a more realistic depiction of potential outcomes than a single deterministic ROI estimate.

Results**

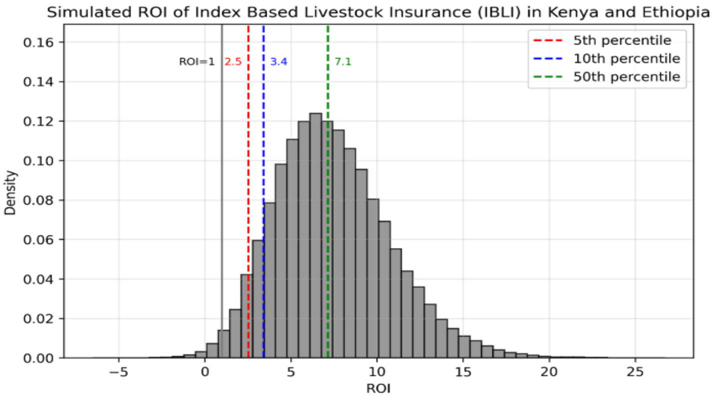
Below are the ROI results of the four innovations:

Median of the ROI estimate distribution could be interpreted as an expected value (i.e., a 50% likelihood that the ROI is at least at least the given value). Decision-makers could also set/use the higher likelihood thresholds.

*** All figures are converted to constant 2022 USD and exclude certain benefits*

Index-Based Livestock Insurance (IBLI) – Kenya, Ethiopia

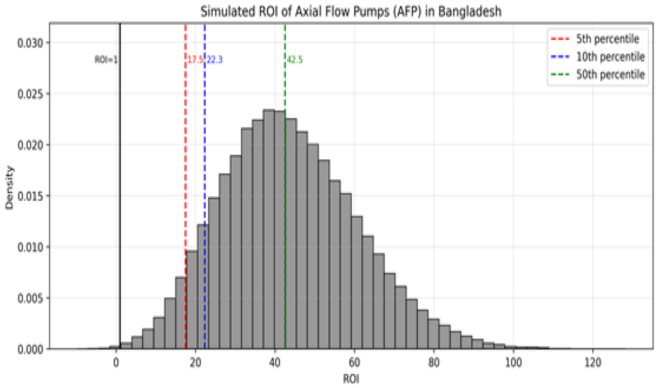
IBLI uses satellite-derived vegetation indices (NDVI) to trigger payouts to households when forage scarcity in their area reaches a critical threshold. This helps protect livestock assets and stabilized incomes and consumption.



This study monetizes the value of two measurable benefits: short-term income gains during droughts of the order of KES 61,000-75,000, and the 7.4 additional years of school attainment of children of IBLI-holding households. It is estimated that 43,931 policies were sold between 2010-2020. These are compared to CGIAR's research and dissemination costs of $17.68 million.

Axial Flow Pumps (AFPs) - Bangladesh

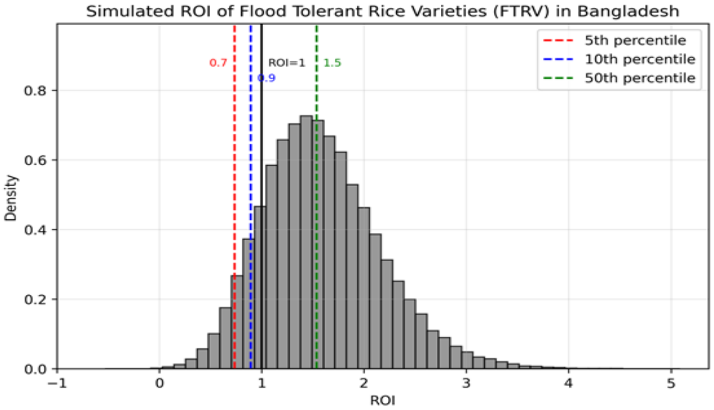
AFPs are a mechanical irrigation technology for shallow water conditions. Compared to traditional centrifugal pumps, they offer high-efficiency water delivery while lowering fuel use and operating costs.



It is estimated that 1.6 million Bangladeshi households used AFPs to irrigate their fields as of 2023. The ROI calculation is based on the estimated fuel cost savings (net of AFP purchase/rental costs) of $10-37 per hectare per season for adopting farmers. These benefits are compared with the $4.87 million cost involved in public R&D, testing and demonstration between 2013 and 2018.

Flood-Tolerant Rice Varieties (FTRV) - Bangladesh

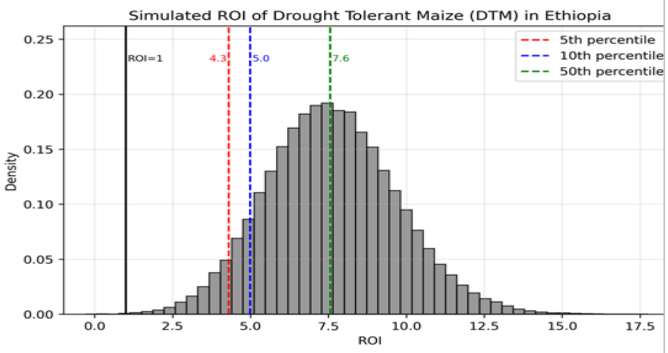
FTRVs, notably those carrying the Sub1 gene, enable rice plants to survive complete submergence for up to two weeks, protecting yields in flood-prone ecosystems.



By combining remote sensing data on floods in Bangladesh with data on household-level adoption of FTRVs, it is estimated that between 49,000 and 102,000 hectares of land under rice benefited from this yield protection between 2002 and 2021. The yield protection during moderate "Goldilocks" floods and adoption is compared against the $5.7 million spent on research and dissemination of FTRVs in Bangladesh.

Drought-Tolerant Maize (DTM) - Kenya

DTM enhances yield stability under rainfall variability. They provide small differences in yields in good seasons, but help avoid loss during mid-season droughts, to the tune of 46-180 kg/ha of maize output protected.



It is estimated that by 2023, 2.6 million households (representing 14% of maize area) were growing DT maize, up from 0.01% of maize area in 2009. The benefits are calculated for adopting households over the period 2009-2021 and compared with the overall costs of $21 million on research and dissemination.

Lessons Learnt

- **Portfolio thinking needed**: The "successes" justify broader portfolio-level investments, precisely because we do not know ex-ante which innovations will succeed
- **ROI estimates involve assumptions:** The distributions reflect uncertainty and data limitations about adoption, costs, and benefit pathways of CGIAR innovations
- **ROIs are necessary but insufficient:** ROIs can only inform, not dictate, investment decisions within/across the CGIAR portfolio

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Estimating Returns on Investments of Select CGIAR Innovations [WORKING DRAFT]

November 2025

Estimating Returns on Investments of Select CGIAR Innovations [WORKING DRAFT]

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1 Background

As part of its mandate to expand and deepen evidence of the impact of CGIAR's research on outcomes in five areas, SPIA's 2019-2024 workplan delivered insights about the reach and impacts of innovations from across the CGIAR research portfolio (SPIA 2024). The dissemination of this evidence aimed to support CGIAR's goal to be a learning organization, and to inform decision-making in the system. It was also hoped that the communication of SPIA's findings would help to make the case that investment in the CGIAR's activities could help funders pursue their development and sustainability goals around the world.

In addition to its technical reporting, SPIA communicated the emerging evidence about the reach and impact of the CGIAR's activities through a set of written briefs and presentations. These highlighted several CGIAR successes and identified challenges in achieving sustained adoption of CGIAR innovations at scale, and also highlighted how impacts for some of the innovations disseminated differed from anticipated results.

Although the different CGIAR stakeholders welcomed the insights from the SPIA portfolio, the System Council also felt that it would be helpful to focus on particular "Showcase Successes" that could help support the business case for the CGIAR system. As a first step, SPIA provided concise, high-level summaries about these showcase successes, but further consultation with System Council members identified the need to estimate returns on investment (ROI) for these particular cases.

While SPIA has consistently documented rigorous evidence of the benefits generated by several CGIAR innovations in a number of CGIAR priority countries, the estimation of ROI for individual innovations goes beyond SPIA's mandate. This is mainly because SPIA has not been tasked with collecting cost or investment data— something the CGIAR centers and programs spearheading the research are better suited to do.

Since this new request from the System Council did not fit the planned SPIA activities for 2025, SPIA agreed to engage an external consultant to develop an approach to estimate the ROI of successful individual CGIAR innovations and then implement this approach for select cases. This report summarizes the main findings of this work conducted by the consultant with guidance from SPIA.

2 An Approach to Estimate ROI of Agricultural Innovations

2.1 Insights from Economics Literature

Since its foundation, CGIAR has been attempting to provide answers to the question of whether it pays to invest in agricultural research. Over the years, it has followed prominent methodological approaches from the economics literature. Until the mid-2000s, ex-post impact assessments were dominated by the partial-equilibrium approach proposed by Griliches (1957), where an innovation reduces the marginal cost of producing an agricultural product, and this then generates a stream of benefits (economic surplus) over time (Stevenson et al 2023).

This approach for estimating the rate of returns on research has been widely used in cost-benefit analysis within CGIAR, and can inform the allocation of agricultural research investments in the System (Alston et al 1995, Raitzer and Kelley 2008). While there is a continued demand for these aggregate estimations among CGIAR funders for making investment decisions, an important concern is that they often incorporate strong assumptions, which can lead to implausible estimates of rates of returns (Hurley et al. 2016).

It has also been argued that the impact of agricultural innovation comes about through complex pathways, so that rather than assessing impact at the micro-level, analyses should be carried out at the macro-level. Often, such analyses include a simulation of the impact of a single innovation on total factor productivity (TFP) or growth rates. Fuglie and coauthors use regression approaches to estimate the impact of research investments on changes in agricultural TFP over time and space (Fuglie 2018).

However, this approach also has drawbacks. Firstly, the risk and heterogeneity inherent in agricultural products makes it very difficult to estimate TFP (Gollin & Udry 2021). Furthermore, at the macro level it can be challenging to cleanly identify the impact of research on agricultural TFP, when institutional features, world prices, weather and climate have changed concurrently (Stevenson et al, 2023).

Recent work by Akerman et al. (2025) avoids this problem in their estimation of the overall effect of public R&D investment on agricultural innovation and productivity growth in Brazil. By exploiting the staggered establishment of regional research centers across the country, they are able to identify the effects of R&D investments on agricultural productivity and input use, leading to increased agricultural output. While this is a promising approach that addresses some of the challenges identified above, there is still work to do in adapting it to complex innovation systems like CGIAR.

For innovations that may not require strong assumptions, the estimation of ROI using the partial-equilibrium approach could be performed using some variations of the cost-benefit framework. The net present value (NPV) estimates the gain in money generated by a particular project until a certain point in time, while the benefit-cost ratio (BCR) explicitly compares the stream of benefits of an innovation/project with the investment required. Likewise, the internal rate of return (IRR) is the maximum rate at which investors/donors break even their investments. While all these indicators aim to assess the efficiency of public expenditures, they do this in different ways: NPV needs to be greater than zero, BCR to be greater than one and IRR greater than the discounted rate used (Shively 2012, GIZ 2023). Each of these variants offer advantages and disadvantages for their calculations, but the selection of any or all of them will depend on data availability (Alston et al. 1995).

Below, we explain the approach used to address the recent request to estimate ROIs for individual innovations and discuss the conditions needed to come up with reliable and informative results.

2.2 ROI-Appropriateness and ROI-Feasibility

As described above, much of the estimation of returns to investment in agricultural research for development organizations has focused on the benefits of increasing agricultural productivity. However, this methodological approach has fallen short in the era of the Sustainable Development Goals (SDGs), which recognize that development is multi-faceted, that increased productivity does not automatically guarantee positive outcomes in all domains, and therefore multiple objectives ought to be tracked and pursued simultaneously. Furthermore, there have been concerns about distributional consequences of the benefits generated.

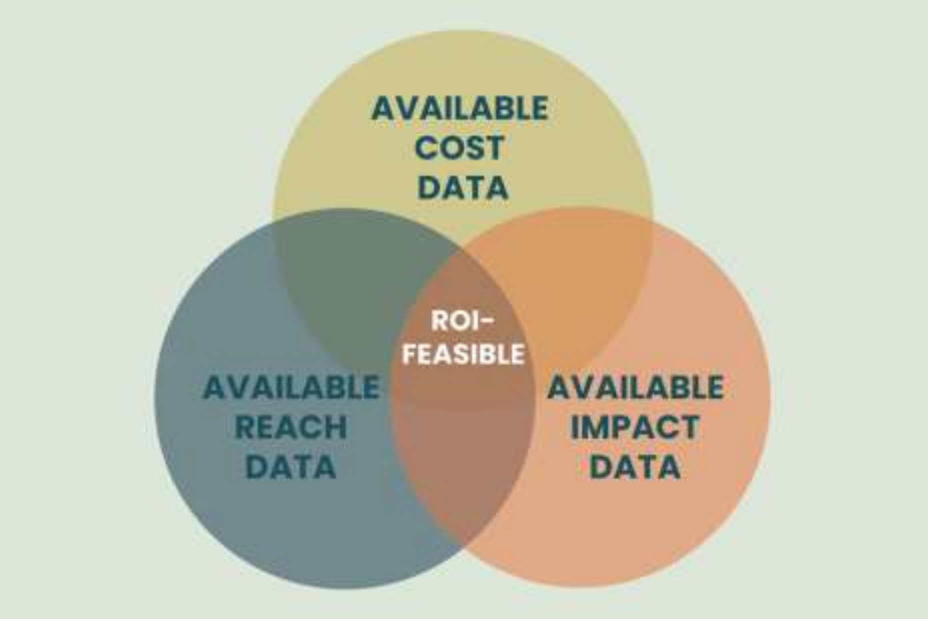
In addition, considerable CGIAR activity is focused on influencing policy at the national or sub-national level, the returns to which are not always tangible or more importantly for the purpose of estimating rates of return, quantifiable. CGIAR also increasingly engages the private sector in the co-design and dissemination of several innovations. These public-private partnerships likely boost the potential for both reach and impacts; but the CG system is unlikely to have accurate information about the costs and benefits to the private sector. To the extent that private sector involvement is pivotal to an innovation's success, our inability to quantify its worth complicates the assessment of the CG's investment.

Finally, and just as importantly, CGIAR's mandate includes the production of and contribution to global public goods, such as for example, seed banks that allow the continuing development of seed varieties across the world, and for posterity. The stream of benefits from such activity can be difficult to assess at a point in time or in a particular place. All of this implies that many of the research activities, innovations and investments of the CGIAR lie outside the ROI framework — in other words, they are not ROI-Appropriate.

Even those investments that *are* ROI-Appropriate may not always be ROI-Feasible. In practical terms, three types of information are necessary for the estimation of returns on investment (Figure 1). First, there should be information about the costs/investments incurred to develop and disseminate the particular innovation. This requires evidence of a clear R&D pathway to the distinct innovation, and a documentation of the role of the CGIAR along this process. Second, one needs rigorous evidence on the reach of the innovation. Depending on the nature of the innovation, it may be adopted at, and the adoption rates best measured at, different levels: household, community, subnational, or national. Third, one needs rigorously estimated estimates of the impacts of the innovation, ideally taking into account not just the immediate but also the longer-term impacts, as well as the downstream benefits on others who may not directly adopt it. Since impacts of new technology do not come about directly through the technology but through their application by people, it is important that impacts are estimated in settings that are as close to the real world as possible (Stevenson et al, 2023, Laajaj et al. 2020).

Should any of these pieces of information be unavailable (or only partially available), ROI estimation would not be feasible. As shown in Figure 1, only innovations that lie in the intersection set of the three components will be strictly ROI-Feasible. However, in some cases, rigorous evidence of the impacts of some innovations may exist, but for different settings/locations. In these cases, the extrapolation of this rigorous evidence could be carefully explored and used to estimate the ROI. Following this pathway will also require accounting for the uncertainly introduced in the extrapolation process, as we show below for Drought-Tolerant Maize and Axial Flow Pumps.

Figure 1. ROI-Feasibility



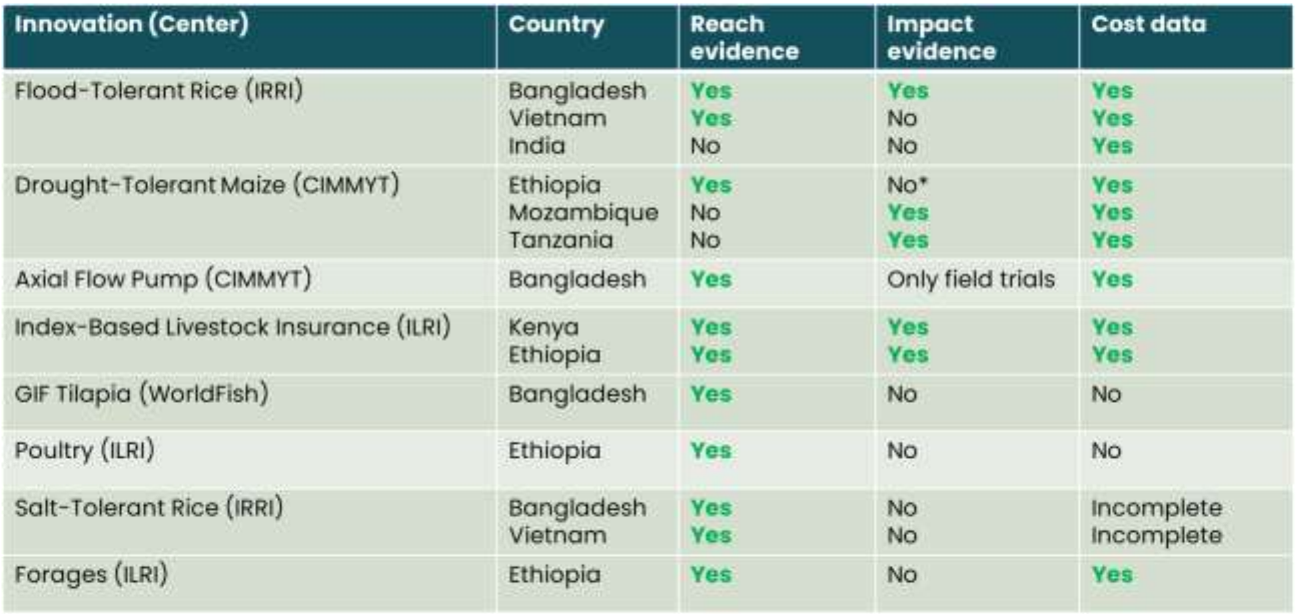
2.3 ROI-Feasible Cases Selected

The synthesis of the findings of the SPIA 2019-2024 portfolio highlighted several "Showcase Successes", or innovations that have been adopted at scale, and have rigorously estimated evidence of impacts to a large extent. SPIA identified eight such CGIAR innovations. Since some have been adopted in more than one country, this made a total of 14 potential cases.[1]

When it came to estimation of ROI, on the cost side, the ROI exercise relied on availability of cost data recorded by CGIAR centers and that could be linked reliably to the development or dissemination of the selected innovations.

As described in Table 1, rigorous evidence on the reach of the CGIAR was available in most cases, except for Flood-tolerant Rice Varieties in India and Drought-Tolerant Maize in Mozambique and Tanzania – cases where the literature provides rigorous evidence of impacts, but where SPIA had not yet focused measurement efforts. In other cases, such as Salt-Tolerant Rice, Genetically Improved (GIF) Tilapia, Improved Poultry and Forages, SPIA has evidence that the innovations have scaled in particular countries, but the impact estimates do not yet exist. Finally, in some cases such as GIF tilapia in Bangladesh and poultry in Ethiopia, it proved difficult to obtain data on the cost of investments undertaken at the CGIAR centers. Eventually, only four innovations were ROI-Feasible: Flood-tolerant Rice in Bangladesh, Drought-Tolerant Maize in Ethiopia, Axial Flow Pumps in Bangladesh and Index-Based Livestock Insurance in Kenya and Ethiopia.

Table 1: Availability of Cost, Reach and Impact Data for CGIAR "Showcase Successes"



Innovation (Center)	Country	Reach evidence	Impact evidence	Cost data
Flood-Tolerant Rice (IRRI)	Bangladesh Vietnam India	Yes Yes No	Yes No No	Yes Yes Yes
Drought-Tolerant Maize (CIMMYT)	Ethiopia Mozambique Tanzania	Yes No No	No* Yes Yes	Yes Yes Yes
Axial Flow Pump (CIMMYT)	Bangladesh	Yes	Only field trials	Yes
Index-Based Livestock Insurance (ILRI)	Kenya Ethiopia	Yes Yes	Yes Yes	Yes Yes
GIF Tilapia (WorldFish)	Bangladesh	Yes	No	No
Poultry (ILRI)	Ethiopia	Yes	No	No
Salt-Tolerant Rice (IRRI)	Bangladesh Vietnam	Yes Yes	No No	Incomplete Incomplete
Forages (ILRI)	Ethiopia	Yes	No	Yes

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[1] *At this stage, it was not yet anticipated that ROI estimates would be requested for these showcase successes, and therefore ROI-Appropriateness or feasibility were not included as selection criteria. However, given SPIA's recent efforts (2019-2024) to use nationally representative household survey data to measure the reach of the CGIAR's innovations that have scaled in four countries, the shortlist is heavily weighted toward cases where there is evidence of widespread adoption. This also means that innovations which do not reach households directly but scale through other pathways did not make it to this shortlist.*

2.4 Methodology for Estimating ROIs

The consultant that SPIA engaged applied a harmonized benefit–cost analysis (BCA) framework to estimate the Return on Investment (ROI) in the four innovations identified. The approach was designed to be transparent, empirically grounded, and comparable, although the innovations differ in type, scale, and evidence base. The ROI is defined as the ratio of total monetized benefits generated by an innovation to the donor-attributable research and dissemination costs required to produce those benefits, and is computed as:

$$\text{ROI} = \frac{\text{Total Benefits}}{\text{Total CGIAR Costs}}$$

Reported ROI values therefore represent the realized economic return over the period covered by available data[2]. Annexes 1.1, 1.2, 1.3 and 1.4 outline how benefits were quantified and monetized, how donor-attributable costs were compiled and harmonized across cases, and how these inputs together underpin the ROI estimates in this report.

2.5 Addressing Uncertainty of ROI Estimations

To account for parameter uncertainty and to assess the robustness of estimated returns, we conducted a Monte Carlo based sensitivity analysis for each intervention. This approach systematically propagates uncertainty from input parameters through to the computed ROI. It thus provides a more realistic depiction of potential outcomes than a single deterministic estimate.

In general, the key cost and benefit parameters were modeled as random variables, typically following normal distributions centered on their best available estimates with a standard deviation of 5 percent of the mean, unless we had empirical evidence that suggested different bounds. In addition, in cases where the impact estimates that were relied on referred to a different context than ours, we incorporated uncertainty around the extrapolation that was made.[3] In addition, when the impact estimates come from experimental studies in laboratory settings rather than field settings, we incorporated uncertainty around real-world gaps between these estimates and expected field performance.

Each simulation run involved 100,000 random draws, generating an empirical distribution of ROI values. This distribution allows us to compute the expected ROI estimate and the share of simulated outcomes with ROI below 1 (break-even) or below 0 (zero gain).[4] Details of how the ROI distributions were constructed are provided in Annex 1.

This stochastic sensitivity analysis enables a transparent quantification of the uncertainty around the estimates and allows identification of interventions whose expected returns are high, and those that are resilient to parameter variability. The approach helps decision-makers prioritize investments under realistic ranges of economic and agronomic conditions, rather than relying on point estimates alone.

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[2] *One exception is IBLI, where a core benefit in the ROI is the increase in children's educational attainment among insured households. That benefit is valued as the present value of gains in education-induced lifetime earnings, net of additional schooling costs*

[3] *For example, in the case of Drought-Tolerant Maize the impact estimates in the literature come from Mozambique and Tanzania whereas the ROI is estimated for Ethiopia. In the case of Axial Flow Pumps, the literature reports fuel cost savings for three major crops only, not all crops that Bangladeshi farmers grow.*

[4] *An ROI of 1 would indicate that each dollar spent on the investment was recovered, but there was no additional gain. An ROI of 0 would indicate the investment generated no return.*

3 The ROI Estimation of Four CGIAR Innovations

3.1 Index-Based Livestock Insurance (IBLI) in Kenya and Ethiopia

IBLI is an insurance product developed by the International Livestock Research Institute (ILRI) and U.S. university partners to address the impact of drought on pastoralist households. The product uses satellite-derived vegetation indices (NDVI) to trigger payouts to households when forage scarcity in their area reaches a critical threshold. This is expected to help protect livestock assets and stabilize incomes and consumption in arid and semi-arid regions (Mude et al., 2011; Jensen et al., 2024). The core innovation is the shift from indemnity-based insurance models to index-based contracts. This allows providers to deliver fast, objective, and scalable insurance at low transaction costs, better suited to settings with limited financial infrastructure.

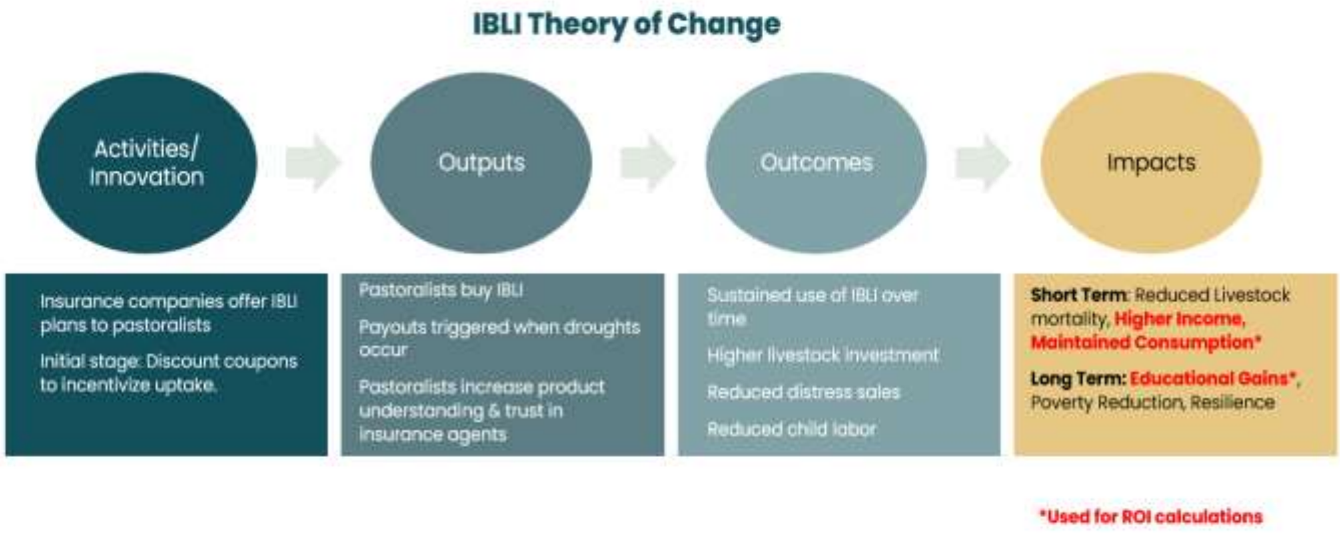
IBLI originated in 2007 as a research partnership between ILRI, Cornell University, and University of California Davis. Following several years of research, product design, and stakeholder engagement, the first Index-Based Livestock Insurance policy was launched in Marsabit County, Kenya in 2010. IBLI then evolved through successive phases—from early micro-level commercial models to meso- and macro-level public–private and government-led programs, which laid the foundation for large-scale public-private partnerships (PPP) such as the Kenya Livestock Insurance Program (KLIP), Satellite Index Insurance for Pastoralists in Ethiopia (SIIPE), and the regional World Bank–supported De-Risking, Inclusion, and Value Enhancement of Pastoral Economies (DRIVE) program. While detailed data on private sector costs and investments into scaling are unavailable, private insurers, reinsurers, and distribution partners appear to have played a pivotal role in underwriting risk, refining index products, testing commercial viability, extending market reach, and supporting the transition from donor-supported pilots to government-backed scaling models.

Estimates of the costs of developing and disseminating IBLI were obtained from ILRI. These include expenditures for research, product design, pilot testing, extension, and delivery support between 2010 and 2025. Using numbers provided by ILRI, costs on development and dissemination appear to have been approximately US$ 14 million during 2010-2021 (or US$ 17.7 million if the period is extended to 2025).

The product was delivered to households by insurance agents, initially at discounted rates to incentivize uptake. The indemnity was calculated as a fraction of the total sum insured, corresponding to the estimated cost of keeping one total livestock unit (TLU) alive (Jensen et al 2024), so that payouts were proportional to the severity of the forage deficit. Jensen et al. (2024, p. 49) estimate that a total of 43,931 policies were sold in Kenya and Ethiopia between 2010 and 2020.

As the theory of change described in Figure 2 indicates, the primary intent was to protect against catastrophic herd losses, and stabilize consumption during drought years, impact assessments found that insurance coverage also influenced household behavior and welfare outcomes—reducing precautionary livestock hoarding, enabling investment in productivity, and, in some cases, increasing children's school attendance and educational attainment.

Figure 2: IBLI Theory of Change



Jensen et al. (2017) estimate that compared to households that do not insure their livestock, each additional cumulative livestock unit insured by IBLI led to an increase in monthly income of KES 275 per adult equivalent, translating to about KES 75,000 per household. On the other hand, Shikuku & Ochenje (2025) estimate a 97% increase in household income, equivalent to about KES 61,000. Finally, Barrett et al. 2025 estimate 7.3 additional years of schooling over 10 years among children who were school-aged when their household first purchased an IBLI policy).

3.1.1 IBLI ROI Estimation

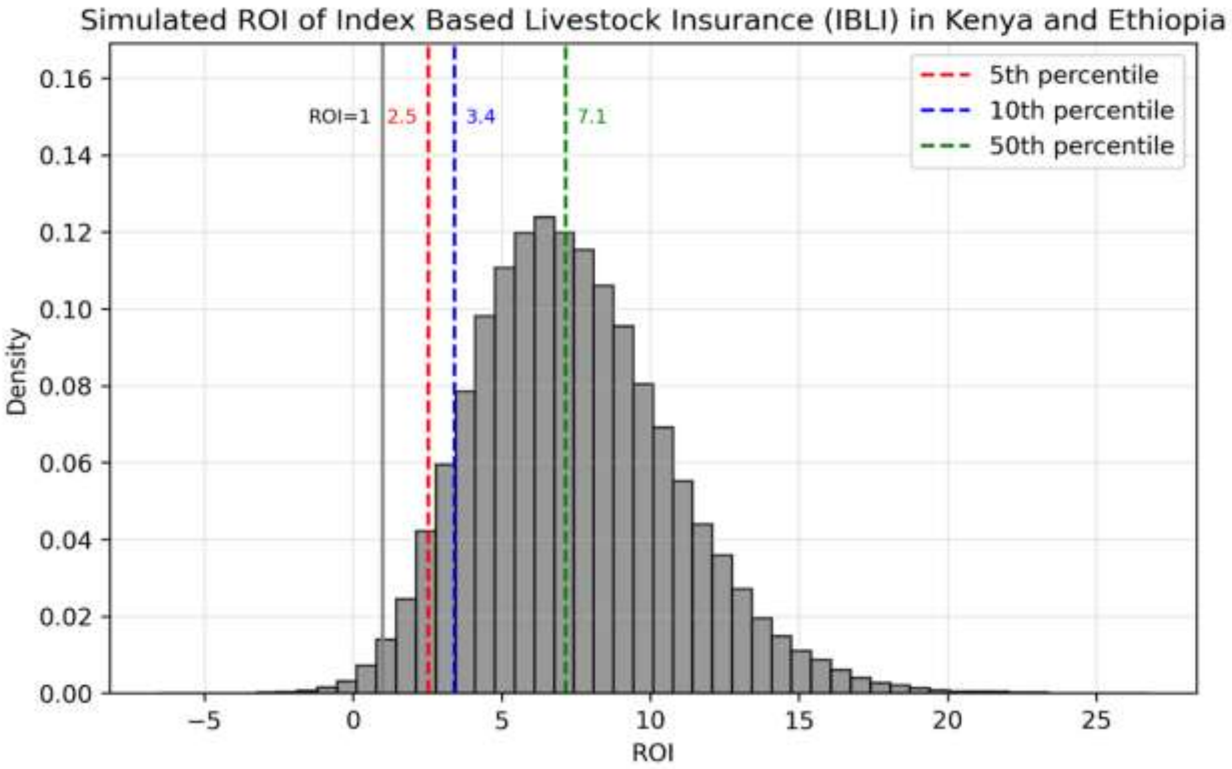
To estimate the ROI for IBLI, the consultant used the number of households that purchased IBLI at least once over the period 2010-2021 (as documented in Jensen et al. 2024), and the estimated increase in lifetime earnings and short-term income gains to first estimate the benefits of the innovation (as reported in Barrett et al. 2024). It was necessary to acknowledge the uncertainty in these estimates for the following reasons. Some households may have purchased IBLI multiple times, and so benefited more from it. However, since it is not clear how many purchases each household made, inferring the exact reach of IBLI from the number of policies sold necessarily involved assumptions. Barrett et al.'s estimates of the increases in schooling attainment needed to be translated into economic returns. And finally, we incorporate the uncertainty driven by the two alternative estimates of the short-term income gains from holding IBLI policies. Our sensitivity analysis propagates the uncertainty around the estimates into the ROI estimates.

Annex 2.1 describes the calculations involved in estimating the ROI. Figure 3 shows the distribution of the simulated ROI estimates and gives a probabilistic interpretation of the ROI into IBLI in Kenya and Ethiopia.

Subject to the assumptions in this simulation, we estimate that there is a 99% chance that the investments into IBLI were fully recovered through the development and adoption of the product in these two countries. We also estimate that there is a 95% chance that every dollar invested led to benefits worth 2.5 dollars and above, and a 90% chance that they led to benefits worth 3.4 dollars and above.

In Figure 3, the median of the distribution is 7.1, indicating that we estimate a 50% chance that a dollar invested in IBLI development and dissemination yielded benefits worth 7.1 dollars.

Figure 3: Simulated ROI of Index-Based Livestock Insurance (IBLI) in Kenya and Ethiopia



3.2 Axial Flow Pumps (AFP) in Bangladesh

The Axial Flow Pump is a mechanical irrigation technology adapted for shallow water conditions. Compared to traditional centrifugal pumps, AFPs offers high-efficiency water delivery with lower fuel use and operating costs (Krupnik et al., 2015; Brown et al., 2024). They enable small-scale irrigation service providers (ISPs) to reach more farmers during critical dry-season periods.

Although the first prototypes of Axial Flow Pumps were developed at the end of the 18th century (Stepanoff 1957), since then there have been additional developments to improve their performance (Miyake et al 1987, Nagahara et al, 2013). They were introduced into Bangladesh under the USAID-funded CSISA-MI (Cereal Systems Initiative for South Asia - Mechanization and Irrigation) project, led by CIMMYT in partnership with iDE. Public R&D and demonstration de-risked the technology and catalyzed its commercial production. CIMMYT research supported the promotion of this innovation and the engagement of the private sector.

Based on data provided by CIMMYT, it is estimated that the CSISA–Mechanization and Irrigation (CSISA–MI) project cost approximately US$ 4.87 million over the six-year period between 2013 and 2018. This includes spending on public R&D, testing, and demonstration activities.

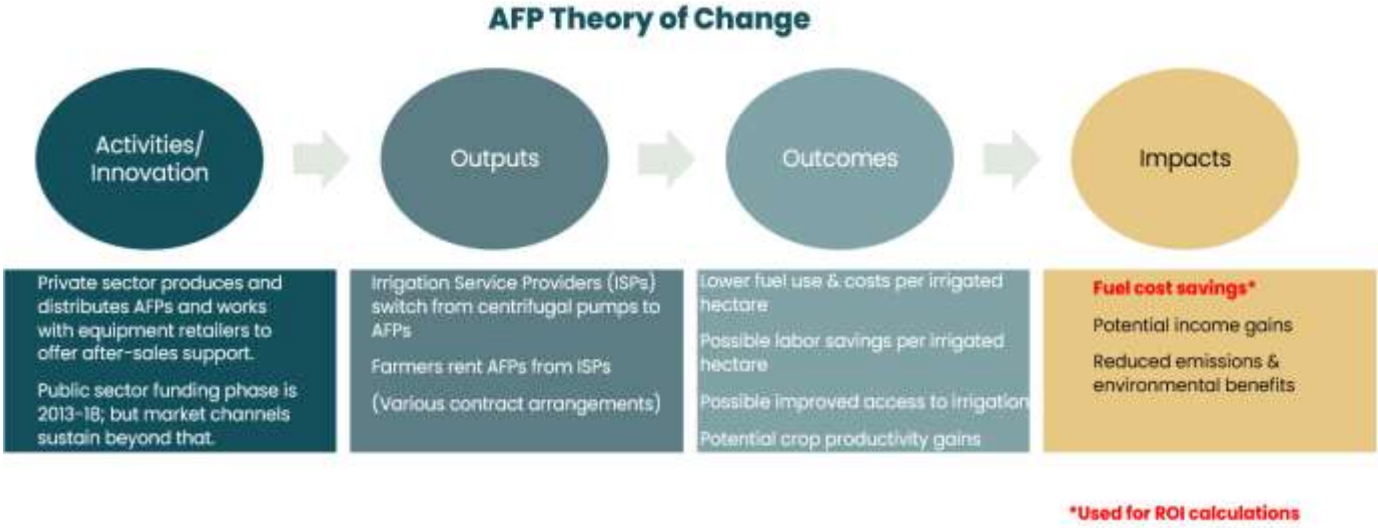
The dissemination of AFPs in Bangladesh built on CSISA-supported research that showed that prototype AFPs are more efficient than alternatives for many applications in southern Bangladesh. Based on engineering field trials, Krupnik et al. (2015) estimate that farmers may save between US$10 and US$37 per hectare per season if they used AFPs rather than centrifugal pumps to irrigate wheat, maize or boro rice.

This was part of a broader initiative to build public-private partnerships to promote AFPs and train farmers to use them, so that they may set up irrigation service businesses.

The private sector played an important role in distributing AFPs to Bangladeshi farm equipment retailers and provided after-sales support, who in turn sold them to input service providers (ISPs). Presumably this reduced ISPs' irrigation costs, and they served more farmers. Data from the Bangladesh Income and Household Survey (BIHS) show that the number of households that reported irrigating their fields with AFPs increased from 0.5% in 2015 to 12.6% in 2023.

Figure 4 presents the theory of change for how AFPs may have improved agricultural and environmental outcomes. It is believed that the use of AFPs improved dry season cropping intensity. It is also possible that the increased fuel efficiency improved profitability for ISPs, raised farm productivity, and contributed to lower emissions through reduced fuel consumption.

Figure 4: AFP Theory of Change



3.2.1 AFP ROI Estimation

The ROI calculations for AFP required an estimate of the cropped area in Bangladesh irrigated with AFPs as an indicator of reach for the years between 2015 and 2024. In the absence of information for non-BIHS years, aggregate statistics from 2023 on the area under different crops irrigated with AFPs (obtained from SPIA, based on the BIHS 2023) were used to infer reach for the three BIHS years and then interpolated to other years. Our sensitivity analysis attempts to account for the arbitrariness of these assumptions. We are also constrained in that the estimated fuel cost savings are derived from engineering field trials rather than field experiments where ISPs operate the AFPs on farmers' fields, subject to real-world conditions. Given this potential overestimation of the AFP impacts, the per-hectare benefits were scaled by 0.465 corresponding to the observed ratio of actual (on-farm) to potential (experimental) yield benefits from irrigated rice in Bangladesh, as reported in the Global Yield Gap Atlas (https://www.yieldgap.org/). The trials also estimate different savings depending on crop, lift height and high or low-water use, and these had to be averaged to estimate the savings for actual farmers. Our sensitivity analysis incorporates the empirical measurement error around each estimate.

We also allow for a standard deviation equal to 5% of the estimated US$ 4.8 million spent on research and development, testing and demonstration. Details of the ROI calculations are described in Annex 2.2.

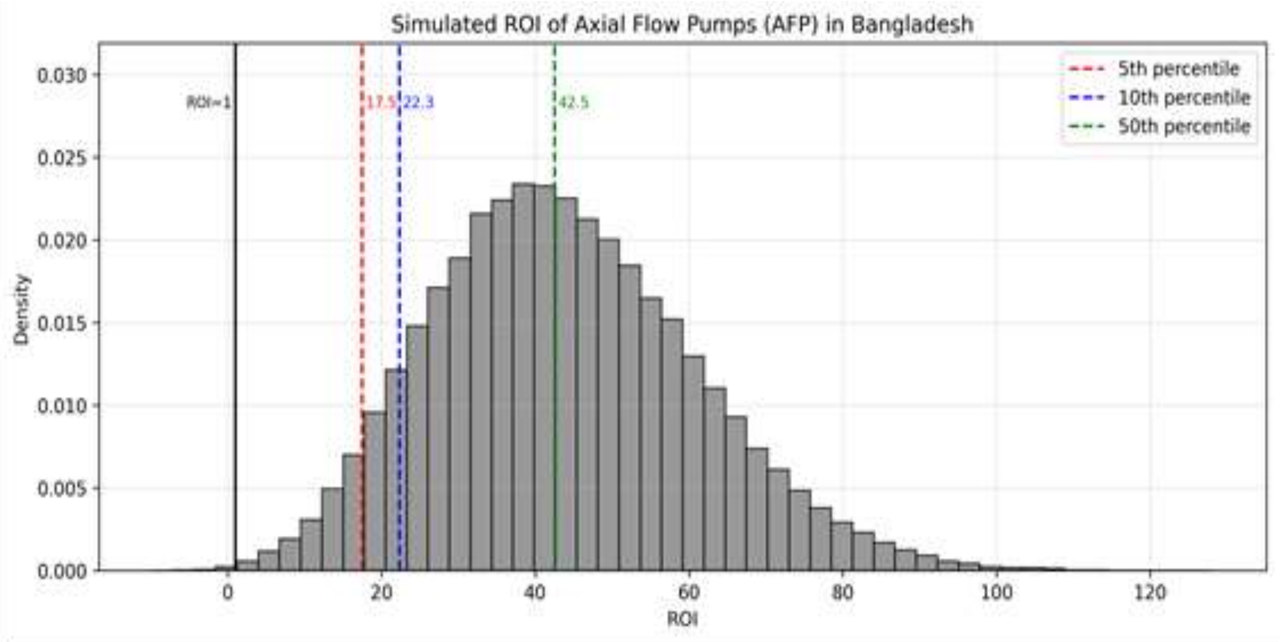
Figure 5 shows the results of the sensitivity analysis. Again, the distribution of the simulated ROI estimates gives a probabilistic interpretation of the ROI into AFP in Bangladesh. Given the level of uncertainty in the available information for the estimation, the distribution of AFP ROI is wide and suggest high returns to investments.

We estimate that there is a 99% chance that the investments into AFP were fully recovered through the promotion and adoption of the innovation in Bangladesh. We also estimate that there is a 95% chance that every dollar invested led to benefits worth 17.5 dollars and above, and a 90% chance that they led to benefits worth 22.3 dollars and above.

In Figure 5, the median of the distribution is 42.5, indicating a 50% chance that a dollar invested in by the CGIAR in the promotion and dissemination yielded benefits worth 42.5 dollars.

Note that costs incurred by the private sector are not included in the calculation, and for society as a whole, the ROI may have been lower. However, it is also likely that our calculation understates the benefits to the private sector investors in AFPs, since this was presumably a profitable investment for them.

Figure 5: Simulated ROI of Axial Flow Pumps (AFP) in Bangladesh



3.3 Flood-Tolerant Rice in Bangladesh

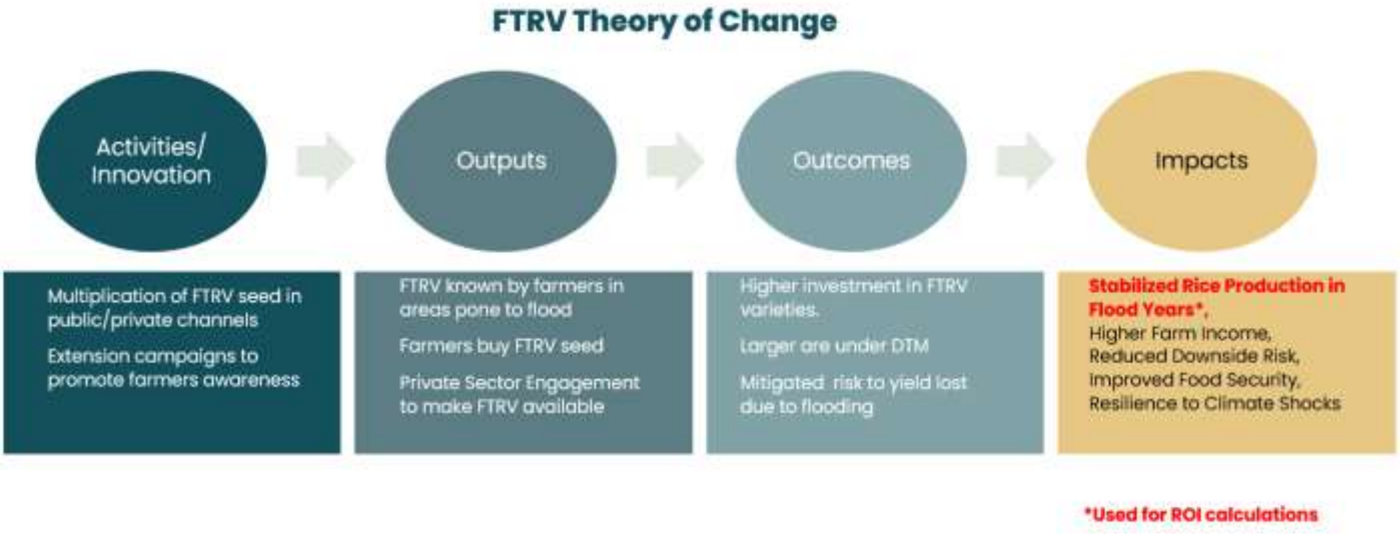
Research by the International Rice Research Institute (IRRI) and partners has led to the development of Flood-Tolerant Rice varieties, notably those carrying the Sub1 gene (e.g., Swarna-Sub1 and BRRI dhan varieties) (Xu et al., 2006; Mackill et al., 2012). These varieties were bred so that rice plants grown from these seeds could survive complete submergence for up to two weeks; this "insurance in the seed" was meant to protect yields in flood-prone ecosystems that were previously highly vulnerable (Anumalla et al. 2025).

The foundational research by IRRI was complemented by varietal release through the Bangladesh Rice Research Institute (BRRI), followed by systematic efforts to multiply and distribute seed through both public and private channels. Parallel extension campaigns by Bangladesh's Department of Agricultural Extension in partnership with IRRI promoted farmer awareness (Ismail et al., 2013). Using data provided by IRRI, it is estimated that about US$ 5.7 million (in 2022 dollars) were spent on the development of FTRVs between 1993 and 2025.

There are multiple sources of information about the adoption of FTRVs in Bangladesh, based on seed production and distribution data, and household-level adoption data from different surveys. However, the exact range of flood conditions under which FTRVs would deliver yield protection was only characterized through more recent agronomic studies. These find that FTRVs confer benefits during shorter and shallower floods than previously believed: so that the submergence is long enough to threaten conventional varieties, but short enough for Sub1 plants to recover once waters recede (Dar et al. 2013; Michler et al. 2025). Using remote sensing data, it was identified that floods of this particular depth and duration had occurred 16 times (or in only 1.25% of the possible observations) over the 20-year period between 2002 and 2021, across the 64 districts of Bangladesh. Putting this together with the reach of FTRVs, it is estimated that somewhere between 49,000 and 102,000 hectares of land under rice was planted with FTRVs and experienced a flood of the type where yield protection could be expected.

The theory of change (Figure 6) links genetic flood tolerance to reduced crop loss during a flood, which in turn expected to stabilized farm income and fostered resilience for farm households. The impact estimates for FTRVs in Bangladesh are reported in terms of improvements in the remotely sensed enhanced vegetation index (EVI) (Michler et al. 2025) where rice area that was exposed to moderate-floods areas and planted with FTRVs has a 0.0001147 higher EVI than moderate-flood areas where FTRV were not planted. However, to estimate income impacts requires a translation to improved yield. A simple regression using data from the yearbooks of agricultural statistics in Bangladesh provides an estimate that a 0.01 increase in EVI would correspond to approximately 7.4 kg/hectare additional yield. Put together, this suggests that area under FTRVs exposed to moderate floods had an estimated 37,104 tons higher yield, corresponding to income gain of 9,197,103 USD.

Figure 6: FTRV Theory of change



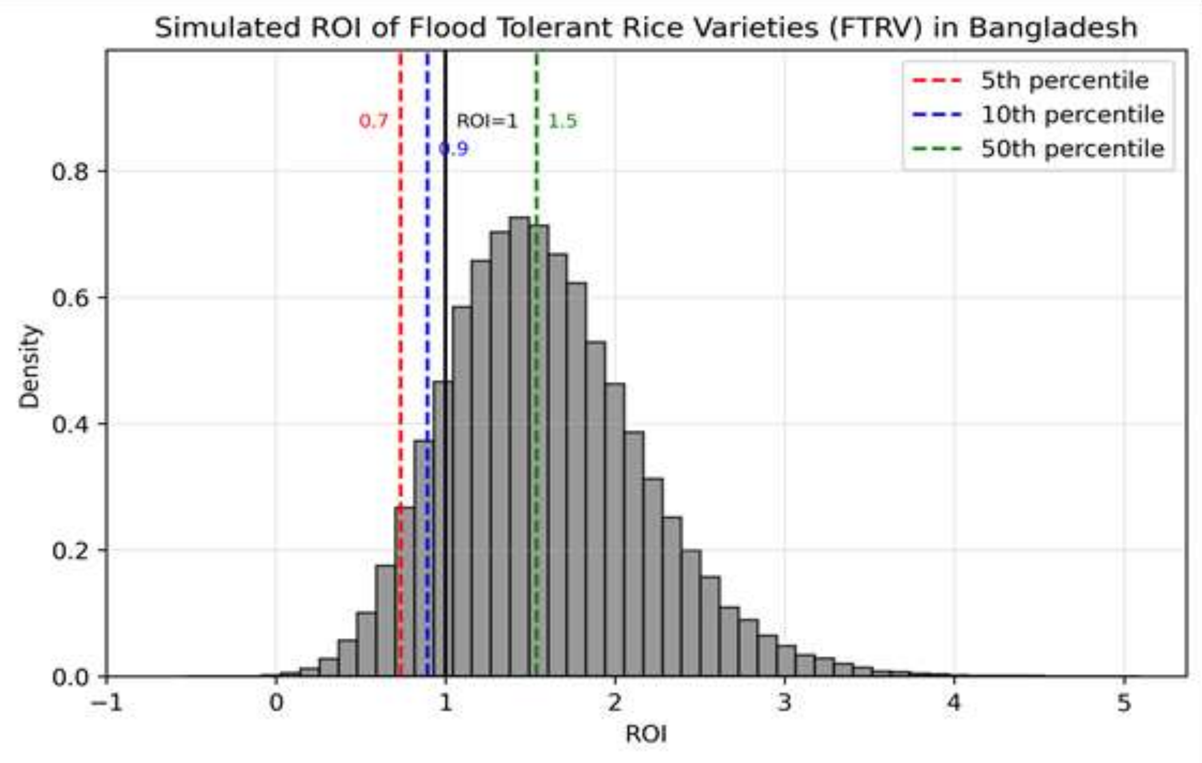
3.3.1 FTRV ROI Estimation

Details of the ROI calculations are described in Annex 2.3. Here we note the sources of uncertainty that we account for in the sensitivity analysis. These include the stochastic nature of the benefits of FTRVs, the conversion of the empirical estimated effects on the remotely sensed vegetation indices to impacts in terms of increased rice yield, and the different estimates of adoption based on different sources.

Results for the sensitivity analysis of the FTRV ROI are presented in Figure 7. We estimate that there is a 95% chance that every dollar invested led to benefits worth at least 70 cents, and a 90% chance that they led to benefits worth at least 90 cents. Our estimated likelihood that the investment into FTRVs was fully recovered (i.e. that a dollar invested generated a return of 1 dollar) is 88%.

In Figure 7, the median of the distribution is 1.5, indicating a 50% chance that a dollar invested in FTRV development and dissemination yielded benefits worth 1.5 dollars.

Figure 7: Simulated ROI of Flood-Tolerant Rice Varieties (FTRV) in Bangladesh



3.4 Drought-Tolerant Maize in Ethiopia

Drought-Tolerant Maize (DTM) varieties are designed to enhance yield stability under rainfall variability. They were developed by CIMMYT and national partners through the Drought-Tolerant Maize for Africa (DTMA) and Stress Tolerant Maize for Africa (STMA) initiatives. Ethiopia has been a major hub for DTM breeding, testing, and adoption, with CGIAR and the Ethiopian Institute of Agricultural Research (EIAR) collaboration spanning over two decades.

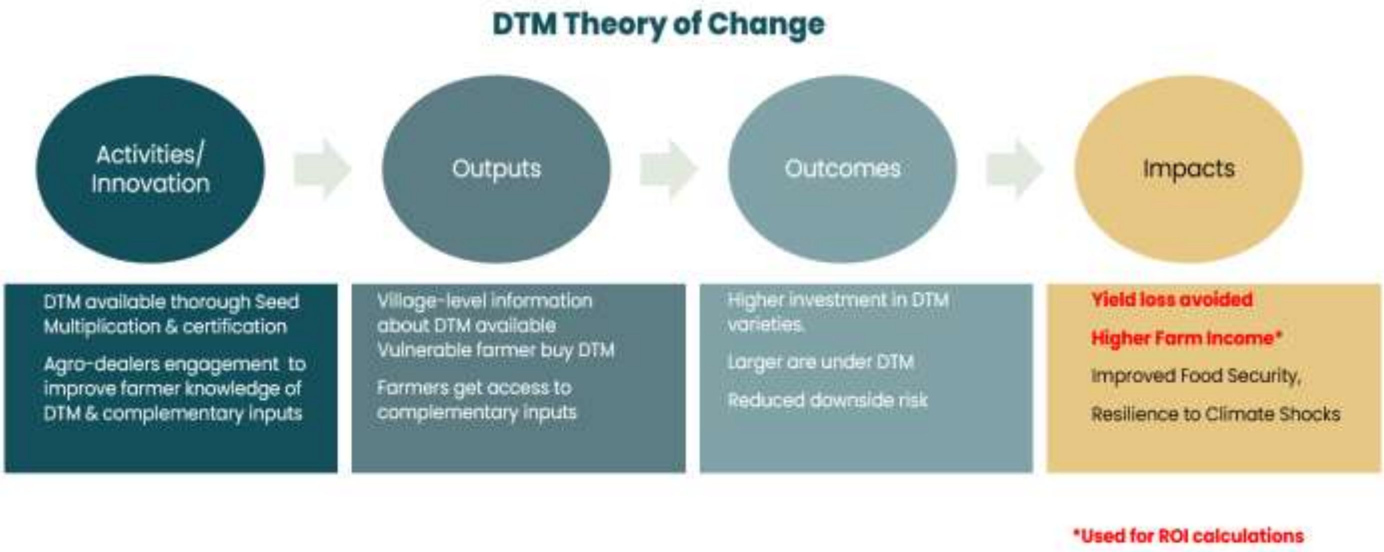
Based on information provided by CIMMYT about the budgets of past DT maize research and dissemination through its DTMA, STMA and related initiatives, it is estimated that about US$21 million (in 2022 dollars) were spent on research costs for DT-maize in Ethiopia, between 2006 and 2024.

Tolerance to drought is present in hybrid varieties (e.g., BH 661, MH-130/140, BH 546/547) and Open Pollinated Varieties (OPV) (e.g. Melkasa series, Gibe-2) available in Ethiopia. These seed varieties are tailored to altitude and rainfall zones (Fisher et al. 2015). In good seasons these varieties provide very similar or slightly lower yield than other maize varieties, but they help avoid crop loss in a mid-season drought.

CGIAR and national investments in breeding and seed-system strengthening led to the release and diffusion of drought-tolerant varieties. As we show in Figure 8, DT maize entered the seed system through seed multiplication and certification, and then agrodealers both provided complementary inputs and spread information of DT maize among farmers, possibly leading to village-level awareness and take-up. DNA fingerprinting data of farmers' maize crops in the SPIA-co-led Ethiopia Socioeconomic Panel Survey (Alemu et al. 2024) suggests that in 2021 about 14% of the area under maize in Ethiopia was planted with a drought-tolerant variety, a substantial increase from the 0.01% estimated in 2009 by the DIIVA study (Fisher et al., 2015).

It was expected that by planting DT maize, farmers would have stable yields, higher farm income and improved food security. Rigorous estimates of the impacts of planting DT maize come from an RCT conducted with Mozambique and Tanzanian maize farmers. Using two different estimation methods, they estimate the benefit of growing DT maize when faced with a mid-season drought to be in the range of 46 to 180 kg/hectares in the same season as the drought, and 117 to 145 kg/ha in the following season. During a normal year, the yield benefits of growing DT maize relative to regular varieties, are on average negative, ranging from -8 to -51 kg/ha.

Figure 8: DTM Theory of Change



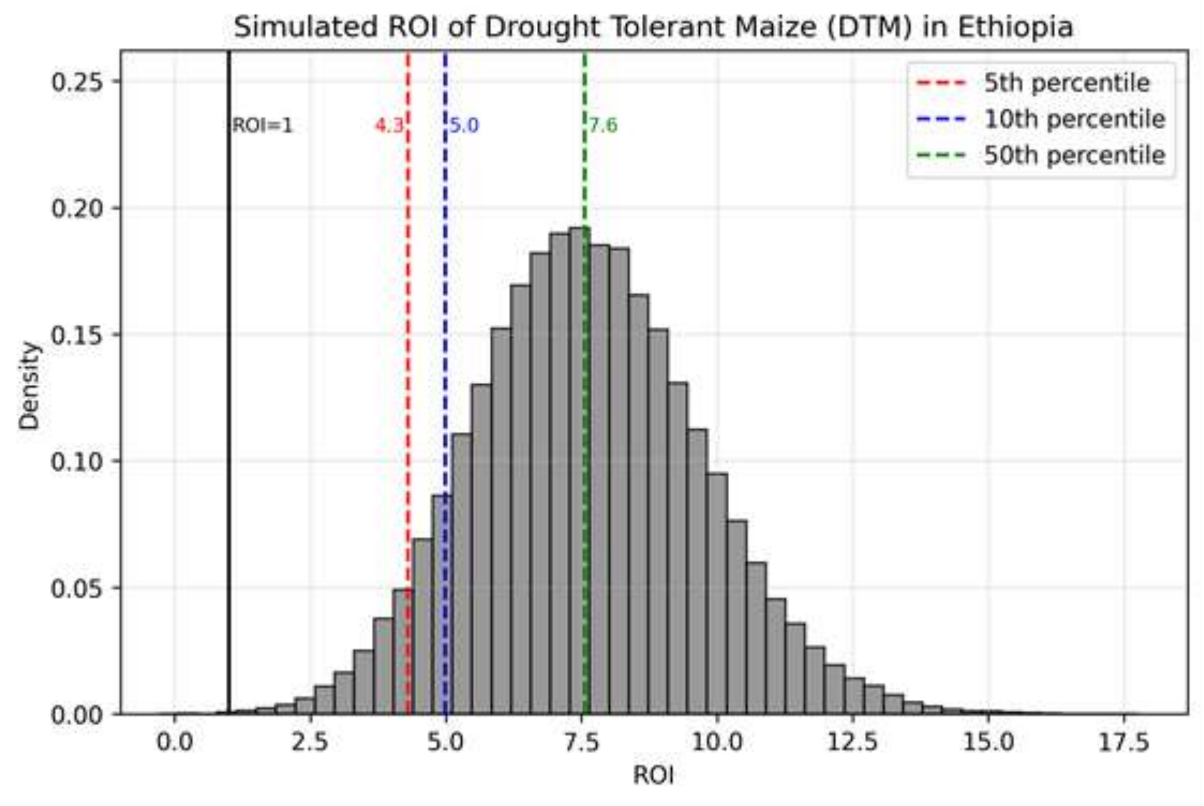
3.4.1 DTM ROI Estimation

Details of the ROI calculations are described in Annex 2.4. Significant sources of uncertainty arise from the different estimates for the impacts that were obtained by different estimation methods, and the fact that the impacts were estimated in Tanzania and Mozambique whereas in Ethiopia maize yields are on average 10 times higher. We allow for the fact that the benefits of DT maize are unlikely to translate in a linear fashion and instead assume that the effects diminish at higher yield levels. However, our sensitivity analysis attempts to account for the arbitrariness of our choice of scaling parameter.

Results for the sensitivity analysis of the DT maize ROI are presented in Figure 9. The results again show high returns on investment of CGIAR innovations. We estimate that there is almost a 100% chance that the investments into DTM were fully recovered through the development and adoption of the innovation in Ethiopia, that there is a 95% chance that every dollar invested led to benefits worth 4.3 dollars and above, and a 90% chance that they led to benefits worth 5.0 dollars and above.

In Figure 9, the median of the distribution is 7.6, indicating a 50% chance that a dollar invested in DTM development and dissemination yielded benefits worth 7.5 dollars.

Figure 9: Simulated ROI of Drought-Tolerant Maize (DTM) in Ethiopia



4 Takeaways and Lessons Learned

In this document we report on selected CGIAR innovations, where it has been possible to combine data on their widespread adoption, estimates of the impacts on farmer outcomes, and costs to the CGIAR the research, development and dissemination to estimate returns to investment. As can be seen, these estimations of ROI require us to make assumptions at various points where particular information may be unknowable or missing, and this makes the estimates inherently uncertain. The sensitivity analysis that accompanies each estimation attempts to communicate this uncertainty.

The study finds that all four innovations likely generate positive returns. Three of these four innovations qualify as 'big wins' of the system, which are rare in Agricultural Research for Development (AR4D), but can help make the business case for investment in the CGIAR, and justify support from donors.

As we highlight in the document, ROI estimation is not always appropriate for all CGIAR innovations. To the extent that AR4D makes multi-faceted contributions to the Sustainable Development Goals (SDG) and can help progress toward multiple objectives, the ROI calculation becomes complex. The returns to investment in policy influence activities or creation and maintenance of global public goods may not be amenable to quantification.

Even when it is appropriate, the estimation is only feasible if it is possible to access reliable information on and estimates of the costs of developing the innovation, its adoption by beneficiaries, and the impacts of adoption on the outcomes of interest. Only partial availability, or unavailability of these pieces of information would make it infeasible to estimate the ROI. As has been noted above, although SPIA identified 14 showcase successes, only 4 were ROI feasible in the end.

While adoption estimates were available for the majority of the selected innovations, there were gaps in rigorous impact estimates of some innovations, as well as some limitations for calculating the level of investment on the development and dissemination of other innovations. Moving forward, CGIAR Centers and Programs should develop a robust system to track investment/costs and link them to specific innovations, group of innovations and programs.

Focusing only on ROI as a measure of impact will necessarily miss some valuable and important innovations and will fall short in documenting the contributions of CGIAR research to each of the five impact areas. SPIA advises that impact assessment for the CGIAR acknowledge that returns to investment in AR4D are likely to be highly skewed, and that the large returns to some "big win" investments alone can exceed the total investment in the system. To the extent that the big wins can only be identified after the fact, this can be a case for investing more broadly. However, as a learning organization, the CGIAR can also benefit from insights about what caused seemingly promising innovations to fail. While it is difficult to predict big wins at the moment of investment, they can be sufficient to justify (ex-post) the entire investment in the system, potentially over many years. Only quantifying the benefits of a few innovations will provide a conservative (lower-bound) estimate under relatively weak assumptions. As such it explicitly acknowledges that there are likely also many smaller wins and wins for which benefits can be harder to quantify.

It is also important to highlight that the four cases examined here are different along multiple dimensions. The countries where the innovations are being studied differ in their stage in the path to development, their institutions and infrastructure. The same ROI per dollar invested may create much larger positive benefit in countries with lower standards of living, where households have fewer alternatives to agriculture. Also, the economic gains from technologies that mitigate risk (three of the four cases we study) are triggered at exactly the time when households are especially vulnerable. The benefits of such technologies on household welfare likely exceed the average return we have estimated above. For these reasons, we caution against comparisons of the ROI estimates across the four cases.

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Annexes

Annex 1. How the ROI distributions were constructed

	IBLI	AFP	FTRV	DTM
Investment costs	2010-2025, N (17.68 million, 5%) [Normally-distributed with (mean, std.dev.)]	2013-2018, N (4.87 million, 5%)	1993-2025, N (5.73 million, 5%) (include IRRI global expenditures and Bangladesh specific share)	2006-2024, N (20.96 million, 5%) (includes DT Maize research & dissemination programs: DTMA, STMA, other
Impacts	**Short term:** N (1345, 5%) Simulation randomly draws: 50:50 chance of drawing one or the other estimate **Long term:** N (3,646, 5%) Product of fixed adoption effect and estimated additional adoption years (negative benefits possible)	Crop (rice, maize, wheat, others) shares N (0.038, 5%) distributed, std dev 5% (no negative shares set) Fuel cost savings N (21, 5%) (from different scenarios (capital/fixed costs, pump prototypes, head type, level of water use). Adjustment factor N (0.465, 0.173) to ensure simulated value < 1	Benefits under observed Goldilocks flood conditions Impacted rice area bounds N (112,674, 92,268) from two survey estimates. Simulation randomly draws: 50:50 chance of drawing one or the other estimate . Seeding rate N (32, 5%). Increased rice yields N (7.41, 5%)	Drought impacted area, adoption, maize yield and market price Production lifts randomly N (259, 74.1) for mid term effects and N(118, 77.1)for long-term effects (includes drought years and normal years. Given maize yields in Ethiopia 10 times higher, conversion factor N (0.787, 5%). Simulated values btw 0.25 & 0.75)
Adoption	N (28,983, 5%)	N (1.6 million, 5%)	N (670,000, 5%)	N (2.6 million, 5%)
Monetary values	All values in 2022 US dollars (using CPI)			
Simulation	100,000 simulation draws			

Annex 2.1. Benefit estimation and cost data used for IBLI

(a) **Benefits**

The ROI analysis focuses on the two benefits for which there is rigorous, long-term evidence and a clear monetization pathway, both of which are observed only among households that purchased IBLI under the early micro-level commercial model[5]. These include:

(1) Educational gains that lead to increased lifetime earnings: Barrett et al. (2025) estimate that households that purchased IBLI at least once experienced on average a 7.3-year increase (standard error 3.704 from Barrett et al. 2024) in total school attainment over a decade among members who were school-aged at the time of the initial purchase, potentially translating into significant lifetime income gains. Although Barrett et al. do not provide estimates of the income gains, one can apply Mincerian estimates of the returns to education for Sub-Saharan Africa (mean: 12.4% from Montenegro y Patrinos 2014) and use the average

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[5] After the micro-level commercial model, IBLI further developed into meso- and macro-level public–private and government-led programs—laying the foundation for large-scale public-private partnerships (PPP) such as Kenya Livestock Insurance Program (KLIP), Satellite Index Insurance for Pastoralists in Ethiopia (SIIPE), and the regional World Bank–supported De-Risking, Inclusion, and Value Enhancement of Pastoral Economies (DRIVE) program

income in Kenya (mean: USD 234 per adult-equivalent, assumed standard error 5%) to estimate the present value benefit per household attributable to education-induced lifetime earnings gains.
The benefit is treated as a one-time, long-term gain per household that participates in IBLI at least once. It is not annualized, since the estimated income effects are already discounted to present value and accrue across the adult working lives of insured children.

We do not subtract household-level education costs (e.g., tuition, school uniforms, transport) from this benefit figure on the grounds that the Mincerian returns we apply capture net income gains conditional on typical household co-investments in education, even if those costs are not explicitly deducted.

(2) Short-term income gains: Participation in IBLI reduced the risk of income loss during a drought and increased average household income (Shikuku et al., 2025; Jensen et al., 2017; Jensen et al. 2016). We rely on two alternative estimates of the short-term income benefits of IBLI purchase, from Jensen et al. (2017) who estimate KES 275.3 (standard error 101.9) per Adult Equivalent (AE) per cumulative livestock units insured, to Shikuku & Ochenje (2025) who estimate an income effect of 0.97 (standard error: 0.24)

Evidence indicates that passive coverage through meso- or macro-level programs such as KLIP or SIIPE does not produce these impacts. According to Barrett et al. 2024, the lack of observed long-term impacts of IBLI may suggest the need for complementary interventions to help relieve the continuing severe poverty that afflicts many pastoralist households, which were not addressed in the meso/macro-level programs

Both estimates were converted to constant 2022 USD using Kenya CPI data and the 2022 exchange rate.

Extending Kenyan income impact estimates to Ethiopia: The income effect estimates from Jensen et al. (2017) and Shikuku & Ochenje (2025) are based on Kenyan households. To extrapolate the estimates to the Ethiopian context, we rely on the fact that the Barrett et al. (2025) study is in both countries. In their work, the Kenyan household income is 84% of the average household income in the pooled sample. Assuming that the income effect translates linearly, we estimate that the income effect in the pooled Kenyan-Ethiopian sample would be 84% (fixed value) of that in Kenya.

This yielded a pooled per-household income effect of USD 1,481 (average upper bound) and USD 1,209 (average lower bound). Taking an average of these two simulated bounds—given them equal weight—provides an average simulated value of USD 1,345, which we use as the per-household income benefit observed during the 2009–2012 period ('short-term'), in contrast to the long-term education effects discussed above.

Multiplying this per household income gain by the estimated number of adopting households (described below) produces total income benefits for each of a set of years. These estimates are adjusted for inflation to obtain the benefit stream in 2022 USD. The aggregated income benefits are combined with long-term education benefits to estimate the overall ROI.

(b) **Adoption**

Jensen et al. (2024, p. 49) estimate that a total of 43,931 policies were sold in Kenya and Ethiopia between 2010 and 2020. Assuming one policy per household and no repeat purchases, this figure represents the maximum cumulative number of unique beneficiary households. However, Jensen et al. (2024) note that using a methodology that avoids double-counting across insurance units and seasons yields a total of 16,158 unique policy sales. Finally, based on data in Barrett et al. (2025) (see their Figure 3), one can calculate that conditional on ever purchasing IBLI, households purchase 1.64 policies on average. Using this conditional average to adjust the total number of policies sold (43,931), we estimate that on average 26,861 unique households may have benefited from IBLI. To reflect this uncertainty about the number of beneficiary households, in our sensitivity analysis we represent this with a normal distribution with a mean of 30044.5 and a standard deviation of 7087.5 (where 95% of the simulated values are within the upper and lower bounds).

(c) **Research and dissemination costs**

ILRI provided annual cost data covering 29 IBLI-related projects implemented between 2010 and 2027. These budgets include expenditures for research, product design, pilot testing, extension, and delivery support.

To estimate the cost of IBLI specifically in Kenya and Ethiopia, we counted 100% of the costs of projects focused solely on these countries. For regional projects, it is unclear how to apportion costs. After discussion with ILRI, an estimate of 20% was considered reasonable if the project targeted Africa broadly, and 40% if it focused specifically on East Africa or the Horn of Africa. Accordingly, we used a distribution of apportionment fractions, with a mean of 19,468,239 and a standard deviation of 973412 (5% of the mean).

Although the estimated benefits are measured only through 2021, we adopt a conservative approach by including all committed project expenditures through 2025.

Annex 2.2 Benefit estimation and cost data used for AFP

(a) **Benefits**

The estimated benefits of Axial Flow Pump (AFP) focus on net fuel cost savings per hectare from switching from conventional centrifugal (CEN) pumps to AFPs. This estimate is based on engineering and controlled field trial that models fuel and cost efficiencies under different crop, lift height, and water use scenarios (Krupnick et al. 2015). In each round of the sensitivity analysis, we randomly sample from different scenarios (with equal probabilities) mentioned in the paper to calculate the benefit, and thus we will only report the average below. Given this potential overestimation of the AFP impacts, the per-hectare benefits were scaled by 0.465 (standard deviation 0.173) corresponding to the observed ratio of actual (on-farm) to potential (experimental) yield benefits from irrigated rice in Bangladesh, as reported in the Global Yield Gap Atlas (https://www.yieldgap.org/

Average fuel cost savings reported by Krupnick et al. 2015 varied by crop (Boro rice 37, wheat 10, maize 16, all in 2013 USD) and did not account for incremental costs associated with AFP ownership (first Year capital cost and fixed cost) that were estimated at 131 USD for 4 years using cost data from Krupnick et al. 2015. Average fuel cost saving did not account for variable costs of the pumps either, therefore an estimate of the difference between operating costs and fuel and capital costs was used.

This net benefit is converted to 2022 USD using the inflation adjustment factor and then multiplied by the estimated AFP adoption area (by crop and year) to produce total annual gross benefits to AFP owners. We therefore used an average net benefit for rice, maize, wheat and other (mainly vegetables) of 31, 7, 12 and 17 (average of rice, maize and wheat).

(b) **Adoption**

Adoption data for AFP comes from the 2024 Bangladesh Integrated Household Survey (BIHS) Round 4, conducted by SPIA and detailed in Singla et al. (2025). The survey included a dedicated irrigation module at the plot, season, and crop level, capturing detailed information on irrigation status, equipment used, and ownership status (owned vs. rented). To minimize misreporting and enhance identification accuracy, enumerators used visual aid with images of different irrigation technologies, enabling farmers to correctly recognize and report the equipment they used. It was hoped that this approach would reduce the likelihood of measurement error in identifying AFP use.

Adoption of Axial Flow Pumps (AFPs) in Bangladesh in 2023 reached 12.6% of rural households, and increase from 0.5% and 1.4% reported in previous rounds of BIHS (2015 and 2018 respectively). But given that the ROI calculation requires an estimate of the acreage under the use of AFP, it was translated into 7.63% of the cropland using information collected during the BIHS round 4. From the same survey, the share of total AFP-irrigated area allocated to rice, maize, wheat, and other crops (primarily vegetables). Were estimated at 79.5%, 1.9%, 1.7% (with a standard deviation of 5% of the mean for each crop, avoiding negative values) and 17.5% (subtracted from the simulated shares of rice, maize and wheat) respectively.

(c) **Research and dissemination costs**

CIMMYT provided expenditure data from the CSISA–Mechanization and Irrigation (CSISA–MI) project covering 2013–2018. Total project spending of US $ 4 million was evenly distributed across six years and converted to constant 2022 USD, yielding a total of US $ 4.87 million (with a standard deviation of 5% of the mean). These expenditures represent public R&D, testing, and demonstration activities. Private-sector manufacturing and user purchase costs are excluded.

Annex 2.3. Benefit estimation and cost data used for FTRVs

(a) **Benefits**

The ROI analysis focuses on causal impact estimates of the adoption of Flood Tolerance Rice Varieties (FTRV) on rice yields rigorously estimated by Michler et al. 2025. Using Earth Observation data, Michler et al, 2025 focused on average vegetation “greenness” or vigor (EVI) within rice areas and evaluated the interaction of district-level FTRV seed supply (in tons, used as a proxy for adoption) and measures of flood occurrence. The authors run thousands of regressions and consistently found that FTRVs provide yield protection within a narrow “Goldilocks” band of moderate floods, indicating that the technology is effective but only under specific, stochastic conditions.

The average impact estimate for this band of Goldilocks flood is 0.0001147 (std. error 0.0000496). This coefficient estimates the impact of the interaction between cumulative FTRV seed (in tons) and flood occurrence, on changes in average EVI associated with an additional ton of seed available in a district during a Goldilocks flood year. In other words, if a Goldilocks flood occurs, each additional ton of cumulative FTRV seed in that district is associated with a 0.0001147 increase in the district’s average EVI, holding other factors constant.

The next step was converting changes in vegetation indices into agronomic yield outcomes. In the absence of context-specific estimates of such a slope for Bangladesh rice systems, we constructed a conversion factor (S) by regressing district-level paddy yields (tons/ha) over time (sourced from the Annual Yearbook of Agricultural Statistics of Bangladesh, various years) on EVI-max values derived from Earth Observation data. The estimate of S = 0.7409494 tons/ha per 1.0 EVI (std. error=0.1694612) indicates that a 0.01 increase in EVI corresponds to an average yield gain of approximately 7.41 kg/ha.

To capture the stochastic nature of Flood-Tolerant Rice benefits, we filter to the actual district-years in which Goldilocks floods occurred. Benefits are therefore realized only for those districts and years. Across the 20-year EO panel (2002–2021) covering 64 districts in Bangladesh—yielding 1,280 district-year observations—Goldilocks floods were identified only 16 times (about 1.25% of cases). Of these, 15 occurred during 2017–2021, concentrated in just eight districts.

(b) **Adoption**

The 2024 Bangladesh Integrated Household Survey (BIHS) Round 4 reports an adoption of 7.98% of the total rice acreage with FTRV (Singla et al. 2024). However, using district-level cumulative seed production and distribution data compiled by Michler et al. 2025 that recorded recycling carry-over, this estimate was adjusted. the total adoption area exposed to Goldilocks floods is estimated to be 49,308 hectares.

Michler et al. 2025 also provides household-level adoption rates for 2014, 2017 and 2022. Using these estimates and assuming a seed rate of 32 kg/ha, the total FTRV adoption area exposed to Goldilocks floods is estimated at 101,627 hectares across the 15 observed flood events between 2017 and 2021.

To reflect this uncertainty about the number of beneficiary households, in our sensitivity analysis we represent this with a normal distribution for each year where 95% of the simulated values are within the upper and lower bounds, avoiding extreme negative values. The upper and lower bounds are [12824, 7345], [41353, 21347], [40822, 17813], [3314, 1407] and [3314, 1406] for 2017~2021 respectively.

(c) **Research and dissemination costs**

IRRI supplied project-level budget data associated with research and dissemination activities on Flood-Tolerant Rice. Relevant projects were identified by IRRI by filtering titles using targeted keywords related to flood tolerance (e.g., Flood-Tolerant Rice varieties, submergence tolerance in rice, rice submergence tolerance (Sub1 gene), flood resilience, and flood resistance genetic traits). The resulting dataset captures expenditures related to both upstream and downstream activities linked to Flood-Tolerant Rice research, though it may not represent the complete costs of early-stage varietal development preceding these projects.

These budgets specify both the country focus and time period of each grant, enabling construction of two aggregates: (i) global IRRI expenditures on FTRVs (across all countries), and (ii) the Bangladesh-specific share. For ROI estimation, only the Bangladesh-specific IRRI investments were included, expressed in 2022 USD. This approach ensures comparability with other cases and reflects the CGIAR/IRRI donor contribution only, excluding expenditures by national partners such as BRRI or the Department of Agricultural Extension.

Annex 2.4. Benefit estimation and cost data used for DTM

(a) **Benefits**

The ROI analysis focuses on causal impact estimates of the adoption of Drought Tolerant Maize on maize yields rigorously estimated by Boucher et al. 2024 for Mozambique and Tanzania. Using the preferred

ANCOVA estimation approach, the authors decomposed the total impact of DTM into three effects: Mid-season drought (yield losses mitigated in the same season), Lagged effect (DT helps recover from lingering drought damage into the following season) and Normal year (effects in non-drought seasons).

The mid-season yield losses mitigated were estimated in 189 kg/ha (standard deviation 81.2), while the lingering effect into the next season in 145 kg/ha (standard deviation 98.7) and the effect in non-drought season in 54.8 kg/ha (standard deviation 76.5). Given that the average maize yields in Ethiopia (≈3-3.5 t/ha) are much higher than in the RCT control group in Mozambique and Tanzania (~0.399 t/ha) we implement percentage-based lifts by converting the working kg/ha into percentages using the RCT's baseline yield, then apply those % effects to Ethiopia's baseline by zone–year. We use 0.5 as conversion factor (standard deviation 0.13, 95% values are between 0.25 and 0.75)

To determine if a specific location and year were affected by drought, CHIRPS dekadal rainfall was aggregated to Ethiopia's ADM2 (zone) level. This allowed the detection of the Start of Season (SOS) and the calculation of total rain over the SOS-anchored mid-season window (SOS+5⋯+8 dekads). From these we computed MID (mid-season rainfall, mm) and MID_LTA (its long-term average) to classify mid-season drought under the absolute and relative rules. (≈ 40-80 days after planting, aligned with the definition of mid-season used by Boucher et al. 2024). We classify mid-season drought with two rules:

1. Absolute: drought = 1 if MID < 200 mm, aligned with Boucher et al. (2024)'s mid-season definition (≈40-80 DAP).
2. Relative: drought = 1 if MID/MID_LTA ≤ 0.80.

(b) **Adoption**

Adoption estimates come from the 5th wave of the Ethiopia Socioeconomic Panel Survey (ESPS-5, 2021/22) led by SPIA (Alemu et al., 2024). The survey collected plot–season–crop information, including variety names, and—crucially—used DNA fingerprinting against a reference library (which includes Ethiopian DT releases) to minimize varietal misreporting. We use these DNA-based identifications to estimate the area under DT maize.

The adoption of DTM varieties in 2021 by region was estimated at 12.6% for Amhara, 27.4% for Oromia, 1.4% for SNNP, 8.6% for Harari and 35.1% for Dire Dawa. The area-weighted national adoption rate in 2021 is about 14%. In 2009, a study on the adoption and impacts of improved varieties in Africa (DIIVA) estimated the adoption of DTM varieties for the same regions at 0.01%, 0.01%, 0.01%, 0.01%, 0.01% respectively (Walker and Alwang 2015). The mid values for the adoption of DTM are calculated by interpolation. For each interpolated value, we use 5% of the mean as standard deviation (avoiding negative values)

(c) **Research and dissemination costs**

CIMMYT provided project-level budget data covering Drought-Tolerant Maize (DTM) research and dissemination activities implemented across Ethiopia, Tanzania, and Mozambique. The compilation included both completed and ongoing projects that contributed to the release and adoption of DT maize varieties. For multi-country projects, investments were proportionally allocated to each country based on project location and scope. For projects extending from 2017 to 2025, CIMMYT estimated the breeding and scaling investments, recognizing that some breeding components would not reach the scaling stage within this period.

Based on these criteria, 56 projects from 2006 to 2025 were identified, representing a total investment of approximately USD 48.0 million across the three countries. The subset attributable to Ethiopia were compiled and harmonized across years and expressed in 2022 USD—totals USD $20.96 million These estimates capture CGIAR and donor investments in DTM breeding, testing, and delivery over time. However, it is expected that though it may not represent the complete costs of early-stage varietal development preceding these projects.

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