Summary of Evaluator Findings and Lessons from AgResults Prize Competitions: 2013 to 2020

Submitted to:
Foreign, Commonwealth and Development Office
Abercrombie House, Eaglesham Road
East Kilbride, Glasgow G75 8EA

March 2021

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In partnership with
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Suggested citation: Mainville, Denise; Sally Cameron; Betsy Ness-Edelstein; and Judy Geyer (2021). *Summary of Evaluator Findings and Lessons from AgResults Prize Competitions: 2013 to 2020*. Rockville, Maryland: Abt Associates. Prepared for the U.K. Foreign, Commonwealth and Development Office and the AgResults Steering Committee.

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The AgResults initiative is a partnership between the Australian Government, the Bill & Melinda Gates Foundation, the Government of Canada, the United Kingdom's Foreign, Commonwealth and Development Office, the United States Agency for International Development, and the World Bank.

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Acknowledgements

We are grateful to have had the opportunity to work with the AgResults community over the last eight years and to have learned alongside so many creative and thoughtful development professionals—the AgResults Steering Committee, the Secretariat, and those implementing the challenge projects in the field. We are also grateful to the project participants—competitors and smallholder farmers—who gave so graciously of their time to answer our many questions and help us understand the projects' impact.

We also recognise contributions of consultants Abdulsamad Isah and Emily Crawford in Nigeria; Tabitha Nduku in Kenya; Miriam Kyotalimye in Uganda; and Kelvin Mulungu, Natasha Chilundika and Robert Nhlane in Zambia. We also acknowledge contributions of previous AgResults evaluators: Tulika Narayan, Steve Bell, Jim Shyne, Abby Conrad, Kate Hausdorff, William Bowser, and Mikal Davis as well as contributions of our quality assurance officer Cris Price, cost-benefit analyst David Cooley, and editor Diane Ferguson.

Executive summary

AgResults is a US$152 million multilateral initiative that tests the use of payment-for-results (PfR) prize competitions as a means of catalysing markets for high-impact agricultural innovations that benefit smallholder farmers in developing countries. AgResults offers prizes to private sector actors ('competitors') to encourage them to engage in markets for these innovations. AgResults' ultimate goal is to develop markets that serve smallholder farmers both during and after the project. To date, AgResults has sponsored nine prize competitions, of which four are complete and five are ongoing.

AgResults has dual mandates of achieving impact and generating learning about the use of PfR prize competitions. Evaluation is integral to achievement of the second AgResults objective. As external evaluator for the AgResults initiative, Abt Associates, in partnership with Denise Mainville Consulting, conducted independent evaluations of AgResults' first four projects using tailored applications of a general evaluation framework.

Our evaluation framework is based on economic principles related to the behaviour of both individual market actors—including smallholder farmers—and agricultural markets as a whole. Our framework was designed to address these areas of inquiry:

- **Market impact.** How has the project affected private sector engagement in the market, particularly investment in the development of a smallholder farmer-inclusive market for the targeted technology? How sustainable is the market likely to be in the medium to long-term?
- **Smallholder farmer impact.** How has the project affected smallholder farmers' adoption of and benefits from the technology?
- **Cost-effectiveness.** What indications are there of the cost-effectiveness of the PfR approach?
- **Lessons**. What lessons can be learnt from from the project about best practices in the design and implementation of PfR competitions?

This report presents findings drawn from our evaluations of the first four prize competitions. (We use the terms 'PfR competition', 'prize competition', 'competition,' and 'project' interchangeably.) We frame the lessons as best practices for sponsors of future competitions.

The four competitions discussed in this report cost $24.1 million[1] and were all completed prior to 2020. The competitions in Nigeria and Kenya ran their full course, whereas the two in Zambia and Uganda were terminated early.

Overarching finding

Our overarching finding is that PfR projects can, indeed, spur the development of new markets for high-impact agricultural technologies that benefit poor farmers. Yet, prize competitions are not simple undertakings. Markets are complex and difficult to influence. There are many steps between prize creation and the birth of a sustainable and growing market. Prize sponsors must have a nuanced understanding of the market system and a clear theory of the causal linkages not only between the prize incentive and private sector investments, but also between private sector investments and the desired development impact.

[1] AgResults Trustee Report, Steering Committee Meeting, October 5, 2020.

At the same time, even with extensive preparation, it is impossible to anticipate precisely how a prize competition will unfold. None of the four projects turned out exactly as envisioned. Two were terminated early because it did not appear that the desired results would be achieved. The other two projects generated strong results in some areas and limited results in others. In all cases, AgResults project managers and competitors had to learn and adapt as the competition proceeded.

The external evaluator learned alongside the implementers and shared our findings and initial lessons as we went along in our presentations at semi-annual meetings and reports. Each evaluation used a mix of rigorous quantitative and qualitative methods to provide high-quality evidence about the extent to which the prize competition generated market and smallholder farmer impact, and the cost-effectiveness of the approach. We group our findings in accordance with those themes.

Thematic findings

In terms of market development, AgResults offers evidence that PfR approaches can spur the development of new markets in certain scenarios that reflect specific supply, demand, and enabling environment conditions, as summarised in the following box.

Findings: Impact on market development

1. **Market development.** AgResults successfully catalysed private sector engagement in markets for AgResults technologies or for products derived from those technologies.
2. **Constraints to market development.** AgResults was most successful in catalysing market development in projects where the key constraints were within the manageable interest of the private sector once incentivized by the prize.
3. **Role of the enabling environment.** The enabling environment was usually supportive or neutral to development of markets for AgResults-targeted technologies; however, at times government action or inaction impeded the market's initial development or its sustainability.
4. **Strong business case.** AgResults was most successful in engaging the private sector when the private sector perceived a strong business case for investing in the market.
5. **Smallholder farmer inclusion.** AgResults successfully promoted inclusion of smallholder farmers in targeted markets, either through explicit project rules or by leveraging the smallholder-inclusive nature of the underlying markets.
6. **Inclusion of women.** AgResults had mixed results in terms of inclusion of women in the markets it developed.
7. **Market sustainability.** There are mixed indications about the likely sustainability of markets catalysed by AgResults.
8. **Economies of scale.** Sustainability appears to be enhanced when the private sector makes 'lumpy' investments that lead to economies of scale.

AgResults also offers evidence that PfR projects can enhance smallholder farmer welfare. Both completed projects achieved substantial gains in adoption but mixed results in terms of the technology uptake's impact on smallholder farmer income and other benefits. The box below summarises our key findings about AgResults' impact on smallholder farmers.

Findings: Impact on smallholder farmers

1. **Technology adoption.** AgResults competitors were able to substantially increase smallholder farmers' adoption of the targeted technologies.
2. **Income.** Technology uptake sometimes, but not always, led to increases in farmer incomes. In Kenya, income impacts were negligible, mainly because farmers used the technology (improved on-farm storage) as a substitute for one they already had (pesticides).
3. **Non-financial benefits.** Some farmers also reported non-financial benefits related to adoption of the technology.
4. **Farmer knowledge.** The PfR approach left farmers with some gaps in their knowledge about use, consumption, and health benefits of the technologies.
5. **Women's participation.** Women can face inherent disadvantages in market-based approaches like AgResults, but gender-sensitive project design can help offset these disadvantages.
6. **Deviations from projected impact.** Certain farmer benefits were not realised to the extent projected, underscoring how farmer response to new technologies may differ from expectations.

Our examination of cost-effectiveness revealed three main findings, as shown below.

Findings: Cost and cost-effectiveness

1. **Risk reduction benefit to prize sponsors.** PfR projects have a financial risk reduction benefit to sponsors since prize pay-outs happen only if results are achieved. At the same time, PfR projects involve some costs regardless of whether all prizes are paid out. In the two projects that were terminated early, sponsors' costs for management, verification, and initial prizes amounted to 52% of what they had planned to spend on the projects.
2. **Management, verification, and prize costs.** PfR projects incur costs to manage the competition, verify whether competitors meet prize requirements, and pay the prizes. The relative share of these costs varies considerably from project to project depending on the type of technology and design of the competition. In the two completed projects, for example, management costs were 44% of one project's total costs and 25% of the other. Verification was 26% of one project's costs and 7% of the other. Prizes amounted to 30% of one project's costs and 69% of the other.
3. **Contextualisation of cost-effectiveness results.** Cost-effectiveness measures, such as cost per smallholder farmer adopting the technology, can provide useful insights if interpreted with care. Comparing costs across technologies or implementation contexts can be misleading, given that complexity, benefits, and costs of uptake are likely to differ.

Best practices

Finally, we draw on the above findings to suggest best practices for sponsors of prize competitions, including how to decide whether a PfR competition is appropriate, develop a theory of change, and design the competition for both market impact and smallholder farmer impact.

Best practices for sponsors of prize competitions

Deciding whether a PfR prize competition is appropriate

1. **Choice of technology.** Verify that the technology under consideration has potential for a significant development impact if adopted at scale.
2. **Constraints to market development.** Consider how government action or inaction in the enabling environment might influence development of the targeted market and ensure that constraints critical to market development are within the competitors' manageable interest.
3. **Business case.** Confirm that there is a plausible business case for potential competitors to engage in the market.
4. **Competing programs.** Consider whether overlapping programs (e.g., a program to subsidise distribution of the technology) might interfere with market development.
5. **Cost of achieving outcomes.** Conduct an ex-ante cost-effectiveness or cost-benefit analysis.

Constructing an effective theory of change

6. **Theory of change.** Construct a theory of change that reflects a thorough understanding of the market, the causal logic by which the incentive structure will motivate competitors to engage in the market, the expected development impacts for farmers, and underlying assumptions.

Designing to increase market impact

7. **Competitor numbers and capacity.** Select competitors that are adequate in number and have the capacity to realise the desired scale.
8. **Prize design.** Choose the prize type, prize pay-out frequency, and duration of the competition to promote the desired market structure.
9. **Inclusion.** Explore ways to increase participation of under-represented firms, such as women-owned or women-managed firms.

Designing to maximise smallholder farmer impact

10. **Targeting smallholder farmers.** Tailor the competition rules to incentivize competitors to engage the intended beneficiary group.
11. **Developing the market's 'nucleus'.** Reward gains among better-off smallholder farmers —who will form the nucleus of the emerging market—to promote early success and increase a technology's visibility.
12. **Integrating 'typical' smallholders into the market.** Reward integration of 'typical' smallholders that will ultimately constitute the bulk of the market.
13. **Improving social and gender inclusion outcomes.** Systematically look for opportunities to be more inclusive of farmers who have lower rates of market integration, such as very poor farmers and women farmers, recognizing that including these groups may involve additional cost and complexity.
14. **Maximizing benefits to farmers.** Consider prize structures that will incentivize competitors to help farmers to draw full benefits from the technology, not just adopt it.

1. Introduction

AgResults is a US$152 million multilateral initiative that tests the use of payment-for-results (PfR) prize competitions as a means of catalysing markets for high-impact agricultural innovations that benefit smallholder farmers in developing countries. Donor-sponsored pay-for-results (PfR) competitions (also known as prize competitions or pull mechanisms) are designed to harness private sector ingenuity and resources to catalyse the development of the market. AgResults offers prizes to private sector actors ('competitors') to encourage them to engage in markets for these innovations, with the ultimate goal to develop markets that serve smallholder farmers both during and beyond the life of the project. Technologies are selected for their potential contributions to improved food security and food safety, increased farmer incomes, and better health and nutrition. To date, AgResults has sponsored nine prize competitions, of which four are complete and five are ongoing. In each case, the 'competitors' are private sector entities that compete for the prizes.

AgResults has dual mandates of achieving impact and generating learning about the use of PfR prize competitions. Evaluation is integral to achievement of the second AgResults objective. As external evaluator for the AgResults initiative, Abt Associates, in partnership with Denise Mainville Consulting, conducted independent evaluations of AgResults' first four projects using tailored applications of a general evaluation framework.

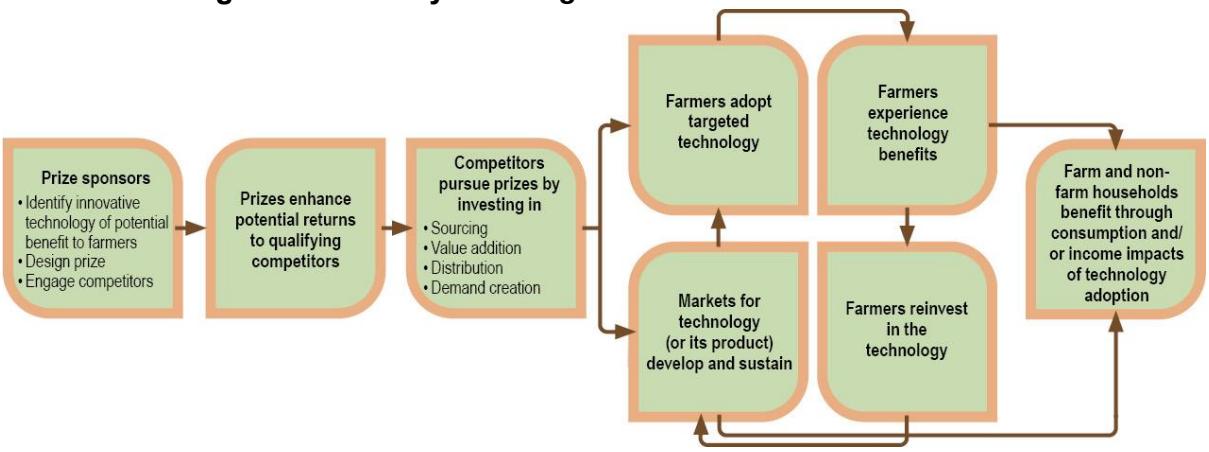
The theory behind the PfR approach is that prize competitions will:

- Direct the private sector's attention toward particular market opportunities, anticipated to be of long-term commercial interest, that involve supplying high-impact agricultural technologies to farmers.
- Offer an attractive monetary prize to incentivize these private companies to invest their own resources in supplying the technology to farmers and developing farmers' demand for the technology.
- Award these prizes to the companies that reach predefined targets related to the uptake (i.e., adoption) of the technology[2] – this is the payment for results. Achieving these results suggests that the winners have had a successful initial engagement in the market and may be expected to sustain their engagement in the market once the incentive is withdrawn.

Each AgResults project is built around an innovative technology with the potential to be both highly beneficial to smallholder farmers and of commercial interest to the private sector in a particular location. The general theory of change, similar from project to project, is as follows:

[2] Some AgResults projects incentivize development of the technology, but those projects are not the subject of this report.

Exhibit 1-1. AgResults' theory of change



Note: For simplicity, this diagram includes only the basic inputs, outputs, outcomes, and impacts expected to take place under AgResults. See Section 3.2 for discussion on constructing a theory of change.

1.1 AgResults projects discussed in this report

This report discusses evaluation results from the four prize competitions completed as of 2020 (refer to Annex A). The projects are summarised in Exhibit 1-2.

Exhibit 1-2. AgResults projects completed as of 2020

Characteristic	Nigeria	Kenya	Zambia	Uganda
Project [a]	Aflasafe Challenge Project	On-Farm Storage Challenge Project	Biofortified Maize Challenge Project	Legume Seeds Challenge Project
Prize period	2013-2019	2015-2018	2014-2018	2017-2018
Technology	Aflasafe, a biocontrol product to reduce proliferation of aflatoxins in maize	On-farm grain storage devices with a capacity up to 540kg that prevent grain loss due to pests	Biofortified pro-Vitamin A maize, an alternative to white maize that can help prevent Vitamin A deficiency	Quality-verified legume seed, which can produce higher yields than commonly used, lower quality seed
Target market	Market for Aflasafe-treated/aflatoxin-reduced maize	Market for improved on-farm storage devices for small-holder farmers to use for storing food staples	Market for pro-Vitamin A maize meal	Market for quality legume seed
AgResults funds expended on project [b]	$9.99 million	$9.11 million	$2.5 million	$2.66 million
Prizes awarded [c]	$3,065,243	$6,251.500	$605,741	$0 (in Year 1 no competitor qualified; thereafter the project was terminated)
Participating competitors [c]	41 maize aggregators	9 storage device suppliers	2 seed companies and 9 maize millers	7 seed companies
Number of competitors who won prizes	41	3	2 maize seed companies, 0 millers	0 (due to project termination)

Characteristic	Nigeria	Kenya	Zambia	Uganda
Number of farmers adopting the technology due to AgResults (evaluator estimate)	75,788	220,477	Not investigated	0 (due to early project termination)

[a] See the Projects tab on the AgResults website (agresults.org) for a full description of each project.

[b] AgResults Trustee Report, Steering Committee Meeting, October 5, 2020.

[c] Prize amounts from the 'Actual Results' section of project webpages, accessed August 25, 2020: AgResults - Nigeria Aflasafe, AgResults - Kenya On-Farm Storage, AgResults - Zambia Biofortified Maize, and AgResults - Uganda Legume Seed.

Two of those projects, in Nigeria and Kenya, ran their full course, whereas the other two, in Zambia and Uganda, were terminated early because the competitions were not advancing toward the intended outcomes. We did not attempt, therefore, to measure impact of the Zambia and Uganda projects, although they contribute to lessons learned and best practices.

1.2 The role of evaluation research in the AgResults initiative

Rigorous evaluation is how the AgResults initiative assesses project impact and develops an evidence base for learning. Consistent with best practices for evaluating complex projects, we began the evaluation of each project by examining the project's specific theory of change. We then assessed the project's impact relative to that theory of change, guided by an overarching evaluation framework. Our evaluation framework is based on economic principles related to the functioning and behaviour of both individual market actors—including smallholder farmers—and agricultural markets as a whole. Because we customised a general framework to each evaluation, we can now compare results across projects and generalise best practices from the initiative as a whole. The evaluation framework is designed around these areas of inquiry:

- **Market impact**. How has the project affected private sector engagement in the market, particularly its investment in the development of a sustainable and smallholder farmer-inclusive market for the targeted technology?
- **Smallholder farmer impact.** How has the project affected smallholder farmers' adoption of and benefits from the technology?
- **Cost-effectiveness.** What indications are there of the cost-effectiveness of the PfR approach?
- **Lessons.** What lessons can be learnt from from the project about best practices in the design and implementation of PfR competitions?

This summary report synthesises our findings according to the first three themes. Our lessons are framed as best practices for potential prize sponsors.

1.3 The link between rigorous methods, high-quality evidence, and learning

Each evaluation used a mix of rigorous quantitative and qualitative methods to provide high-quality evidence about the extent to which the prize competition led to its expected outcomes. The more rigorous the method, the more confidence we can have that the results are attributable to AgResults rather than to factors external to the project. Our investigations also allowed us to offer insights into why actual outcomes may have differed from what was expected. Exhibit 1-3 shows the evaluation designs and data sources we used for each project.

Exhibit 1-3. Evaluation designs and data sources

Area of inquiry	Design and data sources
Impact of the project on private sector engagement in the market	**Design:** Pre–post comparison of the market for the technology using a qualitative industrial organisation framework that systematically assesses relationships between the market's underlying conditions, firms' strategic behaviour, and the market's structure and performance. **Data sources:** Semi-structured key informant interviews of AgResults competitors, market actors, government representatives, and subject matter experts; project monitoring data; and data from the quantitative farmer surveys.
Impact of the project on smallholder farmers	**Design for Nigeria:** A quasi-experimental design comparing 944 smallholder farmers reached by companies participating in the competition to 879 comparison farmers not reached by AgResults competitors. **Design for Kenya**: An interrupted time series to estimate impacts on adoption of improved on-farm storage devices, combined with a difference-in-differences design to compare the outcomes of 1554 smallholder farmer adopters with a matched group of 1554 non-adopters before and after the project. **Data sources:** Structured survey of smallholder farmers at baseline and endline.
Cost-effectiveness of the project	**Design**: Descriptive analysis of project component costs; cost-effectiveness analysis (calculations of AgResults cost per additional farmer adopting the technology, cost per unit of technology). **Data sources:** AgResults cost data; estimated impacts on participating smallholder farmers.

For readers interested in evaluating PfR prize competitions, visit the AgResults website in mid-2021 for our forthcoming brief on this topic.

2. Evaluation findings

This section synthesises our findings across AgResults prize competitions according to three main themes: impact on markets, impact on smallholder farmers, and cost-effectiveness. For the markets and smallholder farmer sections, we first present the situation at baseline, then our high-level findings, then a table with findings by country. For cost-effectiveness, we present high-level findings and a table with key cost metrics by country.

2.1 Impact on markets

AgResults offers evidence that PfR approaches can spur the development of new markets in certain scenarios. Here, we discuss the markets targeted in each AgResults competition and summarise the projects' results with respect to market development and conditions that supported these results.

2.1.1 Markets targeted by AgResults competitions

The AgResults project targeted four distinct markets, as summarised in Exhibit 1-2 and further detailed in Exhibit 2-1. In Nigeria, Kenya, and Zambia, AgResults sought to catalyse development of a market that was otherwise 'missing'. We use the term 'missing market' to refer to a situation in which a viable market has not emerged despite its underlying potential. In the contexts in which AgResults has operated, markets are often missing because of constraints such as lack of awareness of a technology and its potential market, high last-mile distribution costs, or inadequate regulation of product quality.

In Nigeria, Aflasafe was a new product. Three entities, only one of which was a private sector actor, grew and marketed Aflasafe-treated maize with support from an international agricultural research organisation. Sales of Aflasafe-treated maize were likewise facilitated by the organisation, which was itself responsible for introduction of Aflasafe to the country. Prior to AgResults, Nigerians in general had little awareness of aflatoxins as a problem, and few maize value chain actors were aware of Aflasafe's potential for reducing the historically high levels of aflatoxin contamination in maize. There was also little enforcement of regulatory limits on aflatoxins in maize markets, in part because of concern that without a supply of aflatoxin-reduced maize, aggressive enforcement could cause a crisis in the supply of a primary food staple.

In Kenya, various improved on-farm storage devices had been promoted for more than 10 years by donor-funded projects, but with very little effect: at baseline, market penetration of improved on-farm storage was under 3 percent. Smallholder farmers had limited awareness of improved devices, and the few suppliers that existed distributed them primarily through donor-funded projects. Several firms (that later became AgResults competitors) recognised that smallholder farmers offered a large potential market, but no firms had yet invested significantly to develop that market. The lack of commercial distribution systems to reach Kenya's many geographically dispersed smallholder farmers and farmers' low awareness of the existence of improved on-farm storage technologies were primary constraints to development of the market.

In Zambia, where white maize is a major agricultural commodity and food staple, pro-Vitamin A maize had been available and promoted among farmers for several years by the global agricultural research organisation that developed it. However, uptake among farmers was extremely limited (a nationally representative survey found only 1 farmer out of approximately 8,000 growing it), and there was essentially no commercial market for it. There was little awareness of pro-Vitamin A maize among either farmers or consumers (except the relatively few directly exposed to campaigns promoting it), and an initial predisposition among both farmers and consumers against it due to its orange colour. Farmers and consumers erroneously associated pro-Vitamin A's orange colour with yellow maize, which is used as animal feed and is historically associated with food relief

distributions during famines. Furthermore, while millers had experience in the highly cost-competitive market for largely standardised white maize meal, they had no experience in developing supply or demand for a differentiated product, which reduced their appetite for it.

In addition to missing markets, AgResults sought to catalyse the development of an 'underserved'[3] market for quality legume seed in Uganda. At baseline, only 9 percent of farmers used quality legume seed. AgResults' Uganda project is an example of an 'underserved market' because, even though a commercial market for quality legume seed existed, sales (and consequently uptake and associated welfare gains) were well below what it would have been if legume seed suppliers' investments to produce and market quality legume seed had been greater. Growth in the market for quality legume seed in Uganda was inhibited by several factors, chief among them being the lack of an effective quality certification system to differentiate 'good' seed from 'bad'. This led to good quality seed's inability to compete in the market—a classic 'lemons market'[4] scenario.

Exhibit 2-1 summarizes these and other salient features of each targeted market as the prize competitions began.

Exhibit 2-1. Overview of market conditions and status in each project at baseline

Characteristic	Nigeria	Kenya	Zambia	Uganda
Project name	Aflasafe Challenge Project	On-Farm Storage Challenge Project	Biofortified Maize Challenge Project	Legume Seeds Challenge Project
Target market	Market for Aflasafe-treated/aflatoxin-reduced maize	Market for improved on-farm storage devices for small-holder farmers to use for storing food staples	Market for pro-Vitamin A maize meal	Market for quality legume seed
Market at baseline	Missing market: Extremely limited production (only three farms nationwide) and sale of Aflasafe-treated maize.	Missing market: Extremely limited availability of improved on-farm storage devices with less than 3% market penetration in target geography.	Missing market: Limited awareness leading to low production (less than 1% uptake among smallholder farmers) and consumption of pro-Vitamin A maize. Less than 1% uptake of pro-Vitamin A maize among smallholder farmers.	Underserved market: Production and use (only 9% of smallholder farmers) of quality legume seed are low despite presence of numerous firms in the market.
Factors inhibiting market development	Lack of awareness of aflatoxin issues or potential market for Aflasafe-treated/aflatoxin-compliant maize. Limited enforcement of	Lack of awareness among farmers about improved on-farm storage technologies. No commercial distribution system for improved on-farm storage technologies.	Limited awareness of pro-Vitamin A maize and consumer predisposition against it due to orange colour. Millers had no experience in	Unregulated labelling of seed due to lack of effective quality certification. Quality seed not price competitive.

[3] We use the term 'underserved market' to refer to a situation where a commercial market exists, but the level of supply and uptake of the technology are lower than would be seen if constraints to the market did not limit its growth.

[4] As described by Akerlof, a 'lemons market' is one in which the lack of effective means for buyers to differentiate quality products from substandard products makes it impossible for suppliers of quality products to compete on price in the market and causes substandard quality products to take over the market. G. Akerlof, The market for 'lemons': Quality uncertainty and the market mechanism, *Quarterly Journal of Economics*, *84*(3), 488-500, 1970.

Characteristic	Nigeria	Kenya	Zambia	Uganda
	regulatory limitations on aflatoxins in maize.		developing supply or demand for a differentiated product.	

2.1.2 Findings related to AgResults' market development objectives

AgResults offers evidence that PfR approaches can spur the development of new markets in scenarios that satisfy certain supply, demand, and enabling environment conditions. We explore these in detail below. These conclusions follow from the evaluation findings regarding market scale, private sector engagement, inclusiveness, and sustainability.

AgResults successfully catalysed private sector engagement in markets for AgResults technologies or for products produced using those technologies.

In Nigeria, AgResults led to the development of a niche market for Aflasafe-treated/aflatoxin-reduced maize. A diverse group of participating firms recruited smallholder farmers to produce Aflasafe-treated maize and supported their production activities; invested in value addition activities such as transport, processing, and branding; and developed demand by marketing directly to buyers in domestic feed and food and export industries. In the final year of the project, the 24 competitors aggregated more than 81,000 MT of Aflasafe-treated/ aflatoxin-compliant maize, accounting for 1 percent of maize produced in Nigeria that year.

In Kenya, AgResults catalysed the development of a market for improved on-farm storage, with substantial increases in both supply of and demand for improved on-farm storage. Diverse domestic and international firms invested to overcome key barriers to entry in the market—particularly last-mile distribution systems and demand creation. The evaluation's final report estimated that adoption of improved on-farm storage devices was 23 percentage points higher in the Eastern region and 6 percentage points higher in the Rift Valley region than it would have been in the absence of the project. Finally, in Zambia, where the project was terminated early, AgResults played a role in the development of a small niche market for pro-Vitamin A maize.

AgResults was most successful in catalysing market development in projects where the key constraints were within the manageable interest of the private sector once incentivized by the prize.

In Nigeria and Kenya, where we observed the development of markets in response to AgResults, competitors were able to overcome the key demand and supply constraints that inhibited the development of a market—the lack of awareness and the lack of last-mile distribution systems. The Uganda Legume Seed project, by contrast, failed and was terminated early because the private sector was not capable of overcoming a key enabling environment challenge: unregulated labelling. The lack of trusted certification resulted in a classic 'lemons market' problem, with buyers being unable to differentiate high-quality seed from poor-quality seed, causing downward pressure on prices that made it difficult for high-quality seed to compete in the market.

The enabling environment influenced the development of markets for AgResults-targeted technologies. A supportive or neutral enabling environment facilitated market development, as seen for example in Kenya and Nigeria. In Uganda, however, the government seed certification program was unable to certify seed quality effectively, and the enabling environment itself was a binding constraint to the market's development. In this case, the project was unable to progress because of the intractability of this constraint. In Nigeria, while the project was successful overall, the sustainability of its impact was questionable because the government was delayed in enacting measures important to the continued development of the market after the project's conclusion. These measures included, for example, increasing awareness of aflatoxins as a human health threat and

enforcement of regulations regarding aflatoxin levels in some segments of the maize market. Similarly, in nearly all AgResults projects, the prospect of subsidised provision of the technology (or of a close substitute to the technology) also affected the market's development at different points. Again referencing Nigeria, the government began to subsidise distribution of Aflasafe following the project's conclusion, which threatened to undermine the market for Aflasafe-treated maize catalysed by AgResults. Similarly in Zambia, the AgResults Secretariat cited the destabilising influence of the Zambian government's heavy involvement in the market for white maize, a substitute to pro-Vitamin A maize, as a factor limiting investment in pro-Vitamin A maize and driving weak results in the project.

AgResults was most successful in engaging the private sector when the private sector perceived a strong business case for investing in the market.

The Kenya and Nigeria projects offer examples where numerous private sector actors already had an interest in the market (Kenya) or were enthusiastic and motivated once they learned of the market and its potential (Nigeria). These actors, who became AgResults 'competitors', saw the AgResults competition and incentive as a motivation to invest in the market at scale, but they were also keenly interested in the underlying potential of the market, independent of the AgResults incentive. In the cases of Zambia and Uganda, in contrast, the lack of an underlying business case for investing in the market spurred lacklustre investment, despite the presence of the AgResults incentive. In Zambia, there was initially a tepid response among millers. They had no experience in developing either demand or supply for a differentiated product, and they were concerned about the tendency for consumers to confuse pro-Vitamin A maize (which is orange in colour) with the yellow maize they perceive as low quality. In Uganda, the lack of an effective quality certification (labelling) system for legume seed, as described in the preceding paragraph, meant that there was a weak business case for seed companies to invest in increasing their production of quality legume seed.

AgResults successfully promoted inclusion of smallholder farmers in targeted markets, either through explicit project rules or by leveraging the smallholder farmer-inclusive nature of the underlying markets.

In Nigeria and Kenya, smallholder famers were explicitly targeted in the competitions, although they were also prevalent in the underlying markets for maize and staple grains that the projects targeted. In Nigeria, competitors were required to source Aflasafe-treated maize from farmers with fewer than 10 hectares. By project end, AgResults competitors were sourcing maize from more than 26,000 smallholder farmers.

In Kenya, qualifying storage devices were limited to 540 kg capacity (the amount of grain the project estimated the average smallholder farmer's family consumes in a year), and only sales made to famers with fewer than 5 hectares were counted. Project verification data showed that more than 90 percent of the storage devices purchased went to smallholder farmers. The independent evaluation showed that 220,000 more smallholder farmers obtained improved on-farm storage technologies than would have in the absence of the project.

In Uganda and Zambia, competitors had no specific directive to engage smallholder farmers; nonetheless, they were integral to the underlying market in which the projects acted. In Uganda, close to 90 percent of legume farmers are smallholders. In Zambia, smallholder farmers are responsible for nearly all of the maize produced for human consumption.

AgResults had mixed results in terms of women's inclusion in the markets that it developed.

The AgResults projects discussed in this report did not have specific gender-inclusion goals, although as a learning initiative it did examine how the projects performed in terms of social inclusion. As stated in our October 2020 gender brief,[5] market-oriented interventions like AgResults can disadvantage women because, compared to men, they tend to be less integrated in agricultural markets to start with, have fewer resources, and are less able to absorb risk.

In Kenya and in keeping with the evaluation team's broader hypotheses about potential inclusion of women, the project's baseline suggested that women might be under-represented in the market due to their lower rates of market integration in general and their higher rates of poverty.[6] Instead, the final project evaluation showed that female-headed households had higher rates of uptake than male-headed households (29 percent vs 26 percent) and women in general described significant benefits including labour savings and improved peace of mind over the security of their food stores.[7] While AgResults competitors did not target their marketing to women, the product's unique relevance to women supported their participation in the market. In Nigeria, an average of 19 percent of farmers supplying Aflasafe-treated maize to project competitors were women; but this participation ranged from 0 to 100 percent across competitors. The Nigeria project had no explicit objectives with respect to women's inclusion in the market, and participation rates were a reflection of the effort that individual competitors made to include women as a result of their own organisational objectives.

There are mixed indications about the likely sustainability of markets catalysed by AgResults.

In Nigeria, despite AgResults project participants' enthusiasm to remain engaged in the market, sustainability of the market for Aflasafe-treated/aflatoxin-reduced maize is threatened by the endemic instability in Nigeria's broader maize markets, the subsidised delivery of Aflasafe by government entities, and delays in government efforts to increase enforcement of aflatoxin standards and increase awareness about the benefits of Aflasafe-treated/aflatoxin-reduced maize among consumers.

In Kenya, the market has sustained and grown since the end of AgResults. Competitors have continued to invest to increase their market penetration, there are several new entrants in the market, and there has been continued product innovation with several new on-farm storage devices being released into the market. The scale of the market has increased by more than 250% since Agresults' conclusion according to self-reported data from only three former AgResults competitors (i.e., less than half the OFS suppliers currently active in the market)[8].

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5 Denise Mainville, Incorporating a Gender Lens into Challenge Project Design, Evaluator's Lessons Learned Series, Issue 5, Rockville, MD: Abt Associates and Denise Mainville Consulting, October 2020.

6 Abt Associates, AgResults Baseline Report: Kenya On-Farm Storage Project, 2015.

7 Betsy Ness-Edelstein, Denise Mainville, Tulika Narayan, Judy Geyer, and David Cooley, AgResults Impact Evaluation Report: Kenya On-Farm Storage Challenge Project, Rockville, Maryland: Abt Associates, 2019.

8 Mainville, Denise; and Betsy Ness-Edelstein (2021). AgResults Evaluation: Kenya On-Farm Storage Challenge Project. Sustainability Assessment. Rockville, Maryland: Abt Associates. Prepared for the U.K. Foreign, Commonwealth, and Development Office and the AgResults Steering Committee.

Sustainability appears to be enhanced when the private sector makes 'lumpy' investments to develop the market that lead to economies of scale.

The examples of Kenya and Nigeria help to illustrate this point. In Kenya, where the market has been sustained since the project's conclusion[9] the major barriers to entry were the lack of awareness among farmers about the existence and potential of improved on-farm storage technologies, and the lack of distribution systems to reach the large number of geographically dispersed smallholder farmers to whom the storage technologies were targeted. Large investments in the development of demand among farmers and the establishment of distribution systems were required to overcome these barriers to entry. Once these investments were made, however, the ongoing costs of serving the market were relatively low, so that continued engagement in the market after the end of the project remained attractive.

In Nigeria, where the sustainability of the market for Aflasafe-treated maize is uncertain, demand was created by individual competitors' grassroots efforts to recruit buyers, and each successive buyer required renewed communication and attention to develop. As such, there were no scale economies to be achieved in recruiting buyers. Similarly, development of product supply offered limited economies of scale. Supply was developed through competitor efforts to recruit, qualify, finance, and train farmers. While limited scale economies were achieved by recruiting farmers in community clusters, other activities involved in procuring Aflasafe-treated maize from smallholder farmers offered little cost advantage from scaling to more farmers.

Exhibit 2-2 presents the key market-impact findings by country.

Exhibit 2-2. AgResults' impact on the market in completed prize competitions

Area of impact	Nigeria	Kenya
AgResults' impact on private sector engagement in market	**Catalytic** AgResults led to the development of a niche market for Aflasafe-treated/ aflatoxin-reduced maize. In the project's final year, 24 competitors aggregated Aflasafe-treated/aflatoxin-reduced maize accounting for 1% of maize produced in Nigeria that year.	**Catalytic** AgResults catalysed the development of an emerging market for improved on-farm storage with penetration rates of 22% in Eastern and 10% Rift Valley regions.
Ability to overcome constraints to market development	**Moderate** Competitors were able to overcome lack of awareness about aflatoxins and Aflasafe within their immediate spheres of activity where they invested heavily to develop a supply base and to cultivate demand.	**Strong** Competitors invested heavily and made significant inroads in both developing demand for their products and in developing distribution systems that were effective in reaching a large number of small farmers.
Existence of business case to motivate private sector investment	**Strong** Numerous private sector actors were enthusiastic and motivated once they learned of the market and its potential.	**Strong** Numerous private sector actors had an interest in the market even before AgResults.
Incorporation of smallholder farmers in market	**Strong** The market for Aflasafe-treated/ aflatoxin-reduced maize was inclusive of smallholder farmers, in part due to the project's rules but also because smallholders dominate maize markets	**Strong** AgResults only rewarded sales of improved on-farm storage devices to smallholder farmers and limited the size of qualifying devices to a size suitable to smallholder farmers.

[9] Mainville, Denise; and Betsy Ness-Edelstein (2021). AgResults Evaluation: Kenya On-Farm Storage Challenge Project. Sustainability Assessment. Rockville, Maryland: Abt Associates. Prepared for the U.K. Foreign, Commonwealth, and Development Office and the AgResults Steering Committee.

Area of impact	Nigeria	Kenya
	in Nigeria. By project end, more than 26,000 smallholder farmers were supplying maize to AgResults competitors.	Verification activities confirmed that more than 90% of buyers of improved on-farm storage devices were smallholders. A total of 220,000 more households purchased improved on-farm storage than would have without AgResults.
Inclusion of women in market	**Moderate** In the project's final year, 19% of project farmers were women, although gender representation ranged hugely—from 0% to 100%—across aggregators.	**Strong** Female-headed households had higher rates of uptake than male-headed households (29% vs 26%), and women in general described significant benefits including labour savings and improved peace of mind over the security of their food stores.
Market sustainability	**Uncertain** Despite AgResults project participants' enthusiasm to remain engaged in the market, sustainability of the market for Aflasafe-treated/aflatoxin-reduced maize is threatened by the endemic instability in Nigeria's broader maize markets, the subsidised delivery of Aflasafe by government entities, and delays in government efforts to increase enforcement of aflatoxin standards and increase awareness about the benefits of Aflasafe-treated/ aflatoxin-reduced maize.	**Strong** The market has sustained and increased in scale. Since the end of AgResults, competitors have continued to invest to increase their market penetration, and there are several new entrants in the market. Self-reported sales data from only three AgResults competitors shows that on-farm storage capacity sold has increased by more than 250% (compared to the total storage capacity sold attributable to AgResults) since the project ended.
Lumpy investments offering scale economies to enhance sustainability	**None** Neither development of a smallholder farmer supply base nor buyer base offered significant scale economies to participating aggregators.	**Considerable** Development of farmer demand and distribution systems both offered scale economies once the investments were realised.

2.2 Impact on smallholder farmers

The ultimate aim of AgResults is to create sustained markets for technologies that benefit smallholder farmers and contribute to a pathway out of poverty. This section explains AgResults' intended and realised impacts on smallholder farmers.

2.2.1 Targeted impacts on smallholder farmers

Each project had a plan to encourage the private sector to engage smallholder farmers with the targeted technology, which was intended to lead to various welfare enhancements. In Nigeria and Zambia, smallholder farmers were expected to benefit from both sale and consumption of the projects' respective maize products—Aflasafe-treated maize in Nigeria and pro-Vitamin A maize in Zambia. In Kenya and Uganda, increased farmer utilisation of improved on-farm storage and high-quality legume seed was expected to benefit smallholder farmers from reduced post-harvest losses and enhanced yield (respectively) relative to existing technology. Exhibit 2-3 shows how this overarching set of goals translated into specific intended benefits for each project.

Exhibit 2-3. Smallholder farmer role and intended impacts

	Nigeria	Kenya	Zambia	Uganda
Project	Aflasafe Challenge Project	On-Farm Storage Challenge Project	Biofortified Maize Challenge Project	Legume Seed Challenge Project
Smallholder farmer role	Producer	Buyer	Producer	Buyer
Smallholder farmer technology use at baseline	<1%	<3%	<1%	9%[a]
Intended economic impact on smallholder farmers	Increased income from access to premium market	Increased income from well-timed maize sales and lower expenditure on maize for consumption enabled by reduced grain losses	None	Increased income from legume sales, driven by higher yields
Intended consumption impact of smallholder farmers	Reduction in health impacts of aflatoxins through consumption of Aflasafe-treated maize by farmers who grow Aflasafe-treated maize	More maize available for home consumption and decreased use of pesticides	Reduced Vitamin A deficiency through consumption of pro-Vitamin A maize by smallholder farmers who grow pro-Vitamin A maize	Increased legume consumption by smallholder farmers who increase their legume production

[a] While 22% of farmers self-reported planting improved varieties of legume seed, our seed quality analysis revealed that only 9% of farmers' seed actually met the relevant quality standards. This difference is due to Uganda's lack of effective quality certification. For details, see *AgResults Evaluation: Abt Associates, Uganda Legume Seed Pilot Baseline Report,* August 2018.

In most cases, adoption of the targeted technology was low or non-existent at the start of each project, in alignment with characterisations of the relevant markets as 'missing'. Uganda is a notable exception—22 percent of farmers self-reported using quality seed prior to the start of the project.

2.2.2 Findings related to smallholder farmers

The evaluation found that AgResults' PfR approach led to large increases in uptake of a technology among smallholder farmers, leading to both economic and non-economic benefits to the farmers. At the same time, the PfR approach can lead to gaps in farmers' knowledge of proper use of a technology or of some of its non-economic benefits. The evaluation team planned rigorous quasi-experimental impact evaluations of each project, involving large-scale surveys of smallholder farmers, as outlined in Exhibit 1-3. The majority of farmer-level findings were realised from only the two completed projects, though some findings could also be drawn from baseline data collected for the projects that did not finish.

AgResults competitors were able to substantially increase smallholder farmers' adoption of the targeted technologies.

The prize design need not specify *how* competitors engage smallholder farmers. Without AgResults itself ever implementing activities to directly engage them, it catalysed substantial increases in technology use among smallholder farmers. In Nigeria, the prize competition led to a 56 percentage point increase in Aflasafe use among smallholder farmers in targeted areas (Exhibit 2-4). In Kenya, AgResults contributed to a 23 percentage point increase in technology use in the Eastern region, and a 6 percentage point increase in the Rift Valley region (Exhibit 2-4). In both projects, contest rules specified that only procurement from or sales to smallholder farmers would qualify them for prizes. In Nigeria, competitors usually organised farmers in community clusters, training them and advancing inputs (including Aflasafe) to facilitate their production and contracts to purchase the Aflasafe-treated maize at

harvest. In Kenya, competitors were required to charge buyers the full market price of the storage device but found other ways to encourage adoption. Their strategies included media promotion; contracting of sales agents; and promotional incentives to distributors, retailers, and farmers to further increase sales.

Technology uptake sometimes, but not always, led to increases in farmer incomes.

In Nigeria, the primary benefit of the technology to smallholder farmers was income: average net revenue from maize among households targeted by AgResults competitors increased 16 percent, largely due to price premiums for maize that the competitors purchased from farmers (Exhibit 2-4). In Kenya, AgResults led to an average increase in average revenue from maize ranging from 2 to 11 percent, depending on region. However, unlike the targeted Nigerian farmers for whom maize represented a primary income source, maize sales for the average household in the targeted regions in Kenya represented less than 1 percent of total income. The AgResults Kenya project did, however, lead to a household's being 6.7 percentage points less likely to purchase any maize for consumption.

Some farmers also reported non-financial benefits related to adoption of the technology.

In Kenya, AgResults had muted income impacts, but non-financial benefits were more prominent. Farmers generally used their improved storage devices to store grain for their own consumption and were pleased that the new technologies did not require pesticides, unlike typical storage bags. This led to improved taste, labour savings on management of farmers' stored food stocks, and improved peace of mind knowing that their products were safe from pests. By contrast, non-financial benefits were not prominent in Nigeria.

Exhibit 2-4. Impact on smallholder farmers

Area of impact	Nigeria	Kenya
Technology adoption	**Substantial** AgResults increased Aflasafe uptake of Aflasafe by 56 percentage points among smallholder farmers in AgResults villages.	**Substantial** The evaluation found that AgResults likely contributed to a 23 percentage point increase in adoption in Eastern and a 6 percentage point increase in Rift Valley over what was projected to happen in the project's absence.
Income	**Moderate** Smallholder farmers' average annual net income from maize increased by $318 or 16% per farmer.	**Limited** There was a small but statistically significant increase in gross annual maize revenue as a result of adopting improved on-farm storage, about $1.69. The impact of adoption on *net* maize revenue (gross revenue less costs of storage and maize purchased for consumption) was not statistically significant. Adoption made farmers 6.7 percentage points less likely to purchase maize for consumption.
Non-financial benefits	**Moderate** Improved market access and sales terms.	**Moderate** Some farmers reported labour savings, 'peace of mind', and 'better taste' as a result of reduced use of pesticides.
Farmer knowledge	**Limited** Only about a quarter of farmers targeted by AgResults competitors (and only 6% of the cooks in their households) knew how Aflasafe worked or understood the health risks of aflatoxins. Accordingly, results show farmers' tendency to sell,	**Limited** Average knowledge scores of proper use among adopters were between 54 and 67 out of 100 depending on region, indicating a knowledge gap. The effects of sub-optimal

Area of impact	Nigeria	Kenya
	rather than consume, Aflasafe-treated maize.	use of the technology on its efficacy were beyond the evaluation's scope.
Differentiated impacts on female farmers	Competitors varied widely in their engagement of women farmers, from 0 to 100%, averaging 19% female farmer participation across the project.	Women-headed households had 3.7% higher uptake of improved on-farm storage than male-headed households (29.3% vs 25.6%) by the end of the project. Women reported particularly high levels of satisfaction with improved on-farm storage because it reduced labour requirements and gave them greater peace of mind.
Deviations from expected impacts	Farmers were far less likely to consume Aflasafe-treated maize than expected—only 13% of maize consumed by targeted farmers was Aflasafe-treated. They largely chose to sell it instead.	Farmers did not tend to store their maize longer in order to sell it later when market prices improved. Instead, they typically used improved storage devices for maize they intended to consume. The minority of farmers who sold maize continued to use non-improved, traditional storage methods for the portion they intended to sell.

The PfR approach left farmers with some gaps in their knowledge about use, consumption, and health benefits of the technologies.

In Nigeria, competitors' interest was in buying Aflasafe-treated maize back from farmers, so there was no motivation for them to teach farmers about the dangers of aflatoxins and the health benefits of using Aflasafe. Accordingly, only 25 percent of farmers targeted by AgResults competitors knew how Aflasafe works, and 23 percent understood the health risks of aflatoxins. Among cooks in the households targeted by AgResults, only 6 percent understood the health risks of aflatoxins. As a result, the majority of farmers using Aflasafe did not adjust their consumption toward Aflasafe-treated maize, thus missing out on its health benefits. In Kenya, competitors had an incentive to teach farmers to use their products correctly so that the farmers would have good results using them and continue to buy them. Indeed, the majority of farmers using improved storage reported that they had received some training in proper use. However, when asked to describe how to properly use their device, their average knowledge scores were between 54 and 67 out of 100 (varies by region). This indicates room for improvement, though it was beyond the scope of the evaluation to assess whether on-farm storage devices are effective if farmers use them imperfectly.

Women can face disadvantages in market-based approaches like AgResults, but gender-sensitive project design can help offset these disadvantages.

Across the AgResults countries, women and women-headed households tended to be less integrated into both input and output markets for the project's targeted technologies. However, their disadvantages were in some cases neutralised by the particulars of the technology or the competition design. In Nigeria, the participation of women fluctuated annually and also varied widely among individual competitors. In the final year of the project, women represented 19 percent of the smallholder farmers supplying AgResults competitors but ranged from 0 to 100 percent of the competitors' farmer bases. In Kenya, despite lower levels of awareness of improved on-farm storage at the outset, women-headed households had 3.7 percent higher uptake of improved on-farm storage than male-headed households (29 percent vs. 26 percent) by the end of the project. Women in general expressed particularly high levels of satisfaction with improved on-farm storage because it reduced labour requirements and gave them greater peace of mind. The facts that the improved on-farm storage products were relatively inexpensive, that they were perceived to have a direct impact on household food security, and that women are usually responsible for managing household food stores all combined to improve outcomes for women and women-headed households.

Certain farmer benefits were not realised to the extent projected, underscoring how farmer response to new technologies may differ from expectations.

In Kenya, AgResults assumed that farmers faced high post-harvest loss of grains prior to the project, while on average this proved not to be the case. Pesticide dust was widely used, and self-reported losses suggest it was effective and losses were minimal compared to project assumptions. In other words, the project design's expected use cases differed substantially from how farmers used the technology in practice. The design hypothesised that farmers who used improved storage would be able to store their maize longer until prices increased after harvest time and sell it for more money. But evaluation findings suggest this shift in farmer behaviour did not materialise. Farmers who sold maize were already preventing losses in maize they planned to sell, and a majority (more than three quarters) of farmers did not report selling any maize at all. For farmers who did sell, a host of economic considerations drove them to sell around harvest time (school fees, presence of buyers, lack of available credit, and other factors)—but lack of storage was not one of them. Rather, household consumption was the main use case for farmers who adopted improved on-farm storage, and they continued to use pesticide dust for maize they planned to sell. In Nigeria, by contrast, farmers tended to sell their Aflasafe-treated maize rather than consume it despite its health benefits. The project's design had not anticipated that farmers may not become aware of Aflasafe's health benefits and that they would be primarily motivated by the income potential from selling their Aflasafe-treated maize.

2.3 Cost and cost-effectiveness

One motivation for the PfR approach is that it reduces financial risk to the sponsor of paying for results not achieved. The evaluation found support for this idea, though project expenditures on management and verification can still be considerable.

PfR projects have a financial risk reduction benefit to sponsors since prize pay-outs happen only if results are achieved, but involve some costs regardless of whether all prizes are paid out.

One motivation for attempting a PfR project is to make the best use of sponsors' funds by avoiding the risk of paying for projects that are not successful. At the same time, PfR projects involve some costs regardless of whether all prizes are paid out. In the two projects that were terminated early, sponsors' costs for management, verification, and initial prizes amounted to 52 percent of what sponsors had planned to spend on the projects. Across the combined first four AgResults projects attempted, prize award costs roughly equalled management costs. This finding suggests that if a sponsor hosts a portfolio of projects, the management costs alone will be a significant proportion of the budget because several projects may not succeed.

PfR projects all involve costs for management, verification, and prizes. The relative size of these costs varies from project to project.

Project management involves coordination between the sponsor and an implementation partner, communications with potential competitors and stakeholders, coordination and sometimes selection of entrants to the competition, ongoing monitoring, event planning (e.g., prize ceremonies), and reporting. Verification costs depend heavily on how difficult it is to confirm the compliance with prize criteria. Some prize criteria (e.g., chemical verification of the presence of Aflasafe in harvested maize) are more complex and expensive than other prize criteria (e.g., sale of storage bags to smallholder farmers). Verification costs were highest in Nigeria (26 percent of that project's total costs) and lowest in Kenya (7 percent of that project's total costs).

Exhibit 2-5. AgResults prize competition costs (in millions of U.S. dollars)

	Nigeria Aflasafe prize competition	Kenya On-Farm Storage prize competition	Zambia Biofortified Maize prize competition*	Uganda Legume Seed prize competition*	Total
Initial expected total cost, including prizes	**11.9**	**10.3**	**5.5**	**4.4**	**31.1**
Amount spent on prizes	3.0 (30%)	6.3 (69%)	0.6 (24%)	0.0 (0%)	**9.9 (41%)**
Verification costs	2.6 (26%)	0.6 (7%)	0.3 (10%)	0.8 (32%)	**4.3 (18%)**
Pilot management costs	4.3 (44%)	2.2 (25%)	1.6 (66%)	1.7 (68%)	**9.9 (41%)**
Actual total project cost	**9.9 (100%)**	**9.1 (100%)**	**2.5 (100%)**	**2.6 (100%)**	**24.1 (100%)**

Sources: AgResults Trustee Report, Steering Committee Meeting October 5, 2020 (actual costs) and the initial Business Plans for each AgResults project.

Note: Design costs are not included, as precise design cost information is not available. The estimated design costs for Nigeria, Kenya, and Zambia were $0.48 million each, and the estimated design cost for Uganda was $0.4 million.

*Project was terminated early.

Contextualizing cost-effectiveness results.

Our cost-effectiveness analysis examines the cost per targeted result: metric ton of Aflasafe-treated maize (Nigeria), metric ton of storage capacity sold (Kenya), and smallholder farmer who adopted the technology as a result of AgResults (Nigeria and Kenya). If traditional development projects intend to reach the same results in the same geographic regions, the associated projects' expected costs per targeted result could be compared with those of AgResults. That said, comparisons should be focused on comparing different approaches to promoting uptake or market development of similar technologies in similar environments, rather than across implementation contexts and technologies.

In Nigeria, the discounted total project cost per added smallholder farmer using Aflasafe was $134, less than half the project's initial estimate that it would cost $340 per added smallholder farmer. The cost per added metric ton of Aflasafe-treated maize was $34 over the project's five years.[10] For reference, the market price of Aflasafe needed to create one metric ton of treated maize is roughly $4.60.[11]

At the conclusion of the project in Kenya, the discounted total project cost per added smallholder farmer was $39, roughly 80 percent more than the project's initial estimate that it would cost $21 per smallholder farmer. The cost per added metric ton of capacity sold was $25.40.[12] Updated cost-effectiveness findings from the sustainability assessment conducted two and a half years after the Kenya project's conclusions showed that the increased scale of the market reduced the cost per metric ton of storage capacity sold to $7.15.

To the extent that the markets for AgResults technologies are sustained in Nigeria and Kenya, project costs per targeted output will decline and cost effectiveness will improve as additional households adopt the technology after the project ends. In this case, end-of-project cost-effectiveness estimates can understate the project's eventual cost effectiveness.

[10] All costs were normalised to 2017 U.S. dollars and annualised using a discount rate of 12 percent.

[11] The average cost of Aflasafe was 447 Naira/kg in the final year of the project (.00278 USD = 1 Naira). The correction application rate is 10 kg/hectare, and average yields are 2.7 MT/hectare.

[12] All costs were normalised to 2017 U.S. dollars and annualised using a discount rate of 12 percent.

For example, in Kenya, our sustainability assessment, conducted two and a half years after the project's conclusion, estimated the market had expanded more than 250% since AgResults' conclusion.[13] Accounting for those additional sales of improved on-farm storage significantly decreased the project cost per unit of output—from $25.40 per metric ton of improved storage capacity to $7.15 per metric ton, increasing the project's cost-effectiveness.

Cost-effectiveness analysis is useful for comparing expected cost-effectiveness to realised cost-effectiveness, and also for comparing similar projects in very similar contexts. However, we note that cost-effectiveness analysis has several limitations. First, it is important to note that the evaluation team conducted cost-effectiveness analysis based on results reached by a particular point in time (endline) and as such those estimates did not encompass results that continue to accrue after the projects concluded. With respect to farmer impacts, the cost per targeted output does not consider either non-financial economic (such as labour) or health impacts on the farmer. Similarly, it does not account for systemic change that a PfR project might catalyse, such as the development of a sustainable market that continues to grow after the project ends. Finally, with respect to private sector benefits and costs, the cost per targeted output does not consider the long-run benefits and costs of market creation. Nor does it consider short-run benefits and costs to private sector competitors (e.g., the investments and profitability of sales in the market that was created as a result of AgResults).

[13] Denise Mainville, Denise; and Betsy Ness-Edelstein (2021)., AgResults Evaluation: Kenya On-Farm Storage Challenge Project., Sustainability Assessment., Rockville, Maryland: Abt Associates. Prepared for the U.K. Foreign, Commonwealth, and Development Office and the AgResults Steering Committee, 2021.

3. Best practices for sponsors of prize competitions

In this section, we draw upon our findings to present generalised best practices that can be applied toward the design of future PfR initiatives. We organise these in four categories—best practices to help prize sponsors (1) decide whether a PfR competition is an appropriate program design option, (2) design a high-quality theory of change, (3) design a PfR competition to maximise market impact, and (4) design a PfR competition to maximise development impact. We also discuss what can appear to be trade-offs between designing for market impact and development impact.

3.1 Deciding whether a PfR competition is an appropriate program design option

One of the first questions designers must consider is whether a prize approach is an appropriate design option for a particular problem or to promote a potential solution to a problem.

Verify that the technology under consideration has potential for a significant development impact if adopted at scale.

When considering whether a technology might be well suited to a prize approach, the design demands and investment requirements faced by both the project designer and private sector investors argue that prize approaches are best suited to technologies that will have potential for significant development impact if adopted at scale. Among the merits of the prize/PfR approach as demonstrated by AgResults is the opportunity to catalyse the development of a market that will sustain and grow after the project ends.

Ensure that constraints critical to market development are within the competitors' manageable interest.

For a PfR project to succeed, its private sector partners (competitors) must have the capacity to overcome the most binding constraints to the market's development. In general, AgResults has shown that a PfR approach can catalyse development of a market, but only if the enabling environment is adequate to support the market. The Uganda project is an example where a weak enabling environment—specifically the lack of effective quality certification—undermined the business case for seed companies to expand their production and sale of quality legume seeds. In contrast, the Kenya project provides an example where a strong enabling environment—with adequate yet not excessive quality control and verification—provided a supportive framework in which the competitors could profitably expand sales of improved on-farm storage technologies to smallholder farmers. The implication for prize sponsors is that it is critical to ensure that the enabling environment is adequate to support the development of the target market.

Confirm that there is a plausible business case for potential competitors to engage in the market.

Prize sponsors must also be able to assess the attractiveness of the potential market from the private sector's point of view: is there a business case? In the context of a supportive enabling environment, firms will likely see a business case if there is evidence of strong potential demand, if they see potential to develop supply that can meet that demand cost-effectively, and if the prize parameters tip the risk/reward ratio in their favour. Given that demand for technologies benefitting smallholder farmers is often uncertain, prize sponsors have an important role to play in creating awareness of the potential demand.

In Nigeria, for example, maize aggregators who were often unaware of aflatoxins as a problem, and broadly unaware of Aflasafe as a potential solution, were easily recruited to compete in the project once they were made aware of the potential market for Aflasafe-treated maize. Similarly, in Kenya, several competitors reported a long-standing interest in

investing in smallholder farmers as a market for improved on-farm storage, although none of them had yet engaged with the intensity that was stimulated by the prize competition. In both Nigeria and Kenya, where private sector actors were able to see a potential business case, the PfR incentive played a critical role in offsetting the risk that inhibited them from investing at scale. In Zambia and Uganda, in contrast, most potential competitors had to be convinced of the business case for the targeted technology, and their investment was tepid as a result.

Consider whether overlapping programs (e.g., a program to subsidise distribution of the technology) might interfere with market development.

Private sector-driven solutions to development problems can be undermined when faced with competition from public programs that are not subject to market or commercial constraints. The subsidised distribution of targeted technologies is a prime example of ways that a parallel program can undermine the development of a market. While concurrently running programs are most problematic, programs that run in advance of the PfR competition can also have an impact by creating expectations of low-cost provision of a technology or service.

Conduct an ex-ante cost-effectiveness or cost-benefit analysis.

Where feasible, weigh the program cost against the cost of achieving the outcomes through a different type of program. PfR competitions are not suitable for all development problems. In addition to development, management, and prize costs, there are costs for third-party verification of results. Ex-ante cost-effectiveness analysis can be a useful tool to compare the cost-effectiveness of a PfR competition to address a development goal, relative to the expected cost-effectiveness of a more traditional approach. Cost-benefit analysis is a tool to assess how a project's costs compare to the expected benefits in economic terms, so it can be useful to assess whether the expected benefits are worth the investment required to achieve them. Sensitivity analysis allows the sponsor to gauge whether the project is still an attractive investment if benefits vary. Issues such as the scale of benefits sought and the timing of those benefits (particularly the degree to which outcomes will be sustained following the program) are important factors to consider in such analysis and can help assess whether the project would still be worthwhile if benefits vary from what is expected—for example, if the number of farmers reached is lower, or if the impact on their income is less than anticipated. This is an important consideration—as our findings have shown, results do not always match expectations. The most prominent example of this is in Kenya, where a market grew quickly but the benefits of the technologies to buyers were largely non-economic in nature. Non-economic benefits can be valuable too, but prize sponsors should consider whether such benefits are worthy of their investment if their primary goals are poverty reduction or economic growth.

3.2 Designing an effective theory of change

Construct a theory of change that reflects a thorough understanding of the market, the causal logic by which the incentive structure will motivate competitors to engage in the market, the expected development impacts for farmers, and underlying assumptions.

A PfR prize competition requires a well-articulated theory of change. While this is true of any development program, it is all the more critical for a PfR project since certain parameters must be defined at the outset, limiting opportunities for adaptive management compared to other types of approaches. The theory of change should lay out the expected causal logic linking the prize structure, the competitors' expected activities in response to the prize structure, the growth of a market, and the development impact. Underlying assumptions (e.g., about the private sector's likely response to the incentive or the impact of the country's regulatory framework on the market's development) should be clearly articulated.

A strong theory of change is fundamental infrastructure by which the project will achieve its goals, so its careful development and validation are critical to success and are worth the time and resources needed. Each AgResults project was fronted by ex-ante analysis and depiction of how each project would achieve its goals, but they did not all have an explicit causal logic or theory of change, nor were assumptions always stated. In hindsight, evaluation results reveal room for tightening of the causal logic in some cases. For example, in Zambia the original design was to catalyse development of an urban market for pro-Vitamin A maize, supplied by smallholder farmer producers, who would then also consume some of the pro-Vitamin A maize themselves. This plan to increase consumption among Vitamin A-deficient farmers involved a complex causal logic that was difficult to realize in practice.

3.3 Designing to increase market impact

Select competitors that are adequate in number and have the capacity to realise the desired market scale and structure.

The best industry actors to recruit as competitors in a PfR competition will be in a position to address the key constraints inhibiting development of a market for the technology or its derivative products. The pool of competitors should be large enough to spur competition and bring the market to a sustainable scale, with individual competitors having adequate technical, managerial, and financial capacity to reach an efficient scale of operations. Operationally, this will vary significantly based on the technology and market environment. In Kenya, for example, at project's end, six firms were engaged in the commercial market for improved on-farm storage, with this relatively small number still driving significant competition and continued investment in the market. In Nigeria, in contrast, there were 26 competitors in the market at the project's conclusion, with more than 40 active throughout the project. Given the size of Nigeria's maize market and the thousands of intermediaries active in it, this number is likely to grow as the market for Aflasafe-treated/aflatoxin-reduced maize expands.

Choose the prize type, prize pay-out frequency, and duration of the competition to promote the desired market structure.

Decisions about the type and timing of prizes and the duration of the competition should encourage industry participation that leads to the desired market structure; for example, the number of firms supplying the technology and the organisation of the value chains along which the technology and its derivative projects flow. With respect to the type of prize—whether it is winner-take-all, proportional, or a per-unit prize—prizes that maximise the likelihood of any individual competitor's winning a pay-out promote a more inclusive market. For example, winner-take-all prizes can discourage participation of firms that are unlikely to be top performers; proportional prizes can encourage more participation but still enhance front-runner advantages, while a per-unit prize can increase participation by ensuring receipt of a prize to every competitor commensurate with its absolute (not relative) individual results. In Nigeria the per-unit prize ensured that any competitor that successfully procured Aflasafe-treated maize from smallholder farmers would receive the prize incentive, promoting continued participation of relatively small-scale actors. This broad participation was conducive to developing an expansive market base. In Kenya, in contrast, six competitors made qualifying sales, but only three reached the minimum threshold required for prizes. The prizes advantaged these firms in the market relative to the others.

The timing of prizes—for example, a single end-of-project pay-out versus annual or milestone-based prizes—can also influence the market structure. Prizes tied to milestones can help competitors focus on meaningful market development milestones. Likewise, relatively frequent (seasonal or annual) prize pay-outs enable competitors to re-invest their prize earnings to make further gains in the market and have also been observed to align more closely with private sector business cycles than end-of-project pay-outs. The duration

of the competition should reflect the number of years it takes to make the needed investments to overcome key constraints. Gradual reductions in prize incentives in later stages of the competition can help orient competitors to overarching market conditions without completely nullifying the incentive offered by the prize to invest in the nascent markets.

Explore ways to increase participation of under-represented firms, such as women-owned or women-managed firms.

Increasing the diversity of the competitor pool may be a worthy goal in itself and can also help to increase the diversity of approaches, solutions, and beneficiaries that are reached. Potential means to increase inclusion can include proactively identifying under-represented groups; favouring selection of firms as AgResults competitors if they are owned or managed by under-represented populations; or linking such firms with resources, such as specialised technical assistance or lines of credit, that may enhance their competitiveness. The first four AgResults competitions—those discussed in this report—did not include explicit gender objectives or activities.

3.4 Designing to maximise smallholder farmer impact

Our first four lessons in this section focus on tailoring a PfR initiative to maximize its inclusion of smallholder farmers. While AgResults broadly seeks to develop inclusive markets for smallholder farmers, smallholder farmers themselves are not a homogeneous group. They vary considerably in how integrated they are into markets and their access to resources. This variation affects the ease and cost, and thereby profitability, of reaching them through commercial distribution channels. These lessons attempt to provide guidance to help prize sponsors decide what types of smallholders they incentivize competitors to target as they develop their market. To this end, it may be helpful to think of three market segments:

- Better-off smallholder farmers, who are easier for competitors to target as they develop their market base.
- 'Typical' smallholder farmers, who are more numerous, but whose development as buyers or suppliers requires more effort and investment on the part of competitors than the first group.
- Smallholder farmers whose demand may be the most difficult to develop because they are less integrated with markets overall, for example, due to their poverty or remoteness. Given their greater tendency to be poor and less integrated into markets, female-headed households may often fall into this group.

Tailor the competition rules to incentivize competitors to engage the intended beneficiary group.

The technologies that may be promoted by PfR prize competitions may be attractive to diverse types of farmers, not just smallholder farmers, which could lead competitors to maximise their gains by selling to wealthier or larger-volume buyers or producers. It is possible to define competition terms to clarify that sales to (or procurement from) only a specific beneficiary group will be rewarded. However, enforcement of the terms requires a clear definition of the beneficiary group (e.g., what specifically distinguishes a smallholder farmer). This can increase compliance costs. An alternative option is to define other competition parameters that are consistent with maximizing sales to the intended beneficiary group.

The Kenya project, for example, rewarded only sales of improved on-farm storage technologies in regions where staple grain production predominated, and for sales of storage devices with capacity appropriate to the storage needs of smallholder farmers. This implicitly

targeted the product to smallholder farmers who would use them to store the food staples they produced, rather than to larger-scale farmers or producers of cash crops. Similarly, in Nigeria, the project ensured that competitors would recruit smallholder farmers to produce Aflasafe-treated maize by limiting the areas cultivated from which competitors would be rewarding for procuring maize.

Reward gains among better-off smallholder farmers—who will form the nucleus of the emerging market—to promote early success and increase a technology's visibility.

PfR prize competitions that aim to develop markets are likely to see their largest and quickest gains related to technology adoption among relatively better-off smallholder farmers who are the most active market participants. It might seem counter-intuitive to reward competitors for gains in sourcing from or marketing to these more accessible farmers in the market. However, doing so can help in early stages of market development when the technology may be little known, increasing the visibility of the technology while also creating the nucleus of a self-sustaining market.

In Nigeria, where project rules ensured that competitors would source Aflasafe-treated maize from smallholder farmers, most competitors sought to recruit relatively more productive smallholder farmers. This made sense for them in that yields needed to be higher than average for the application of Aflasafe to be economical, and also facilitated the changes in production and management that were required of farmers to produce and market Aflasafe-treated maize successfully. The successful establishment of a commercial, yet niche, market for Aflasafe-treated maize —whose backbone was relatively more productive smallholder farmers—during AgResults set the stage for further expansion of the market following the project's conclusion.

Reward integration of 'typical' smallholders that will ultimately constitute the bulk of the market.

Unlike the better-off farmers whom competitors are likely to reach most easily and quickly, the 'typical' smallholders are likely to form the 'core' of the market in terms of representing the majority of buyers of the technology or suppliers or its products. While their development as a market segment may be more costly than market development for the better-off smallholders, their attractiveness lies in the size of the market that they represent.

In Kenya the integration of 'typical' smallholders was achieved by defining a minimum threshold of sales for competitors to obtain a portion of the cash prize and otherwise by making the proportion of the prize rewarded commensurate with each competitor's market share. Both of these provisions pushed competitors to expand their market beyond the relatively easy-to-reach but small segment of relatively wealthy smallholder farmers to penetrate a much greater portion of the smallholder farmer population.

Systematically look for opportunities to be more inclusive of farmers who have lower rates of market integration, such as very poor farmers and women farmers, recognizing that including these groups may involve additional cost and complexity.

Some groups, such as very poor people and woman-headed households may have lower rates of market integration and less purchasing power, and consequently may be less likely to benefit from the development of markets for a technology in the short run. (We discuss opportunities to increase inclusion of women and other under-represented beneficiary groups below). While development of the latter market segment can be rewarded, it should not be targeted to exclusion of the previous two market segments, which offer lower costs and a more easily sustained and rewarding core market.

Gender outcomes can be improved through proactive design strategies. These include incorporating gender inquiries and household-level analysis during project scoping, which can help identify gendered patterns of behaviour to consider during project design. PfR

approaches that promote low-cost technologies relevant to food security may ease uptake among and benefits to women. While prize criteria can be defined to encourage more inclusion of women, PfR projects' dependence on catalysing private sector investment and ingenuity requires balancing social and development goals with the motivations and business interest of the project's private sector competitors. Operationally, this may mean providing a bonus for achieving gender goals rather than predicating receipt of a prize on gender goals. The idea is to avoid undermining the development of a viable market by focusing too closely on integration of more costly and less profitable smallholder market segments.

Looking at the example of Kenya, very poor households had lower uptake of improved on-farm storage than less poor households. This is not inherently problematic; however, the scale and sustainability of impact comes from achieving rapid market growth, which implies targeting uptake among the most likely market participants first. This point does not argue that there is a trade-off between market impact and development impact, so much as that development impact is realised through market impact. The opportunity to leverage a large-scale impact through the market can increase pathways and resources available for targeting of beneficiaries who are less integrated into markets through other types of initiatives.

Consider ways to structure the prize to incentivize competitors to help farmers draw full benefit from the technology, not just adopt it.

Farmers usually need to be trained or otherwise enabled to use new technologies correctly in order to obtain full benefits and for the development objectives of the project to be met. This is especially the case when the technology has potential not only for farmers to increase their incomes but also improve non-financial outcomes. Requirements for farmer training can be written into competition requirements. The imposition of such requirements can be appropriate if it is in the competitor's interest at some level to provide the needed training, and if the requirement is likely to stimulate the development of business models where such training becomes integral. If competitors are not already motivated to provide adequate training (e.g., because they intend to buy back a derivative product and thus want to optimise production volumes or quality), the project must verify whether training was provided.

For example, in Kenya, it was in the competitors' long-term interest to teach farmers to use the products correctly, and therefore be effective, to attract repeat purchases. In some cases, however, the competitors have no commercial interest in certain aspects of training, and it may be preferable for the project to offer, or partner with another entity to provide that. For example, in the Nigeria project, competitors had an interest in training farmers to use Aflasafe correctly because they usually intended to buy the product back to re-sell. They did not, however, have an interest in teaching farmers or household cooks about the health implications of aflatoxins, so they tended to emphasise these issues less. The result was relatively low farmer consumption of Aflasafe-treated maize despite the fact that one of the project's goals was to increase farm-level consumption.

Annex A: Bibliography of AgResults evaluation resources

The evaluation designs, baseline reports, final evaluations, and evaluation briefs for each project are listed below.

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