ideas 42

Reducing Post-Harvest Loss

A Behavioral Approach

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About ideas42

ideas42 is a non-profit that uses insights from behavioral science to design innovative solutions to tough social problems at scale. The consequences of the behavioral issues we tackle are often profound. All too frequently, the reasons for these failures turn out to be small and remediable, but they are usually overlooked or dismissed as unimportant. We work, therefore, to identify subtle but important contextual details that can have a disproportionate impact on outcomes. We work in a number of areas: consumer finance, economic mobility, health, education, criminal justice, energy efficiency, and international development. Our work involves a lot of observation, a deep understanding of behavioral science, plenty of patience, and a willingness to be surprised.

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Overview

How might we encourage men and women in the Philippines to save more for the future? How could we help young women in South Africa avoid behaviors that put them at increased risk of contracting HIV? What might we do to nudge Costa Rican households to reduce their water consumption? One answer to these and many other international development problems: apply insights from behavioral science. This field, which draws from economics, psychology, and related disciplines, has rapidly gained momentum as program designers, practitioners, and policymakers alike recognize that successful initiatives must be built on accurate—rather than idealized—models of human behavior.

Over several decades, behavioral scientists have systematically documented the surprising factors that influence our decisions, the seemingly critical considerations we often overlook, and the mental shortcuts we repeatedly take as we navigate the world. When deciding how much money to deposit into a savings account, for instance, people may default to the minimum balance rather than contribute as much as they're financially able.[1] Young women may consistently underestimate the HIV risk of a relationship with an older man, because they fail to factor the length of his sexual history into their assessment.[2] Information about how peers behave may be more influential than information about the environmental costs of heavy resource consumption when it comes to prompting families to curb water usage.[3] In short, behaviors that seem puzzling and problems that seem intractable when understood in purely economic terms make more sense when the role of context in shaping humans' perceptions and actions is taken into account.

In international agricultural development, individual-level behavior change is often a necessary component for productivity growth, enhanced sustainability, and increased resilience, among other outcomes. For example, the benefit of improved seed varieties will go unrealized if farmers do not use them and the promise of innovative best practices will remain untapped if farmers do not adopt them. Often farmers may express an intention to adopt new inputs and apply new practices, yet their actions may not align with this intention and specific behavior change may not follow. One such vexing problem is the high rate of post-harvest crop loss—with its attendant economic, health, and environmental consequences—in Sub-Saharan Africa. Many promising technologies and solutions for reducing post-harvest loss exist, yet farmers do not always use them.

In early 2016, a Rockefeller Foundation grant funded ideas42 to study the behavioral challenges contributing to post-harvest loss among smallholder maize farmers in Tanzania. In partnership with the Rockefeller Foundation and its YieldWise initiative team, ideas42 honed in on low uptake of improved crop storage technologies, inconsistent use of agricultural best practices, and limited participation in collective crop storage and sale as key behavioral barriers to successful loss reduction. In addition to pinpointing the underlying causes of these problems—which range from present bias to prospective memory failure—the ideas42 team crafted promising design concepts that could be used to enhance farmer trainings, improve the design of crop storage solutions, and create new market linkages. Though the specific findings outlined here center on maize in Tanzania, ideas42's analysis affirms the value of studying development challenges from a behavioral perspective, both in Tanzania and well beyond its borders.

Behavioral Challenges in Post-Harvest Loss Reduction

"Post-harvest loss" is the term used to describe the crops lost to waste, spoilage, and other factors in between harvest and consumption by the end user. Whereas conversations about loss in the U.S. and Europe center on consumer food waste, in the developing world the majority of loss occurs before crops reach the market. In Sub-Saharan Africa, as much as 50% of fruits and vegetables, 40% of roots and tubers, and 20% of cereals are lost before they even hit the market.[4] This astonishing level of waste substantially reduces the incomes of millions of smallholder farmers and contributes to food insecurity for African households.

These dynamics are on display in Tanzania, where ideas42 focused its analysis on smallholder maize farmers. More than three-quarters of the Tanzanian population depend on agriculture for their livelihood, and about a third of children under the age of five years are stunted.[5] Maize is a particularly important crop: along with other cereals, it forms the bulk of the Tanzanian diet, yet 20-40% of the maize harvest is lost each year.[6] Scaling back such losses could substantially improve the economic and health prospects of millions of Tanzanians.

Data collected by the YieldWise team, together with a review of the academic literature and conversations with key staff, pointed to uptake of Purdue Improved Cowpea Storage (PICS) bags, a crop storage technology invented in the early 2000s, as a potential focal point for deeper investigation. PICS bags consist of three layers—two inner liners made of polyethylene and an outer layer of woven polypropylene—that, when tied off individually, create a hermetically sealed grain storage environment in which common pests cannot survive. Because this technology is relatively inexpensive and highly effective, encouraging farmers to make the switch from single-layer polypropylene ("poly" bags) to PICS bags is a key goal of the YieldWise initiative in Tanzania. Decades of behavioral research, however, indicate that uptake of new technologies can often be much lower than we might expect even given relative costs and benefits.[7] PICs bags are an example of this kind of new technology that might not be taken up as much as expected given the relative benefits to be gained.

A field visit further strengthened the hypothesis that uptake of PICS bags could be a key challenge hindering the post-harvest loss reduction efforts. Many farmers intended to use PICS bags for their household grain storage, yet were not always following through on their intention. Interviews with farmers and observation of activities on the ground also surfaced two unexpected behavioral problems related to the use of agricultural best practices and participation in collective storage. First, farmers are not consistently implementing non-technology-based agricultural practices prior to storage that could reduce crop loss. These practices include using a plastic tarp to dry grain and checking grain moisture content before storing, among others. Second, farmers are not always storing and selling their grain collectively. Collective storage and sale allows farmers to access forward contracts from buyers and make use of more secure storage facilities.

With a clear understanding of the specific behaviors interfering with the reduction of post-harvest maize loss in Tanzania, the next step was to identify the behavioral and contextual drivers of these three challenges.

Diagnosis of the Primary Behavioral and Contextual Drivers

Traditional economic models often attribute problematic behaviors to a lack of information, individual motivations, or other person-centered factors. If someone fails to show up to a vaccination clinic, for example, it must be because he didn't know it was happening or didn't understand the value of prophylaxis. Behavioral models, meanwhile, shift the focus to the situation: what features of the environment might channel a person toward or away from a particular action? In the case of the vaccination clinic, factors such as the difficulty of arranging transport, the perception that one's peers are not vaccinated, or even simple forgetfulness might all play a role.

Behavioral diagnosis hinges on accurately pinpointing such "bottlenecks," or contextual features and cognitive biases that contribute to the problems in question. Outlined below are a number of likely bottlenecks driving the behavioral problems at hand. As the YieldWise initiative unfolds, the partners will closely monitor these likely bottlenecks to proactively identify and address potential issues that may emerge.

Problem 1: *Farmers intend to use PICS bags to store grain destined for household consumption but may not follow through on this intention.*

A key driver of this problem is a **misalignment of available capital, intention to purchase, and need for storage**. In the current iteration of the YieldWise intervention, farmers are introduced to the concept of post-harvest loss and prevention strategies during sessions led by agricultural trainers a couple of months prior to harvest. Attendees likely form an intention to begin using PICS bags during these sessions, yet most of them will wait until several months later, when they are getting ready to harvest their maize, to actually purchase crop storage supplies. By this time, however, farmers have very little cash on hand. Their profits from the previous harvest must last an entire year, and have likely dwindled substantially by the time the next harvest is approaching. Thus, while PICS bags are relatively inexpensive at 5000 TZS (versus 1000 TZS for poly bags, the most

Images from Purdue Agriculture: https://ag.purdue.edu/ipia/pics/Pages/home.aspx

popular existing storage option), farmers may nevertheless be unable to afford them at the right time. A few months later, once the harvest has sold and farmers are flush with cash, price is less of an obstacle. By then, however, crop storage has dropped far down farmers' priority lists.[8]

A second bottleneck centers on the role of **present bias as a driver of short-term thinking**. Present bias is the term behavioral scientists use to describe the tendency to overweight gains and losses in the present relative to those in the future. Simply put, losing $5 today "hurts" more than losing $5 a week from now. People are even willing to lose *more* in the future, up to a point, in order to avoid giving something up today.[9] This universal tendency has important implications for the adoption of PICS bags in Tanzania. The upfront cost of PICS bags is five times greater than the cost of standard poly bags—5000 TZS (about $2.25 USD) compared to 1000 TZS. Farmers stand to gain by switching to PICS, but that investment won't pay off until the second or third year they use the bags. Exacerbating the problem is the fact that calculating the return on investment of PICS bags, relative to poly bags, is difficult to do given the differing cost structures of the two options. Finally, research has shown that when resources are scarce—as is the case when farmers are making crop storage purchases just before the harvest—present bias is heightened.[10]

Finally, **mental models of the PICS bags may limit their appeal to farmers.** "Mental models" are individual perceptions of something: how the mind categorizes it, the way it understands its purpose or function, and the understanding of whom it is for.[11] Those perceptions in turn shape our behaviors, consciously or unconsciously. PICS bags are categorized as grain storage bags: they look and feel similar enough to poly bags that many farmers don't mentally categorize them as new technologies worth five times as much as what they've been using.

Problem 2: *Farmers are not implementing non-technology-based agricultural practices prior to storage that could reduce crop loss.*

The first bottleneck in this problem area centers on the difficulty of **retaining and recalling information about best practices at the right time.**[12] In a series of trainings on post-harvest handling, each several hours long, farmers are asked to absorb a large amount of information about a wide range of practices. Typically, this information is delivered weeks or months before harvest begins. By the time the opportunity to act on this knowledge arises, farmers may have forgotten the specifics of what they learned, or may remember at the wrong time—too late to act on it this time around.

Second, it's quite easy for farmers to **overlook or miscalculate the impact of particular practices**. During trainings, farmers learn upwards of ten storage principles, ranging from the optimal moisture level for harvesting maize to the ideal frequency of storage space cleanings. In an ideal world, farmers would immediately adhere to all of these principles; in reality, however, limited resources likely require them to pick and choose. Without guidance as to which practices are most impactful, farmers may inadvertently fail to implement particularly important new behaviors.[13] Similarly, farmers may abandon constructive new habits—and stick to less effective old ones—because they receive little feedback on the effects of individual actions. Dozens of factors affect post-harvest loss and often this loss is hard

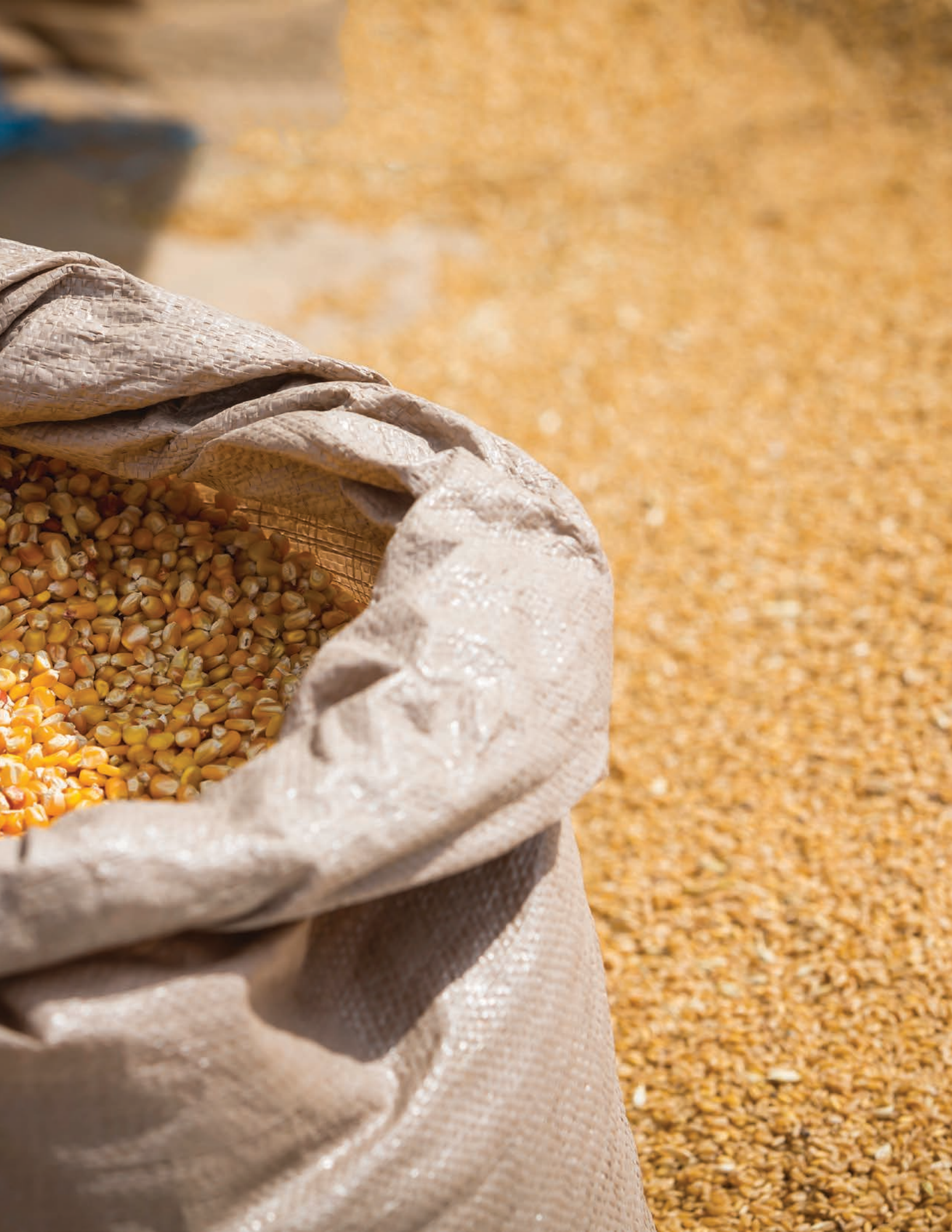
to identify because it occurs gradually. Because of these characteristics of post-harvest loss, farmers cannot know with absolute certainty which of their actions made a difference; for the most part, they must take trainers at their word when it comes to deciding which practices are important enough to adopt.

Last, many of the post-harvest best practices **require pre-planning or coordination with others**. For instance, agronomists recommend that farmers dry their maize on a tarp rather than a wooden platform, as is traditional, and suggest that they use a sufficiently large storage space with both an entrance and an exit for storage of large quantities of grain. Purchasing or borrowing a tarp and constructing or remodeling a storage facility take time and often help from others. Farmers may fail to plan far enough in advance and run out of time to complete such tasks before harvest, even if they had every intention of doing so. Furthermore, most of the post-harvest best practices are rife with costs and hassles. Though these may appear small, the fact that they require effort, time, and even money means that they are likely to have an outsized impact on behavior.[14]

Problem 3: *Farmers are not storing and selling their grain collectively.*

To understand the bottlenecks that limit uptake of collective storage, and why this is problematic, it is helpful to have some context on the current organization, crop storage, and selling practices of smallholder maize farmers in Tanzania. Many such farmers operate independently: they either sell their grain immediately after harvest, store their harvest at home for household consumption, or store the harvest at home and seek out buyers if and when they feel they can get a good price for their crop. A fraction of farmers—approximately 25-30%, according to estimates from YieldWise partner organizations—choose to join farmers' associations. For a fee (upfront and/or annual), these farmers gain access to resources such as trainings and storage facilities. When association members complete their harvest, they typically store some portion of their grain at home and some portion in the group's warehouse. Collectively, the group decides when, to whom, and at what price to sell the jointly stored grain. The buyer pays the group's leaders, who then distribute the profits to association members based on the amount of grain they contributed. Collective sale is typically beneficial to farmers because the group has more negotiating power than the individual, and the stress of seeking out buyers and deciding when to sell is distributed widely.

Why, then, do many farmers choose not to join associations, and why do some who join choose to put little or no grain into the collective pot? The first bottleneck identified by the ideas42 team is that **farmers use home storage as a liquid savings mechanism**. Without access to formal financial institutions, farmers are responsible for holding onto their own savings. One option is to keep cash on hand. The ease with which such cash can be used for non-urgent expenses, however, limits its appeal.[15] Instead, many farmers prefer to keep their savings in maize form: if an emergency arises, they can sell it in exchange for cash, but the hassles involved in doing so are significant enough to deter frivolous spending. Grain that is stored collectively, meanwhile, is effectively inaccessible. Even if they desperately need cash, farmers will have to wait until the group decides to sell. For many, this is a risky prospect.



A second factor is that **the costs and benefits of various storage options are not clear-cut**. On the one hand, farmers may be overconfident in their ability to "beat the market," or to get a higher price for their grain than the group will. The maize market is not unlike the stock market, in the sense that prices regularly fluctuate, and it's difficult to predict how they will change from week to week. Just as investors often overestimate their own or a money manger's predictive power, smallholder farmers may misjudge their market savvy relative to collective wisdom and overestimate the benefits of home storage and self-sale.[16] In addition, it is easy to misjudge the costs of storing collectively, relative to storing at home: will collectively stored grain command a high enough price to offset storage fees, transportation costs, and any other expenses incurred? In the face of ambiguity, farmers may decide to stick with the status quo and keep their crops at home.[17]

The final bottleneck is that **collective storage is typically farmers' lowest priority**. When farmers conclude their harvest, they begin by setting aside the maize they will use to feed their family over the coming year. Second, they pull out the amount they would like to store at home as "liquid savings." Whatever is left over is contributed to collective storage. Particularly in low-yield years, this may be a relatively low fraction of the total harvest.

Potential Design Solutions

Once the contextual features driving the problems in question have been identified, it is possible to begin crafting solutions that will remove or counteract those features. The ideas42 team focused its loss-reduction design work on bottlenecks related to uptake of PICS bags, as this was the problem area of greatest priority to the YieldWise team. This work ultimately produced a shortlist of eight promising design concepts, which are described below in relationship to an identified bottleneck.

Bottleneck 1: *A misalignment of capital, intention to purchase PICS bags, and need for crop storage hinders uptake. How might intention, need, and ability to pay be synced?*

One strategy would be to **make it easy for farmers to purchase PICS when their financial resources are greatest**—that is, right after they've sold their harvest. This strategy would primarily apply to farmers storing some portion of their grain collectively: after the buyer has paid the farmers association, the group's leaders portion out the revenue to each farmer. Rather than automatically paying out 100% of the profits in cash, leaders would give farmers the option to be "paid in PICS." In other words, the farmer could opt to divert some portion of her profits to the purchase of PICS bags. Depending on logistical constraints and farmer preferences, farmers could receive the bags on the spot or get a coupon redeemable for bags the following summer. This intervention would effectively close the gap between intention and action by creating a moment of action at the very time farmers are in a position to make a financial investment.[18]

A second option would be to **add PICS bags to the input bundles some farmers receive on credit at the beginning of a growing season**. Several ongoing initiatives, most notably the World Food Programme-led "Patient Procurement Platform" (PPP), distribute a set of agricultural inputs to participating farmers.[19] These high quality seeds, fertilizers, and other tools help farmers increase their crop yield at no upfront cost. Instead, farmers pay for the inputs at harvest months

later, when the cost of the bundle is subtracted from their total crop sales. The farmers ideas42 spoke with highly valued these inputs, noting that they had indeed seen higher yields after using them. By including PICS bags in the input bundle, by default or as an option, program designers would be able to capitalize on both positive sentiment and established channels for repayment. Like the previous design concept, this strategy effectively moves payment to a moment when farmers have the greatest resources.

A third option for combating the misalignment would be to **establish a layaway program that breaks the cost of PICS bags into manageable sums.** At the start of the growing season, farmers would commit to purchasing a certain number of PICS bags. On a weekly or monthly basis, they would pay a fraction of the total cost to either the leaders of the farmers' association or to the staff of a participating non-profit. By harvest time, the bags would be nearly or entirely paid off and could be picked up when farmers are ready to use them. In addition to making the cost of the bags feel more manageable, this strategy would reduce the amount of time that passes between forming an intention to purchase PICS bags and acting on that intention.

Bottleneck 2: *Present bias drives short-term thinking among farmers. How might it be made easier for them to take a long-term view?*

One major driver of short-term thinking is the steep difference in upfront costs of PICS and the poly bags. To combat this, look for opportunities to focus farmers' attention on the ***total*** cost of each option over the typical lifespan of a PICS bag – on average three years. Once pesticide costs over this lifespan are factored into the price of poly bags, the PICS bags become a relative bargain. One way to reframe the price would be to **help farmers visualize the true costs of each option**. For instance, farmers might break into small groups during post-harvest handling trainings; half of the groups would be assigned to represent poly bags, and the other half would represent PICS. Each group would receive an equivalent amount of Tanzanian shillings. As the activity progressed, they would gain and lose money in accordance with the costs and payments associated with their bag type over the three-year lifespan. At the end, the groups would compare their assets and see that PICS bags left them with significantly more cash.

Because not all farmers are likely to attend trainings, an alternative strategy for making the long-term benefits of using PICS bags salient is to distribute a **cost comparison tag or handout**. This tag, which could be affixed to the PICS bags or distributed as a flyer wherever the bags are sold, would highlight the cost per year of each option, making it immediately obvious that PICS bags are a more cost-effective choice.[20]

A third way to combat present bias would be to **offset the cost of PICS bags by reducing the degree of risk associated with the purchase**. This could be done in at least two ways: first, each PICS bag could be sold with a money-back guarantee. If farmers are unsatisfied with their purchase, they could return the bag for a partial refund. Alternatively, PICS bags might come with insurance against crop loss: farmers using the bags to store their grain would be eligible for a partial refund if their grain is affected by the pests PICS bags are designed to prevent. Under either scenario, the upfront cost of PICS begins to seem a little less painful; farmers will be reassured that they aren't making an irrevocable decision and that any losses they accrue while trying this new technology could be recouped. Recognizing that money back guarantees are uncommon in

Tanzania, various aspects of this design solution, especially the business model, would need to be further investigated for successful implementation.

Bottleneck 3: *Current mental models limit the appeal of PICS bags. How might they be made more attractive to farmers?*

One major challenge is that PICS bags aren't perceived as different enough from poly bags to justify their cost. One method of encouraging farmers to mentally re-categorize PICS bags as cutting-edge technology is to **redesign the bags in ways that enhance their functionality and increase the perceived value**. For instance, include a free hand cart with the sale of every ten bags, create a sturdy outer layer for the bags that could also double as a tarp, or include a standard poly bag as a fourth, innermost layer. Making it easier to transport grain stored in PICS, creating the perception that farmers are getting a two-for-one deal, and enhancing the visual differences between PICS and poly bags should increase the likelihood that farmers see PICS bags as a new product and worthwhile investment.

A related strategy would be to **increase the salience of PICS bag features that already appeal to farmers**. Many farmers cite the health benefits of PICS bags as their primary selling point: by removing the need to treat grain with pesticides, farmers can feel good about feeding their families with untreated but nevertheless pest-free grain. A prominent label on each PICS bag would indicate the pesticide-free status of the grain inside, making farmers feel good about their purchase and sending a quality signal to potential buyers.

Moving Forward

Taken together, this work strengthens the case for deploying behavioral science in the context of international development initiatives. In particular, the behavioral lens helps draw program designers' attention to the so-called "last mile problem:" once the big-picture logistical and financial elements of a program are in place, how do designers ensure that end users actually benefit? In the case of reducing post-harvest loss, securing large corporate buyers, increasing the availability of crop storage technologies on the market, and disseminating important information about post-harvest handling are necessary but not sufficient components of a successful intervention. Program designers must also find a way to effectively change farmers' behaviors. If farmers do not store their grain collectively, purchase and properly use new technologies, and successfully adopt post-harvest best practices, the impacts will be blunted.

Though this paper centers on maize in Tanzania, the principles discussed throughout are likely to be relevant in a wide range of countries and crop value chains, and the behavioral science perspective is a valuable approach within the agricultural development toolkit. Last mile behavior change is often the critical factor for game-changing agricultural innovations – modern inputs are only valuable if used properly, best practices are only effective if faithfully implemented, and the success of novel financing or extension mechanisms is co-dependent to some extent on farmer field-level behavior. Program designers, implementers, and evaluators can benefit from applying a behavioral science lens at all stages of the program or product lifecycle – from the formative research that informs a design, to troubleshooting behavioral challenges that emerge during implementation, to evaluating and analyzing outcomes.

ideas42 is currently engaged in applying behavioral science to a number of international agriculture projects, including increasing savings among cocoa farmers in Indonesia, helping farmers in Kenya optimize investments in agricultural assets, and encouraging timely planting among cotton farmers in Mozambique. Despite contextual differences, common insights are emerging. The misalignment between the availability of capital and the timing of input purchases is a prevalent bottleneck leading many farmers to forgo modern inputs, despite an intention to use these widely available, generally affordable inputs. The tendency to overlook the value of relatively small, low-cost best practices leads many farmers to not use these techniques which could help them realize significant productivity gains. Present-biased preferences are also broadly prevalent tendencies that limit investment in productive assets and high-quality inputs. Many new technologies and best practices are precision-oriented and require careful attention to small details, which presents an added challenge for effective implementation or use. Lastly, ideas42's ongoing work has shed light on the urgent need for financial products and services that are designed with the smallholder farmer in mind. Currently, there are very few financial products and services that are tailored to a farmer's cyclical income cycle, easily accessible in rural areas, and offer mutual benefit for the farmer and the financial institution offering the product or service. The application of behavioral science holds great promise to generate innovative and impactful solutions to the aforementioned challenges, and, undoubtedly, many others. In the months and years to come, it is the hope of ideas42 that these insights will spark new solutions to persistent challenges, spur product innovation, and inspire behaviorally-optimized programs, all towards the end goal of tangible improvement in the lives of smallholder farmers and their families.

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