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## **The Business Case for Biocontrol Use – A Case Study on Combating Aflatoxins in Corn**

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## Introduction

Rafhan Maize Products Co. ('Rafhan' or 'the Company') is a Pakistani manufacturing company that produces food ingredients and industrial products derived from corn or maize. Rafhan is an affiliate of Ingredion Incorporated USA (Ingredion), one of the world's leading ingredient providers. Ingredion has committed to multiple sustainability goals, including ethically sourcing 100% of the corn crops in their supply chain by 2025 as well as reducing waste and its overall carbon footprint.

Rafhan's business depends on procuring and processing clean corn (corn that adheres to strict food safety requirements), which can be negatively impacted by higher than acceptable levels of toxic fungus *aflatoxin* in crops. In recent years, Rafhan along with the United States Department of Agriculture (USDA) and other Pakistani agencies has invested in the development of a biological control product (AflaPak™) to alleviate aflatoxin contamination in Pakistani corn. AflaPak™ has been tested on ~25,000 acres of cornfields in Pakistan and found to be effective in controlling the toxins. Reducing aflatoxins reduces food waste, increases grower marketable yields, reduces the risk of poisoning humans and livestock from consuming contaminated produce, and allows access to export markets. AflaPak™ addresses the company's environmental goals and improves Rafhan's ability to proactively manage regulatory compliance in Pakistan.

This case study is a part of the NYU Stern's Center for Sustainable Business (CSB) Food and Agriculture research which is funded by HSBC. In partnership with Ingredion and Rafhan, CSB has developed materials that provide information about societal impacts and financial benefits of agricultural interventions for growers and for downstream companies. The Return on Sustainability Investment (ROSI™) Monetization model was used to quantify those benefits and calculate the return on investment. The accompanying project report suggests areas for future use and evolution of the models. The ROSI™ Monetization Model can be a useful template to corn growers or food and agriculture companies at large.

## Food Waste, Public Health, and Climate Change

Aflatoxins are naturally occurring toxins found in agricultural crops, and they pose a severe health risk to plants, humans and animals. If crops are not protected or treated, contaminated loads may have to be destroyed or sold at reduced prices, and thus pose a food waste problem and an economic risk to growers.

Aflatoxin poisoning, aflatoxicosis, can occur in humans or animals with regular consumption of crops that have even low levels of contamination. The crops can enter the human diet through direct consumption, or through livestock products. For humans, aflatoxins are linked to liver cancer, synergistic effects with Hepatitis B, and potential association with stunting and immunosuppression. Chronic aflatoxin exposure is also associated with child growth impairment and malnutrition in humans. Aflatoxicosis in livestock and poultry can result in hemorrhage,

bloody diarrhea, and death in 1-3 days. Rafhan can contribute positively to human and animal welfare by promoting practices that help grow and preserve clean and safe corn.

The public health and food waste problem caused by aflatoxins are growing worldwide - climate change, thus warmer temperatures and less predictable droughts and floods, threatens to increase aflatoxin presence in corn<sup>1</sup>. Water related stress like drought allows *aspergillus* fungi that produce aflatoxin to thrive, especially when it occurs in the reproductive stage of the crop's life cycle.<sup>2</sup>

Starting in mid-June 2022, southern Pakistan experienced devastating floods, and 80% of crops in the Sindh province were destroyed.<sup>3</sup> Months after the floods, some areas remain submerged due to the flat landscape and subpar water infrastructure. The corn life cycle depends heavily on steady levels of water, and water inconsistency at any growth stage can damage the grain yield. Therefore, in a time of climate disaster in Pakistan, it is ever more crucial to prevent food waste because unpredictable weather will continue to put crops at risk.

## Rafhan's Role in the Corn Industry in Pakistan

Agriculture constituted 18.9% of the total Gross Domestic Product (GDP) employing 42.7% of Pakistan's labor force<sup>4</sup>. Corn is one of Pakistan's most important cash and food crops and is a staple of the local diet and an animal feed ingredient.

Demand for and production of corn has boomed in recent years partly due to growth in the poultry and aquaculture sectors which both require corn as feed. In its annual report, the US Department of Agriculture (USDA) attaché puts Pakistan's corn production in 2021-22 at a record 7.9



million tons, up from 7.8 million the previous year.

Rafhan's products are used in international markets and in more than 50 industries in Pakistan, where they have grown to become the largest corn processor in the country. Improving the supply of clean and safe corn by reducing aflatoxin levels will provide Rafhan access to new

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<sup>1</sup> Jina Yu et al 2022 Environ. Res. Lett. 17 054017

<sup>2</sup> Cotty P J and Jaime-Garcia R 2007 Influences of climate on aflatoxin producing fungi and aflatoxin contamination Int. J. Food Microbiol. 119 109–15

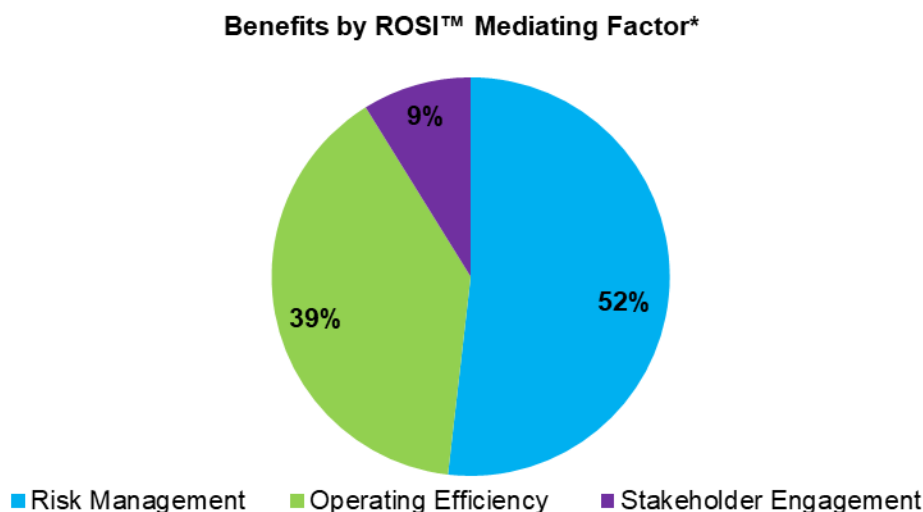
<sup>3</sup> <https://foreignpolicy.com/2022/11/16/pakistan-flooding-farmers-climate-disaster/>, accessed 1/5/23.

<sup>4</sup> Pakistan Economic Survey

export markets<sup>5</sup>. The US and EU have regulations in place regarding acceptable levels of aflatoxin in produce. For example, the U.S. Food and Drug Administration (FDA) requires that corn contain less than 20 parts aflatoxin per billion for use in all human feed and corn exceeding 300 parts per billion must be blended with corn containing little or no aflatoxin before feeding to animals.

## The Business Case for Biocontrol use to combat Aflatoxins: ROSI™ Benefits

NYU Stern CSB's Food & Agriculture Return on Sustainability Investment Framework was used to identify benefits for corn growers and for Rafhan. A total of twenty benefits were assessed across Rafhan's operations, of which nine benefits were monetized. The analysis shows a net positive financial benefit for Rafhan; factors contributing to this benefit are risk avoidance, operating efficiencies, and enhanced stakeholder engagement. In monetary terms, the 10-year Net Present Value is assessed at \$9.3M (present value of total benefits \$15.5M less program costs of \$6.1M). On an average annual basis, the net benefit is likely to be \$2.1M over the same period. A description of the monetized benefits and their relative importance are provided below:



\*10-year benefit in Present Value (PV) terms

- Risk management relates to supply disruption, price volatility and reputational events

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<sup>5</sup> The World Bank estimates that this year's devastating flooding has cost the country more than \$30 billion in total damage and economic losses. In this way, Rafhan has a unique opportunity to "build back better" with climate resilient practices, as the World Bank has called on Pakistani companies and government to do in the wake of the floods.

<https://www.worldbank.org/en/news/press-release/2022/10/28/pakistan-flood-damages-and-economic-losses-over-usd-30-billion-and-reconstruction-needs-over-usd-16-billion-new-assessment#:~:text=The%20assessment%20estimates%20total%20damages,reach%20about%20USD%2015.2%20billion>, accessed 1/5/23

- Operating efficiencies relates to diversion to less profitable industrial versus food product processing plants and corn testing
- Stakeholder engagement captures benefits of leveraging its investment in the development of AflaPak to partner with Foundations, Key Global Clients among other stakeholders to support the AflaPak™ program via cost sharing options

*Additional benefits include access to new export market sales and shifting Rafhan's domestic client mix towards high demand sectors such as poultry feed and global clients that drive revenues across geographies. These were not monetized due to the limited scope of the project and further research is needed for quantification.*

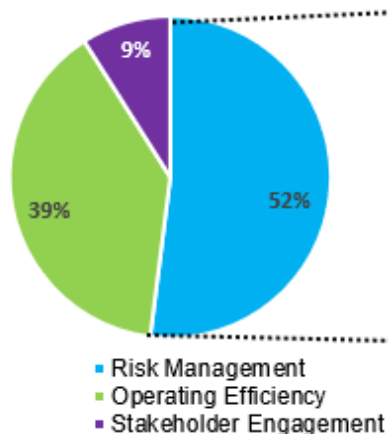
## Methodology: Applying ROSI™

NYU Stern CSB undertook desktop research, interviewed key staff from Ingredion and Rafhan to learn about Rafhan's procurement, manufacturing and sales practices. Rafhan provided NYU Stern CSB with information and data on procurement and sales volumes including procurement channel mix ratios, sales by segments, products, and client type as well as financial data such as average corn procurement prices, manufacturing and operating costs, and contribution margins. Research associated with a comparable product (Aflasafe rolled out in Nigeria) informed some of the assumptions used in the monetization process. The team reviewed relevant research and designed approaches to monetize the benefits.

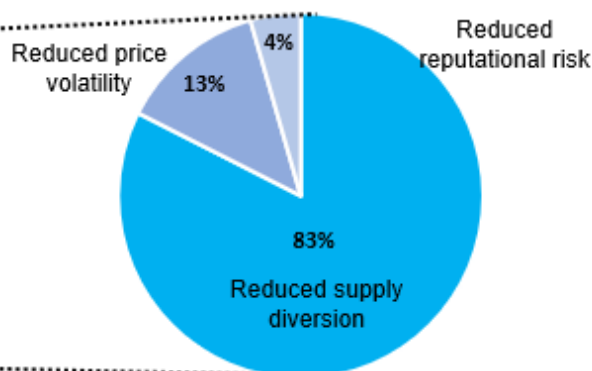
## Risk Management

Benefits from risk management/risk reduction accounting for a little over half (52%) of the total benefits assessed for Rafhan, comprise benefits from lower risk from supply disruption, price volatility and reputational events. The monetization process and the results are explained in detail below.

Benefits by ROSI™ Mediating Factor



Risk Management Benefits



## Benefit I: Improved supply resiliency

*Reduces risk of supply disruption driven by a major outbreak of aflatoxin*

### Description

In the event of a major aflatoxin outbreak, Rafhan's ability to procure clean corn locally, and sell/fulfill customer's orders of finished product may be adversely affected. More so for specialty varieties such as waxy corn (specific corn variety grown in a closed loop system whereby seed is provided to growers under a contract to deliver their corn production) where if the crop were to be contaminated, alternate supply would be difficult to procure locally. In the case of more widely available varieties such as dent corn, Rafhan may be able to procure the corn locally, albeit from a different channel or region and potentially at a higher cost. Research shows promoting regular use of AflaPak™ among growers' guards against occurrence of large toxin outbreaks and thus creates supply resiliency for Rafhan<sup>6</sup>.

### Methodology

For this metric, the probability and severity of an aflatoxin occurrence is estimated for both dent and waxy corn. These estimates are used to calculate the estimated sales loss. In the case of waxy corn, a complete sales loss is expected so the likely volumes lost are multiplied with the contribution margin to calculate a benefit of avoided loss. In the case of dent corn, purchase volumes likely to be impacted are multiplied with the additional purchase cost to calculate the benefit of avoided costs.

### Benefit Value

Expected average annual earnings benefit is \$1.3M with a 10-year Present Value (PV) totaling to \$6.6M.

## Benefit II: Reduced Price Volatility

*Reduces procurement price volatility*

### Description

Estimates that the ability to procure more corn at the time of harvest creates stability of supply and ability of Rafhan to procure at cheaper prices.

### Methodology

For this metric, assess the annual change in procurement prices experienced for both waxy and dent corn over a historical period and calculate the historical average annual rate. Forecast corn procurement prices using this historical average rate. Based on the assumption that greater availability of corn at the time of harvest creates stability in prices, estimate a potential decrease in price volatility by adjusting the historical average rate downwards with a volatility reduction

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<sup>6</sup> \*Aflasafe™ has been shown to consistently reduce aflatoxin contamination in maize and groundnut by 80–99% during crop development, post-harvest storage, and throughout the value chain in several countries across Africa ([Grace et al., 2015](#)) \*\*Due to limitations of data availability, no value is estimated presently. Details provided on slide\_. Source: Rafhan Benefit Monetization Model



factor. Estimate waxy and dent corn procurement volumes in the future and multiply the volumes by the forecasted prices to estimate purchase costs under the two different scenarios. The difference in the purchase cost represents the savings from reduced price volatility. Given the limited scope nature of our project, we are unable to confirm the validity of this claim as it is based on discussions with the Rafhan/Ingredion teams and requires further research.

#### **Benefit Value**

Expected average annual earnings benefit is \$258K with a 10-year PV totaling \$1.1M.

### **Benefit III: Reduced Reputational Risk**

*Reduces risk of a reputational scandal*

#### **Description**

By procuring AflaPak treated corn and adhering to testing protocol, Rafhan lowers the risk of a reputational scandal from supplying contaminated product. Any instance of contamination found in Rafhan's finished product would lead to product recall costs being incurred and cancellation of clients' orders causing sales or margin loss. The risk of a sales loss is higher with global or domestic food-grade clients focused on using high quality ingredients.

#### **Methodology**

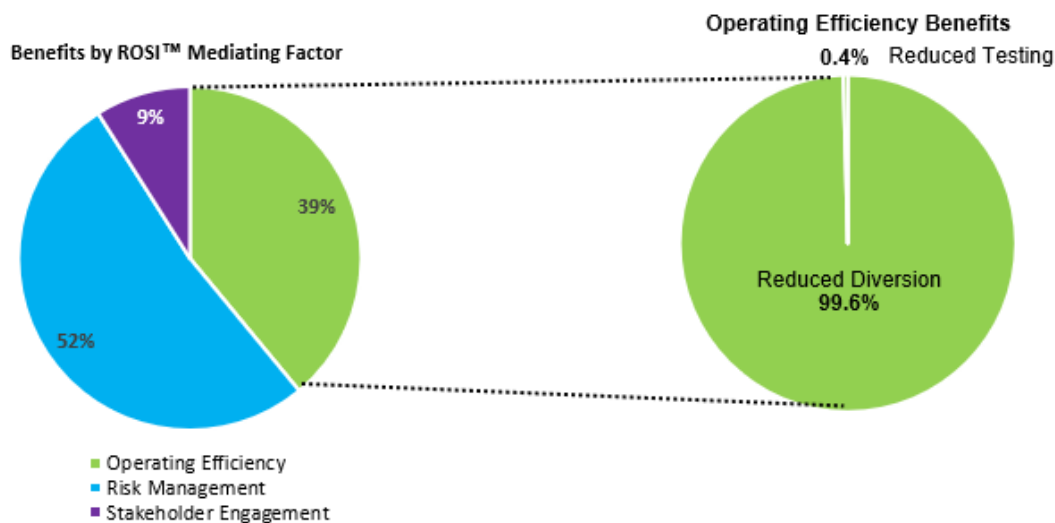
For this metric, analyze the current customer segment mix by sales volumes and identify quality conscious customers. Forecast future corn sales to the 'Identified' clients, estimate how much and for how long would the adverse sales impact last to estimate the future corn sales volumes 'at risk'. Additionally, estimate product recall costs i.e., product write off costs, legal and PR expenses etc. Add the sales or margin loss with the product recall costs and adjust it with the probability of the event occurring to calculate the annualized impact. This represents an avoided loss or risk reduction benefit. Presently, the extent of local regulation in Pakistan on acceptable levels of aflatoxin in food grade corn products is evolving and thus, we are unable to assess the full impact of a negative reputational event, and these are company estimates of costs incurred on past incident.

#### **Benefit Value**

Expected average annual earnings benefit is \$71K with a 10-year PV totaling \$358K.

### **Operating Efficiency**

Operating efficiency benefits are mainly from reduced diversion towards non food/industrial uses and a small percentage from lower testing costs.



## Benefit IV: Operating efficiency driven by lower rejections

*Reduces diversion of corn towards non-food/industrial uses*

### Description

At Rafhan's food grade plant, corn is regularly tested for aflatoxins, and if found to be contaminated beyond acceptable levels, the corn is rejected and diverted to their industrial plant, producing non-food grade products. Industrial products on average realize a lower contribution margin as compared to food grade products and thus there is a lost opportunity to sell higher margin products.

By promoting the use of and rolling out AflaPak™ among its corn growers, Rafhan will have access to larger levels of AflaPak™ treated or clean corn in the years to come. As the supply of AflaPak™ treated corn increases in Rafhan's sourcing region, it will likely experience reduced diversion of corn from its food grade plant towards nonfood/industrial uses and sell more (higher margin) food grade products. This could reduce the current annual corn rejection rate of 6%\* at the food grade plant thus preventing diversion towards non-food/industrial grade plant uses.

### Methodology

Forecast the amount of treated corn procurement volumes based on Rafhan's AflaPak™ roll out plan over the projected-timeline. Estimated the reduction in historical corn rejection/diversion rates to reflect the impacts of growth in treated volumes. The adjustment is based on findings from academic studies and a similar experiment conducted in corn in Nigeria titled- Nigeria Aflasafe™ Challenge Project <sup>7</sup>. Calculate the amount of incremental and cumulative corn treated with AflaPak™ and multiplied the latter by the estimated reduction in the diversion rate to calculate the incremental amounts used for food production. Multiplied the incremental volumes to food plants by the contribution margin difference between food grade and industrial

<sup>7</sup> "AgResults Impact Evaluation Report: Nigeria Aflasafe™ Challenge Project," AgResults, Abt Associates, Denise Mainville Consulting. November, 2020. [Source.](#)



grade to estimate total savings.

### **Benefit Value**

Expected average annual earnings benefit is \$1.3M with a 10-year PV totaling to \$6M

### **Benefit V: Reduced Testing Costs**

*Savings from reduced testing frequency*

#### **Description**

By promoting the use of and rolling out AflaPak among its corn growers, Rafhan will have access to larger quantities of AflaPak™ treated/clean corn in the years to come. A stable supply of clean corn may require less rigorous testing at Rafhan's plants as the likelihood of contamination is known to be lower in AflaPak treated corn. Rafhan is presently testing corn twice at its food grade plant - first at the factory gate and then again prior to manufacturing. Reducing the testing frequency from twice to once per vehicle, subject to internal quality and AflaPak roll out thresholds being met, may result in cost savings.

#### **Methodology**

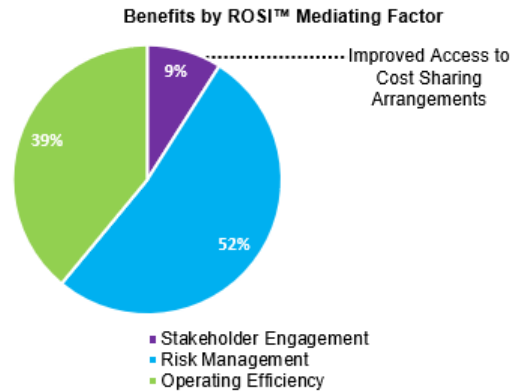
Calculate the annual corn volumes procured and the percentage used for food grade products. Forecast future procurement of AflaPak treated corn volumes based on the roll out plan. Using the current frequency of testing of #2 tests per vehicle of corn delivered, forecast the total number of annual tests to be done (no change scenario). Assuming that testing frequency is reduced from twice per vehicle to once per vehicle of corn delivered, forecast the total number of tests on the total corn procurement in the future (reduced testing scenario). Calculate the difference between the two scenarios and multiply by the costs per test to estimate the total savings.

### **Benefit Value**

Expected average annual earnings benefit is \$7.8K with a 10-year PV totaling to \$26K

### **Stakeholder Engagement**

Stakeholder engagement benefits are entirely assessed from improved access to cost sharing arrangements.



## Benefit VI: Enhanced Stakeholder Relations

*Improves access to cost sharing arrangements*

### Description

AflaPak™ contributes positively to larger societal goals of promoting public health and reducing food waste in an important food security crop-corn. Controlling contamination will have positive and wide reaching implications for the agricultural sector including for smallholder growers and their families who often end up consuming contaminated corn themselves instead of destroying it. A similar pilot in Nigeria - Nigeria Aflasafe™ Challenge Project was widely supported by mission driven organizations such as the Bill and Melinda Gates Foundation, USAID, State Governments etc.,<sup>8</sup> and thus Rafhan should leverage its investment in the research and development of AflaPak™ to partner with foundations, key global clients to share in the future costs of rolling out AflaPak™ to corn growers.

### Methodology

Future costs of the AflaPak™ roll out plan are estimated by including the AflaPak™ (product) costs, allocated costs for agronomist support to growers and price premium paid to corn growers. Price premium represents an amount over and above the market price of corn that Rafhan would likely pay its growers to incentivize Aflapak™ adoption and/or to cover grower's costs of applying AflaPak™. Given Rafhan's market leadership position and ability to leverage global account relationships, Rafhan should be able to pass on this price premium in part or in whole to its customers. Estimated total costs are then multiplied with the percentage of the cost sharing assumption (50% in this case) to calculate the total benefits of these arrangements to Rafhan.


### Benefit Value

Expected average annual earnings benefit is \$293K with a 10-year PV totaling to \$1.3M

<sup>8</sup> **\*Note:** The Aflasafe project, a partnership between the Australian Government, the Bill & Melinda Gates Foundation, the Government of Canada, the United Kingdom's Foreign, Commonwealth, and Development Office (FCDO), the United States Agency for International Development (USAID), and the World Bank. Within the project, the prize competition awarded participating maize aggregators a prize of US\$18.75 for each metric ton of AT maize that they procured from smallholder farmers

## Partner Feedback: Embedding ROSI™ into Operations

Ingredion has found the ROSI™ approach to be a highly effective tool in helping us evaluate the true costs and benefits of sustainability initiatives. In the past, our process has been more focused on cost and traditional Return on Investment calculations, but this methodology gives us deeper insight into how we can capture the true benefits associated with a project, both to the company and to society. The monetization models used here will be beneficial not only in helping our Rafhan Maize operations evaluate strategies around combatting Aflatoxin, but in helping us more broadly assess sustainability initiatives across our global enterprise. We look forward to embedding the ROSI™ methodology in future decision making to better understand financial and other impacts, so we can continue to make the best strategic sustainability decisions for minimizing risk and driving growth.



*"In my role as Ingredion's Head of Sustainability, I often face the challenge of justifying the business case for investment in one project over another. The ROSI™ tool has given us great insight on the various considerations that factor into that financial justification and has evolved how we will address this challenge going forward"*

**Brian Nash, Vice President, Corporate Sustainability, Ingredion Inc.**

## Conclusion

Aflatoxins regularly **contaminate crops** and pose a **severe health risk** to plants, humans and animals. Crop and livestock loss pose an economic risk to growers while consumption of contaminated produce can cause significant public health issues. Even though regulations on acceptable levels of aflatoxin in produce in developing countries such as Pakistan are still evolving, Rafhan has an opportunity to be proactive in managing regulatory compliance and also fulfilling its environmental goals. Promoting the use of AflaPak™ will increase access to clean corn and opens up Rafhan products to export markets.

Numerous studies and field experiments have confirmed the efficacy of biocontrol agents when applied to the corn fields in controlling aflatoxins. Rafhan has already taken the important step of investing, creating and testing a biocontrol product suitable for Pakistan. NYU Stern CSB's analysis shows that promoting the use of AflaPak™ within its corn procurement operations has financial benefits for Rafhan. The ROSI™ monetization model yields a total **10-year Net Present Value of \$9.3M (Present value of total benefits \$15.5M less program costs of \$6.1M)**. **On an average annual basis, the net benefit is likely to be \$2.1M over the same period.**

Lastly, the ROSI™ tools help foster discussions on sustainability investments and their prioritization, embedding it across functional areas within the organization (sustainability, sales and marketing, procurement, HR, finance) helps enhance resiliency and accountability.



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