Comparative Analysis of Plastic versus Cardboard Banana Corner Boards

FINAL REPORT

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1 Summary

Corner boards, often called “angle boards,” are a commonly used form of tertiary packaging. In the fresh produce industry, corner boards are used to address weaknesses in the structural integrity of pallets of produce during their transport and distribution. In the banana industry, a sector described by vendors as having experienced little innovation in decades due to cost competitiveness pressures, a move from plastic to cardboard corner boards has been proposed.

The following is a concise description of results produced by an indicative environmental and economic analysis that compared the potential implications – opportunities, challenges, costs, and risks – associated with an assumed current state where 50 percent of plastic banana corner boards manufactured from recycled sheaths and string used during the growing of bananas, 50 percent of corner boards are manufactured from virgin plastic, and just 10 percent of all plastic corner boards are recycled, versus:

- All plastic corner boards manufactured from recycled sheaths and string, of which 90 percent are recycled; and
- All cardboard corner boards manufactured from virgin pulp fiber, of which 90 percent are recycled.

This report identifies GHG emissions associated with banana production and transport. Reported as carbon dioxide equivalents (CO_2E), this includes: plastic used in the production of bananas, along with GHGs associated with corner boards manufactured from recycled and virgin plastic, and virgin (cardboard) fiber. Costs are aggregated averages based on individual vendors’ responses. The boundary of the comparison is virgin plastics used in the production of bananas and their disposal versus recycling, landfill or burning, through to the disposal of corner boards via recycling or landfill. GHG emissions associated with transport and distribution are beyond the scope of this analysis.

Based on insights provided by produce industry and packaging material experts, and a review of the literature related to banana production and marketing, three scenarios were developed to estimate the effect of packaging material decisions on total GHG emissions. The lowest CO_2E emissions (3,162 tonnes) is where all corner boards are manufactured from recycled plastics first used in the production of bananas, of which 90 percent are recycled on receipt in Canada. This is one third of the 9,672 tonnes of CO_2E emissions associated with cardboard corner boards having been manufactured from virgin fiber, of which 90 percent are recycled.

Eighty percent of produce industry respondents and packaging material experts consulted during the study believed that cardboard corner boards have less structural integrity than those manufactured from plastic. The respondents feel that this could lead to an increase in shrink, and subsequently GHG emissions.

If an additional half of one percent (0.5%) above current levels of bananas imported into Canada are damaged during transportation and subsequently lost during distribution or at the point of sale, compared to having established a circular economy for the majority of plastics associated with the production and transportation of bananas, the true total emissions due to a widespread move to cardboard corner boards equates to 11,420 tonnes of CO_2E. This is 133 percent more than the

current state scenario of 4,909 tonnes of CO_2E. With a typical car annually emitting 4.6 tonnes of CO_2E (EPA, 2021), this is equivalent to 1,415 cars being driven for a year. On a per unit basis, based on 2021 imports, this potential increase in total emissions equate to 0.20kg of CO_2E per 40lb carton. For reasons detailed in the report, the widespread move to cardboard corner boards could increase the cost of a 40lb carton of bananas by 23 cents. For overall industry, this equates to $7.45 million.

Without having found alternative solutions for banana sheaths and string, a widespread move to cardboard would also go against a recognized need to prioritize the responsible management of plastics used in the production of bananas.

In addition to assessing the potential environmental and economic effects associated with plastic versus cardboard corner boards, the analysis assessed challenges and opportunities pertaining to the recycling of plastic and cardboard in Canada. The findings concluded that it is primarily the present system, not the material itself, which limits the recycling of plastic corner boards.

2 Analysis

The analysis of secondary data established baseline estimates of CO_2E intensities of packaging materials and banana growing. Data on the degree to which CO_2E emissions are exacerbated or mitigated by the recycling, landfilling or burning of packaging materials was also sourced. Data on GHG emission intensities was sourced from peer-reviewed life cycle analysis (Craig & Blanco, 2009), the WARM V.15 model (US EPA, 2020), and publications (FAO, 2021/2022; Berners-Lee & Duncan, 2010). Production and import data were sourced from Statistics Canada (2022), FAO (2021/2022), Agriculture and Agri-Food Canada (2021), Berners-Lee & Duncan (2010), and vendors. Packaging material specifications, along with data on operational and commercial considerations, were captured from confidential discussions with twelve representatives from banana vendors and retailers, and two packaging material experts.

Challenges and opportunities relating to establishing a circular economy by recycling plastic and cardboard corner boards were assessed and validated through discussions with vendors, packaging experts, packaging industry associations, and the analysis of secondary data (Gooch et al, 2020; Gooch et al, 2019; Lord et al, 2016; Cabalova et al, 2011). The research identified that banana corner boards are presently manufactured from a range of materials and combinations of such. These include recycled plastic, virgin plastic, various grades of cardboard, and plastic covered in a cardboard veneer. As compactors are located at distribution centers and many retail stores, cardboard corner boards are presently the easiest to handle from a waste management perspective. For reasons discussed in subsequent sections, this does not however mean that cardboard is automatically appropriate for or able to be recycled.

2.1 Banana Production

The economic production of bananas rests on the utilization of plastic covers that sheath the banana bunch, and plastic string. Due to the role of sheaths in reducing production losses due to diseases and pests, while simultaneously maximizing the yield of marketable bananas, FAO (2021) describe them as an intractable plastic. The vast majority of banana sheaths are single use.

String is used to support the banana bunch and hold the sheath in place, thereby further aiding the economic viability of banana production. In the absence of compostable sheaths, FAO (2021) state that the recovery and recycling of spent sheaths – and string therefore – is an environmental priority. This is because, if not recycled, sheaths and string are buried or burned.

The need to responsibly manage plastics used in the production of bananas was strengthened by the United National Environmental Program General Assembly in March 2022 passing a resolution to establish an international legally binding agreement to end plastic pollution by 2024 (UNEP, 2022).

2.2 Production and Emission Data

The following section summaries the production, material volumes, corner board specifications, and GHG emission intensity data used in the comparative analysis.

In 2021, Canada imported almost 586,520 tonnes of bananas (Statistics Canada, 2022). Based on a typical yield of 19,100 kg of marketable bananas per acre of production, it requires 30,708 acres of plantation to produce the volume of bananas consumed annually in Canada.

Presented below in Tables 2-1 and 2-2 are the production and material volumes used to complete the analysis.

Table 2-1: Banana Production, Corner Board Materials and Specifications

Banana Growing (per annum)		Plastic Corner Boards		Cardboard Corner Boards	
Per acre yield	19,100 kg	Material[2]	75% polyethylene	Material	100% virgin fiber
# Sheaths per acre	1,130		25% polypropylene	Length	1.905 metres
Sheath weight	30gms	Length	1.905 metres	Weight	680gms
String weight[1]	30gms	Weight	470gms		

[1]*Assumed weight of string associated with each bunch of bananas and sheath. For the comparative analysis, both sheaths and string are manufactured from virgin polyethylene.*
[2]*Some plastic corner boards are coated in paper. As the prevalence of this is unknown, it is not included in the analysis.*

Based on a pallet of bananas typically weighing 1,920 pounds (48 x 40lb cartons), this equates to 673,465 pallets, 2.69 million corner boards, and 32.3 million 40lb cartons. Presented in Table 2-2 are material volumes associated with banana production and plastic versus cardboard corner boards, respectively.

Table 2-2: Volume of Production and Corner Board Materials (Metric Tonnes = MT)

Banana Sheaths & String		Plastic Cornerboards[1]		Cardboard Cornerboards[2]	
Total number: sheaths[3]	33.83 million	Total number	2.69 million	Total number	2.69 million
Total weight: sheaths and string	2,030 MT	Total weight	1.266 million MT	Total weight	1.832 million MT

[1] *Manufactured from virgin plastic or recycled plastics (including sheaths and string): 75% High Density Polyethylene (HDPE) and 25% Polypropylene (PP).*
[2] *Manufactured from 100% virgin fiber.*
[3] *Based on 95% of banana sheaths and string each being used once.*

Table 2-3 shows the CO_2E emissions associated with each tonne of virgin and recycled material, along with the impacts of each material being recycled versus landfilled.

Table 2-3: Comparative Emissions Intensities (Metric Tonne CO_2E / Metric Tonne of Material)

Material	Polyethylene (HDPE)	Polypropylene (PP)	Cardboard
Virgin	1.57	1.68	6.15
Recycled	0.73	0.8	2.69
Landfill	0.02	0.02	0.20
Burning/incineration	1.42	1.42	N/A

As detailed in subsequent sections of the report, a demand exists for recycled HDPE in particular, and distinct opportunities exist to improve the plastic recycling system. The greatest challenge impacting the recycling of plastic corner boards is not the material itself, it is how the recycling systems operate and the commercial demand to collect, process and resell recycled plastic resin/flakes/pellets.

3 Scenarios

Three scenarios were employed to complete the comparative analysis described below. Together, they illustrate the comparative CO_2E emissions associated with corner boards manufactured from recycled banana production plastics, virgin plastic, and virgin fiber. Details on the resulting CO_2E emission intensities of each scenario is then presented. The first scenario reflects two industry respondents' assumptions that just 10 percent of plastic corner boards are presently recycled.

Industry and packaging experts stated that manufacturing cardboard corner boards from partly or fully recycled fiber was not an option, because it would result in a measurable loss of structural integrity. Compared to virgin materials, the strength of cardboard manufactured from recycled fibers also degrades faster when exposed to moisture. As confirmed by a literature search (e.g. Cabalova et al, 2011), this is due to the recycling process negatively affecting pulp fiber length and physical characteristics. The scenarios therefore do not include the option of reducing emissions by manufacturing cardboard corner boards from recycled fiber.

3.1 Plastic Corner Boards

Scenario #1: Plastic Corner Boards (Current State)

The first scenario reflects a current state, where half of the banana corner boards imported into Canada are manufactured from recycled plastic and the other half are manufactured from virgin Polyethylene. Calculating the true proportion of corner boards imported in Canada that are manufactured from recycled versus virgin plastic was beyond the scope of this study.

It should be noted that one industry respondent estimated that over 90 percent of banana corner boards imported into Canada may be manufactured from virgin plastic. This would mean that a measurably higher proportion of plastics used in the production of bananas consumed in Canada would be disposed of in landfill or burned, and a higher utilization of virgin plastic, than the scenario presented below implies. Both factors would result in higher emissions than indicated.

- Of plastic banana sheaths and string, 95% is used once, 5% is used twice
- Of the plastic sheaths and string used in banana production that are not recycled into corner boards, 70% is landfilled, 30% is burned
- Half (50%) of plastic sheaths and string used in banana production is recycled into corner boards
- Half (50%) of corner boards is manufactured from virgin plastic
- On receipt in Canada, 10% of plastic corner boards are recycled, 90% is landfilled

Table 3-1: Plastic Corner Boards – Current State CO_2E Emissions

Corner Boards: 50% manufactured from recycled plastic, 50% from virgin plastic	**Tonnes CO_2E**
GHG from plastic bags and plastic string used in banana production	3,177
Disposal of production plastic not used in corner boards (70% incinerated, 30% landfilled)	333
50% of corner board plastic from recycled plastic	473
50% of corner board plastic from virgin plastic	1,008
In Canada, 90% of corner boards landfilled in Canada	25
In Canada, 10% of corner boards recycled in Canada	-107
TOTAL	**4,909**

As can be seen, the total GHG footprint associated with plastic corner boards, of which 50 percent are manufactured from recycled banana sheaths and string, is 4,909 tonnes of CO_2E. This includes the 3,177 tonnes of CO_2E that result from the manufacture of sheaths and string used in banana production, plus the 473 tonnes of CO_2E associated with the conversion of those materials into half of the corner boards imported in Canada, and 1,008 tonnes of CO_2E from the remaining corner boards being manufactured from virgin plastic. In addition, 333 tonnes of CO_2E result from non-recycled production plastic being landfilled and burned; 25 tonnes of CO_2E result from the disposal of 90 percent of corner boards being landfilled. One hundred and seven tonnes of CO_2E is “captured” from 10 percent of corner boards being recycled into new products.

Scenario #2: Plastic Corner Boards (Future State)

The second scenario reflects a future state, where all banana corner boards imported into Canada are manufactured from recycled plastic; 90 percent of which are then recycled in Canada.

- Of plastic banana sheaths and string, 95% is used once, 5% is used twice
- All plastic sheaths and string used in banana production are recycled into corner boards
- On receipt in Canada, 90% of plastic corner boards are recycled, 10% is landfilled

Table 3-2: Plastic Corner Boards – Future State CO_2E Emissions

Corner Boards Manufactured From Recycled Plastic, 90% Recycled	**Tonnes CO_2E**
GHG from plastic bags and plastic string used in banana production	3,177
Recycling of these plastics into corner boards	946
After use, 90% of corner boards recycled in Canada	-964
After use, 10% landfilled in Canada	3
TOTAL	**3,162**

As can be seen, total CO_2E emissions associated with all plastic corner boards being manufactured from recycled banana sheaths and string, of which 90 percent are recycled in Canada, is 3,162 tonnes. Compared to Scenario #1, this represents a 1,747 tonne (36%) reduction in CO_2E emissions. This is due to a circular economy having been established for the majority of plastics associated with the production and transportation of bananas.

3.2 Cardboard Corner Boards

The third scenario reflects a situation where all banana corner boards are manufactured from virgin fiber. Calculating, for comparative purposes, the proportion of corner boards presently imported into Canada that are manufactured from cardboard is beyond the scope of this study.

- Of plastic banana sheaths and string, 95% is used once, 5% is used twice
- Of the plastic sheaths and string used in banana production, 70% is landfilled, 30% is burned
- All corner boards are cardboard, manufactured from 100% virgin fiber
- On receipt in Canada, 90% of cardboard is recycled and 10% is landfilled

Table 3-3: Cardboard Corner Boards – CO_2E Emissions

Cardboard Corner Boards Manufactured from Virgin Fiber, 90% Recycled	Metric Tonnes CO_2E
GHG from plastic bags and plastic string used in banana production	3,177
If 30% bags/string burned (or incinerated) in production region	866
If 70% bags/string landfilled in production region	31
Cardboard manufactured from 100% virgin fiber	11,267
After use, 90% of corner boards recycled	- 5,706
After use, 10% cardboard corner boards landfilled	37
Total tonnes GHG	**9,672**

Due to a circular economy not having been established for plastics, all production plastics are landfilled or burned. As can be seen, the total CO_2E footprint associated with cardboard corner boards manufactured from virgin fiber is 9,672 tonnes of CO_2E. This is 4,763 tonnes of CO_2E higher than scenario #1, and 6,511 tonnes of CO_2E higher than scenario #2.

This 133 percent difference compared to scenario #2 is partly due to none of the 3,177 tonnes of CO_2E resulting from the manufacture of sheaths and string used in banana production having been "captured" by recycling, plus another 897 tonnes of CO_2E which result from 30 percent of that material being incinerated and 70 percent being landfilled (866 and 31 tonnes, respectively). Of the 11,267 tonnes of CO_2E emissions associated with the manufacture of cardboard corner boards from virgin fiber, 5,706 tonnes is "captured" from 90 percent of the corner boards being recycled. The disposal of 10 percent of the corner boards in landfill equates to an additional 37 tonnes of CO_2E.

4 Unintended Consequences

The majority (80 percent) of industry respondents and both packaging material experts voiced a number of concerns regarding a widespread transition from plastic to cardboard corner boards. These concerns included the integral strength of cardboard versus the integral strength of plastic, particularly given the humid conditions in which bananas are transported. Concerns regarding the ability to guarantee the availability of the high quality cardboard necessary to ensure the integrity of cardboard corner boards were also voiced by industry and packaging experts alike.

Additional concerns include that the exponential increase in demand being experienced by the cardboard packaging industry, combined with challenges relating to the access of virgin fiber, will further (negatively) affect the quality, consistency and supply of corner boards. Concerns were also expressed about the timelines and scale of potential price increases; especially given the impact of geopolitical uncertainties, such as the Ukrainian war, on fiber availability and supply. As previously mentioned, because recycled fiber negatively affects cardboard's structural integrity, particularly in high-moisture environments, the inclusion of recycled fiber is not considered a viable option.

Feedback received from industry and packaging experts, along with reviewed materials such as FAO (2021/2022) and UNEP (2022), suggested that the scenarios presented in Section 3 do not adequately reflect the true potential effects of a widespread move from plastic to cardboard corner boards. Therefore, scenarios regarding true emissions and true costs are presented below.

4.1 Total Emissions

Multiple discussions with vendors and packaging experts led to an assumption that the loss of structural integrity associated with moving to cardboard corner boards could lead to increased losses (shrink) during transport and distribution due to damage. If the embedded footprint of each tonne of bananas equates to 0.726 tonnes of CO_2E emissions, as shown below in Table 4-1, the environmental impact of a half of one percent increase in the volume (2,933 tonnes) of bananas being lost during distribution and at the point of purchase by consumers equates to an increase of 1,748 tonnes in avoidable CO_2E. This estimate assumes that a proportion of CO_2E emissions (381 tonnes) is captured by 100 percent of these bananas having been composted.

Table 4-1: Banana Production, Loss and Destination Effects (Tonnes CO_2E)

Food Production and Destination GHG	Metric Tonnes of Bananas	Tonnes CO_2E per Tonne of Bananas	Tonnes CO_2E
If 0.5% loss due to change in packaging	2,933	0.726	2,129
100% loss is composted		-0.13	- 381
Emission of avoidable GHGs due to a 0.5% increase in shrink over current levels			**1,748**

Presented below in Table 4-2 is the complete comparative analysis of GHG emissions associated with the three scenarios, plus the additional half of one percent of bananas being lost due to the integrity of cardboard corner boards not matching that of corner boards manufactured from virgin plastic.

Table 4-2: Total Potential GHG Emissions Associated with Each Scenario (Tonnes CO_2E)

Scenario	Material from Which Corner Boards Manufactured	Corner Board (tonnes CO_2E)	Increased Shrink (tonnes CO_2E)	Total GHG (tonnes CO_2E)
Scenario #1	Plastic: 50% recycled, 50% virgin	4,909	0[1]	4,909
Scenario #2	Plastic: 100% recycled	3,162	0[1]	3,162
Scenario #3	Cardboard: 100% virgin	9,672	1,748	11,420
Increase in emissions associated with move to cardboard				**6,510**

[1]*It is assumed that this scenario will not increase distribution and point of sale shrink above current levels.*

As can be seen, compared to the assumed current state (scenario #1), the total potential emissions associated with a widespread move from plastic to cardboard corner boards, manufactured from virgin fiber, equates to more than a doubling of the annual emissions. This 6,510 tonne elevation of CO_2E above current levels represents a 133 percent increase in emissions.

In addition to increased GHG emissions, the widespread use of cardboard corner boards would go against the agricultural production plastic priorities identified by FAO (2021), and the General Assembly of the United Nations Environmental Program's aim to establish an international legally binding agreement to end plastic pollution (UNEP, 2022) by 2024. The recycling of production and corner board plastics would align with the FAO and UNEP mandates, and represents a 1,748 tonne reduction in CO_2E. Compared to current state scenario, this equates to a 36 percent decrease in emissions.

4.2 Per Carton Costs and Emissions

The cost of corner boards manufactured from recycled and virgin plastic is assumed to be similar. Discussions with industry identified that, compared to plastic corner boards, on average, cardboard corner boards are likely to increase the current cost of a 40lb case of bananas by 12 cents. If an unintended consequence of changing to cardboard was an additional half of one percent of imports being lost due to damage during transportation (based on it costing $22 to land a 40lb carton of bananas in Canada), as shown below in Table 4-3, the true cost of moving to cardboard corner boards would be 23 cents per carton. As also shown below, excluding transport and distribution, based on 32.3 million 40lb cartons of bananas having been imported into Canada in 2021, the additional GHG emissions described in Section 4.1 cardboard corner boards equate to 0.35kg of CO_2E per 40lb carton. This represents an increase of 0.2kg CO_2E per carton above current emissions (scenario #1).

Table 4-3: True Potential Emissions and Costs

	Per 40lb Carton	
	$	**kg CO_2E**
Plastic corner boards (scenario #1)	Current Cost	0.15
Cardboard corner boards	$0.12	0.30
Impact of expected shrink (0.5% of total volume)	$0.11	0.05
Total cardboard corner boards (scenario #3)	$0.23	0.35
Comparative Per 40lb Carton Increase in Costs and Emissions	**$0.23**	**0.20**

Based on Statistics Canada data that the equivalent of 32.3 million 40lb cartons of bananas were imported into Canada in 2021, the annual cost implications associated with the industry as a whole transitioning from plastic to cardboard corner boards equate to $7.45 million.

5 Post-Life Disposal or Reuse of Corner Boards

The research identified opportunities and challenges relating to the post-life management of plastic and cardboard corner boards. Described below, then summarized in Table 6-1, these factors relate to packaging materials and design, recycling, and alternative options: complete removal and reuse.

5.1 Plastic Recycling

For plastic, packaging experts stated that a growing demand exists for polyethylene that can be recycled into dark plastics, such as automobile components. The key challenge, experts expressed, is that Material Recovery Centres (MRFs) are set up to handle discrete packaging such as bottles and cans, not long unusually shaped items such as corner boards. This could be addressed by sending corner boards directly to recycling facilities. The fact that corner boards often contain 25 percent polypropylene, say packaging material experts, does not inhibit their recycling.

In most cases, the wrapping of plastic corner boards in paper would, however, prevent their recycling. This is particularly the case if the paper or adhesive contains ingredients that degrade the quality of recycled plastic.

5.2 Recycling Cardboard

While a high proportion of cardboard is compacted at distribution centers and stores, which eases its management compared to plastic corner boards, manufacturing corner boards from cardboard does not automatically guarantee that they will be recycled.

The described effect of recycling on pulp fiber's structural strength and resilience means that the inclusion of meaningful amounts of recycled material could only be achieved by applying a hydrophobic barrier, which could limit cardboard's recyclability. A hydrophobic layer of atomized plastic that exceeds five percent of the cardboard corner boards' total volume, applying a layer of plastic instead of atomized plastic, or the use of waxed cardboard, would almost invariably prevent cardboard from being recycled. The same factors will negatively affect the revenue that can be captured by directing cardboard into the recycling stream.

5.3 Alternative Solutions

In terms of alternative solutions, a number of industry respondents proposed two innovative options: 1) removing corner boards completely, and 2) establishing a closed loop (returnable) systems.

A number of respondents suggested that corner boards account for an estimated 10 percent of a pallet's total integral strength; the majority of a pallet's integral strength coming from the skid, cartons, binding, and the bananas themselves. Opportunities cited by respondents include removing corner boards completely by redesigning cartons; for example, increasing glue strength and replacing current banding with webbing that does not restrict airflow.

The removal of corner boards could 1) provide cost and labour savings, 2) provide logistical benefits such as not having to manufacture, distribute and store corner boards, 3) ease the breaking of skids, and 4) reduce transport-related GHG emissions. Respondents all stated, however, that removing corner boards without modifying current carton and banding design was not an option. A number of respondents also stated that it would not address challenges relating to the responsible management of plastics used in the production of bananas.

The second option is establishing a closed loop system, enabling corner boards to be returned and reused in the same way as occurs with returnable plastic containers (RPCs). Respondents stated that ships returning to banana producing regions have underutilized capacity, meaning that international transportation is not an issue. The bigger challenge is establishing the domestic systems required to transport used corner boards to departure ports and their cleaning for phytosanitary reasons.

6 Conclusions and Next Steps

Research findings pertaining to the opportunities, challenges and risks associated with banana corner boards are presented below. From an environmental and economic perspective, evidence suggests that the greatest and most immediate opportunities lie in establishing a circular economy for plastic corner boards. This represents the opportunity to decrease total GHG emissions by 36 percent. Compared to the current state, a widespread move to cardboard corner boards represents a total potential increase of 6,510 tonnes of CO_2E. This represents a more than doubling (133 percent) of total GHG emissions. Based on the estimation that a typical car annually emits 4.6 tonnes of CO_2E (EPA, 2021), this is equivalent to 1,415 cars being driven for a year. The estimated cost implication of this change is $0.23 cents per 40lb carton, and $7.45 million per year for the overall industry.

Depending on circumstances that pertain to production region, along with transport and distribution arrangements, longer-term options may include redesigning cartons and tertiary packaging to enable the removal of corner boards and establishing a closed loop system where corner boards are used multiple times. Both these options would significantly reduce GHG emissions.

Table 6-1: Post-Use Material Management and Alternative Options

	Plastic Corner Boards	Cardboard Corner Boards	Alternative Option 1	Alternative Option 2
Opportunities	• Increase volume of boards recycled • Capture revenue from recycling	• Ensure consistent and predictable structural integrity • Revenue stream	• Remove corners completely • Reduce logistical and labour costs	• Circular returnable system • Utilize existing freight capacity
Challenges	• MRFs inability to handle corners • Establishing dedicated recycling streams	• Comparative costs and GHG emissions • Criticality of fiber quality, consistency	• Requires changes to carton design • Testing and validating design, cost structure	• Reverse collection and delivering to port • Testing and validating design, cost structure
Risks	• Direct to recycling delivery systems • Resistance to change	• Unviable economic model, higher GHGs • Inability to recycle	• Insufficient testing and analysis • Resistance to change	• Management and coordination costs • Resistance to change

6.1 Next Steps

The research and analysis described in this document produced indicative findings. No evidence was found of a thorough change impact study having been completed to evaluate the full effects of transitioning from plastic to cardboard corner boards and determining alternative options through objective whole-of-chain testing, experimentation and measurement.

Summarized below is a concise description of what a full change impact study that extends from growing region to retail DCs and stores would encompass and how it could be completed. Given that change will invariably be resisted in some manner, one objective of an impact analysis is to expose possible resistance to change and manage that resistance, should it materialize. Another objective of the change impact study is to establish realistic timelines over which the proposed innovations would occur and determine tollgate reviews for evaluating progress against predetermined targets.

Stakeholder Engagement

Provide a short description of the proposed change and why it is required. Include all elements of production, packing, shipment and retailer operations that will be impacted by the change and ask stakeholders for their input on aspects of the proposed change which is applicable to them.

Research Questions

1. What is the proposed specification of the new corner board?
   a. How does it compare to the current corner boards?
   b. How will the change impact product shrink?
2. Have the alternate corner boards been tested to confirm that they meet specification?
   a. What was the outcome of the test?
3. What is the economic order quantity for the new corner boards?
   a. How does this compare to the current boards?
4. Is any additional or modified storage required for the new corner boards?
5. Are any changes to internal handling processes required as a result of the proposed change?
6. Does the same process for locating corner boards to skids apply to the new boards?
   a. Does the change impact the packing labour content?
7. What is the backup plan if:
   a. Packers run out of new corner boards?
   b. There is a problem with corner boards?
8. Are there any changes to packed banana shipping processes and costs?
9. How are the new corner boards to be handled and disposed of at:
   a. DCs
   b. Retail stores
10. Are any changes required to packaging processes, disposal equipment, or carriers?
11. What is the proposed cut in point (time, location, customer, etc.) that the change will occur?
    a. How is any old stock to be disposed of?
12. What is the difference in cost between the new corner boards and the existing corner boards?

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