2017 Sustainability Lab Project

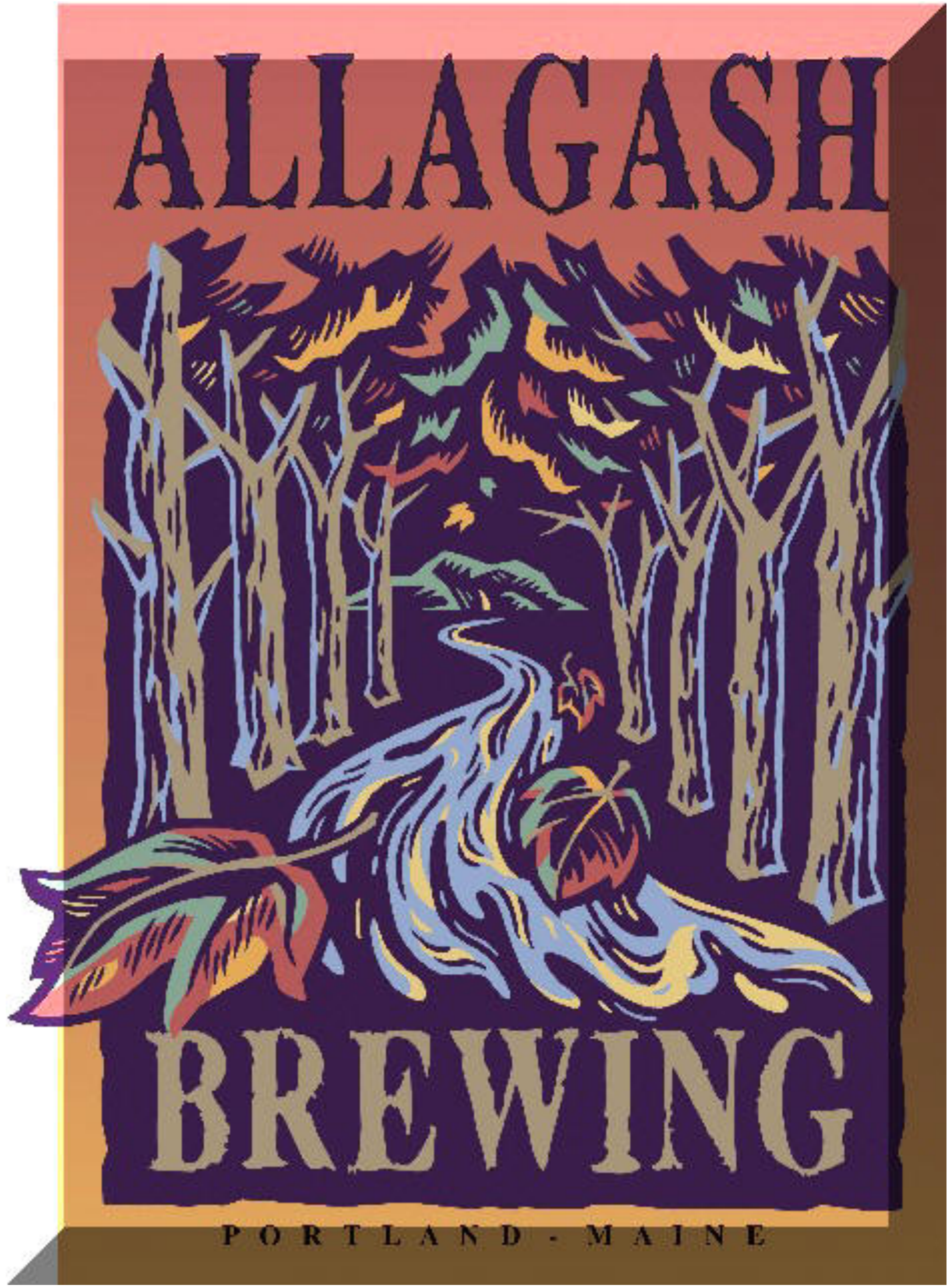
Presented by:

Rodrigo Errea
Ben Housman
Kyle Hurst

May 18, 2017

MIT MANAGEMENT SLOAN SCHOOL

ALLAGASH BREWING COMPANY



Contents

Overview

Allagash Problem Statement

Allagash has committed to purchasing <u>1 million lbs</u> of grains annually from Maine farmers by 2021

- Currently, Allagash purchases ~100,000 lbs of local grains annually, which represents approximately 2% of their total grains purchased
- Grain prices from local Maine farmers are approximately 2-3x higher than prices from farmers in Wisconsin (where Allagash currently purchases ~98% of its grains)

Allagash Sixteen Counties Beer

(Local Beer Brewed Using Only Maine Grains)

MIT MANAGEMENT SLOAN SCHOOL

ALLAGASH BREWING COMPANY

Overview

Executive Summary

Given our *preliminary* analysis, if Allagash were to purchase an extra 900,000 lbs of Maine grains then the company could create approximately 20 new local jobs and reduce carbon emissions by 55,000 kg of CO2 eq at an additional purchasing cost of $390,000

Summary Table

	Difference (New Supplier Mix minus Business As Usual)					Minimize Costs - Optimal Supplier Mix					Business As Usual[1]				
	Cost Impact			Sustainability Impact		Cost Impact			Sustainability Impact		Cost Impact			Sustainability Impact	
	Supply *(lbs)*	Price *($/lb)*	Cost *($/yr)*	Local Jobs Created *(count)*	Global Warming *(kg CO2 eq)*	Supply *(lbs)*	Price *($/lb)*	Cost *($/yr)*	Local Jobs Created *(count)*	Global Warming *(kg CO2 eq)*	Supply *(lbs)*	Price *($/lb)*	Cost *($/yr)*	Local Jobs Created *(count)*	Global Warming *(kg CO2 eq)*
Barley															
Midwest	-700,000	$0.00	-$245,000	*n/a*	-693,581	5,950,000	$0.35	$2,082,500	*n/a*	5,895,440	6,650,000	$0.35	$2,327,500	*n/a*	6,589,021
Local	700,000	$0.06	$512,656	15	655,024	800,000	$0.72	$579,178	17	748,598	100,000	$0.67	$66,521	2	93,575
Wheat															
Midwest	-200,000	$0.00	-$60,000	*n/a*	-186,072	700,000	$0.30	$210,000	*n/a*	651,251	900,000	$0.30	$270,000	*n/a*	837,323
Local	200,000	*n/a*	*n/a*	5	169,352	200,000	$0.90	$180,157	5	169,352	0	*n/a*	*n/a*	0	0
Oats															
Midwest	0	$0.00	$0	*n/a*	0	900,000	$0.30	$270,000	*n/a*	634,591	900,000	$0.30	$270,000	*n/a*	634,591
Local	0	*n/a*	*n/a*	0	0	0	*n/a*	*n/a*	0	0	0	*n/a*	*n/a*	0	0
Total	**0**	**$0.05**	**$387,813**	**20**	**-55,277**	**8,550,000**	**$0.39**	**$3,321,834**	**22**	**8,099,232**	**8,550,000**	**$0.34**	**$2,934,021**	**2**	**8,154,509**

Notes:

[1] Business as usual assumes 100,000 lbs of grains are purchased in Maine.

Contents

Supplier Landscape

Industrial Midwest

BRIESS® MALT & INGREDIENTS Co.
All Natural Since 1876

Local Maine

MAINE GRAINS
BLUE OX MALTHOUSE
100% ORGANIC Aurora MILLS & FARM
MAINE MALT HOUSE EST. 2015

98% of Grain Supply

- **Malted Barley:** 3.5M lbs
- **Wheat:** 2.1M lbs
- **Oats:** 0.35M lbs

2% of Grain Supply

- **Malted Barley:** 0.07M lbs
- **Wheat:** 0.007M lbs
- **Oats:** 0.019M lbs

MIT MANAGEMENT SLOAN SCHOOL
ALLAGASH BREWING COMPANY

Capacity Constraints

- **Maine's primary agricultural export is potatoes**
  - Shifted from grains in the 20th century
- **1.65M lbs of Barley are produced in Maine annually (as of 2012)**
  - The majority of the Barley is used for feedstocks
  - Not malt quality
  - Farmer techniques, inadequate storage facilities, and low demand constrain growth
- **Maine only has two malt houses**
  - These malt houses are limited to 400,000 lbs of malted grain per year per malt house
  - Maine Malt House is currently working to increase capacity by 500%
- **Recent increase in red wheat production for bakeries**
  - White wheat is not produced in significant quantities in Maine currently

Contents

MIT MANAGEMENT SLOAN SCHOOL ALLAGASH BREWING COMPANY

Approach

Preliminary Data Analysis

We analyzed suppliers cost, labor and emissions data to obtain reasonable inputs for our model.

Optimization Modeling

We built two **optimization models** using the data to inform Allagash of the optimal grain mix while considering various constraints (local supply requirement, farmer and malting capacities, grain mix, etc.)

Quantifiable Results

We then summarized and quantified the: **(1) economic** and **(2) sustainability** implications of increasing local Maine grain supply by 9x in the next five years versus Allagash's "business as usual" case.

Key Inputs

Cost

- **Grain prices** are a key determinant in assessing the economic impact of purchasing local grains
- **Capacity constraints**, both production and malting, were also considered and affect the supply available for purchase

Local Economy

- **Jobs created** per $ of revenue local farms generate
- **Indirect job multiplier**
- **No job loss in Midwest** due to industrial farming scale and ability to absorb loss of Allagash business

Emissions

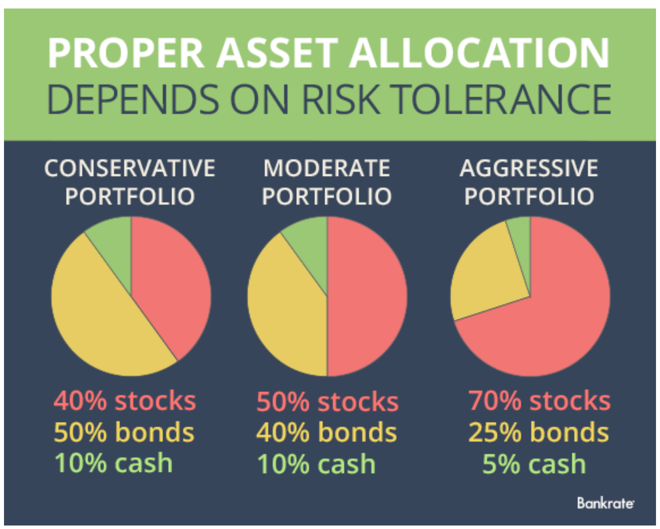
- **Distance** between local farms compared to the Midwest
- **Transportation type** (i.e. truck or rail), which informed:
  - **Freight capacity**
  - **Fuel efficiency**
  - **Emissions rate**

Why Optimization?

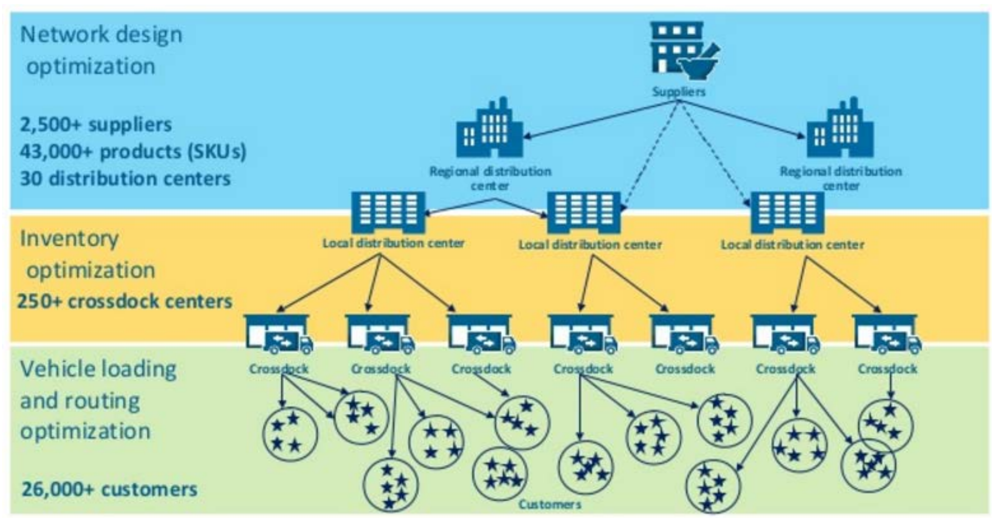
- **Optimization is a common analytical tool used to determine the "optimal", or best, mix of options given various internal rules/targets and external limitations (constraints)**
- **An optimization model can provide Allagash with the lowest cost (i.e. best) mix of Maine and Midwest suppliers to meet its goal of 1M lbs of local grains**

Other Examples of Optimization Modeling

Finance, Investment Portfolios



Retail, Supply Chain Analytics



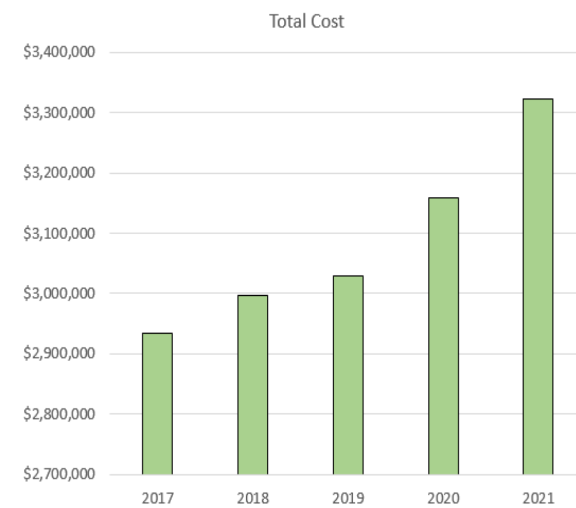
Assumptions – Cost and Local Economy

Cost Assumptions

- Grain and transportation prices are constant
- Prices provided by Allagash are accurate
- All dollars are in "today's" dollars

Cost Impact

Supply *(lbs)*	Price *($/lb)*	Cost *($/yr)*
5,950,000	$0.35	$2,082,500
800,000	$0.72	$579,178
700,000	$0.30	$210,000
200,000	$0.90	$180,157
900,000	$0.30	$270,000
0	*n/a*	*n/a*
8,550,000	**$0.39**	**$3,321,834**



Local Economy Assumptions

- 50% of revenue contributes to wage expenses
- Average worker salary $12.29 [See Works Cited 7]
- 2,087 annual work hours/worker
- 1.5 standard job multiplier for indirect job creation
- Job creation in Maine will not impact jobs at Midwest supplier since Allagash is a small customer for them.

Local Economy Impact

	(Units)		Jobs creation *Local*	*Data Source*
Wage Expense	*(% of Revenue)*	*[1]*	50%	**Assumption
Average Worker Salary	*($/hr)*	*[2]*	$12.29	University of Maine Enterprise Budgets
Work Hours per Year	*(hrs/yr)*	*[3]*	2,087	U.S. Office of Personnel Management
Salary per Year	*($/yr)*	*[4]*	25,649	[4] = [2] * [3]
Jobs Equivalent	*(Direct Jobs/$)*	*[5]*	0.000019	[5] = [1] / [4]
Job Multiplier	*(Total Jobs/Direct Jobs)*	*[6]*	1.5	Standard assumption
Total Job Creation	**(Total Local Jobs/$)**	***[7]***	**0.000029**	**[7] = [5] * [6]**

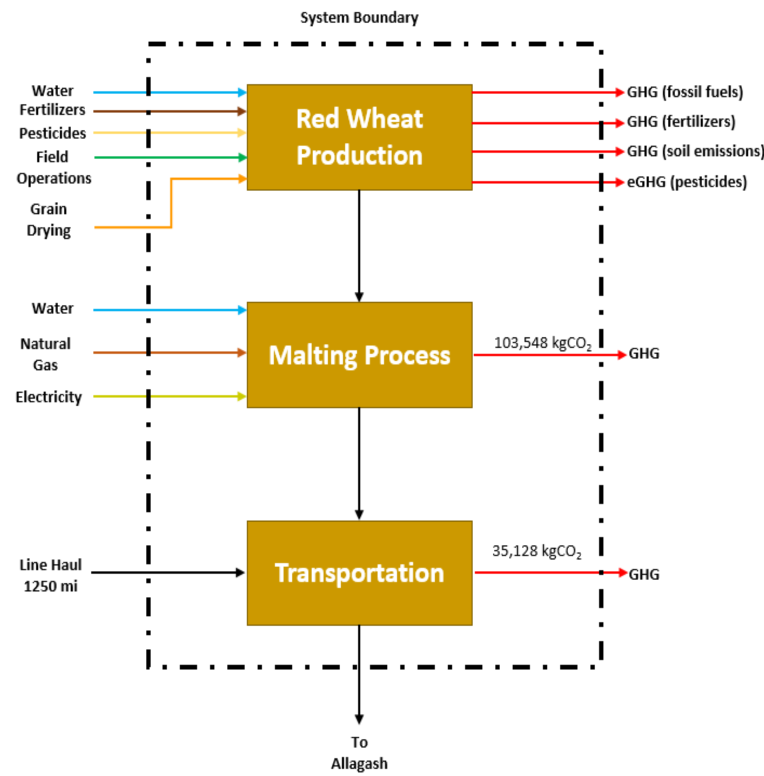
MIT MANAGEMENT SLOAN SCHOOL

ALLAGASH BREWING COMPANY

Framework & Analysis

Assumptions - Emissions

- Due to supplier process data constraints, all agricultural emissions are assumed the same for commercial and local suppliers [See Works Cited 2, 3, 4, 5, 6]
- Agriculture production per grain assumed industry standard values associated with analogous climates [2]
- Rail fuel efficiency assumed to be 423 short ton-miles per gallon
- Line haul efficiency assumed to be 6.5 miles per gallon
- Diesel fuel emissions assumed to be 22.38 lbs CO2 per gallon
- Red wheat malting process assumed to produce 30% less emissions than barley malting process due to reduced energy requirements associated with red wheat malting processes [1]
- Blue Ox and Maine Malt House assumed to have max annual capacity of 400,000 lbs of malted grain [7]
- Maine Malt House expansion expected to achieve additional production capacity in 2019



Transportation GHG

Rail			
Distance	1100	miles	(estimated miles from Stevens Point, WI to Newport VT)
Barley	3,500,000	lbs	
Barley	1750	short tons	
Rail Fuel Efficiency	423	mile - short tons / gallon	*CSX.com
CO2 / gallon (diesel	22.38	lbsCO2	
Rail Calculations			
1100 miles × 1750 short tons	gallon / 423 short ton miles	22.4 lbs CO2 / gallon	= 101,847.52 lbs CO2 Annually; 46,294.33 kg CO2 Annually; **0.03 lbs CO2 / lbs Barley**
Line Haul (Truck)			
Distance	423	miles	(estimated miles from Newport VT to Allagash)
Barley	3,500,000	lbs	
Barley	1750	tons	
Truck capacity	25	tons	
Total Trucks	70	trucks annually	
Truck Fuel Efficienc	6.5	mpg	
CO2 / gallon (diesel	22.38	lbsCO2	
423 miles	gallon / 6.5 miles	22.4 lbs CO2 / gallon × 70 trucks annually	= 101,949.51 lbs CO2 Annually; 46,340.69 kg CO2 Annually; **0.03 lbs CO2 / lbs Barley**

Malt GHG

GHG Emissions per six pack (average	167.60	grams CO2	(Fat Tire LCA)
Total Malt Weight per sixpack	463.50	grams	
GHG to Malt Ratio	0.36	dmnl	
Total Malted Barley	3,500,000.00	lbs	
Estimated GHG for Malted Barley	1,265,587.92	lbs CO2	
Est. GHG for Malted Barley	575,267.24	kg CO2	
Est. CO2 / lbs Barley	0.36	lbs CO2 / lbs Barley	

Agriculture GHG

Average Barley Yield per hectare	3,380.00	kg/hectare
Annual Demand	1,590,909.09	kg
Annual Demand	470.68	hectare
Total GHG emissions per hectare	1,930.00	kg/hectare
Estimated GHG for Barley Production	908,418.50	kg CO2
Estimated GHG for Barley Production	1,998,520.71	lbs CO2
Est. CO2 / lbs Barley	0.57	lbs CO2 / lbs Red Barley

Optimization Model 1 – Minimize Cost

Model 1: Minimize total economic costs of purchasing grains while meeting local sourcing targets

Total Cost of Sourcing: Objective Function

Sustainability Impacts

Allagash Inputs/Outputs

Total Cost

$	3,333,150

(blue)	Inputs
(green)	Outputs

Annual Demand

Total Beer Demand	90,000	*(barrels)*
	lbs/Barrel*	**lbs/year**
Barley	75	6,750,000
Red Wheat*	10	900,000
Oat	10	900,000
Total		8,550,000

*Estimates

**White wheat not currently produced in Maine

Sustainability Issue Caps

	Sustainability Issues[1]	Max/Min Value	Total Value
GW	Global Warming - Max (kg CO2 eq)	1,000,000,000	7,581,000
LE	Local Economy - Min (Jobs Impacted)	-	225
		-	-

Local Sourcing Minimum (lbs)	999,999	999,999
Local Sourcing Maximum (lbs)	1,000,000	999,999

Local Sourcing Target

MIT MANAGEMENT SLOAN SCHOOL ALLAGASH BREWING COMPANY

Optimization Model 2 – Minimize Impacts

Model 2: Minimize sustainability impacts while meeting local sourcing targets

Total Cost of Sourcing

Sustainability weight

Sustainability Impacts

Allagash Inputs/Outputs

Total Cost	
$	3,527,500

(blue)	Inputs
(green)	Outputs

Annual Demand

Total Beer Demand	90,000 *(barrels)*	
	Lbs/Barrel	Pounds
Barley	75	6,750,000
Wheat	10	900,000
Oat	10	900,000
Total		8,550,000

Sustainability Issue Caps

Importance		Sustainability Issues[1]	Target Value	Total Value	Relative Value
10%	GW	Global Warming (kg CO2 eq)	8,000,000	8,042,980	1.01
90%	LE	Local Economy (Jobs Impacted)	1	225	225.00
					(202)

Local Sourcing Minimum (lbs)	999,999	1,000,000
Local Sourcing Maximum (lbs)	1,000,000	1,000,000

Objective Function

Local Sourcing Target

Optimization Models – Supplier's information

Each supplier faces capacity constraints and impacts both the environment and the local economy differently

Decision Variables: How much to buy from each supplier

Sustainability Impacts per supplier

Detailed Supplier Inputs/Outputs

	Barley					
	Xi	Price	Cost	Capacity	GW	LE
	(lb)	($/lb)	($)	(lb/year)	(CO2/lb)	(Jobs/pound)
Briess	6,050,000	0.35	$2,117,500	15,000,000	0.99	0
Maine Malthouse	0	0.78	$0	700,000	0.94	0.00023
Blue Ox	700,000	0.67	$465,650	700,000	0.94	0.00023
Supplier 4	0	10.00	$0	-	0.94	0.00023
Supplier 5	0	0.70	$0	-	0.94	0.00023
Supplier 6	0	0.57	$0	-	0.94	0.00023
Supplier 7	0	0.90	$0	-	0.94	0.00023
Supplier 8	0	0.36	$0	-	0.94	0.00023
Supplier 9	0	0.94	$0	-	0.94	0.00023
Supplier 10	0	0.70	$0	-	0.94	0.00023
Total	**6,750,000**	**$0.38**	**$2,583,150**		**6,649,546**	**157.5**

Capacity per supplier

MIT MANAGEMENT SLOAN SCHOOL

ALLAGASH BREWING COMPANY

Optimization Models Results

Both models recommend the best quantity per grain type and per supplier to achieve the firm's local targets while satisfying its constraints

Detailed Supplier Inputs/Outputs

Barley							
Name	Category	Xi	Price	Cost	Capacity	GW	LE
		(lb)	*($/lb)*	*($)*	*(lb/year)*	*(CO2/lb)*	*'Jobs/pound)*
Briess	*(Midwest)*	5,750,000	0.35	$2,012,500	15,000,000	0.99	0
Maine Malthouse	*(Local)*	300,000	0.78	$234,819	700,000	0.94	0.00023
Blue Ox	*(Local)*	700,000	0.67	$465,650	700,000	0.94	0.00023
Supplier 4	-	0	10.00	$0	-	0.94	0.00023
Supplier 5	-	0	0.70	$0	-	0.94	0.00023
Supplier 6	-	0	0.57	$0	-	0.94	0.00023
Supplier 7	-	0	0.90	$0	-	0.94	0.00023
Supplier 8	-	0	0.36	$0	-	0.94	0.00023
Supplier 9	-	0	0.94	$0	-	0.94	0.00023
Supplier 10	-	0	0.70	$0	-	0.94	0.00023
Total		**6,750,000**	**$0.40**	**$2,712,969**		**6,633,021**	**225.0**
Midwest Total		**5,750,000**	**$0.35**	**$2,012,500**	**15,000,000**	**5,697,274**	**0**
Local Total		**1,000,000**	**$0.70**	**$700,469**	**1,400,000**	**935,748**	**225**

Red Wheat							
Name	Category	Xi	Price	Cost	Capacity	GW	LE
		(lb)	*($/lb)*	*($)*	*(lb/year)*	*(CO2/lb)*	*(Jobs/pound)*
Briess	*(Midwest)*	900,000	0.3	$270,000	1,000,000	0.93	0
Maine Grain	*(Local)*	0	0.90	$0	900,000	0.85	0.00023
Supplier 3	-	0	0.98	$0	-	0.85	0.00023
Supplier 4	-	0	0.76	$0	-	0.85	0.00023
Supplier 5	-	0	0.61	$0	-	0.85	0.00023
Supplier 6	-	0	0.80	$0	-	0.85	0.00023
Supplier 7	-	0	0.65	$0	-	0.85	0.00023
Supplier 8	-	0	0.40	$0	-	0.85	0.00023
Supplier 9	-	0	0.78	$0	-	0.85	0.00023
Supplier 10	-	0	0.93	$0	-	0.85	0.00023
Total		**900,000**	**$0.30**	**$270,000**	**1,900,000**	**837,323**	**0.0**
Midwest Total		**900,000**	**$0.30**	**$270,000**	**1,000,000**	**837,323**	**0**
Local Total		**0**	**#DIV/0!**	**$0**	**900,000**	**0**	**0**

Oats							
Name	Category	Zi	Price	Cost	Capacity	GW	LE
		(lb)	*($/lb)*	*($)*	*(lb/year)*	*(CO2/lb)*	*'Jobs/pound)*
Briess	*(Midwest)*	900,000	0.3	$270,000	1,000,000	0.71	0
Aurora Mills	*(Local)*	0	1.00	$0	700,000	0.57	0.00023
Maine Grains	*(Local)*	0	0.99	$0	-	0.57	0.00023
Supplier 4	-	0	0.80	$0	-	0.57	0.00023
Supplier 5	-	0	0.77	$0	-	0.57	0.00023
Supplier 6	-	0	0.69	$0	-	0.57	0.00023
Supplier 7	-	0	0.48	$0	-	0.57	0.00023
Supplier 8	-	0	0.41	$0	-	0.57	0.00023
Supplier 9	-	0	0.88	$0	-	0.57	0.00023
Supplier 10	-	0	0.76	$0	-	0.57	0.00023
Total		**900,000**	**$0.30**			**634,591**	**0.0**
Midwest Total		**900,000**	**$0.30**	**$270,000**	**1,000,000**	**634,591**	**0**
Local Total		**0**	**#DIV/0!**	**$0**	**700,000**	**0**	**0**

Contents

Recommendations

Ultimately, Allagash's decision about investing in local grains boils down to the company's values. The 1M lb local grain initiative will cost about $390,000 more than if Allagash were to purchase those grains from the Midwest; however, we estimate that it will create approximately 20 more local jobs and ~55,000 fewer kg of carbon emissions.

One consideration that fell beyond the scope of our research but is worth evaluating is the potential branding effect of purchasing more local grains, which could generate positive marketing and reception from consumers as Allagash positions itself as a more sustainable craft brewery. This branding could potentially increase revenues, thereby offsetting the higher cost

Roadmap – Most Economical

55 tons CO2 emissions mitigated

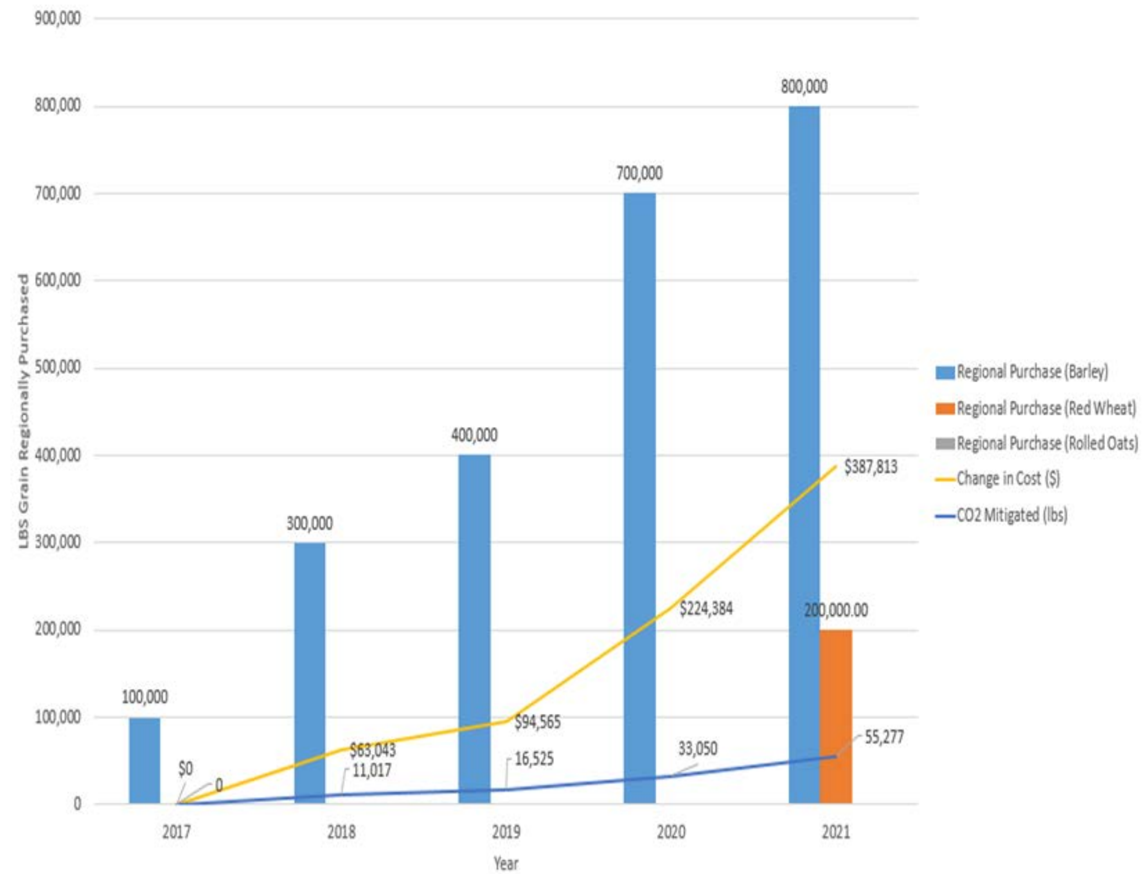
Assuming no capacity change for each supplier

Increased material cost of $390,000

Maximizes malted barley purchase from Maine malting facilities

$7,100 / ton CO2 mitigated

Roadmap to 1M lbs of Local Grains
(Most Economical Strategy)



Roadmap – Most Sustainable

126 tons CO2 emissions mitigated

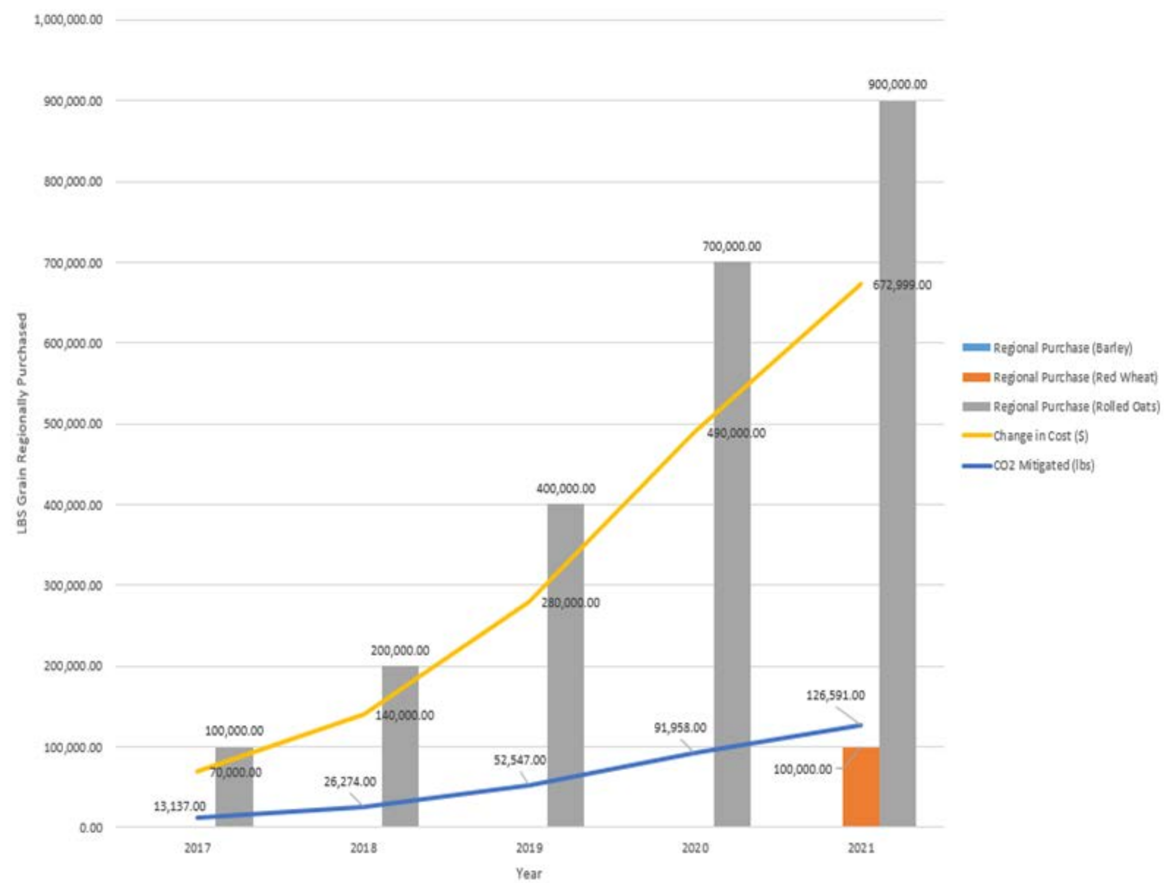
Assuming no capacity change for each supplier

Increased material cost of $675,000

Maximizes rolled oat purchase from local suppliers

$5,500 / ton CO2 mitigated

Roadmap to 1M lbs of Local Grains
(Most Sustainable Strategy)



MIT MANAGEMENT SLOAN SCHOOL
ALLAGASH BREWING COMPANY

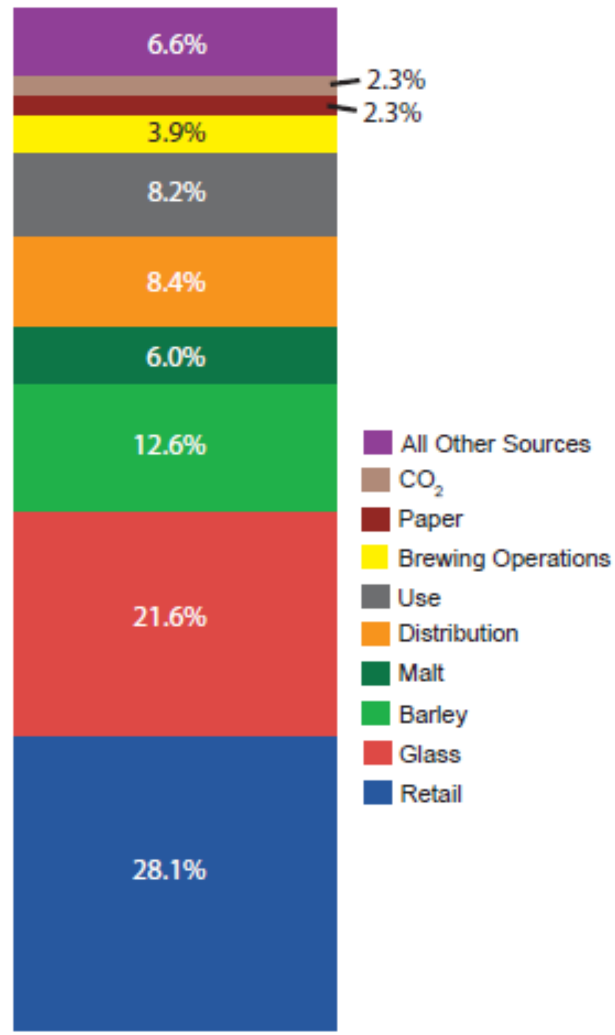
Future Work

Upstream Supply Chain Optimization

- **Coordinate with Suppliers to:**
  - Discuss efficient GHG tilling practices
  - Share grain knowledge
  - Discuss operational sustainability practices
- **Facilitate Grain Storage Cooperative**
  - Discuss investment into grain storage
  - Enter risk sharing contracts to incentivize capacity investment
  - Communicate with suppliers to facilitate planned crop expansion of specific grain strains

Downstream Supply Chain Optimization

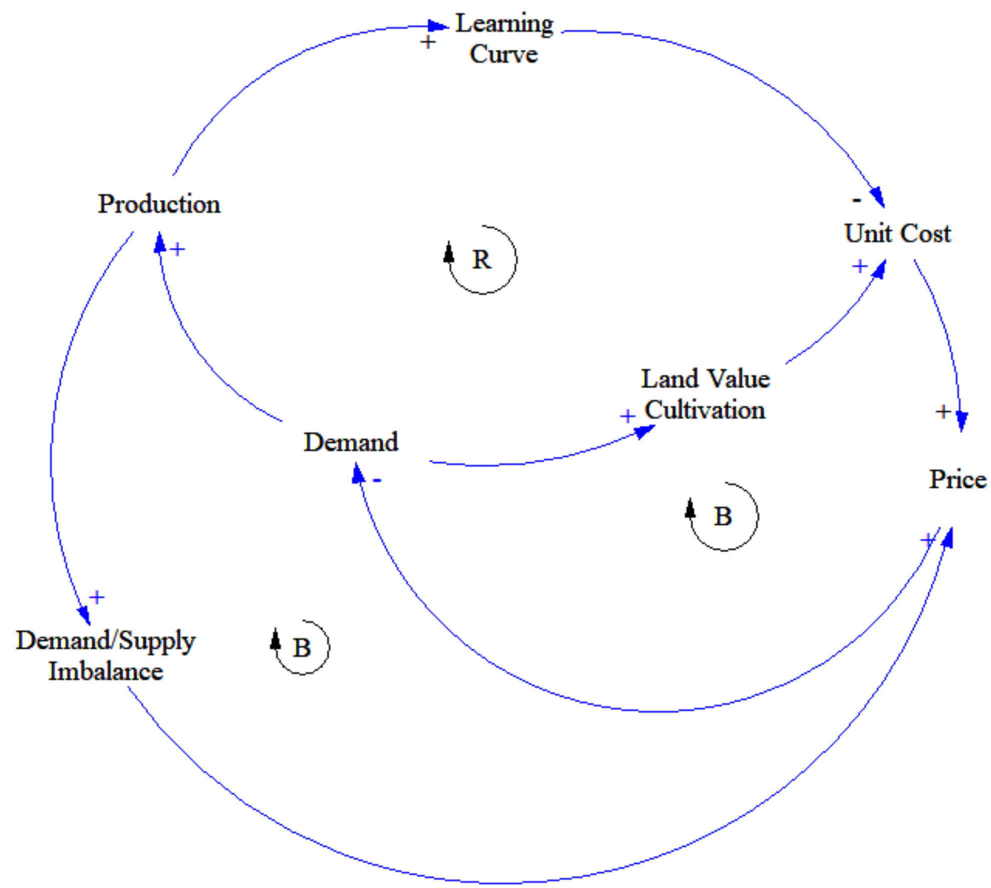
- **Examine packaging to:**
  - Reduce carton footprint
  - Maximize use of recycled bottles



GHG emissions by percentage of total emissions. *Courtesy of The Carbon Footprint of Fat Tire Amber Ale, 2008*

Future Work – Supply/Demand Dynamics

- As Allagash starts demanding more local grains, the production will increase and the learning curve will help costs and prices go down.
- However, it will also increase the value of land cultivation, which might ultimately increase costs.
- Finally, as production goes up in response to higher demand, the imbalance of Supply and Demand will also increase, thus increasing the prices to find a new equilibrium.
- Allagash should consider all the feedback loops in the system and look for ways to make the reinforcing loop the dominant one.



PASSION

LOVING BEER AND DOING WHAT WE LOVE.

Contents

Works Cited

[1] The Climate Conservancy, "The Carbon Footprint of Fat Tire ® Amber Ale." p. 33, 2008.

[2] M. Rajaniemi, H. Mikkola, and J. Ahokas, "Greenhouse gas emissions from oats , barley , wheat and rye production," *Agron. Res. Biosyst. Eng.*, no. 1, pp. 189–194, 2011.

[3] J. H. Kløverpris, N. Elvig, P. H. Nielsen, A. M. Nielsen, O. Ratzel, and A. Karl, "Comparative Life Cycle Assessment of Malt-based Beer and 100 % Barley Beer," p. 66, 2009.

[4] Y. Gan, C. Liang, X. Wang, and B. McConkey, "Lowering carbon footprint of durum wheat by diversifying cropping systems," *F. Crop. Res.*, vol. 122, no. 3, pp. 199–206, 2011.

[5] M. Collison, "Understanding carbon footprinting for cereals and oilseeds Introduction," Aberdeen, MD, 2012.

[6] R. L. Desjardins and D. E. Worth, "Carbon Footprint of Agricultural Products -A Measure of the Impact of Agricultural Production on Climate Change," *Agriclture and Agri-Food Canada*, 2010.

[7] T. Noyes, "Conversation with Tristan Noyes, e-mail," *Maine Grain Alliance*, 2017. .

[8] "Soil & Agronomy Workshop," *Univ. Maine Coop. Ext.*, 2017.

[9] R. Wilson and J. Roberts, "Action Plan for Agriculture and Food System Development," *North. Community Invest. Corp.*, no. 1, 2014.

[10] U. D. of Agriculture, "Maine Census of Agriculture 2012," *Natl. Agric. Stat. Serv.*, pp. 1–2, 2012.

[11] G. Keough, "MAINE POTATO SIZE AND GRADE REPORT," Concord, NH, 2017.

[12] U. S. D. of Agriculture, "2012 Census of Agriculture - County Data," *Natl. Agric. Stat. Serv.*, pp. 227–250, 2012.

[13] U. S. D. of Agriculture, "Northeast Crop Values 2016," *Natl. Agric. Stat. Serv.*, vol. 203, pp. 1–3, 2017.

[14] "2014 Census of Horticultural Specialties - MAine," *Natl. Agric. Stat. Serv.*, vol. 3301, no. December, 2015.

[15] Bland, A. (2013). Small-scale grain farmers: Can local grains be profitable? Retrieved May 15, 2017, from http://www.slate.com/articles/life/food/2013/06/small_scale_grain_farmers_can_local_grains_be_profitable.html

[16] "Countries Compared by Agriculture > Workers per hectare. International Statistics at NationMaster.com", World Resources Institute. Aggregates compiled by NationMaster. Retrieved from http://www.nationmaster.com/country-info/stats/Agriculture/Workers-per-hectare

Contents

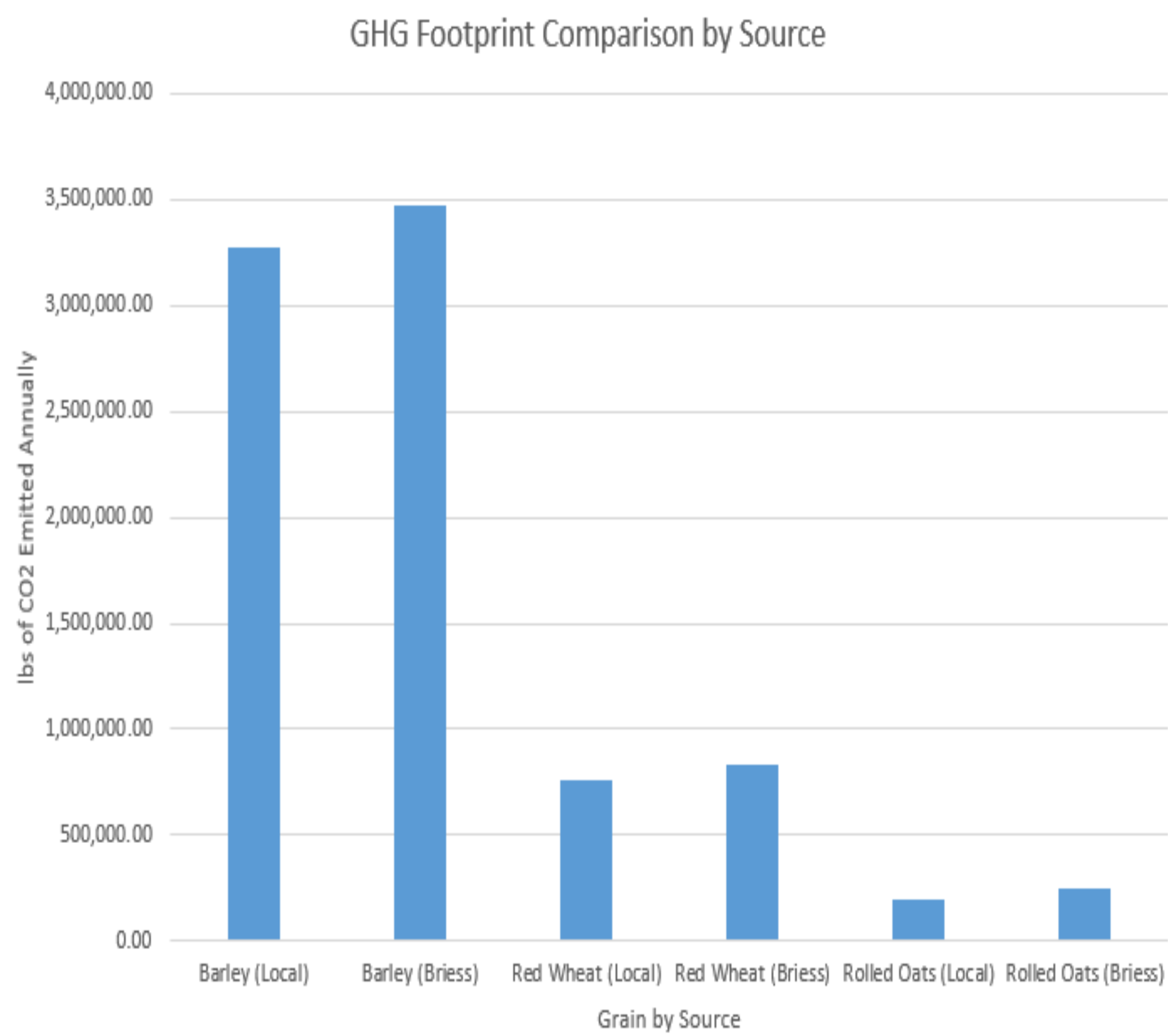
Effects of 100% Regional Sourcing

Barley emissions reduced by 5%

Red Wheat emissions reduced by 9%

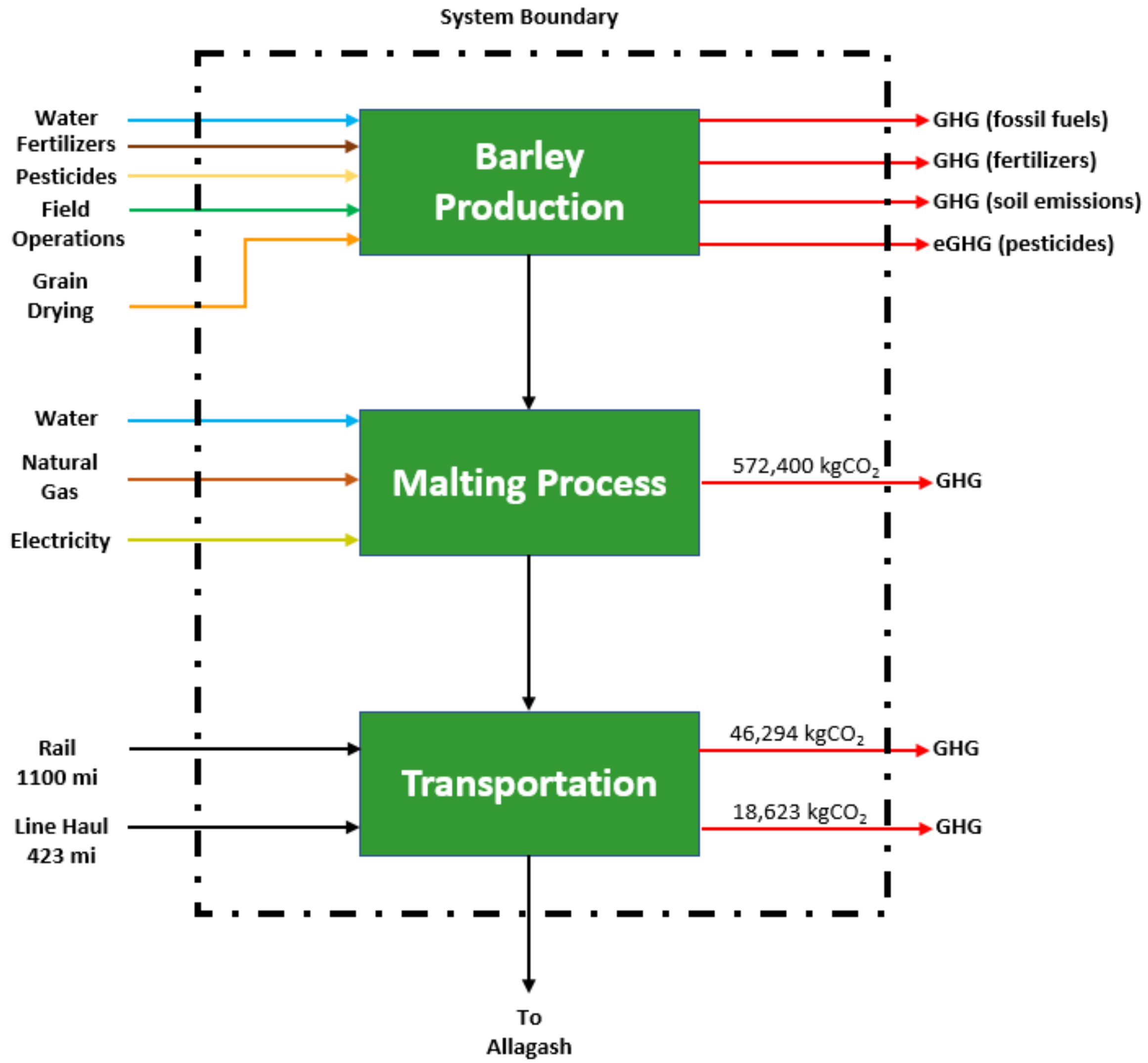
Rolled Oat emissions reduced by 18%

276 tons CO_2 emissions potentially mitigated

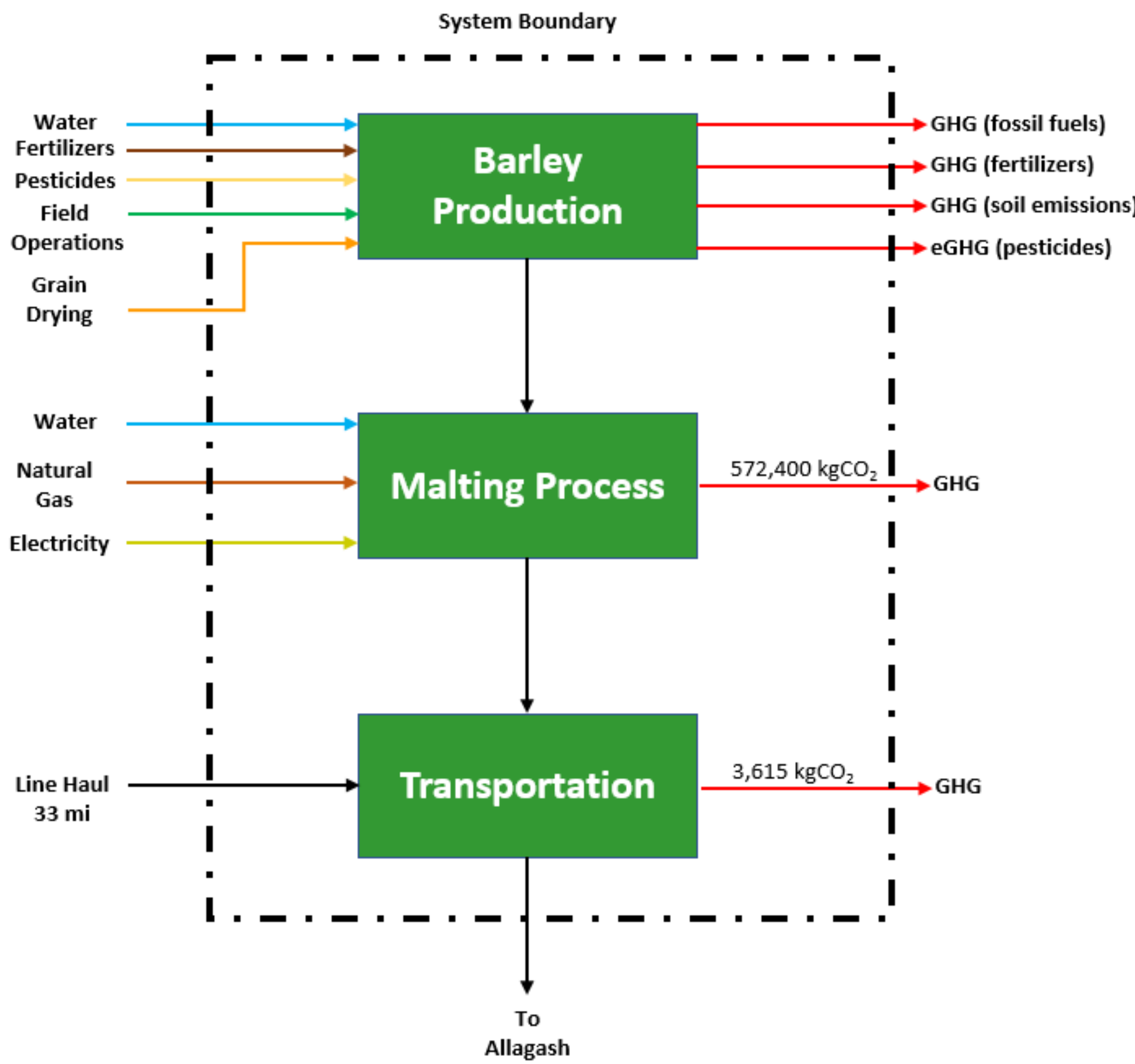


MIT MANAGEMENT SLOAN SCHOOL ALLAGASH BREWING COMPANY

Barley Footprint Analysis (Briess)

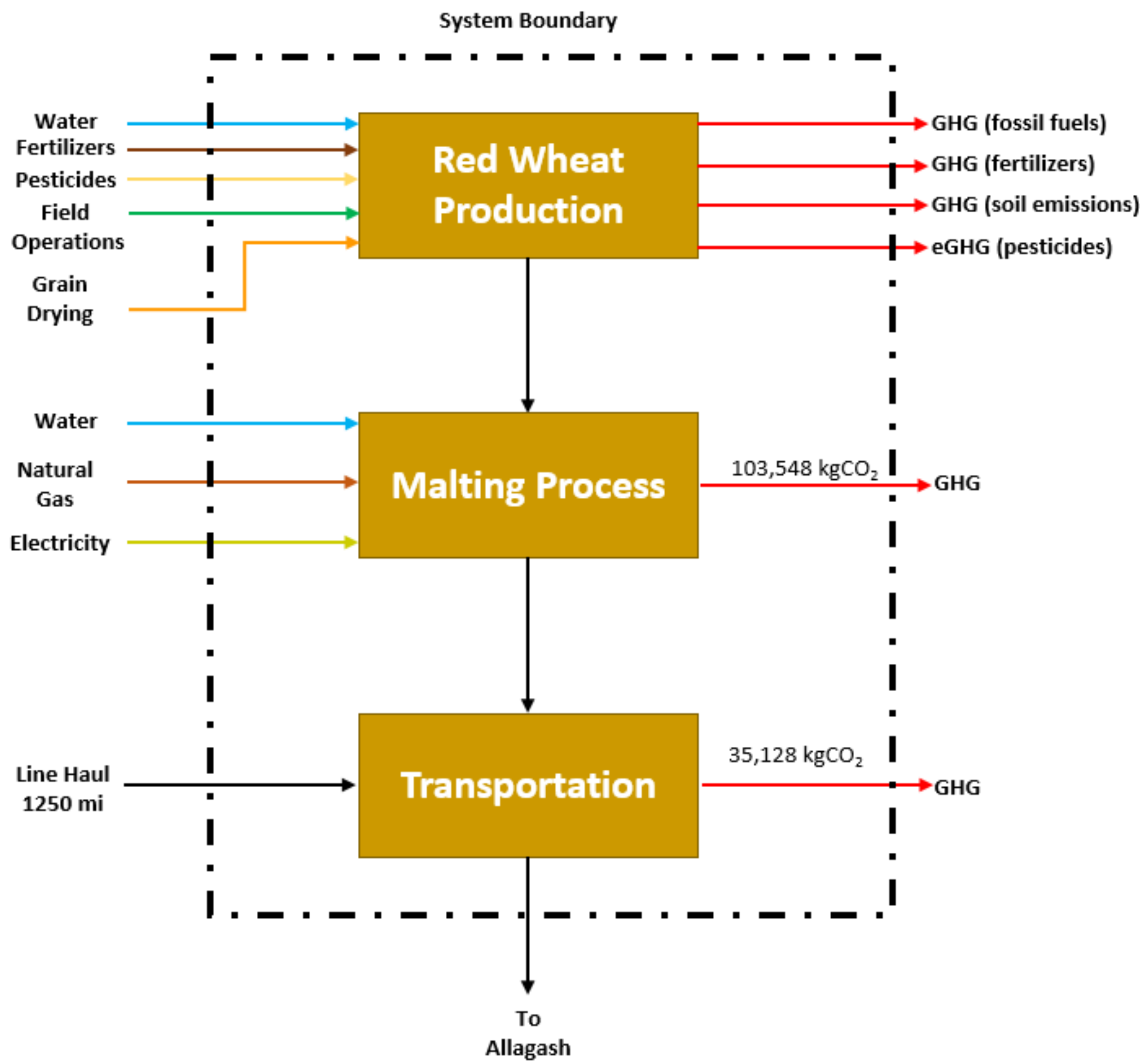


Barley Footprint Analysis (Local)



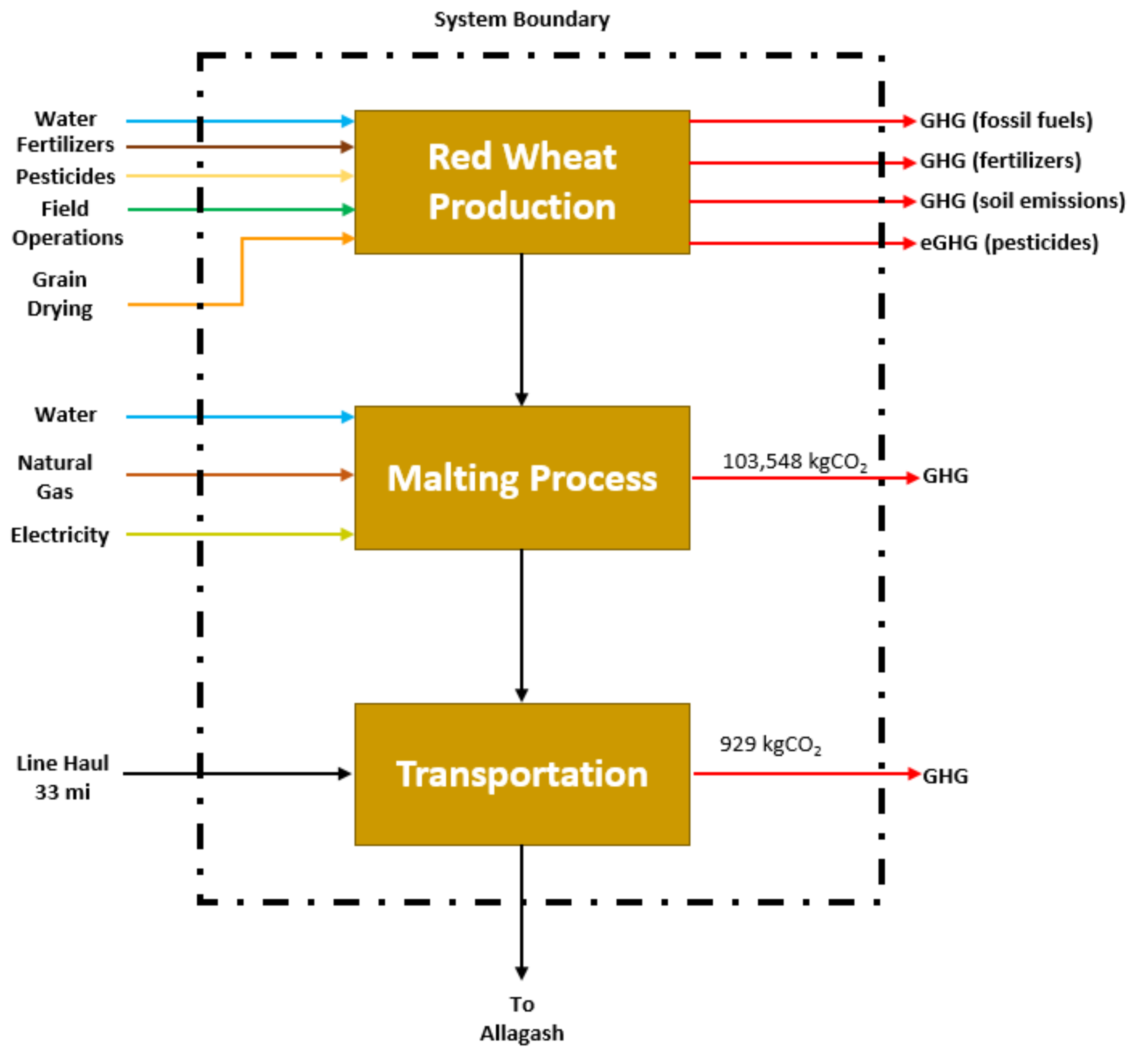
MIT MANAGEMENT SLOAN SCHOOL
ALLAGASH BREWING COMPANY

Red Wheat Footprint Analysis (Briess)

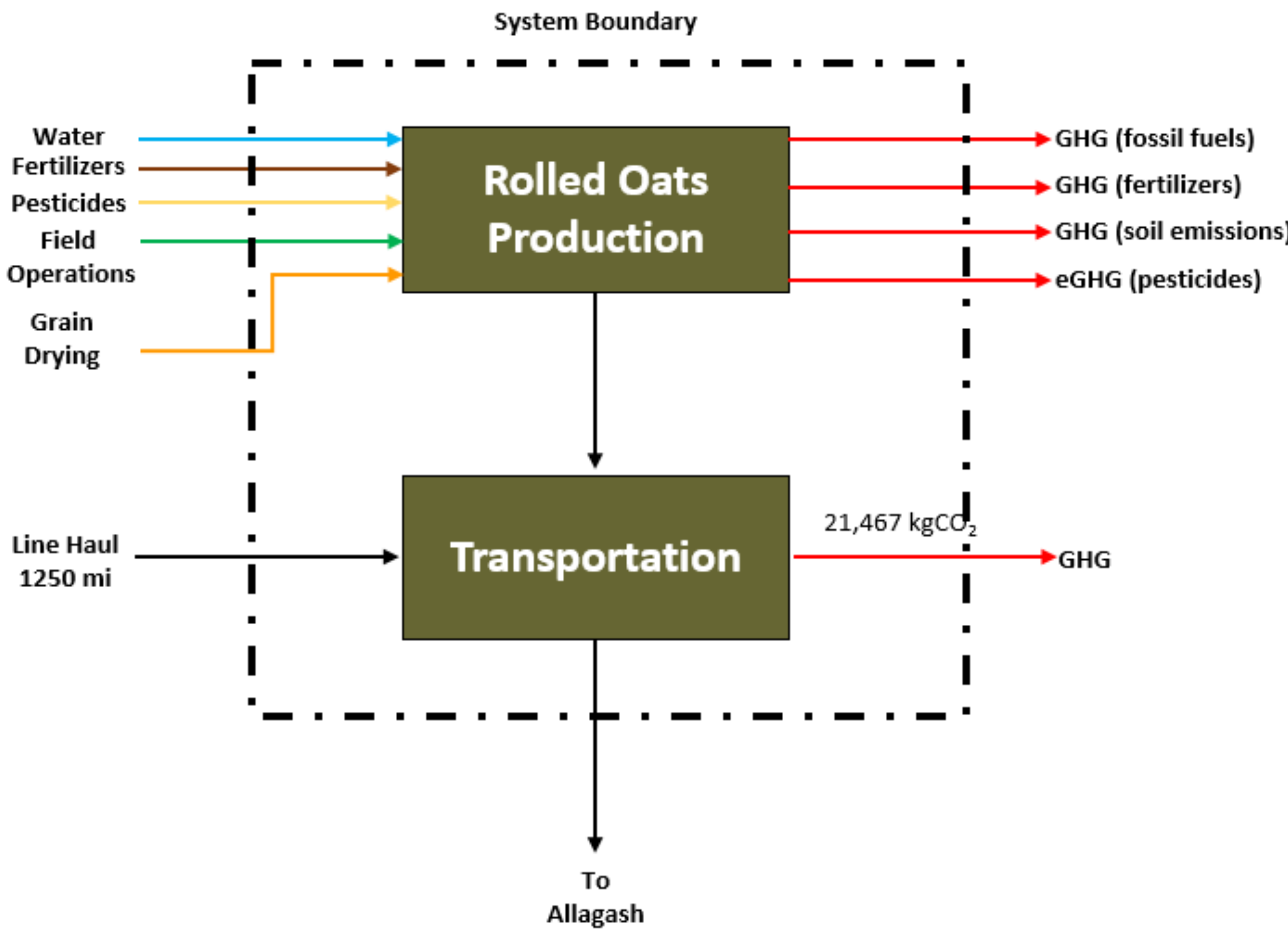


MIT MANAGEMENT SLOAN SCHOOL
ALLAGASH BREWING COMPANY

Red Wheat Footprint Analysis (Local)



Rolled Oats Footprint Analysis (Briess)



MIT MANAGEMENT SLOAN SCHOOL | ALLAGASH BREWING COMPANY

Rolled Oats Footprint Analysis (Local)