

Assessing and Mitigating Climate Change Risks to Mint Supply
A Project for Colgate-Palmolive Company in Partnership with MIT
Sloan Sustainability Lab

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Introduction

Companies in the consumer products industry rely heavily on agricultural inputs, and climate change poses significant risks to agricultural production. Companies need to understand the risks and impacts that climate change poses to agricultural inputs to develop mitigation strategies, prepare for impacts, ensure supply chain resiliency, and continue to meet demand for their products at reasonable costs.

For Colgate-Palmolive Company (CP), mint is a key agricultural input, as the oil and compounds derived from mint are used in many of the company's products. CP must have access to an adequate supply of mint that meets its quality standards to meet demand for its products. The purpose of this study was to conduct a near- and long-term assessment of how climate change may affect CP's North American mint and Indian menthol supply chains by conducting a literature review of available climate research and tools and developing recommendations to help CP prepare for these potential climate-related impacts.

Background and Context

Colgate-Palmolive Company

CP is a multinational consumer products company focused on the production and distribution of household, health care, and personal products such as soaps, detergents, and oral hygiene products including toothpaste and toothbrushes. CP had net sales of more than \$16 billion in 2015, and they market products in more than 200 countries around the world.^{1,2}

Mint and Menthol

The oil derived from mint, in particular peppermint (*mentha piperita*) and spearmint (*mentha spicata*), as well as the menthol compound derived from *mentha arvensis* are key ingredients in many of CP's products. These varieties of mint are grown in different regions of the world and in different cultivation contexts (Table 1).

Table 1: Summary of Mint Growing Information

	Location	Use	Cultivation
Mint oil (<i>mentha piperita</i> and <i>mentha spicata</i>)	US (and some parts of Canada)	Flavor	~250 large farms; one of many crops
Menthol (<i>mentha arvensis</i>)	India	Cooling refreshing effect, as well as flavor	~2 million smallholder farms; rotational crop

Mint has a short growing period and grows within 41 degrees north and south of the equator. It grows best with warm days and cool nights. According to experts, mint is more sensitive to water shortages

¹ Colgate-Palmolive Company 10-K. Available from: <http://www.sec.gov/Archives/edgar/data/21665/000162828015000846/cl-12312014x10k.htm>. (Accessed 27 April 2016.)

² Colgate-Palmolive Company Earnings Report. Available from: <http://investor.colgate.com/releasedetailpop.cfm?ReleaseID=952369>. (Accessed 27 April 2016.)

than it is to temperature changes.³ Water availability or rainfall pattern changes are more likely to impact mint than temperature change, within reasonable bounds.

S-Lab Project

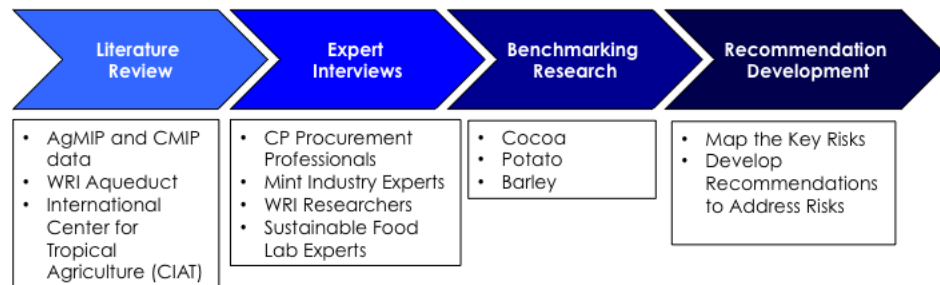
Problem Statement

Mint and menthol are key ingredients in many of CP’s products. Climate change could affect the growing locations, seasons, yield, and/or quality of these crops over time, potentially leading to supply chain and economic impacts. CP aims to maintain a resilient mint and menthol supply chain and ensure adequate supply at reasonable cost to meet future demand for their products. To accomplish this goal, CP needs to understand whether and how climate change could disrupt their supply chain and what strategies exist to mitigate these risks.

Approach

We developed a baseline understanding of CP’s mint and menthol supply chain through preliminary calls with key stakeholders within CP as well as mint industry experts. We then conducted a review and analysis of publicly available academic research on climate change as it pertains to future agricultural production and water availability. We also analyzed water risk projections specific to the Northern American and Indian regions in which mint is grown. With this background research, we developed a risk map for the mint and menthol supply chain risk map. In addition, we conducted benchmarking research on the supply chain risk mitigation strategies and initiatives of companies that, like CP, rely heavily on agricultural inputs to make their products. Finally, we analyzed these data and findings to develop recommendations for how CP can prepare for the risks and potential impacts of climate change on its mint and menthol supply chain.

Figure 1: Project Approach



Climate Impact Assessment

Literature Review

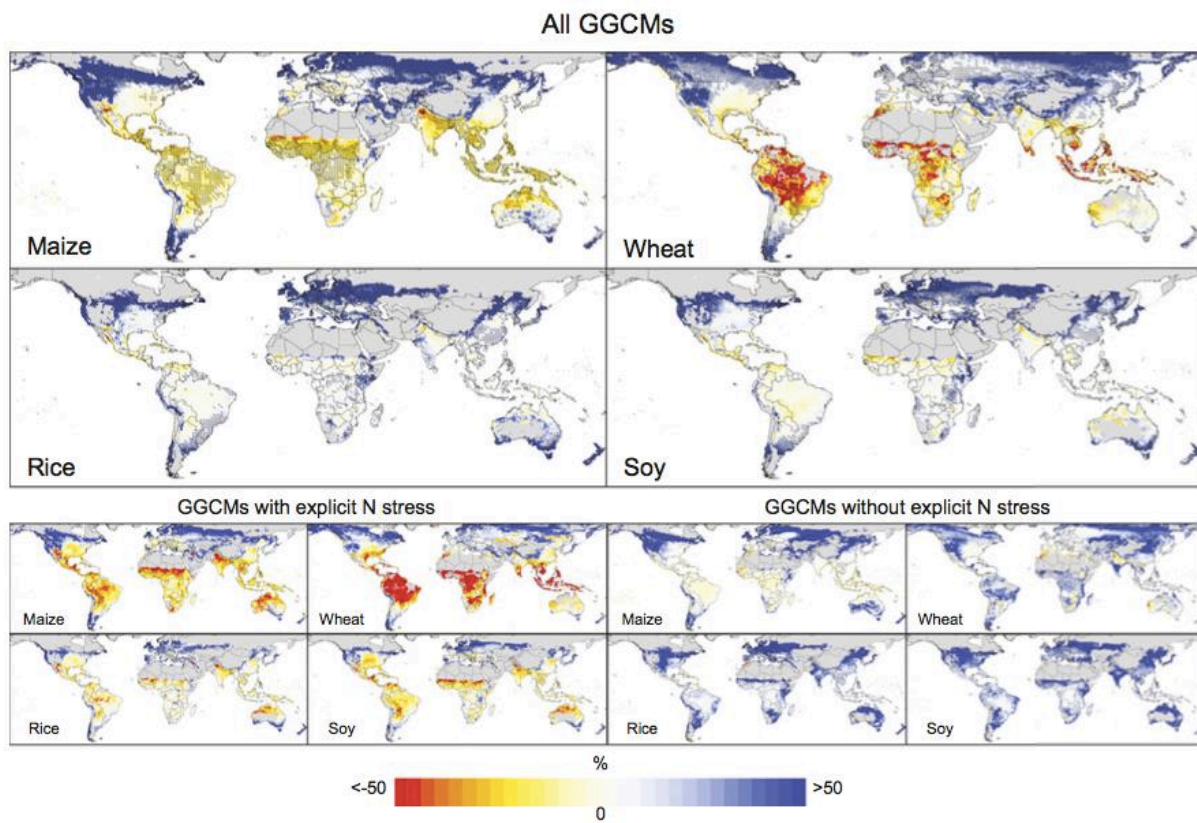
Climate change is having and will continue to have potentially significant, multi-faceted impacts on agricultural production around the world, particularly in terms of temperature increases, atmospheric

³ Interviews and conversations with members of Colgate-Palmolive procurement team during April 2016; conversations and interviews with Henry Todd, Jr. and Henry Todd, Sr., executives from AM Todd, a mint agriculture company recently acquired by WILD.

carbon dioxide concentration, and water availability, not to mention more nuanced changes such as the frequency and severity of extreme weather events (e.g. droughts, storms, heat waves) and soil nutrient deficiencies. In this section, we provide a high level review of the literature on two climate change factors that are especially salient for agricultural production: temperature change and water availability.

An intercomparison of seven global gridded crop models “indicate strong negative effects of climate change” on yields for four major crops (wheat, maize, rice, and soy), especially at greater levels of global warming and in low latitudes. Looking specifically at the regions where mint is grown, median crop yield changes indicate an increase in crop yields in the Pacific Northwest of the United States and both increases and decreases in crop yields in India, depending on the crop. Models that incorporated nitrogen stress show even more severe climate change impacts (Figure 2).

Figure 2: Projected Median Yield Changes for Rainfed Maize, Wheat, Rice, and Soy

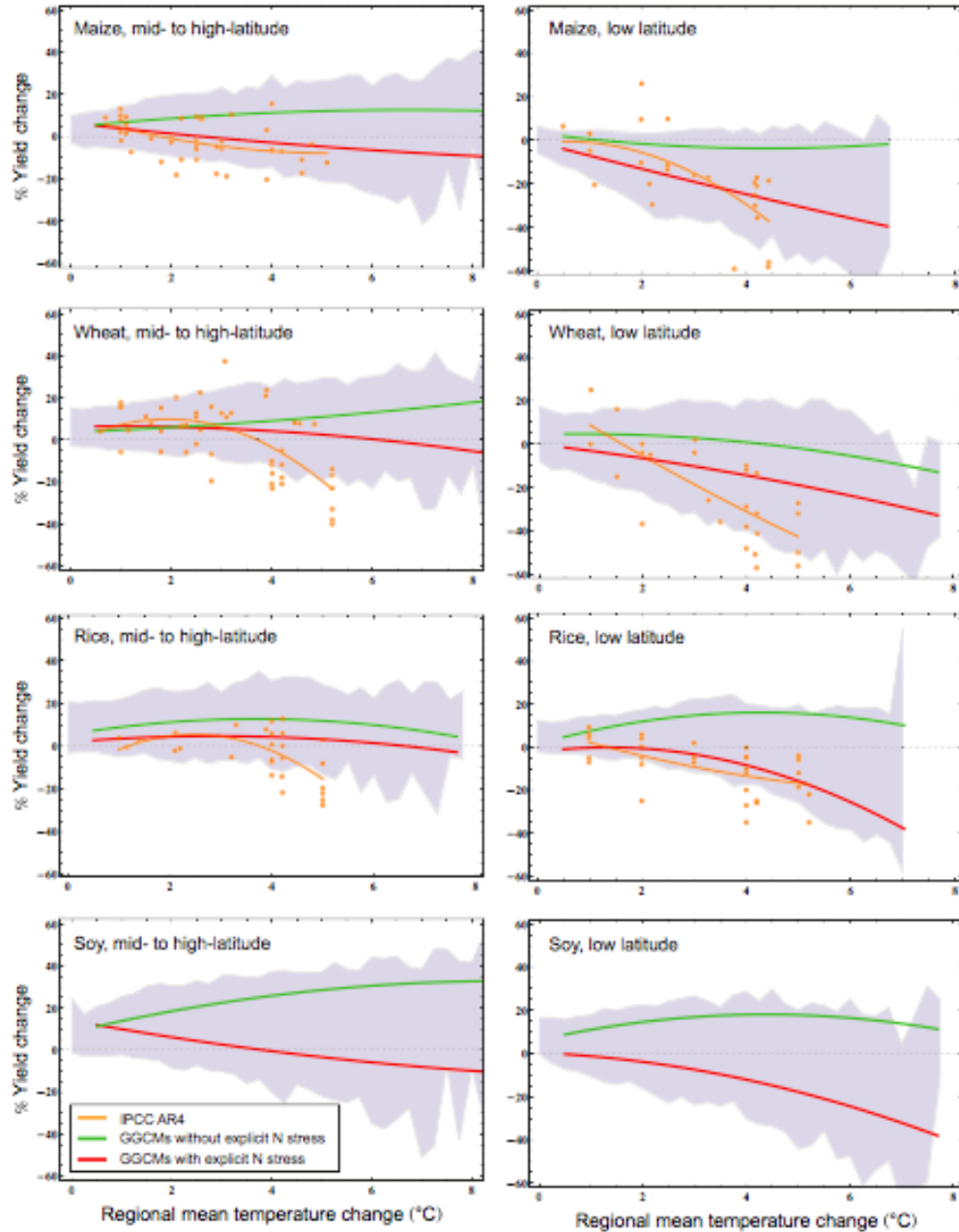


Source: Rosenzweig, Cynthia, et al. “Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison.” *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3268-3273. Print. Published online before print December 16, 2013.

However, the models also indicated significant uncertainty. At mid- and high-latitudes, crop yields spanned both positive and negative responses, especially at higher levels of warming (Figure 2). As a result, corporate mitigation plans should take into account not just mean and median projections, but also the full range of uncertainty in order to ensure adequate supply chain planning. In addition, uncertainty regarding the impacts of carbon dioxide concentration, soil nutrient deficiency, water

scarcity, and high temperature effects indicate that further research is needed to fully understand the potential impact of climate change on agricultural production.⁴

Figure 3: Mean Relative Yield Change from Reference Period (1980-2010) for Rainfed Maize, Wheat, Rice, and Soy Compared to Local Mean Temperature Change

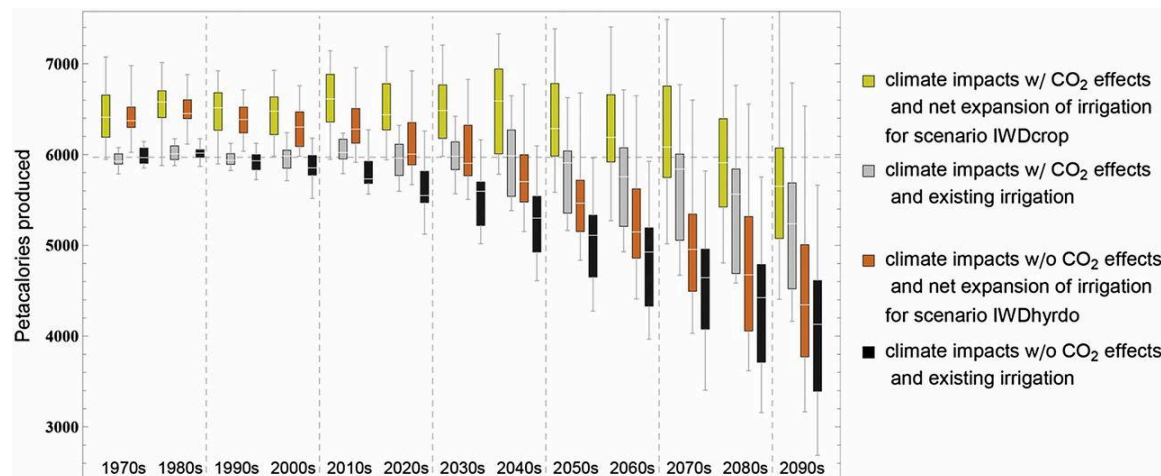


Source: Rosenzweig, Cynthia, et al. "Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3268-3273. Print. Published online before print December 16, 2013.

⁴ Rosenzweig, Cynthia, et al. "Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3268-3273. Print. Published online before print December 16, 2013.

A similar comparison of water supply and demand projections from ten global hydrological models and six global gridded crop models projects that direct climate impacts to wheat, corn, rice, and soy will result in crop yield losses of 8-24% of the present day totals (measured calorically) when carbon dioxide fertilization effects are incorporated, or losses of 24-43% otherwise (Figure 4). Freshwater limits in currently irrigated regions, including the western United States (where mint is grown), could require the conversion of 20-60 million hectares of cropland from irrigated to rainfed by 2100, causing further food production losses. Other regions, including Southeast Asia (where mentha arvensis is grown), could in theory support an increase in irrigation, but only with significant investment in infrastructure.⁵

Figure 4: Comparison of Total Annual Global Calories of Maize, Soy, Wheat, and Rice (as Projected by Four Sets of Ensemble Simulations)



Source: Elliott, Joshua, et al. "Constraints and potentials of future irrigation water availability on agricultural production under climate change." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3239-3244. Print. Published online before print December 16, 2013.

A multimodel assessment of global hydrological models indicates "climate change is likely to exacerbate regional and global water scarcity considerably. In particular, the ensemble average projects that a global warming of 2°C above present temperatures will confront an additional approximate 15% of the global population with a severe decrease in water resources and will increase the number of people living under absolute water scarcity...by another 40% compared with the effect of population growth alone." Looking particularly at the regions where mint is cultivated, the multimodel assessment projects annual river discharge will increase on the Indian peninsula but decrease in large parts of North America. However, population growth is projected to play a major role in increasing water scarcity, since it can reduce per capita water availability even in regions with unchanged or increased water resources. Overall, significant uncertainty remains in the models, particularly in terms of the magnitude of changes and the manner in which precipitation changes will translate into changes in other water variables, as well as in regions where water resources are already decreasing.⁶

⁵ Elliott, Joshua, et al. "Constraints and potentials of future irrigation water availability on agricultural production under climate change." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3239-3244. Print. Published online before print December 16, 2013.

⁶ Schewe, Jacob, et al. "Multimodel assessment of water scarcity under climate change." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3245-3250. Print. Published online before print December 16, 2013.

It is important to consider the combined effects of these climate change impacts on global food security. The projected growth in global population clearly implies greater demand for food and, as indicated above, climate change is likely to impact the supply of food through changes in agricultural production and crop yields.⁷ An analysis of linked socioeconomic and climate scenarios indicates that the world will likely be able to continue feeding itself through the remainder of the century. However, it appears this will primarily be achieved through food production in developed countries offsetting projected decreases in production in developing countries. As a result, “while global production appears stable, regional differences in crop production are likely to grow stronger through time, leading to a significant polarization of effects, with substantial increases in prices and risk of hunger amongst the poorer nations, especially under scenarios of greater inequality.”⁸

There are also agricultural economic factors to consider. A study comparing seven scenarios of crop yield changes under climate change across nine economic models projects that as climate change reduces agricultural productivity, crop prices will increase and compel farmers to undertake more intensive farm management practices and crop area expansion (though the models show considerable variation in the relative magnitude of these responses).⁹ The literature also indicates that climate change may exacerbate farm profitability challenges in some regions. Studies examining the biophysical response of crops to climate change and expected farmer responses indicate that farm-level net revenue losses could be between 9% to 25% if global temperature were to rise between 2.0 and 3.5°C. Developing countries are considered particularly vulnerable to such changes due to more limited ability to adapt.¹⁰

The World Resources Institute’s Aqueduct Tool

Following the climate change literature review, we researched publicly-available datasets and tools that companies use to monitor current and future risks. We focused on water risk tools for two reasons: 1) the literature review highlighted water availability as a key risk to agricultural production; and 2) mint is more sensitive to water than it is to temperature. We reviewed a number of water risk models and chose Aqueduct, an interactive water risk atlas developed by the World Resources Institute (WRI). We outline the other water tools in the appendix of this paper.

We chose Aqueduct for many reasons. First, it combines six different studies. As mentioned in the literature review section of this paper, while there is relative agreement regarding projected increases in temperature, models and predictions of other climate impacts indicate much less consensus. As a result,

⁷ Aggarwal, P.K.; Singh, A.K. “Implications of Global Climatic Change on Water and Food Security.” *Water Resources Development and Management*: 49-63. Berlin: Springer-Verlag, 2010. Available from: http://link.springer.com.libproxy.mit.edu/chapter/10.1007/978-3-642-04615-5_3/fulltext.html. (Accessed 30 April 2016.)

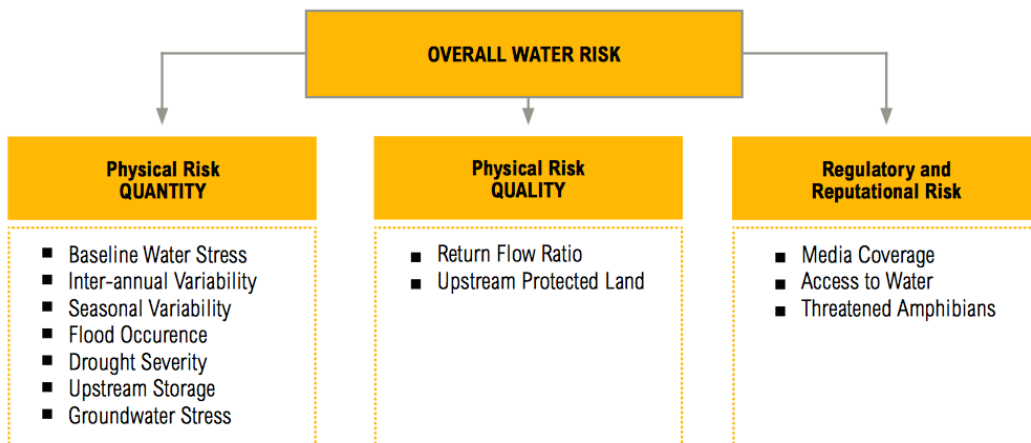
⁸ Parry, M.L.; Rosenzweig, C.; Iglesias, A.; Livermore, M.; Fischer, G. “Effects of climate change on global food production under SRES emissions and socio-economic scenarios.” *Global Environmental Change* 14. 1 (2004); 53-67. Available from: <http://www.sciencedirect.com/science/article/pii/S0959378003000827>. (Accessed 30 April 2016.)

⁹ Nelson, Gerald C., et al. “Climate change effects on agriculture: Economic responses to biophysical shocks.” *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3274-3279. Published online before print December 16, 2013. Available from: <http://www.pnas.org/content/111/9/3274.full>. (Accessed 30 April 2016.)

¹⁰ Aggarwal, P.K.; Singh, A.K. “Implications of Global Climatic Change on Water and Food Security.” *Water Resources Development and Management*: 49-63. Berlin: Springer-Verlag, 2010. Available from: http://link.springer.com.libproxy.mit.edu/chapter/10.1007/978-3-642-04615-5_3/fulltext.html. (Accessed 30 April 2016.)

it is important to use a multimodel assessments of these impacts. Second, Aqueduct compiles data into twelve indicators into three risk categories into a user-friendly and comprehensive framework that provides useful information without becoming overwhelming (Figure 5).¹¹ The tool measures and evaluates different types of water risk, generating maps and water risk scores for specific regions. Third, Aqueduct is free and publicly available.

Figure 5: Aqueduct Tool Water Risk Indicators



Source: Reig, Paul; Shiao, Tien; Gassert, Francis. "Aqueduct Water Risk Framework." Water Resources Institute. January 2013. Available from: <http://www.wri.org/publication/aqueduct-water-risk-framework>. (Accessed 24 April 2016.)

Aqueduct Findings

We used WRI’s Aqueduct tool to analyze the current and future water stress in the two main mint growing regions: North America and India. Specifically, we collected data on Uttar Pradesh in India, the US Pacific Northwest, and the US Midwest to identify region-specific causes of water stress and estimate current and future water stress patterns.

India - Uttar Pradesh

The Uttar Pradesh region in India is the primary source of CP’s mentha arvensis. India as a whole faces current severe water stress, and Aqueduct shows Uttar Pradesh as a high water risk region. Risk factors such as ground water stress, seasonal variability, risk of floods, and limited upstream storage all pose significant threats to the quantity of water available and the return flow ratio (waste water) and no upstream protected land significantly threaten the water quality (Figure 7 and Figure 6).

¹¹ Reig, Paul; Shiao, Tien; Gassert, Francis. "Aqueduct Water Risk Framework." Water Resources Institute. January 2013. Available from: <http://www.wri.org/publication/aqueduct-water-risk-framework>. (Accessed 24 April 2016.)

Figure 6: Aqueduct Water Stress by Region

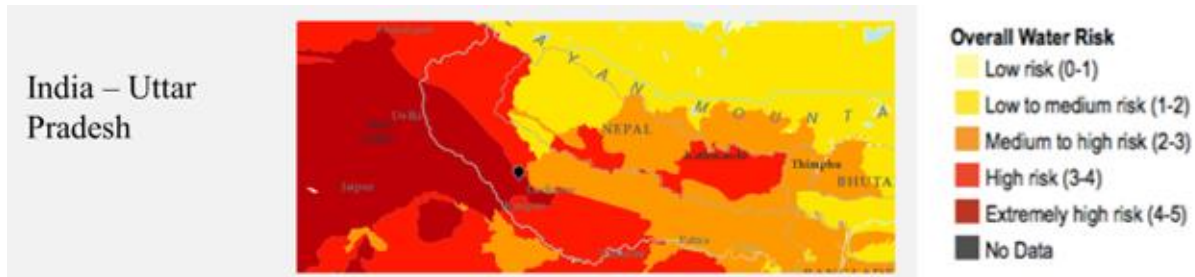
Aqueduct Water Stress Data				
Location	Uttar Pradesh, India	Yakima Washington, USA	Willamette Valley Oregon, USA	Idaho, USA
Overall Water Risk	High risk (3-4)	Medium to high risk (2-3)	Low to medium risk (1-2)	Medium to high risk (2-3)
Physical Risk Quantity	Extremely high risk (4-5)	Medium to high risk (2-3)	Low to medium risk (1-2)	Medium to high risk (2-3)
Baseline Water Stress	5. Extremely high (>80%)	3. Medium to high (20-40%)	2. Low to medium (10-20%)	4. High (40-80%)
Inter-annual Variability	2. Low to medium (0.25-0.5)	1. Low (<0.25)	2. Low to medium (0.25-0.5)	3. Medium to high (0.5-0.75)
Seasonal Variability	5. Extremely high (>1.33)	4. High (1.0-1.33)	4. High (1.0-1.33)	3. Medium to high (0.66-1.0)
Flood Occurrence	5. Extremely high (>27)	4. High (10-27)	4. High (10-27)	2. Low to medium (2-3)
Drought Severity	2. Low to medium (20-30)	2. Low to medium (20-30)	2. Low to medium (20-30)	2. Low to medium (20-30)
Upstream Storage*	No major reservoirs	3. Medium to low (0.5-0.25)	4. Low (0.25-0.12)	1. High (>1)
Groundwater Stress	5. Extremely high (>20)	No data	1. Low (<1)	No data
Physical Risk Quality	Extremely high risk (4-5)	Low to medium risk (1-2)	Medium to high risk (2-3)	Extremely high risk (4-5)
Return Flow Ratio	4. High (40-80%)	3. Medium to high (20-40%)	1. Low (<10%)	5. Extremely high (>80%)
Upstream Protected Land*	5. Extremely low (<5%)	2. High to medium (20-40%)	5. Extremely low (<5%)	4. Low (10-5%)
Regulatory & Reputational Risk	Medium to high risk (2-3)	Low risk (0-1)	Low to medium risk (1-2)	Low risk (0-1)
Media Coverage	2. Low to medium (0.05-0.1%)	3. Medium to high (0.1-0.2%)	3. Medium to high (0.1-0.2%)	3. Medium to high (0.1-0.2%)
Access to Water	3. Medium to high (5-10%)	1. Low (<2%)	1. Low (<2%)	1. Low (<2%)
Threatened Amphibians	1. Low (0%)	1. Low (0%)	3. Medium to high (5-15%)	1. Low (0%)

* Low values equate to higher risk

KEY :	Severe Risk	Medium Risk	Mild Risk	Low Risk
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Source: Compilation and analysis of data from WRI Aqueduct Tool, color-coded by MIT Sloan S-Lab team.

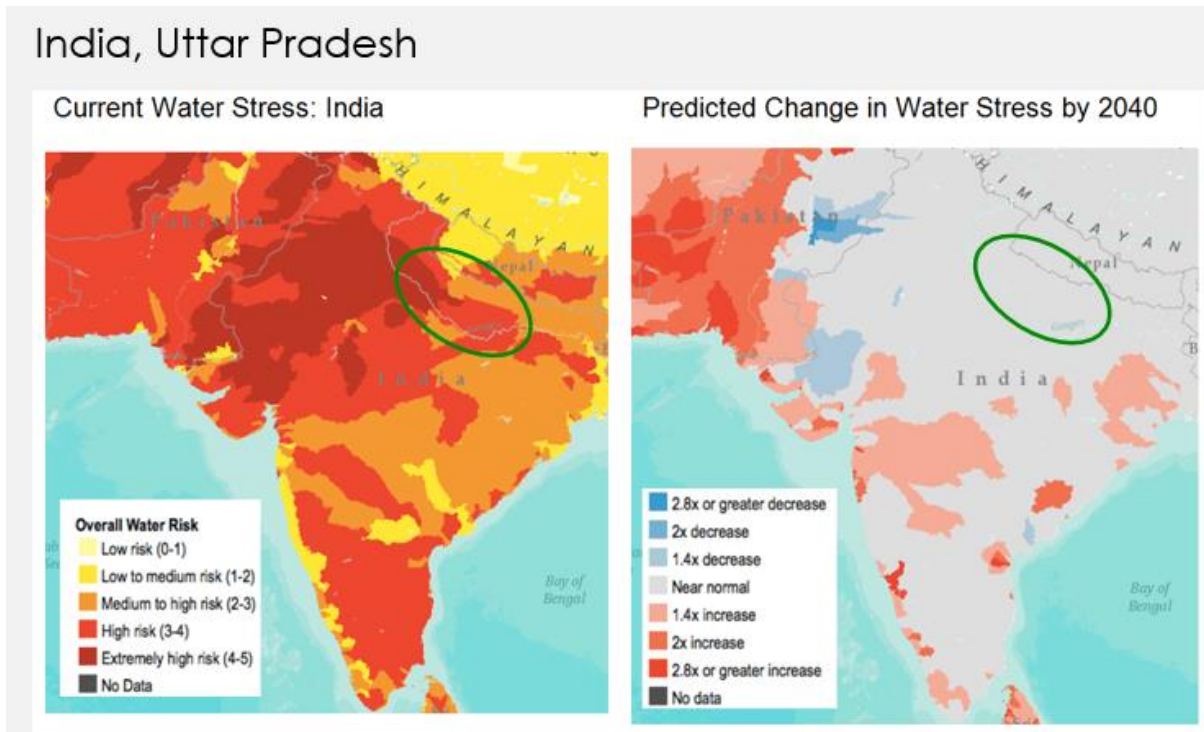
Figure 7: Current Water Risk for India - Uttar Pradesh



Source: Data generated by MIT Sloan S-Lab team from analysis using WRI Aqueduct Tool.

When using the Aqueduct tool for predicting future water stress, we do not see any significant changes in this region 2030 or 2040. However, water stress increases in other regions of India and in surrounding areas (Figure 8).

Figure 8: Current Water Stress and Predicted Change in Water Stress in India - Uttar Pradesh



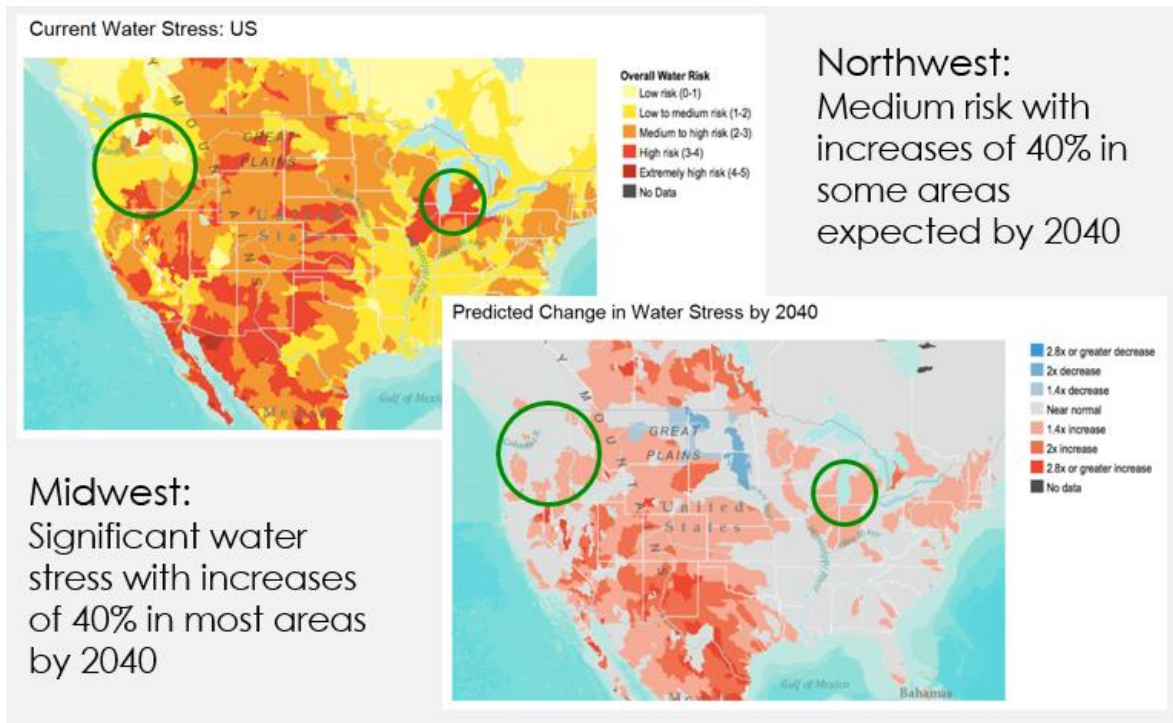
Source: Data generated by MIT Sloan S-Lab team from analysis using WRI Aqueduct Tool.

US - The Pacific Northwest

The US Pacific Northwest, including Washington, Oregon, and Idaho, is the primary source for CP's North American mint. Using WRI's Aqueduct tool, we mapped the overall current water risk for the region and found that a majority of the area falls in the medium risk range (Figure 6). Oregon is the lowest risk area. We used Willamette Valley as an example location (Figure 10). In this region, seasonal variability and the risk of flooding were the highest risk factors.

Washington and Idaho both fall into a slightly higher risk range. In Washington, seasonal variability and flooding are also the primary risk factors. In Idaho, the baseline water stress, quality of water based on the return flow ratio (waste water), and lack of upstream-protected land are also risks (Figure 9 and Figure 6).

Figure 9: Current Water Stress and Predicted Change in Future Water Stress in US - Pacific Northwest and US - Midwest



Source: Data generated by MIT Sloan S-Lab team from analysis using WRI Aqueduct Tool.

When using the Aqueduct prediction tool for future water stress in the region in 2030, we found a 1.4x increase in some areas in the region (Figure 10).

Figure 10: Predicted change in water stress by 2030, Oregon, Pacific Northwest, US



Source: Data generated by MIT Sloan S-Lab team from analysis using WRI Aqueduct Tool.

US - The Midwest

The Midwest is a secondary source of CP's North American mint. In this region, there is significant water stress, as most of the region is already in the medium to high risk range (Figure 6). Additionally, when using the Aqueduct prediction tool we found that the water risk in much of the region is slated to increase by 1.4x by 2040 (Figure 11).

Figure 11: Predicted change in water stress by 2040, Midwest, US

Current Water Stress: Midwest USA



Predicted Change in Water Stress by 2040



Source: Data generated by MIT Sloan S-Lab team from analysis using WRI Aqueduct Tool.

North America Analysis

There are large areas in North America that are currently in the medium to high range for water risk. According to the Aqueduct predictive tool, the water risk in these areas could increase between 1.4x and 2.8x in the next 25 years (Figure 9). Although the Pacific Northwest is not at high risk for water shortages, other areas in the US are. If areas where farmers grow food crops experience severe and increasing water stress, there may be increased pressure and incentive to allocate areas like the Pacific Northwest to food crops rather than non-food crops like mint. Water stress could change crop competition dynamics.

Regulatory and Reputational Risk

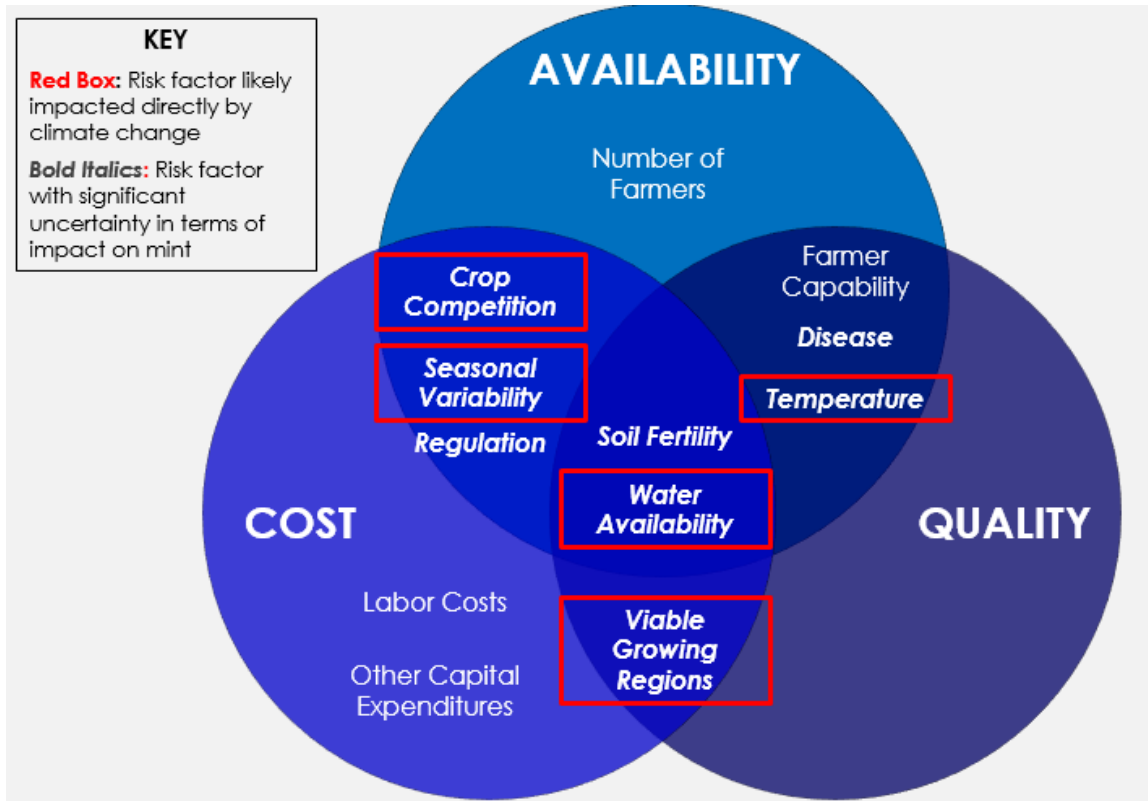
The Aqueduct tool estimates that the regulatory and reputational risk is in the medium or low range for all of the areas where CP sources mint. India has the highest reputational risk due to lack of access to clean drinking water in the region.

Summary of Risk

In summary, the literature indicates that climate change will have significant impacts on agricultural production and water stress. Although little research has been conducted on how climate change will impact the production of mint specifically, through our research we developed a preliminary map of the

key risks that could impact the cost, availability, and quality of mint (Figure 12). Based on the research findings outlined in the previous sections, there are several risk factors that are likely to be directly impacted by climate change: seasonal variability, water availability, viable growing regions, and temperature.

Figure 12: Map of Risk Factors to Availability, Quality, and Cost of Mint

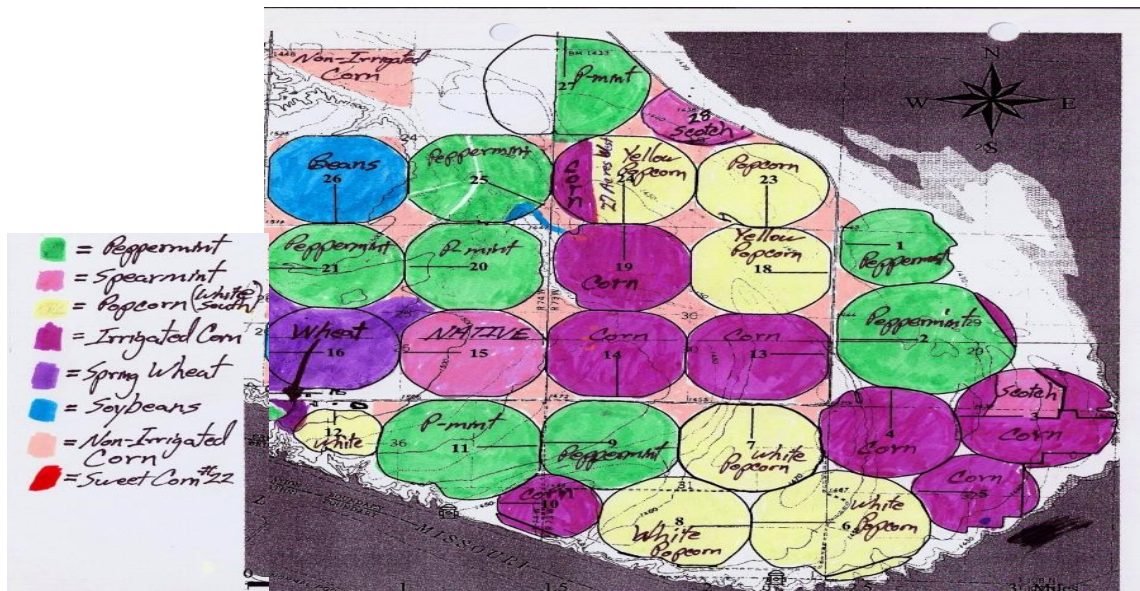


We include other risks that climate change may not impact directly and that are not associated with significant uncertainty, yet still play a role in assessing overall risk. For instance, labor costs and other capital expenditures can impact the cost of mint but are not directly impacted by climate change. Similarly, while the number of farmers and farmer capabilities have the potential to impact the availability and quality of mint, respectively, they too are not expected to be impacted directly by climate change, nor do they carry significant uncertainty. Regulation and (crop) disease do carry uncertainty, but are also not expected to be directly impacted by climate change.

Our business analysis of the research data also led to the identification of fifth risk factor likely to be impacted by climate change with significant uncertainty: competition from other crops.

As described in the Background and Context section, mint is typically grown as one of a number of different crops on a farm, either adjacent to or in rotation with other crops. Figure 13 below is a representative crop layout of a U.S. farm growing mint as well as other crops. Green and lighter pink circles represent land dedicated to mint varieties, while other colored circles indicate area dedicated other crops such as corn, wheat, and soy. It is relatively easy for farmers to change their farm layout and crop allocations season to season.

Figure 13: Typical Farm Layout for U.S. Farm Growing Mint and Other Crops (Mint Varieties Represented by Green and Light Pink Circles)



Source: Colgate-Palmolive Company procurement team.

This is important, because as indicated in the previous sections, the literature shows that climate change will reduce yields of the four major food crops (maize, wheat, rice, and soy), and has the potential to increase food insecurity, particularly in the developing world.¹² As agricultural productivity goes down and crop prices go up, farmers may be motivated to expand the areas dedicated to staple food crop farming and, as a result, reduce the amount of land dedicate to growing non-staple crops like mint.¹³ Such reductions would significantly impact the availability and cost of mint.

BENCHMARKING ANALYSIS

With the literature review and risk factors in mind, we researched companies that rely heavily on agricultural products to determine the actions they are taking to mitigate these risks in the long term. We researched Mars and Nestle with cocoa, PepsiCo with potatoes, and AB InBev with barley. All of these companies are taking action to prepare for and adapt to climate change and the risk this poses to their agricultural inputs. We identified five of the most common risk mitigations strategies employed by these companies. These include: farmer engagement, biotech research to increase yield and resilience, data science and knowledge sharing, industry collaboration/partnership, and water stewardship.

¹² Parry, M.L.; Rosenzweig, C.; Iglesias, A.; Livermore, M.; Fischer, G. "Effects of climate change on global food production under SRES emissions and socio-economic scenarios." *Global Environmental Change* 14. 1 (2004): 53-67. Available from: <http://www.sciencedirect.com/science/article/pii/S0959378003000827>. (Accessed 30 April 2016.)

¹³ Nelson, Gerald C., et al. "Climate change effects on agriculture: Economic responses to biophysical shocks." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3274-3279. Published online before print December 16, 2013. Available from: <http://www.pnas.org/content/111/9/3274.full>. (Accessed 30 April 2016.)

Cocoa: A Case Study of Mars and Nestle

At the recent COP21 conference in Paris, Mars, one of the world's leading chocolate manufacturers, raised concerns about the environmental effects of climate change on cocoa. While cocoa is just one of 100 agricultural commodities Mars sources, cocoa is a key input for Mars and a social sustainability issue for the local farmers.¹⁴

Recent research by the International Center for Tropical Agriculture (CIAT) found that the increasing temperatures in the West Africa cocoa belt, which supplies 70% of the world's cocoa, could be even more devastating for the world's cocoa than previously thought. Due to increasing temperatures, cocoa production will need to "migrate" south, west, and east of the current West Africa cocoa belt, and this movement could trigger a wave of deforestation.¹⁵ The changes could cause cocoa scarcity. Additionally, cocoa is a labor-intensive crop and mostly grown in developing countries where farmers struggle with aging trees, pests and disease, depleted soils and poor access to training and other resources. Thus these farmers' ability to adapt to dramatic change is limited.¹⁶

Due to current and future danger to supply, major companies in the chocolate industry have launched a variety of mitigation strategies to control and reduce the risk of cocoa shortage.

Cross-Industry Collaboration

One such initiative was cross-industry collaboration through the World Cocoa Foundation (WCF). Founded in 2000, WCF is an international membership organization representing more than 100 member companies across the cocoa value chain. The WCF is committed to creating a sustainable cocoa economy by putting farmers first, promoting agricultural & environmental stewardship, and strengthening development in cocoa-growing communities.¹⁷

The WCF acts as the convener and strategy holder for "CocoaAction," facilitating the implementation of this voluntary industry-wide strategy, driving alignment and generating new insights to amplify its impact. The WCF member companies committed to CocoaAction include: Barry Callebaut, Blommer, Cargill, Ferrero, The Hershey Company, Mars, Mondelez International, Nestle and Olam. The main goal of the "Action" is to incentivize and enable these companies to implement sustainability practices in the relevant growing areas.¹⁸ Figure 14 shows an example of WCF's action model for West Africa.

¹⁴ National Confectioners Association. "Mars Pushes Environmental Agenda At COP21 Paris Talks." December 1, 2015. Available from: <http://www.candyusa.com/news/mars-pushes-environmental-agenda-at-cop21-paris-talks/>. (Accessed 5.2.2016.)

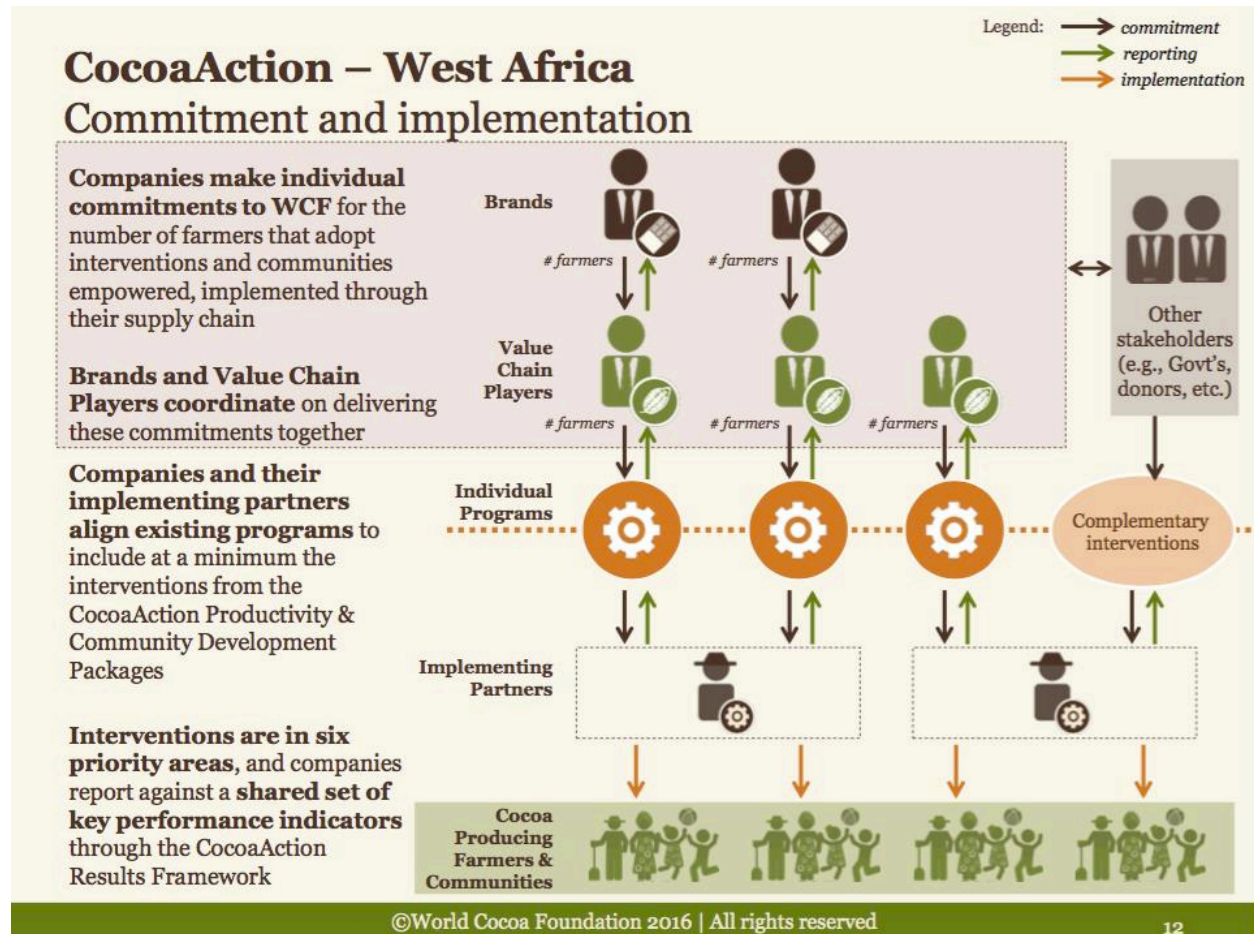
¹⁵ Smith, Georgina. "Chocolate meltdown: feeling the heat." International Center for Tropical Agriculture. April 4, 2016. Available from: <http://blog.ciat.cgiar.org/chocolate-meltdown-feeling-the-heat/>. (Accessed 5.2.2016)

¹⁶ Mars, Inc. "Mars and cocoa sustainability." Available from: <http://www.mars.com/global/brands/cocoa-sustainability/mars-and-cocoa-sustainability.aspx>. (Accessed 5.2.2016)

¹⁷ World Cocoa Foundation. "Cocoa Action." Available from: <http://www.worldcocoafoundation.org/about-wcf/cocoaaction/>. (Accessed 5.2.2016)

¹⁸ World Cocoa Foundation. "Cocoa Action Primer." May 2016. Available from: http://www.worldcocoafoundation.org/wp-content/uploads/CocoaAction-Primer-v1_English_May-2016.pdf. (Accessed 5.2.2016)

Figure 14: Example Action Model from WRC



Source: World Cocoa Foundation

Mars

The Mars risk mitigation strategies fell into three main areas: 1) farmer engagement; 2) research and development; and 3) knowledge sharing.

Farmer Engagement by Certification

Mars' approach to cocoa sustainability is to put the farmers in the center. The company makes efforts to prioritize the farmers' needs to tackle the challenges in the industry. Accordingly, Mars mission vision is: "By 2020, (our Vision for Change program aims) to reach 150,000 of Côte d'Ivoire's 750,000 farmers and triple their yields to up to 1.5 tons per hectare."¹⁹

Mars believes that certification gives farmers a better organizational structure within which to work and improved access to markets to help them build viable farms and increase their income. In turn, they get a traceable, safe supply of quality, sustainably produced cocoa. Mars was the first global chocolate company to commit to sourcing only certified cocoa, and will do so by 2020. They intend to buy a

¹⁹ Mars, Inc. "Cocoa." Available from: <http://www.mars.com/global/about-mars/mars-pia/our-supply-chain/cocoa.aspx>. (Accessed 5.2.2016)

minimum of 100,000 tons of certified cocoa annually from both Rainforest Alliance certified and UTZ certified supplies. Moreover, they continue to develop new cocoa-growing regions in Asia and have also purchased UTZ- certified cocoa from Vietnam.

Research to increase yield and resilience

Mars funds and leads innovative programs that will advance the industry's understanding of how to increase the quality and performance of cocoa plants and better control pests and disease. In one of the programs, for example, Mars partnered with IBM and the USDA to sequence and annotate the cocoa genome. The gene has not been patented and the results were released into the public domain, where they are permanently accessible via the Cocoa Genome Database.²⁰

Knowledge sharing between growing regions

Mars is building Cocoa Development Centers (CDCs) in several cocoa-growing regions of Asia and West Africa, in partnership with international donor agencies, governments and others. These centers provide farmers with the tools, techniques and training to cultivate high-quality yields. Farmers can use planting materials from CDCs to establish Cocoa Village Clinics — local nurseries that facilitate the commercial distribution of cocoa plants, providing an additional source of income.²¹

Nestle²²

Nestle's mitigation strategies are divided into two main categories: 1) farmer engagement and direct training; and 2) research and development investments.

Farmer Engagement

The Cocoa Plan provides farmer training and assistance on more efficient, sustainable farming methods, such as the effective pruning of trees, fermentation and drying of beans. It also provides plant expertise, aiming to improve the quantity and quality of yields by providing 12 million stronger, more productive plantlets over the next 10 years. In 2012, for example, Nestlé trained more than 21,000 cocoa farmers, including 9,900 in Côte d'Ivoire, in more efficient and sustainable growing techniques such as how to prune trees and ferment and dry beans more effectively.²³

Research to increase yield and resilience

Nestlé's Research and Development (R&D) Centre in Tours, France, works with its sister R&D Centre in Abidjan, Côte d'Ivoire, as well as other research institutes to produce large quantities of first-class cocoa plants that, once mature, are stronger, less vulnerable to disease, and more productive than average cocoa tree. These more resilient plants may be better adapted to deal with the current and projected impacts of climate change.

²⁰ IBM. "Consortium for Sequencing the Food Supply Chain." Available from: <http://www.research.ibm.com/client-programs/foodsafety/>. (Accessed 5.2.2016)

²¹ Mars, Inc. "Cocoa." Available from: <http://www.mars.com/global/about-mars/mars-pia/our-supply-chain/cocoa.aspx>. (Accessed 5.2.2016)

²² United Nations Framework Convention on Climate Change. "UN Private Sector Initiative Actions on Adaptation." Available from: http://unfccc.int/files/adaptation/nairobi_work_programme/private_sector_initiative/application/pdf/nestle.pdf. (Accessed 5.2.2016)

²³ Nestle. "Nestlé helps farmers adapt to climate change." December 14, 2012. Available from: <http://www.nestle.com/media/newsandfeatures/un-climate-change>. (Accessed 25 April 2016)

Potato: A Case Study of PepsiCo

Agricultural inputs make up the majority of PepsiCo's raw materials in terms of dollar spent.²⁴ The company's sustainability strategy sets standards of performance for their supply chain across 16 environmental, social, and economic areas.²⁵ PepsiCo acknowledges the climate change risk to its agriculture supply chain and is taking actions to mitigate those risks, including: 1) farmer engagement; 2) researched based collaboration; and 3) water use stewardship.

Farmer Engagement to Expand Growing Areas

In Inner Mongolia, PepsiCo worked with the Chinese government and local farmers to develop a highly productive method of growing potatoes, wheat, and corn. The method should improve soil productivity and stability in areas hurt by sand storms. To conduct this project, PepsiCo installed infrastructure such as roads, electric supply, and water-conserving pivot irrigators in the region. It also installed sand dune stabilizing crops such as sand willows to protect the soil from erosion caused by sand storms.²⁶

Research based collaboration

PepsiCo signed an agreement with Bayer CropScience to provide potato farmers with a comprehensive package that makes sustainable potato farming possible in Peru. This specially developed program aims to ensure that the farms are profitable while protecting the environment and the health of the farmers. The idea is to stabilize the market for PepsiCo's suppliers throughout the year by providing monitoring and training while establishing and implementing the use of Good Agricultural Practices (GAP) tools.²⁷

Water Use Stewardship

PepsiCo has been evaluating the impact of drip irrigation technology on water use, chemical use, and energy use of potato production. In the U.S., a study showed success in reducing irrigation water by more than 20 percent with an average yield increase of 19 percent.²⁸

Barley - AB InBev Case Study

In its 2014 Global Citizenship Report, AB InBev recognized that as the world's largest beer brewer, it had the opportunity to use its expertise and scale to address the issue of climate change, water scarcity, and natural resource depletion.

Farmer Engagement

A key piece of AB InBev's work in this area is its emphasis on forming partnerships with local stakeholders, particularly growers of malt barley. According to the company's Global Manager of Agricultural Development, AB InBev buys and uses almost 25% of the world's malt barley, half of it

²⁴ <http://www.pepsico.com/Purpose/Environmental-Sustainability/Agriculture> (accessed 5 May 2016)

²⁵ http://www.pepsico.com/docs/album/sustainability-reporting/pep_rpt14_gri_v10.pdf?sfvrsn=2 (accessed 5 May 2016)

²⁶ https://www.pepsico.com/docs/album/sustainability-reporting/water-agriculture-reports/pepsico_agri_0531_final.pdf?sfvrsn=2 (accessed 5 May 2016)

²⁷ http://www.cropscience.bayer.com/~media/Bayer%20CropScience/Global-Portal/Commitment/Food%20Chain%20Partnership/Downloads/PERU_Potatoes_PepsiCo_ES_LowRes.ashx (accessed 5 May 2016)

²⁸ https://www.pepsico.com/docs/album/sustainability-reporting/water-agriculture-reports/pepsico_agri_0531_final.pdf?sfvrsn=2 (accessed 5 May 2016)

directly from growers.^{29,30} The company relies on a network of more than 20,000 growers to cultivate this ingredient, which is key to the production of its beers. The company has worked with these farmers to implement initiatives and investments aimed at not only improving their environmental impact, but also accessing high quality inputs, improving yields, reducing costs, and mitigating supply chain risk, thus improving the economics of barley growing.³¹

Data Science and Knowledge Sharing

At the core of this work is SmartBarley, a web-enabled farm-level benchmarking tool developed by AB InBev that provides barley growers with access to more than 40 different environmental and productivity metrics—such as irrigation productivity, nitrogen use efficiency, tillage method, and soil health indicators—enabling them to measure and anonymously compare their barley production to growers in their region and around the world, as well as share best practices.³² Growers involved in the SmartBarley program are able to connect with AB InBev agronomists to identify ways to improve productivity, resource use efficiency, and profitability. More than 2,000 growers are participating in the program, which has been particularly instrumental in helping AB InBev identify opportunities to improve water management, reduce water risks, increase water efficiency, and measure the effectiveness of irrigation management initiatives.³³ In addition, AB InBev recently established what it calls the “Bud Lab” at the University of Illinois Urbana-Champaign, where data scientists will help create models and algorithms to analyze climate, soil, topography, and other data that impacts barley production; the company plans to share the insights from this work with growers via the SmartBarley application.^{34,35}

Water Stewardship

Water availability is, not surprisingly, of particular concern to a large beer company like AB InBev. “Because alcoholic beverage companies rely heavily on access to a large volume of clean water and water stress is increasing in different regions globally, companies may be exposed to supply disruptions that could significantly impact operations and add to costs,” according to the Sustainability Accounting Standards Board. “Companies operating in water-stressed regions that fail to address local water

²⁹ Rayapura, Aarthi. “AB InBev Working with Growers to Optimize Water Management, Barley Production.” Available from: http://www.sustainablebrands.com/news_and_views/collaboration/aarthi_rayapura/ab_inbev_working_growers_optimize_water_management_barl. (Accessed 24 April 2016.)

³⁰ Hildebrant, Dale. “Anheuser-Busch hold barley grower appreciation field day.” Farm and Ranch Guide. August 10, 2015. Available from: http://www.farmandranchguide.com/news/crop/anheuser-busch-hold-barley-grower-appreciation-field-day/article_f70ffd78-3d45-11e5-900d-fffe797ca58b.html. (Accessed 24 April 2016.)

³¹ AB InBev. “Bringing People Together for a Better World. Anheuser-Busch InBev 2014 Global Citizenship Report.” Available from: http://www.ab-inbev.com/content/dam/universaltemplate/abinbev/pdf/sr/global-citizenship-report/AB_InBev_GCR_2014.pdf. (Accessed 24 April 2016.)

³² Rayapura, Aarthi. “AB InBev Working with Growers to Optimize Water Management, Barley Production.” Available from: http://www.sustainablebrands.com/news_and_views/collaboration/aarthi_rayapura/ab_inbev_working_growers_optimize_water_management_barl. (Accessed 24 April 2016.)

³³ AB InBev. “Bringing People Together for a Better World. Anheuser-Busch InBev 2014 Global Citizenship Report.” Available from: http://www.ab-inbev.com/content/dam/universaltemplate/abinbev/pdf/sr/global-citizenship-report/AB_InBev_GCR_2014.pdf. (Accessed 24 April 2016.)

³⁴ Helper, Laura. “From Budweiser to Miller, greening the Big Beer supply chain.” GreenBiz. July 2, 2015. Available from: <https://www.greenbiz.com/article/budweiser-miller-greening-big-beer-supply-chain>. (Accessed 24 April 2016.)

³⁵ Roach, John. “Can Data-Driven Agriculture Help Feed a Hungry World?” Yale Environment 360. March 3, 2016. Available from: <http://e360.yale.edu/mobile/feature.msp?id=2969>. (Accessed 24 April 2016.)

concerns may face further risk of losing their social license to operate.”³⁶ In 2014, AB InBev established a goal to “reduce water risks and improve water management in 100% of [its] key barley-growing regions.”³⁷

In 2014, the company implemented multiple water management pilot programs. In Idaho, the company partnered with local stakeholders to create an irrigation-scheduling program called AgriMet. The program pulled data from a satellite-based network of weather stations managed by the Idaho Bureau of Reclamation and provided that data to Idaho barley farmers through the SmartBarley web and mobile application, enabling the farmers to maximize water conservation while still producing maximum yields. Wherever an AgriMet system was installed, a control field was also established to help the company and farmers involved in the program measure results. Farmers involved in the pilot used between 9% and 20% less water on fields with the system than on those without it.³⁸ In 2015, the company added additional AgriMet systems in Idaho and established new ones in Montana.³⁹

In China, AB InBev implemented a large-scale irrigation pilot program in partnership with the state-run Gansu Academy of Agriculture Sciences, with the aim of determining irrigation best practices for certain varieties of barley grown in the region. The company held meetings with growers to discuss the pilot and its results, and share best practices; findings from the pilot have also been shared with the scientific community.⁴⁰

Industry Collaboration/Partnership

AB InBev is a member of the Sustainable Agriculture Initiative (SAI) Platform, a non-profit organization created by Nestle, Unilever, and Danone in 2002 (see below for further details). AB InBev has used the tools developed by the SAI Platform to develop methods for identifying water risks.

AB InBev also gains environmental management expertise through its Environmental Technical Advisory Committee, which consists of three external experts that help the company evaluate its initiatives and approaches, particularly in the areas of water systems and sustainable agriculture. The members of the committee come from the World Wildlife Fund, the Sustainable Food Lab, and the Department of Biological and Agricultural Engineering at the University of Idaho.

³⁶ Helper, Laura. “From Budweiser to Miller, greening the Big Beer supply chain.” GreenBiz. July 2, 2015. Available from: <https://www.greenbiz.com/article/budweiser-miller-greening-big-beer-supply-chain>. (Accessed 24 April 2016.)

³⁷ AB InBev. “Bringing People Together for a Better World. Anheuser-Busch InBev 2014 Global Citizenship Report.” Available from: http://www.ab-inbev.com/content/dam/universaltemplate/abinbev/pdf/sr/global-citizenship-report/AB_InBev_GCR_2014.pdf. (Accessed 24 April 2016.)

³⁸ Ibid.

³⁹ Wieber, Aubrey. “AB-InBev looks to technology to help farmers.” Post Register. July 14, 2015. Available from: <http://www.postregister.com/articles/featured-news-daily-email-todays-headlines/2015/07/14/ab-inbev-looks-technology-help>. (Accessed 24 April 2016.)

⁴⁰ AB InBev. “Bringing People Together for a Better World. Anheuser-Busch InBev 2014 Global Citizenship Report.” Available from: http://www.ab-inbev.com/content/dam/universaltemplate/abinbev/pdf/sr/global-citizenship-report/AB_InBev_GCR_2014.pdf. (Accessed 24 April 2016.)

Food Industry Collaborations- The Sustainable Agriculture Initiative Platform⁴¹

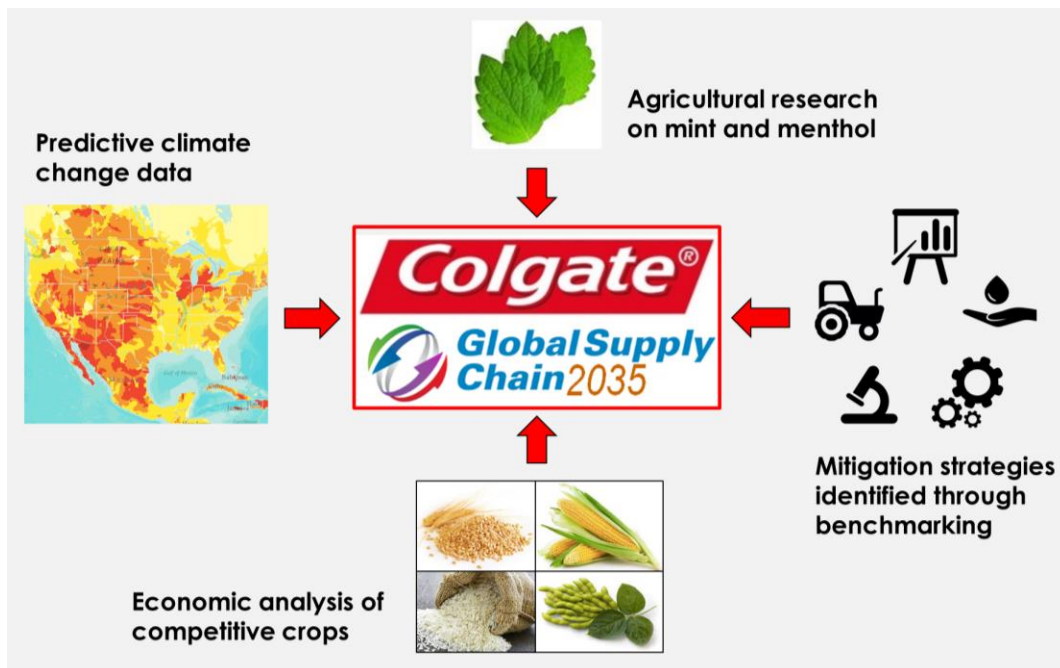
In 2002, several food companies joined forces created the Sustainable Agriculture Initiative (SAI) Platform, a non-profit organization to facilitate sharing, at precompetitive level, of knowledge and best practices to support the development and implementation of sustainable agriculture practices involving stakeholders throughout the food value chain.

SAI Platform today counts over 80 members including Coca-Cola, General Mills, Kellogg's, Mars, Mondelez International and others. Their shared vision is "the efficient production of safe, high quality agricultural products, in a way that protects and improves the natural environment, the social and economic conditions of farmers, their employees and local communities, and safeguards the health and welfare of all farmed species."

The SAI platform operates in two main areas. First, to build capacity on sustainable agriculture - based on research and development activities undertaken by SAI Platform itself, its members and other relevant stakeholder groups. Second, communicating about sustainable agriculture - towards food industries as well as all food chain stakeholders.

Key Recommendations

Through conversations with the CP procurement team, we learned that the risk mitigation strategy for mint currently focuses within a 5 year horizon. Based on the findings of this study, we recommend that CP add long term data on climate change into the risk mitigation strategy in order to create a robust, long term plan to protect CP's mint supply chain into the future.



⁴¹ Sustainable Agriculture Initiative Platform. "Who We Are." Available from: <http://www.saiplatform.org/about-us/who-we-are>. (Accessed 24 April 2016.)

Data is improving significantly as climate change is being studied more rigorously. Additionally, every month that passes provides another data point which will help to predict future environmental conditions globally. Practically, the CP procurement team can plan to review the most updated climate data on an annual basis and overlay this with the work they are already doing tracking yields and crop competition. From there, they will be in a position to make the best long term decisions about where to invest more heavily in order to protect their agricultural supply chain and manage risk.

Conclusion

Climate change will affect global temperature, water availability, and crop yields for the four major food crops within the next five to twenty years. While there is uncertainty in the models, and specific impacts on mint is still unclear, it is likely that climate change will force agricultural supply chains adapt.

Key risk factors that may affect the availability, quality, and cost of mint in the long term include temperature, water availability, extreme weather events, viable growing regions. These risk factors, combined with others such as food security, may affect create an economic risk we call “crop competition.” As the global population grows and crop yields decrease, mint risks being replaced in fields by food crops.

With these risk factors in mind, we then benchmarked consumer product companies that rely heavily on agricultural products such as cocoa, potatoes, and barley. We determined that companies are taking action to protect their supply chain from the impacts of climate change.

Finally, we recommend that CP should integrate predictive climate change data, such as the WRI Aqueduct tool, economic analysis of food crops, and any applicable strategies from the benchmarking summary into their risk mitigation strategy. By shifting from a five year horizon to a 20 year horizon and by incorporating climate change data, the CP procurement team can create a more robust risk mitigation strategy for their mint and menthol supply chain.

Appendix

Aqueduct Glossary

Physical Risk Quantity

Baseline Water Stress - measures the ratio of total annual water withdrawals to total available annual renewable supply, accounting for upstream consumptive use. Higher values indicate more competition among users.

Inter-annual Variability - measures the variation in water supply from year-to-year.

Seasonal Variability - measures variation in water supply between months of the year.

Flood Occurrence - a count of the number of floods recorded from 1985-2011

Drought Severity - estimates the average of the length times the dryness of droughts from 1901 to 2008. Drought is defined as a continuous period where soil moisture remains below the 20th percentile, length is measured in months, and dryness is the number of percentage points below the 20th percentile.

Upstream Storage - measures the water storage capacity available upstream of a location relative to the total water supply at that location; higher values indicate areas more capable of buffering variations in water supply (i.e. droughts and floods).

Groundwater Stress - measures the relative ratio of groundwater withdrawal to recharge rate. Values above one indicate where unsustainable groundwater consumption could affect groundwater availability and groundwater-dependent ecosystems

Physical Risk Quality

Return Flow Ratio - measures the percentage of available water that has been previously used and discharged upstream as wastewater higher values indicate higher dependency on treatment plants and potentially poor water quality in areas that lack sufficient treatment infrastructure.

Upstream Protected Land - measures the percentage of total water supply that originates from protected ecosystems. Lower values indicate areas located downstream from less -protected watersheds. Water quality could, therefore, be compromised in that area.

Regulatory & Reputational Risk

Media Coverage - measures the percentage of all media articles in an area that cover water-related issues. Higher values indicate areas with higher public awareness around water issues, and consequently higher reputational risks to those not sustainably managing water.




Access to Water - measures the percentage of population without access to improved drinking water sources. Higher values indicate areas where people have less access to safe drinking water supplies, and indicating high reputational risks to those using water in an inequitable way.

Threatened Amphibians - measures the percentage of freshwater amphibian species that are classified by IUCN as threatened in an area. Higher values indicate more fragile freshwater ecosystems that may be subject to water withdrawal and discharge regulations.

Source: <http://www.wri.org/applications/maps/aqueduct-atlas> (Accessed 24 April 2016.)

Water Risk Tool Comparison

Source: World Wildlife Fund, 2014. "The Water Risk Filter. Water Tool Comparison." Available from: <http://waterriskfilter.panda.org/Content/Documents/Tool%20comparison.pdf>. (Accessed 28 April 2016.)

		PRODUCED IN COLLABORATION WITH 	 THE WATER RISK FILTER	Water Tool Comparison		May 2014			
Disclaimer: this comparison has been prepared but the Water Risk Filter project team, and is therefore not objective. We welcome your feedback on this list.									
	Description	Risk analysis	Clear framework covering all water risk aspects	Geographical coverage	Industry coverage	Underlying water data challenges	Mitigation responses	User friendliness	Supporting disclosure of water information
The AWS International Water Stewardship Standard	A platform for applied water stewardship. The Standard provides a step-by-step description how to apply Water Stewardship on site level and can soon be used for the certification of a particular facility against different levels of the Standard.	No risk analysis is performed. Risk analysis is outlined within the overall framework and key considerations are shown for a meaningful risk assessment. Further the Standard refers to different tools, mentioned within this comparison, to conduct the risk assessment	Clear framework covering all relevant Water Stewardship steps. Within the risk assessment section all relevant aspects are mentioned as guidance	Not relevant in the tool. Can be applied independent of site location	The Standard can be applied anywhere in the world	Not relevant - the platform is not supported by water data. The focus is on gathering information critical water-related information for business to facilitate informed decision making in applied water stewardship.	The Standard provides guidance how to build a strategic plan to mitigate risk in the framework of applied water stewardship. Further the Standard provides guidance for the implementation phase also resulting in actual risk mitigation	The Standard is a clear structured guidance to undertake relevant steps necessary to go through a Water Stewardship process which beside other important topics contains the risk analysis	The Standard provides guidance on effective disclosure and directs towards supporting initiatives specialised in corporate water disclosure
CDP Water Disclosure	A platform for corporate water disclosure. Each year a questionnaire is issued on behalf of investors and purchasing companies to corporations that have the greatest potential to be impacted by, or impact upon, fresh water resources.	No risk analysis is performed. CDP requests companies to disclose information about their risk assessment practices and their exposure to substantive water risks across their business.	Questionnaire is based on a water stewardship framework that covers all relevant elements of water use and impact in a structured format aligned with the UN CEO Water Mandate Disclosure Guidelines.	Not relevant in the tool	No distinction in the water questionnaire between industries. Request to report risks at a basin level across direct and supply chain operations.	Not relevant - the platform is not supported by water data. The focus is on gathering business critical water-related information to facilitate informed decision making and promote good water stewardship.	Not current. CDP is building a large public database of corporate water risk mitigation responses.	The questionnaire is long and made up of 3 parts - water management and governance; risks and opportunities; and water accounting with both closed and open-ended questions. User can determine level of aggregation of the answers. CDP does not validate the provided answers.	The tool is a global, standardized system focusing on disclosure of corporate water-related information. All responses are shared with investor signatories.
CERES Aqua Gauge	A scorecard that allows investors to grade a company's water management activities against detailed definitions of leading practice.	No risk analysis is performed in this tool. Answers in the questionnaire may be rough indication of risk levels.	Questionnaire based on performance and management of water issues	Not relevant in the tool	No distinction between industries. Tool works on company (portfolio) level	Not supported by water data	Gives examples of activities and actions that might improve risk management.	Easy to use - Excel based and downloadable for free.	Links actions to several disclosure platforms (GRI, CDP)
GEMI Local Water Tool (and specific LWT for Oil & Gas)	Online tool to assess water risks of a specific site	Quantifying water risks through a system of weighted risk indicators, provides template for management plan, and provides raw data for disclosure purposes.	Analysis of physical supply, regulatory, social, competition and climate variability risks. Includes both location as company performance related risks. Unclear whether all indicators are determining risks.	Global	No distinction between industries in general tool. Specific LWT for Oil & Gas sector	Assessment of local situation primarily based on user input via questionnaire. Scarcity based on older data sets with annual withdrawal data, not consumption (similar to Global Water Tool).	No	Download required. The manual is essential to assess risk, user has to provide most input in the Excel tool. Prepared answers from drop-down list simplify answering process.	Yes - connection to GRI, Dow Jones, CDP and Bloomberg. Provision of raw data for specific disclosure platforms in dataset
WBKSD Global Water Tool	First tool available to business, Excel based. Location, water use and discharge input from user is put into relationship with water data; mapping tool with different overlays.	No risk analysis. Results of the tool may be a rough indication of risk levels	Small set of basin and country level datapoints are provided, based on input from user on location. Covering a small and not unique set of water aspects, with an emphasis on water withdrawal (instead of consumption) data.	Global	Distinction in three types of industries: Industrial, Office/Retail, Supplier. Several separate industry specific tool versions.	Challenge: Scarcity based on old annual withdrawals data, not on consumption.	No	Easy to use - Excel based- data presentation populated automatically. User has to interpret resulting table of provided raw data	No. However, certain indicators can be used as input for disclosure.
WRI Aqueduct	Online based water risk tool with strong mapping functionality. Key indicator is the 'base-line water stress' indicator developed by WRI.	Various risk indicators for which the weightings can be adjusted by the user.	Clear framework of risk indicators, grouped in 3 categories similar to the Water Risk Filter. Focus on risks related to a specific location, not to the company's water management and performance	Global	Eight different industries with specific weightings. Assessment at facility level.	Challenges: Key datasets not peer-reviewed. Main indicator ('baseline water stress') is based on annual withdrawal data, not on consumption with monthly temporal resolution. Strong: Risk methodology similar to Water Risk Filter but with difference in the underlying data and risk ranges applied. Unique is the projected future water stress indicator.	No	Very easy-to-use online interface to assess risks with attractive mapping. Results are more difficult to draw conclusions from.	No. However, certain indicators can be used as input for disclosure.
JNEP GRID	The PREVIEW Global Risk Data Platform aims to share spatial global risk information resulting from natural hazards.	No risk analysis.	Database with thematic order not following a risk framework	Global	No distinction between industries.	Challenge: only few freshwater related indicators (such as droughts and floods). Strong: Good resource for a general overview of business risks caused by natural hazards.	No	Easy-to-use online data base with many individual data sets	No

List of Sources

Colgate-Palmolive Company 10-K. Available from:

<http://www.sec.gov/Archives/edgar/data/21665/000162828015000846/cl-12312014x10k.htm>.

(Accessed 27 April 2016.)

Colgate-Palmolive Company Earnings Report. Available from:

<http://investor.colgate.com/releasedetailpop.cfm?ReleaseID=952369>. (Accessed 27 April 2016.)

Interviews and conversations with members of Colgate-Palmolive procurement team during April 2016; conversations and interviews with Henry Todd, Jr. and Henry Todd, Sr., executives from AM Todd, a mint agriculture company recently acquired by WILD.

Rosenzweig, Cynthia, et al. "Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3268-3273. Print. Published online before print December 16, 2013.

Elliott, Joshua, et al. "Constraints and potentials of future irrigation water availability on agricultural production under climate change." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3239-3244. Print. Published online before print December 16, 2013.

Schewe, Jacob, et al. "Multimodel assessment of water scarcity under climate change." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3245-3250. Print. Published online before print December 16, 2013.

Aggarwal, P.K.; Singh, A.K. "Implications of Global Climatic Change on Water and Food Security." *Water Resources Development and Management*: 49-63. Berlin: Springer-Verlag, 2010. Available from: http://link.springer.com.libproxy.mit.edu/chapter/10.1007/978-3-642-04615-5_3/fulltext.html. (Accessed 30 April 2016.)

Parry, M.L.; Rosenzweig, C.; Iglesias, A.; Livermore, M.; Fischer, G. "Effects of climate change on global food production under SRES emissions and socio-economic scenarios." *Global Environmental Change* 14. 1 (2004): 53-67. Available from: <http://www.sciencedirect.com/science/article/pii/S0959378003000827>. (Accessed 30 April 2016.)

Nelson, Gerald C., et al. "Climate change effects on agriculture: Economic responses to biophysical shocks." *Proceedings of the National Academy of Sciences* 111. 9 (2014): 3274-3279. Published online before print December 16, 2013. Available from: <http://www.pnas.org/content/111/9/3274.full>. (Accessed 30 April 2016.)

Reig, Paul; Shiao, Tien; Gassert, Francis. "Aqueduct Water Risk Framework." Water Resources Institute. January 2013. Available from: <http://www.wri.org/publication/aqueduct-water-risk-framework>. (Accessed 24 April 2016.)

National Confectioners Association. "Mars Pushes Environmental Agenda At COP21 Paris Talks." December 1, 2015. Available from: <http://www.candyusa.com/news/mars-pushes-environmental-agenda-at-cop21-paris-talks/>. (Accessed 12 May 2016)

Smith, Georgina. "Chocolate meltdown: feeling the heat." International Center for Tropical Agriculture. April 4, 2016. Available from: <http://blog.ciat.cgiar.org/chocolate-meltdown-feeling-the-heat/>. (Accessed 12 May 2016)

Mars, Inc. "Mars and cocoa sustainability." Available from: <http://www.mars.com/global/brands/cocoa-sustainability/mars-and-cocoa-sustainability.aspx>. (Accessed 12 May 2016)

World Cocoa Foundation. "Cocoa Action." Available from: <http://www.worldcocoafoundation.org/about-wcf/cocoaaction/>. (Accessed 12 May 2016)

World Cocoa Foundation. "Cocoa Action Primer." May 2016. Available from: http://www.worldcocoafoundation.org/wp-content/uploads/CocoaAction-Primer-v1_English_May-2016.pdf. (Accessed 12 May 2016)

Mars, Inc. "Cocoa." Available from: <http://www.mars.com/global/about-mars/mars-pia/our-supply-chain/cocoa.aspx>. (Accessed 12 May 2016)

IBM. "Consortium for Sequencing the Food Supply Chain." Available from: <http://www.research.ibm.com/client-programs/foodsafety/>. (Accessed 12 May 2016)

United Nations Framework Convention on Climate Change. "UN Private Sector Initiative Actions on Adaptation." Available from: http://unfccc.int/files/adaptation/nairobi_work_programme/private_sector_initiative/application/pdf/nestle.pdf. (Accessed 12 May 2016)

Nestle. "Nestlé helps farmers adapt to climate change." December 14, 2012. Available from: <http://www.nestle.com/media/newsandfeatures/un-climate-change>. (Accessed 12 May 2016)

Pepsico. "Sustainable Farming." Available from: <http://www.pepsico.com/Purpose/Environmental-Sustainability/Agriculture>. (Accessed 12 May 2016)

Pepsico. "Performance with Purpose. 2014 GRI Report." Available from: http://www.pepsico.com/docs/album/sustainability-reporting/pep_rpt14_gri_v10.pdf?sfvrsn=2. (Accessed 12 May 2016)

Bayer CropScience AG. "The Global Tuber." Available from: <http://www.cropsience.bayer.com/Magazine/The-Global-Tuber.aspx>. (Accessed 12 May 2016)

Rayapura, Aarthi. "AB InBev Working with Growers to Optimize Water Management, Barley Production." Available from: http://www.sustainablebrands.com/news_and_views/collaboration/aarthi_rayapura/ab_inbev_working_growers_optimize_water_management_barl. (Accessed 24 April 2016.)

Hildebrant, Dale. "Anheuser-Busch hold barley grower appreciation field day." Farm and Ranch Guide. August 10, 2015. Available from: <http://www.farmandranchguide.com/news/crop/anheuser-busch->

hold-barley-grower-appreciation-field-day/article_f70ffd78-3d45-11e5-900d-ffe797ca58b.html.
(Accessed 24 April 2016.)

AB InBev. "Bringing People Together for a Better World. Anheuser-Busch InBev 2014 Global Citizenship Report." Available from: http://www.ab-inbev.com/content/dam/universaltemplate/abinbev/pdf/sr/global-citizenship-report/AB_InBev_GCR_2014.pdf. (Accessed 24 April 2016.)

Roach, John. "Can Data-Driven Agriculture Help Feed a Hungry World?" *Yale Environment* 360. March 3, 2016. Available from: <http://e360.yale.edu/mobile/feature.msp?id=2969>. (Accessed 24 April 2016.)

Helper, Laura. "From Budweiser to Miller, greening the Big Beer supply chain." *GreenBiz*. July 2, 2015. Available from: <https://www.greenbiz.com/article/budweiser-miller-greening-big-beer-supply-chain>. (Accessed 24 April 2016.)

Wieber, Aubrey. "AB-InBev looks to technology to help farmers." *Post Register*. July 14, 2015. Available from: <http://www.postregister.com/articles/featured-news-daily-email-todays-headlines/2015/07/14/ab-inbev-looks-technology-help>. (Accessed 24 April 2016.)

Sustainable Agriculture Initiative Platform. "Who We Are." Available from: <http://www.saiplatform.org/about-us/who-we-are>. (Accessed 24 April 2016.)

World Wildlife Fund, 2014. "The Water Risk Filter. Water Tool Comparison." Available from: <http://waterriskfilter.panda.org/Content/Documents/Tool%20comparison.pdf>. (Accessed 28 April 2016.)