

Impact of Climate Change on agricultural production: Paben
Foods case study



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ผลกระทบของการเปลี่ยนแปลงสภาพภูมิอากาศต่อการผลิตทางการเกษตร: Paben Foods
กรณีศึกษา



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อารีจา ราน่า : ผลกระทบของการเปลี่ยนแปลงสภาพภูมิอากาศต่อการผลิตทางการเกษตร: Paben Foods กรณีศึกษา. (Impact of Climate Change on agricultural production: Paben Foods case study) อ.ที่ปรึกษาหลัก : สันต์ สัมปัตตะวนิช

ด้วยรูปแบบสภาพอากาศใหม่ในแต่ละปีมันกลายเป็นความท้าทายมากขึ้นสำหรับเกษตรกรในการรักษาอุปทานที่สอดคล้องกัน สิ่งนี้ไม่เพียงสร้างความเสี่ยงให้กับชุมชน แต่ยังรวมถึงธุรกิจการเกษตรเช่น Paben Foods ส่วนผสมหลักของอาหาร Paben คือพริกกระเทียมและหัวหอมที่มีความไวสูงต่อการเปลี่ยนแปลงของอุณหภูมิ การศึกษาจำนวนมากแสดงให้เห็นว่าแม้ว่าอุตสาหกรรมอาหารได้รับผลกระทบจากการเปลี่ยนแปลงสภาพภูมิอากาศและตระหนักถึงความเสี่ยง แต่พวกเขาไม่เห็นว่ามันเป็นความกังวลในทันที เอกสารนี้แสดงให้เห็นว่าซัพพลายเออร์ของอาหาร Paben ในประเทศไทยและอินเดียได้รับผลกระทบทางลบจากการเปลี่ยนแปลงสภาพภูมิอากาศ นอกจากนี้ตั้งแต่ปี 2563 เป็นต้นไปอินเดียคาดว่าจะเริ่มผลิตพริกที่ให้ผลผลิตต่ำลงเมื่ออุณหภูมิสูงขึ้นเกินระดับที่เหมาะสม ข้อเสนอแนะของกระดาษสำหรับ Paben Foods คือการลงทุนในการวิจัยและพัฒนาสร้างกลยุทธ์การปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศร่วมกับผู้มีส่วนได้เสียในอุตสาหกรรมได้ตระหนักถึงความกังวล และที่สำคัญที่สุดฝึกฝนกลยุทธ์ห่วงโซ่อุปทานที่มีประสิทธิภาพเพื่อป้องกันตนเองจากความเสี่ยงที่ไม่คาดฝันเช่นสัญญาณป้องกันความเสี่ยงการเจรจาเงื่อนไขสัญญาการกระจายซัพพลายเออร์ เป็นต้น



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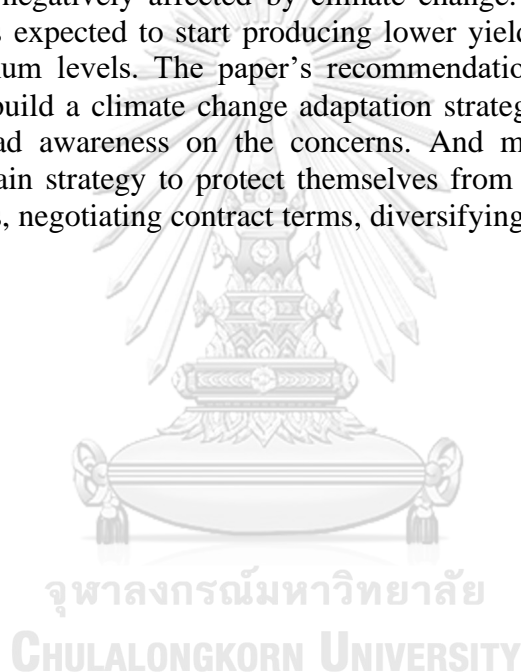
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With new weather patterns each year, it has become more and more challenging for farmers to maintain a consistent supply. This not only poses risks to communities but also agriculture-based business such as Paben Foods. Paben food's main ingredient are chili, garlic and onions that are all highly sensitive to temperature changes. Studies have showcased that although the food industry has been impacted by climate change and are aware of the risks, they do not see it as an immediate concern. This paper shows that Paben foods' suppliers in Thailand and India have been negatively affected by climate change. Additionally, from 2020 onwards, India is expected to start producing lower yield of chili as temperatures rise above optimum levels. The paper's recommendation for Paben Foods is to invest in R&D, build a climate change adaptation strategy, together with industry stakeholder spread awareness on the concerns. And most importantly, practice robust supply chain strategy to protect themselves from unforeseen risks, such as hedging contracts, negotiating contract terms, diversifying supplier etc.



Field of Study:	Business and Managerial Economics	Student's Signature
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INTRODUCTION

Paben Food Co., Ltd. has been in the food and agri business for the past 40 years, currently manufacturing chili, pickle, and Thai curry pastes. The company distinguishes itself by guaranteeing fresh and authentic flavors through selectively picking quality raw materials / ingredients from farms. The company has become a household name and has also made its mark internationally. Paben Food's strong reliance on raw materials that are sensitive to climate and weather conditions brings unpredictability around the availability, quality, cost, and price of production. As farmers are finding it hard to manage new weather pattern conditions every year, it makes it difficult for the agriculture sector to remain consistent in its supply. With this backdrop, it's crucial for such companies to identify their climate related risks and develop a practical strategy to overcome upcoming challenges.

The research question for this study is "does climate change affect agricultural crop production that could consequently affect the production of Paben Foods co., ltd?". The purpose of this paper is to study the impacts of climate change on agricultural crop production in Thailand that could potentially affect Paben Food Co., Ltd. The study will also explore the impacts of climate change on chili family plants as chili is the key ingredient for Paben Foods. Additionally, an analysis of the food industry in Thailand & India, the biggest producer of chilies and a supplier for Paben Foods. The analysis will be used to identify climate change risk as the biggest threat to Paben Foods' suppliers.

The planet's average surface temperature has risen about 1.62 degrees Fahrenheit since the late 19th century and the last two decades have been the hottest years. Unfortunately, Climate change impacts will be irreversible by the next decade, having the most detrimental impacts of food security, natural disasters, crop yield reductions, water scarcity etc. on Asian mega-

deltas and subtropical regions. According to the UN, Humans must drastically change food production methods to prevent the most catastrophic effects of global warming.

This study will be important for companies that depend on agricultural raw materials for production. Such companies should identify their threats & take part in public policies and institutional practices that enforce concrete steps towards sustainable practices. They should also build strong supply chain management strategies to secure consistent supply of raw materials. Additionally, invest in R&D around agro-technology such as varieties of crops that can withstand extreme weather condition stress.

Paben Foods has currently established 4 guidelines to achieve goals in their operations. First is to constantly invest in R&D to differentiate their products, second is to use modern technology to maintain & meet industry standards, third is to encourage & motivate their employees to develop their knowledge and experience and the fourth one is to contribute to the community, and other stakeholders such as employees, customers, and business partners. This paper will also introduce strategies that should be incorporated in these guidelines such as climate change risk management strategy and maintaining a strong & secure supply chain management

The contribution of this paper is to study and integrate various existing papers on climate change impact on agriculture production and yield. Additionally, this paper will be also exploring climate change impact on household corporate companies of Thailand such as Paben Foods and give recommendations to Paben Foods and stakeholders about the practices that need to be incorporated in the core missions & strategies.

LITERATURE REVIEW

Bandara and Cai (2014) raised concern over the risk of climate change on the food industry in South Asia. They document that most countries' food industries are quite vulnerable to climate conditions due to their heavy reliance on agricultural products. The study used a computable general equilibrium model to analyze impacts on crop yields due to climate change on food prices and supply. They concluded that the food industry in South Asia is likely to have negative impact on food production and prices due to climate change induced crop productivity decline. Vulnerabilities of the food industry profits and production processes to climate change are expected to be detrimental to South Asia. They further conclude that the food industries that are suffering due to droughts, are the one that have had the most negative impact on profits. Bandara and Cai (2014) suggest policy analysts and food industries to immediately develop climate change adaption strategies.

In accordance with Bandara and Cai (2014), Bradbear and Friel (2013) also concluded that negative impact of climate change on food prices and production, and ultimately on population health. The study analyzed how climate change has directly impacted consumer food prices, agricultural productivity, and food industry's short-term supply shocks. Indirect effects include impacts on input costs and policies. Taking the Australian food market to study the concerns, the study concluded that the complex nature of pricing mechanisms makes it difficult to pinpoint how prices would be impacted because of climate change, however the study was able to conclude that the prices will be increasing specially for healthier foods. The study raises concern that as healthier food becomes more expensive, population health will deteriorate as health food is substituted with less healthy food.

A very conclusive study by Hong, Li and Xu (2019) on climate change risk and market efficiency further added to Bandara and Cai (2014) & Bradbear and Friel (2013) conclusions. Climate change risks are not only limited to carbon

exposures. Threat to production processes of companies that are risk prone to natural disasters is amplified by climate change, which severely harm corporate profits. Regulators are also aware that markets and companies aren't considering climate change risks and are significantly underacting, hence they are promoting markets to disclose information on climate change risk exposures & adaption strategies.

Hong, Li and Xu (2019) analyze how food industry's stock prices reflect the droughts across the world, as droughts have had the most adverse impacts on food supply. They test the hypothesis that food stocks are reflecting risks that are faced by the future of the food industry using data from 31 countries' publicly traded equities in the food industries. The study used time trends to rank which countries are most risk prone to droughts and concluded that countries with negative time trends (rising risk of droughts) experience significantly lower growth in profit than countries with positive time trends (lower risk of droughts). Hong, Li and Xu (2019) also show that stock markets are inefficient in reflecting drought risks to the food industry, which is one of the biggest threats to the food industry according climate change scientists. This suggests that food stock prices are underplaying to climate change risks. Some important implications of this study for governments and market is that it's very important to understand the reason for the underreaction of the market to climate risks, so the markets are prepared for future downfall. It also confirms regulators' concerns over companies not considering their climate change risks & suggests to explore the value of climate change risk disclosure of companies as well as strategies.

Evans (2012) studies how food industry should be adapting to climate change risks. She conducted qualitative interviews with 40 small to medium sized food businesses in UK to gather evidence on their behaviors and business risks to form apt recommendations. The majority of them were keen to adapt to the climate change as they were aware of the risks. All the businesses conveyed that their business or their suppliers have been impacted by

incidents of climate change such as extreme weather, rainfall, droughts. Large manufacturers who relied on limited key suppliers were much more aware of the difficulties faced by their suppliers than the ones that had a large base of suppliers, consequently in instances of extreme weather, such manufacturers would help their suppliers overcome and prepare for the impacts. The business were questions about their financial risk to climate change and if it had been impacted in the past. They shared that although the extreme weather hasn't stopped them from conducting business, it has still been costly as manufacturers have had to switch suppliers or have to bear high raw material prices as operational costs for their suppliers increases. The interviewees also shared that the financial impact must be bared by them and can't be passed on to retailers, which makes it hard for them to increase margins. Larger business shared that despite of risks, they only have a social responsibility campaign and no climate change risk plan. They believed that there is not an immediate problem, they can overcome problems of shortage by sourcing from different suppliers, however, they acknowledge the impact on costs due to climate change. This study may explain Hong, Li and Xu (2019) concern as to why there is an underreaction of the food industry to climate change risk – they do not think it is an immediate problem.

The conclusions about food industry climate risk by the studies above are not surprising, especially considering the industrial model of today's agriculture. We ignore long term consequences of unsustainable practices such as excessive use of pesticides and fertilizers, rapid deforestation to gain agricultural land etc. The flawed agricultural model risks the future of farmers, dependent companies, and our food supplies. Hence, the second part of the literature review will shed light on how exactly climate change effects the food industry and how Paben food's key ingredient (Chili) is expected to be effected.

The agriculture sector is highly sensitive to climate change that even a minor increase in 1° to 2°C global mean temperature can cause significant effects

on crop yield specially in regions that are tropics (Stevanović et al., 2016). Changes in temperature, atmospheric carbon dioxide and the frequency and intensity of extreme weather could have significant impacts on crop yields. For any crop, the effect of increased or decreased temperatures will depend on the crop's optimum temperatures for growth and reproduction. Therefore, in some regions, warming may benefit some crops or allow farmers to shift to crops that are suitable for warmer conditions. However, if the temperature rises above the optimum temperature, yield will suffer, similarly if temperatures fall below optimum temperature, yield will also suffer. Precipitation patterns within a region will begin to shift heavily and become unreliable, farmers will not have a reliable yield. This also means that unexpectedly the rainfall may be heavy, and droughts may be longer. Such unreliability also applies to natural disasters as flood and droughts become common. The intensity and occurrence of flooding in coastal regions has become increasingly frequent as sea-level rises. Consequently, irrecoverably costing the world crops, livestock, accelerating soil erosion & water pollution as well as damaging infrastructure such as road, bridges, and building. Due to extreme temperatures, and unreliable rainfall, farmers also start to heavily rely on irrigation which further depletes water supplies. As water supplies continue to deplete, droughts become more rampant and will last longer unexpected periods within the same region. Dealing with drought also becomes a much bigger challenge in regions where summer temperatures make the soil drier. (UCSUSA.org, 2019) (EPA.gov, n.d.)

In developing countries, agriculture sector is also a key indicator of economic health as the sector represents a large share of the GDP. Global economic losses in the major crops of wheat, barley and maize has been estimated in the past to be approximately US\$5 billion per year. As warming continues, the vulnerability of the economic health and future development trajectory of poorer regions is at high risk. As the climate change affects agriculture, the consequences of fluctuations in the production patterns impacts producers and consumers as profits and prices are affected. If food prices inflate due to

climate change effects, communities not only have to spend a higher share of their income on food production, but they could also face risk of food security, nutritional shortage, or access to inadequate food. (Stevanović et al., 2016)

Due to the importance of agriculture, there has been a significant amount of research on the topic. Most studies measure climate change impacts by using a combination of climate, crop and economic models and the studies have drawn conclusions are different from each other due to difference in models, data and scenarios (Nelson et al., 2013). Ayyogari, K., Sidhya, P. and Pandit, M. (2014) reviewed existing literature and concluded that changes in seasonal patterns caused by climate change can be detrimental to the health of crops as it stimulates crop failure, yield shortage, and increases in pests and other crop diseases; drought and salinity being the most dangerous to agriculture and vegetable cultivation. Puttanapong (2013) & Peña, R. and Hughes, J. (2007) support the findings, and further brings attention to the incremental vulnerabilities of food security due to climate change in tropical and developing countries such as Thailand. Thailand employs half of its total labor and land for agricultural activities and is the most climate change risk prone food-exporting country. The economic impact of low crop yields has been significantly high. Puttanapong (2013) uses Monte-Carlo CGE models to show the prices and quantities of four major crops (corn, cassava, sugar cane, corn) are sensitive to weather oscillation, and the yield fluctuations have economy-wide impacts on Thailand's income distribution.

Lobell and Field (2007) study the climate change impact on yield trend by applying regression models as well as using timeseries graphs to plot yields, growing season, average monthly temperature, and rainfall for 6 crops from 1961–2002. The result suggests that the trends of global warming as a result of human activity has negative impacts on various major crops. The study also suggests that effects of climate change may be offset by the fertilization effects due to increased atmospheric CO₂ levels. Fertilization effect is caused when increased CO₂ levels make plants increase the rate of photosynthesis,

biomass growth, yield. The study's model concludes that the effects of increased CO₂ and increase temperature will likely largely cancel each other out as long as the temperature related losses are up to ~ 2° warming.

Similarly, Aydinalp, A. and Malcolm, C. (2008) says the effects of warming, rainfall and CO₂ varies by crop, location, and the level of warming. Increasing temperatures decrease crop yields but increase in rainfall will offset the effect and increasing CO₂ levels significantly raise yield of many crops due to CO₂ fertilization. However, Ayyogari, K., Sidhya, P. and Pandit, M. (2014) argues that increase in carbon dioxide may result in increased yield for some crops (due to CO₂ fertilization), but the yield will eventually fall. In accordance with Ayyogari, K., Sidhya, P. and Pandit, M. (2014), Hartwell and Jr (1991) also suggest that CO₂ fertilization is not a guaranteed outcome for all plant species. Many plants such as cucumber & cabbage may increase photosynthesis rate at first in response to elevated CO₂ levels but after some days the photosynthesis rate will fall (Hartwell and Jr, 1991). Hence, the magnitude of the fertilization effect may vary across the plant families. This suggests that the "offset" impact Lobell and Field (2007) referred to may not be applicable in all regions.

Regarding the economic consequences of agricultural yield changes, in agreement with Stevanović et al. (2016), Lobell, D. and Field, C. (2007) also concurs on the economic loss caused to the world due to global warming since 1981-2002, which has caused an annual combined crop (wheat, maize and barley) loss of roughly 40 Mt or \$5 billion per year. For wheat, maize and barley climate trends indicate suppressed global yields was due to warming temperatures while precipitation has had a minor effect on the crop yield. The absolute losses in global production due to climate change since 1981 have been significant. The production yield of major crops (Wheat, maize, and barley) in 2002 would have been 2% to 3% higher in 1981 if the impacts of climate change were not there. Lobell, D. and Field, C. (2007) also suggested that agriculture loss due to climate change may be relatively small to the

technological advancements made over 1981-2002 such as farmer practices, machinery, crop cycle, planting dates, cultivars – which have significantly improved production efficiency and productivity. Nevertheless, the study still concluded that climate trends are negatively impacting crops yield on the global level. Additionally, although technological advancements improve yield, the quality of the food may suffer due to chemicals and added supplements

As Paben Foods main ingredient for its pastes are chili, this paper also reviews existing literature on climate change impact on chili and chili family vegetables. Butia et al., (2018) and Sarada et al., (2015) supported each other's conclusion that climate change has adverse effects on chili production. Butia et al., (2018) illustrated that climate change is already affecting global crop production levels and chili being the biggest spice crop is at risk due to extreme temperature, drought, floods, soil acidity & salinity. Specially in India, the mean annual temperature has increased by 0.46°C from 1901 to 2014 which has had an adverse effect on crop growth rate & physiology as the temperature of the environment creates the balance between photosynthesis and respiration rates as well as impacts pollen viability and germination. Bell peppers that were grown under non-optimum conditions of 33°C resulted in a reduced fruit set and resulted in flower malformation under conditions of temperature below 18°C. The temperatures also influenced the growth of diseases in the chili plants. Diseases such as bacterial wilt, bacterial spot and anthracnose became more frequent in environment conditions of high temperatures, while diseases such as *Phytophthora capsica* were observed in environment conditions of low temperatures. The study also concluded that the temperature stress effects the physical attributes of chili plants such as plant height, fruit diameter which consequently leads to poor growth and development of chili plants and reduction in yield. Genetic Engineering, advanced breeding techniques and drip irrigation technology are one of the few adopted technologies that are helping chili plants stay resilient against extreme weather conditions and water shortage. (Butia et al., 2018)

Sarada et al., (2015) also studied the productivity of chili in Guntur district of Andhra Pradesh, using a regression model to showcase the sensitivity of chili plant to weather parameters (temperature, sunshine, rainfall) and their fluctuation. The paper found a positive correlation between Chili production and productivity with rainfall (when rainfall lower than <750mm) and temperature (when rainfall lower was 750-100mm), which further illustrates the paramount dependability & sensitivity of chili plants to weather conditions.

Erickson and Markhart (2002) and Lee et al., (2017) study the impact of extreme weather conditions on *Capsicum annuum* - a plant classification for chili, bell peppers, hot peppers etc. Erickson and Markhart (2002) conducted experiments and morphological examination on bell peppers and concluded that elevated post-pollination temperatures inhibit fruit set which suggests that fertilization is sensitive to high temperatures. Lee et al., (2017) also conducted experiments and observed the growth of hot pepper plants in various environmental conditions. The study supported Erickson and Markhart (2002) in its findings that severe climate conditions reduced growth and yield of hot peppers and negatively impacted morphogenesis, photosynthesis, and fruit characteristics. The experiment also found that hot peppers were resilient in moderate climate change scenarios, hence future breeding programs should be dedicated to hot pepper cultivars to be able to cope with extreme weather conditions. Taking into account the existing literature and considering parts of Thailand are suffering the worst drought in 50 years and overall Thailand is going through the worst drought of the decade, it's safe to conclude that the weather conditions in Thailand can be classified as extreme and harmful to crop yields.

In conclusion – based on the studies integrated above, Global warming is detrimental to crop yield. Global warming may benefit some colder regions as they will soon be able to grow crops that they were not able to grow before, but the agriculture sectors of tropical regions such as Thailand or South Asian

regions like India will be adversely affected. Agri-based business must understand and anticipate these risks to prepare adequately. There will be added costs related to mitigation and adaption, investment in R&D, investment in resilient supply chain operations & infrastructure. But the benefits will allow the business to sustain their future and even improve baseline productivity and profitability. (Dowling and Wit, 2019)

As this paper will use industry SWOT analysis, this part of the literature review will convey how the tool has been utilized in previous studies. SWOT analysis is a strategic management tool to curtail Strengths-Weaknesses-Opportunities-Threats. Helms and Nixon (2010) study SWOT to assess where the methodology works and where it needs changes. The study concluded that the SWOT analysis has seeped into academic literature and research support SWOT as crucial planning tool. Over the past 10 years, the analysis has directed organizations regarding strategic actions. As a tool for strategic positioning, SWOT analysis is now applied to beyond companies to markets, countries and industries as a guide to practitioners and policy makers. The analysis is widely used specially because of its simplicity and also because of its result-oriented application in strategy building.

Moghaddaszadeh et al. (2015) introduced some shortcomings of the analysis as well. The tool allows stakeholder to collect information around their biggest assets, their shortcomings and the opportunities and threats posed by the external environment which allows managers to build a strategy. However, the analysis is qualitative and has its inadequacies in measuring the importance of contributing factors. Moghaddaszadeh (2015) conducted a study on analyzing the Persian food industry by integrating SWOT and the factors analysis. The first part is to determine the Matrix and the second part is to prioritize the strategies by weights. A study by Hill, Terry, and Roy Westbrook (1997) also conducted a similar approach to analysis tools to improve the corporate strategy development process. Out of the 50 companies they interviewed over 20 companies used the SWOT analysis to build their case.

PABEN FOODS CASE:

From the literature review, we can draw the conclusions that Thailand crop production has likely suffered due to climate change impacts (Floods, droughts...), consequently affecting the supply and prices of Paben Foods' raw materials.

CLIMATE CHANGE IMPACT ON PABEN FOODS

Upon the findings, we conducted a short interview with Mr. Chalermkiat Thantongpaiboon - Marketing Manager of Paben Foods via email. The question raised to him was if Paben Foods has experienced any kind of discrepancies in Paben Foods' supplies, prices, or production due to the impact of Thailand's droughts and flooding. Mr. Chalermkiat shared that the green chilies he sourced from domestic production had a significant increase in the price due to the flooding and droughts in Thailand, which led to them diverting their sourcing to India & China.

The past two years the chili prices skyrocketed by 100%. Unlike raw materials like ginger, Paben foods cannot store chili through semi-processing due to the it's complex anatomy. Hence, to not increase selling prices, Paben Foods is forced to limit production volume to restrict loss.

Mr. Chalermkiat further added as they started to import from India & China and limit production to limit loss, the overall impact of Thailand floods & droughts on production supply and prices has been insignificant.

Keeping that in mind, we can conclude Paben foods has been affected by climate change when they were sourcing from Thailand, however, the impact has not been significant as they quickly switched to another supply chain. We will analyze how Thailand's climate change induced agriculture loss affected Paben Foods and what prospects does India's agriculture industry holds.

COVID-19 IMPACT ON PABEN FOOD SUPPLY:

Considering the company is completely reliant on foreign suppliers, it raises concern on the risks faced by the supply chain due to unanticipated events such as sudden climate change impacts or Covid-19 in recent times.

According to WTO, Covid-19 pandemic has caused unprecedented disruption to the world trade across the globe. Paben Foods shared with us that the impact of Covid-19 can be felt all over the country and they are anticipating indirect impact. However, their supply has not been impacted yet due to their robust supply chain management strategies. The company secures itself against such risks by indulging in forward contracts with suppliers that cover their stock 6 months ahead. As Thailand didn't halt import-export activities, shipping lines have been running their container ships – maintaining business as-usual.

RESEARCH METHODOLOGY – PABEN FOODS

This paper has used a descriptive approach using in-depth study of existing papers and literature on climate change effect on agriculture crop production as well as the food industry & Businesses.

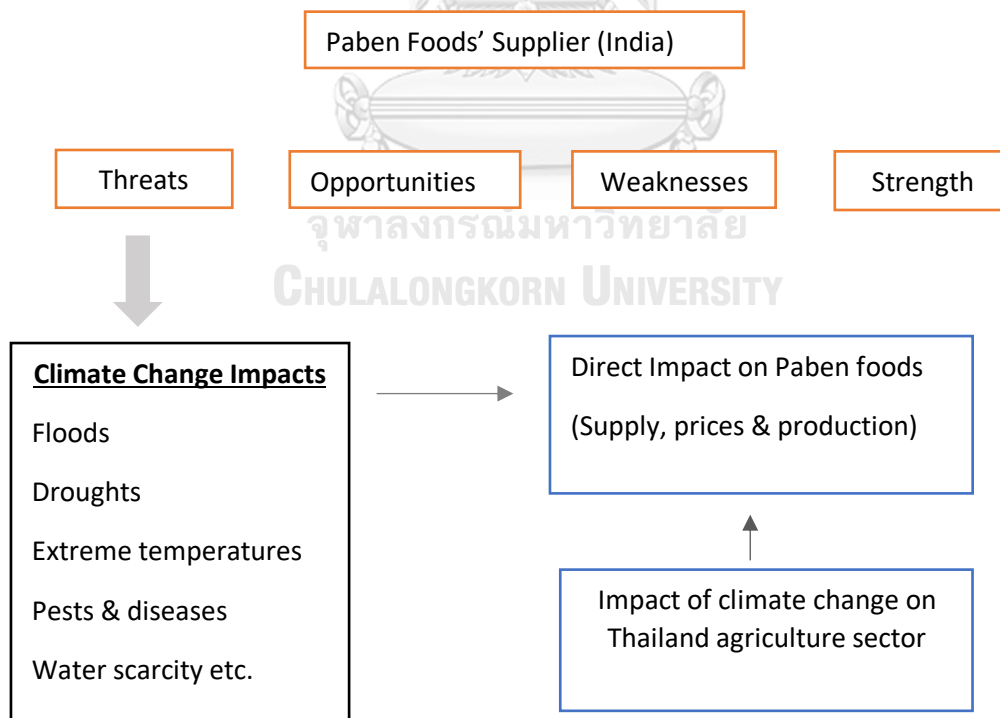
Moving to analysis part, to answer if Paben Foods Co., Ltd will be impacted by climate change, the paper will now analyze how the domestic industries of Paben Foods' suppliers have been affected by climate change and also future prospects of the industries. This analysis will be split in three parts.

First part: For suppliers in India, the study will conduct a SWOT analysis based on existing industry literature to conclude the biggest threat being faced by the industry.

Second part: For suppliers in Thailand, we will be giving evidence of agricultural yield loss due to climate change incidences through timeseries graphs, backed by literature review. The timeseries graph will show trends in agricultural yields of Thailand, especially for chili as it is a key ingredient. We will make the case to explain how Paben foods has already been impacted by climate change when they had Thai suppliers and then moved sourcing primarily to foreign suppliers (India & China)

Third part: We will also explore how the future prediction for global temperature will be impacting chili production throughout the year for India (Paben food current key supplier) as temperatures fall or rise above optimum temperature for chili.

CONCEPTUAL FRAMEWORK



The conceptual framework above shows the structure of this study. Using the SWOT analysis, we will study the industry & identify climate change as the key threat to India's agriculture industry (key supplier to Paben foods), using existing literature. Paben foods also sourced their raw materials domestically, we will also see how Thailand's climate change has already impacted Paben foods.

PART 1: INDIAN SUPPLIERS

Strengths of India's agro industry:

The biggest asset for the industry is India's large natural resources, shoreline, river systems extending to 132,000 kms, and world's second largest irrigation system. India has apt weather conditions and geographical location for crops, which makes it suitable for all kinds of grains, commercial crops and other plantations. With greatly advance research institutions backed by The National Agricultural Research System (NARS), India has been at the forefront of the green revolution. Large domestic demand, and large labor supply are also key to the success of the industry.

The Agriculture industry has been continuously growing and contributes to 14% of India's GDP and employs over 52% of the labor force (Ibef.org 2020). The industry had achieved fourfold increase in food production from 1950 (50 Million Tones) to 2010 (230 million tons). It was due to the strength of the agriculture sector in Indian that India was hardly hit by global recession in 2008 (Kumar and M.S. Nain, 2013). The sector is expected to grow exponentially in the next few years due to increased investments in infrastructure, technology, irrigation facilities, warehousing. As India also adopts global standard level food safety and quality assurance, agro exports are expected to exceed US\$ 60 billion by 2022 (Ibef.org 2020)

Weaknesses of Indian Agro Industry

As concluded by Kumar and M.S. Nain (2013) as well as Shrikrishna S Mahajan and Parashram J Patil (2019), weaknesses of the industry are low average yields compared to other countries. High dependability on the monsoon season which makes the production inconsistent. Lack of infrastructure such as roads in rural areas. Difficult export procedure which has a lot of red tape attached to it. A highlighted weakness of the industry by Kumar and M.S. Nain (2013) is also poor management which causes food wastage due to water or pests entering storage warehouses.

Other weaknesses include lack of financial support such as loan for farmers, very traditional approach, political conjectures, and lack of modern technology which would improve efficiency,

Opportunities to Indian Agro Industry

Opportunities identified by Shrikrishna S Mahajan and Parashram J Patil (2019) are to increase & promote more exports as the industry can produce all cash crops abundantly. As the agri-industry is established in rural India, we will also be seeing entrepreneurial & infrastructure development in the region which again benefit the agro industry. Organic farming is also a sector that India's agriculture sector should expand to (Kumar and M.S. Nain, 2013) to mitigate use of harmful fertilizers and also to meet the demand of organic eating habit of people nowadays. There are areas in India known as the "Sleeping Giants" that are yet to be exploited by the agricultural industry to add to their green revolution. Provision of supply chain infrastructure and technology will also improve allow skilled employment to flourish in the industry rather than only unskilled labor (Kumar and M.S. Nain, 2013) allowing for poverty alleviation.

R&D in the sector through national level project such as the National Agriculture Technology Project and the National Agriculture Innovation Project have been working toward these initiatives.

Threats to Indian Agro Industry

Key threats faced by the industry is global competition from leading economies like China, unorganized and informal market is also identified as a threat as most of the industry is based in rural areas with loose management from policy makers. Other threats include land degradation as land is deprived of nutrients and deforested. Crop loss due to weeds and pests where weeds contribute to 37% of the total loss.

Research by Kumar and M.S. Nain, (2013), reports by World Bank & OECD as well as Ministry of Finance, India place Climate Change as the biggest threat to the agricultural industry of India. Climate change is expected to increase infertile lands by 11% where extreme temperatures result in 4.7% decline in yield, and inconsistent rainfall results in 12.8% decline in yields. All through the 21st century, India will encounter warming above global levels, averaging temperature change to be 2.33°C-4.78°C and double the CO₂ concentrations. This will result in inconsistent weather conditions as well as lead to unsuitable growing conditions for some areas. (Kumar and Raj Gautam 2014)

In conclusion, we identify India's agriculture sector's biggest threat is Climate change, Hence, although Paben Foods shifted their supply to Indian, the future may still cause them to face changes in supply and/or prices of the raw material.

PART 2: THAILAND SUPPLIERS

Thailand's food industry has been known to the world due to its natural resources and the advancements in research. The industry accounts for 23% of Thailand's total GDP and with a food trade balance of USD 16.7 Billion in 2016 (Bot.or.th, 2016). The country is takes advantage of its geographical

location and vast resources that are given to the county by the governments Thailand 4.0 initiative.

Thailand leverages on natural resources, all year growing season, cheap & abundant un-skilled labor as well as skilled labor. The country is top global producer of various main crops and provides them domestically at competitive prices. Thailand hosts over 9000 food processing companies, and the business accounts for 15% of total Thai manufacturing output & 52% of food exports. Thailand government is working to ensure the output is meeting the global standards by integrating advanced technologies.

DATA ANALYSIS

In addition to the literature reviewed, this part of the paper will conduct descriptive statistics to show how climate change events have impacted Thailand crop production, specially of Chilies and pepper, as that is the key ingredient used by Paben foods

DATA COLLECTION:

This paper will use secondary data from Food and Agriculture Organization of the United Nations (FAO) data sets:

Crop production index (2004-2006 = 100) - Thailand

Crop production index shows agricultural production for each year relative to the base period 2004-2006. It includes all crops except fodder crops. Regional and income group aggregates for the FAO's production indexes are calculated from the underlying values in international dollars, normalized to the base period 2004-2006. (Data.worldbank.org, 2019)

Production quantities of Chilies and peppers, green - Thailand (Fao.org, 2019)

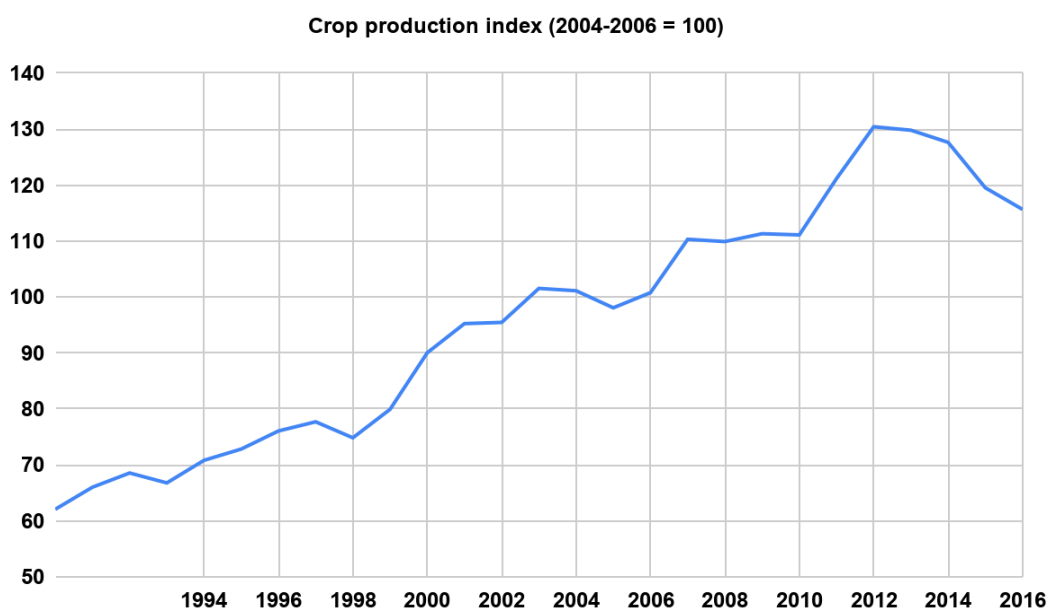
The data will show the production & yields of dry and green chilies and peppers of Thailand.

Production quantities of spices - Thailand (Fao.org, 2019)

The data will show the production & yields of spices in Thailand.

Variable	Unit	Years
Crop production index (2004-2006 = 100)	(2004-2006 = 100) Index	1994-2014
Production quantities of Spices	Tons	1994-2014
Production quantities of Chilies	Tons	1994-2014

Graph 1: Thailand Crop Production Index (2004-2006=100)



Data source: Fao.org, 2019

Graph 1 above shows the agricultural production of Thailand for each year relative to the base period 2004-2006.

Over- all trend: We can observe an overall positive trend, which suggests that crop production since 2004 has been increasing, this can be attributed to the advancements made in agro-technology, farmer practices, cultivars, industrial crop supplements and advanced irrigation systems (Lobell, D. and Field, C. 2007). However, although the overall crop production is greater than the base years, we can observe the fall of crop production during 2012 - 2016.

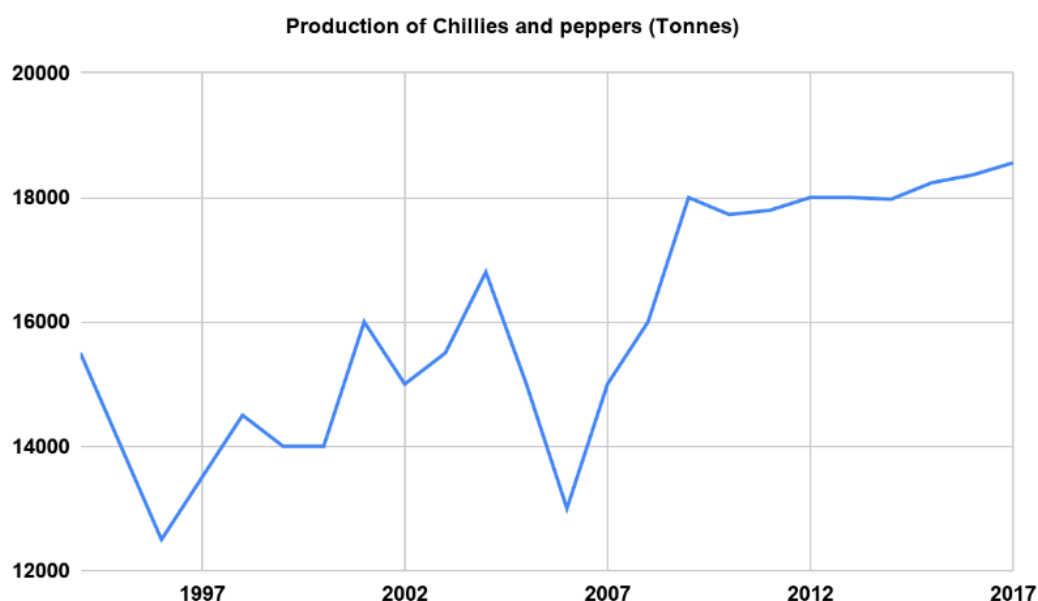
2012-2014: The fall of crop production from 2012- 2014 is a direct consequence of the 2012 floods of Thailand as the monsoon season became chaotic, affecting 12.8 million people as well as causing 728 deaths (Poapomsakorn and Meethom, 2013). The World Bank estimated an economic loss of 45.7 billion USD due to the flood damage where Thailand's agriculture sector suffered the worst loss (Nara, Mao and Yen, 2014). The 2012 floods damaged an estimate of 16,668.55 square km of agricultural area in Thailand (Ministry of Agriculture 2012). According to Poapomsakorn and Meethom (2013), the floods happened due to 4 main factors and the biggest factor was the unprecedented rainfall patterns & frequent storms experienced in 2011. The average rainfall from January to October 2011 was 1,781 millimeters, reaching the highest recorded rainfall during the period ever. Additionally, 5 subsequent tropic storms that happened between June to October, caused flash floods in various northern regions which caused most dams to reach max capacity. Moreover, the capacity of major rivers also exceeded due to water runoff. The 2011 floods are concrete evidence of climate change's disastrous consequence and illustrates how vulnerable Thailand can be to such instances as well as the vulnerability Thailand's agricultural sector experiences in the face of climate changes.

2014-2016: The graph trend's rapid fall in 2014-2016 can be attributed to the 2015-16 off-season drought that occurred unexpectedly during mid-rainy season. Thailand's suffered one of the worst droughts in decades, leading to

critically low levels in water reservoirs countrywide. The agriculture sector was again disastrously affected, where farmers lost all their investments due to crop failure. Rice Farmers were asked to delay planting their crops until August, which could have potentially cost farmers 60 billion baht in losses and straddled them in debt (OAE, 2020). Additionally, The Office of Agricultural Economics estimated that the drought will reduce crop exports by 30%. According to Open Development Thailand (2018), the Climate Data Center has recorded that droughts in Thailand are becoming more frequent and lasting longer periods, which will be impacting water reservoirs and drying up water sources. Consequently, this will result in a reduced length of growing seasons and crop yields will suffer. Additionally, according to economic projections the next two decades will be the worst to come where Thailand could be facing severe droughts, creating significantly unfavorable conditions for growing crops – this is projected to result in total crop production levels to fall in by 30.9% (Open Development Thailand, 2018). Another threat to the agricultural sector is the sea level rise. This makes floods more frequent and saltwater intrusion in agricultural fields has massively destroyed rice crop yields in the Upper Gulf of Thailand. Research has shown a hike of 5 mm/year in the local mean sea level. This should cause great alarm for the community because if strong measures are not taken, such coastal areas may end up below water, which will also make floods more frequent and people will lose their agricultural land – putting food security & resources of the region at high risk.

The 2011 flood, 2015-16 drought and the projections by Open Development Thailand (2018) for the next two decades are strong examples of the detrimental impacts of climate change on the agriculture sector of Thailand. Such impacts will be directly affecting the raw material supply and prices of Paben Food in the next two decades.

As Paben Food Co., Ltd.'s key ingredient is Chilies and spices, this paper also observed the production trends of such crops during 1997-2017

Graph 2: Thailand Production of Chillies & peppers (Tons)

Data source: Fao.org, 2019

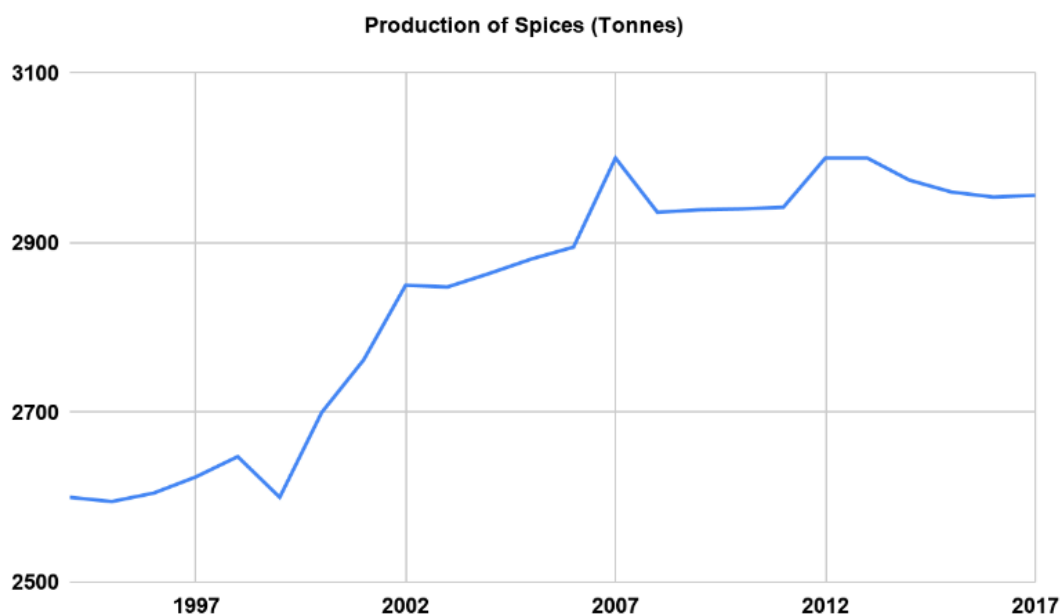
Overall trend: Graph 2 shows the overall growth trend of chili and pepper production. We can observe the overall trend to be positive and accelerating due to the technological advancements made in the agricultural sector over the last two decades, introducing new farming practices as well as genetically engineering seed varieties that are able to survive better – all this to achieve the yield requirements needed to meet the ever growing population. However, there is sharp decline in chili and spice production in 2006 and we can also observe a period of no growth during 2012-2014.

2006: The sharp decline of production in 2006 can be attributed to the severe flash floods in Thailand that damaged many parts of Thailand in 2006 - according to World Health Organization causing a loss of US\$9.94 million.

2012-2014: The almost no-growth rate during 2012-2014 can also be attributed to the 2011 floods in Thailand which were much more severe and unlike yearly floods experienced by Thailand. We can also observe that production starts to recover from 2014 to 2017 but the growth is much slower. This could be credited to the severe droughts Thailand has been facing – the

worst in the past 40 years and expected to cost 46 billion baht according to Bank of Ayudhya's Krungsri Research.

Graph 3: Thailand Production of spices (Tons)



Data source: Fao.org, 2019

Overall trend: Graph 3 shows the overall growth trend of spice production. We can observe that despite the overall growth of spice production, there is a short period of no growth and eventually a fall in production after 2012. Similar to Graph 3 which shows the production trend of chilies and peppers, the period of no growth and the decline in production can be attributed to the subsequent effects of severe floods and droughts during 2012 to 2017. The spice crop sector seems to have been impacted quite significantly as we see the sector has not recovered yet.

According to Bank of Thailand's analysis on Thailand Agriculture sector in 2016, the farmer income increased due to higher agricultural prices after a four-year contraction. This was due to the reduced supply following unstable weather conditions in Thailand and high demand from China. Bank of

Thailand report further elaborated that the Agriculture production of Thailand has been in contraction for the past few years due to unstable and poor weather conditions that do not meet optimum conditions for various crops as well as more frequent and unexpected flooding. Floods further caused price pressure on the prices of agricultural products. (BOT, 2016)

Some regions faced severe and prolonged droughts during the first half of 2016 which had deterred the production yields of various crops. While regions in the south were facing heavy and unusual rainfall which hindered the cultivation processes of crops and severely impacted production and yield (BOT, 2016). This would explain the relatively low production we observe in the Chillies, spices and peppers and further explains the impact of climate change on the agriculture sector.

Given the above, it illustrates that Paben Foods and other alike companies may already be facing high prices for raw material or will be facing shortages for production in the near future.

PART 3: FUTURE PREDICTION FOR INDIA: PABEN FOODS CURRENT SUPPLIER

According to National Center for Atmospheric Research, Climate models predict that Earth's global average temperature will rise in the future.

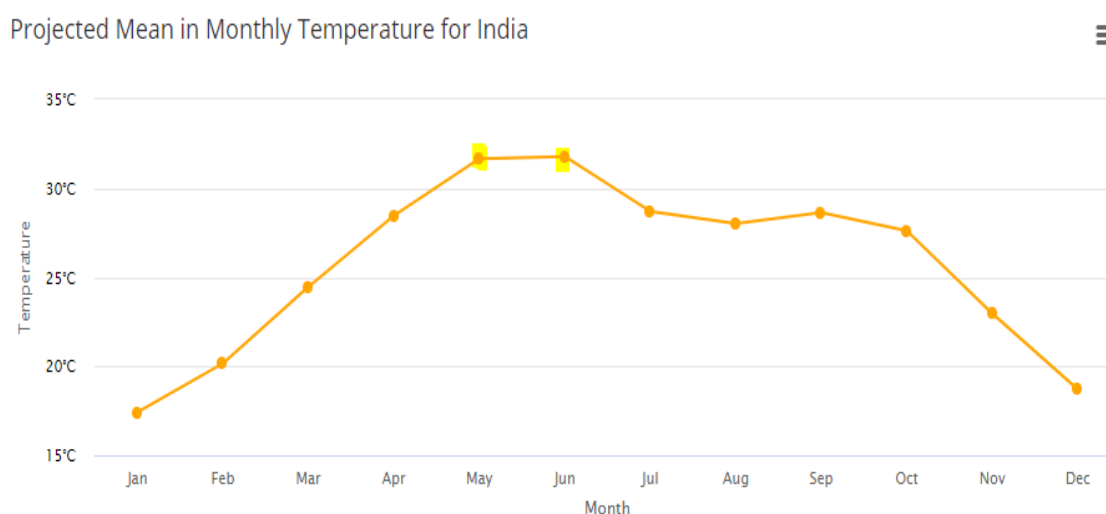
India:

In Indian subcontinent, chillies are produced throughout the year and the optimum temperature for Chillies to grow is 20°C to 30°C and yields suffer if temperatures exceed 30°C or drops below 15°C for extended periods (Ministry of Agriculture India, 2009)

According to World Bank, India's temperatures are projected to increase by approximately 4°C by 2080-2099. Warming is stronger in annual minimum

and maximum temperatures than in the average. Under all emissions pathways, the rise in annual minimum temperatures is around 18-21% higher than the rise in average temperatures. Warming on higher emissions pathways is strongly biased towards the winter and pre-monsoon months.

Graph 4: Projected Mean in Monthly Temperature for India 2020-2039



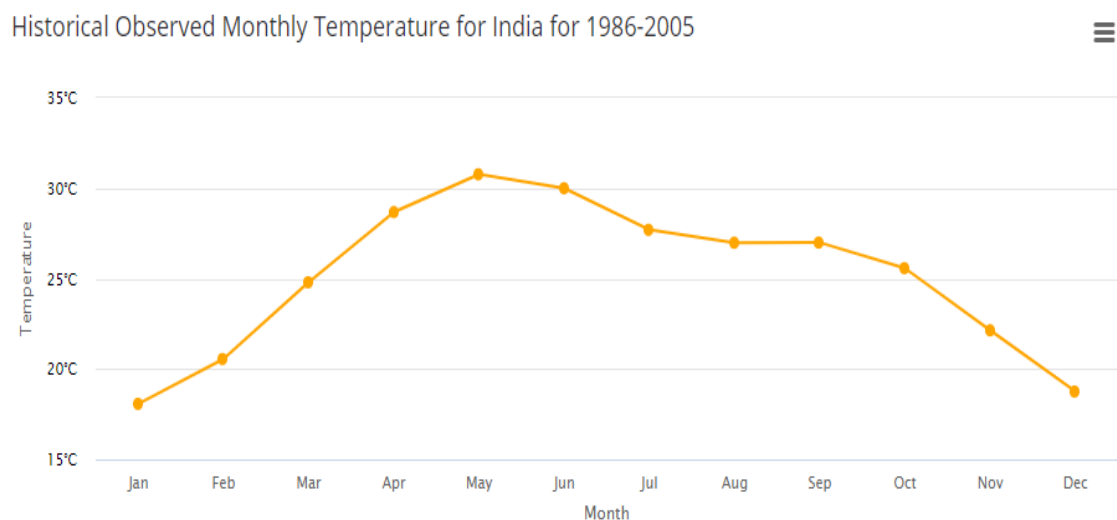
Data source: World Bank Climate Change Knowledge Portal, 2020

According to the projection, although chili is grown through-out the year June & July in India will be producing lower yields of chili (Optimum temperature 20°C to 30°C where yield suffer if temperature below 15°C or 30°C) which means that during the months of June & July Paben Foods should expect a rise in prices of their raw materials imported from India.

This also takes us to the study analyzed in the literature review by Butia et al., (2018). Butia et al., (2018) concluded that that temperature in India have risen 0.46°C from 1901 to 2014 which has been affecting chili yields. An experiment was conducted to grow bell peppers (chili family plant) under non-optimum conditions of 33°C, and it resulted in a reduced fruit set. When the experiment was indicted under temperature of below 18°C it resulted in flower malformation. Additionally, high temperatures introduced diseases in the chili plants such as bacterial wilt, bacterial spot and anthracnose, while diseases

such as *Phytophthora capsica* were observed in environment conditions of low temperatures.

Graph 5: Historically Recorded Monthly Temperature for India 1986-2005 (World Bank Climate Change Knowledge Portal, 2020):



Data source: World Bank Climate Change Knowledge Portal, 2020

For comparison, during 1986-2005 India was able to grow Chilies at their optimum temperature 20°C to 30°C throughout the year - without temperatures falling below 15°C or above 30°C where yields and growth of crops would have suffered according to Ministry of Agriculture India, (2009)

LIMITATIONS:

The timeseries graphs and the literature review do not attempt to prove the magnitude of the effect of global warming on crop yields. For a more quantitative evaluation, econometric techniques or experiments may need to be conducted. The limitations of this study are also that the data for Chili, Peppers and Spice production was only available till 2014 & 2017 hence the latest trend was not observable.

Additionally, it was challenging to get historical data on Paben Food's raw material prices or information Paben Foods' supply or production metrics. It

would have been quite instrumental to see how such data has trended over the years and if it corresponded with climate change impacts or events (Flood, drought...)

CONCLUSION

This study integrated various literatures, as well as looked at SWOT analysis to conclude climate change as a threat to India's agriculture sector; Paben food supplier. Additionally, also analyzed timeseries graphs to conclude that climate change has been affecting Thailand's agriculture sector. The study also specifically looked at the impacts of climate change on chili, pepper and spice crops that are key raw materials for Paben Foods. It was observed that crop yields were fallen during periods of flood and droughts that are caused by climate change. The findings corresponded with the information we received from Paben Foods about changes to their supply or prices over the past few years due to flood or droughts. Paben Foods shared with us that the prices for their Thai Green Curry chilies were impacted due to the floods and droughts but then they started sourcing their raw materials from China and India, hence overall impact on business has been low.

Hence, we also looked at how India's chili, pepper and spice crop yield will be affected from 2020 to 2039 as temperature in the country do not meet the optimum temperatures for Chili. The study concluded that India will not be producing maximum yields Chili during June and July. During the mentioned months, Paben Foods can expect to be quoted higher prices of raw materials as well as potential raw material shortages or lower quality products. Due to the current world situation with the Covid-19, World trade is expected to fall between 13% and 32% in 2020 according to the World Trade Organization. This suggests that Paben Foods may need to source completely from domestic raw material supply.

In 2010 Thailand faced its worst drought in 20 years, in 2011 over a million people were affected by floods, in 2020 again millions are affected by one of the worst droughts in decades. And according to reports, Thailand will most likely continue to suffer from climate change consequences. The Thai government has realized the risk and has been making efforts through initiatives like Climate Change Master Plan (2012–2050), assisting drought-stricken farmers, investigating new water sources and prioritizing agricultural productivity in their 11th National Economic and Social Development Plan (NESDP). To also collaborate with other countries to stabilize the global warming impact, Thailand submitted an Intended Nationally Determined Contribution (INDC) plan ahead of 2015 Paris Agreement to reduce greenhouse gasses by 20-25% before 2030

Nevertheless, Thailand still has a long way to go. In 2016, Thailand was ranked 20th globally in terms of carbon dioxide (CO₂) emissions, producing 0.9% of global emissions. Thailand should continue to shift to organic and higher-value production and make reforms in the agriculture sector through new cultivation, processing, and marketing techniques. The government and the private sector must take collective responsibility and address inefficiencies within small-plot farming and improve modern technology, and knowledge of modern farming techniques. “Improved productivity could have a direct effect on Thailand’s agribusiness and food-processing sectors further increasing agriculture’s contribution to GDP and food security.” (Climate Change Adaption, 2020)

RECOMMENDATIONS

As global warming heats up the planet, the effects on food production companies will be felt globally. Companies that are dependent on agricultural products such as Paben Foods will inevitably be affected as this paper concluded and must anticipate these risks and prepare accordingly.

Based on the suggestions of existing literature, this study would recommend Paben Foods to adopt the following practices:

Identify climate change risks (Hong, Li and Xu, 2019): Identify risks and build climate change adaptation strategy as Paben foods future depend on it.

Robust Supply Chain Management (Evans, 2012) (Dowling and Wit, 2019): Increased risks on the supply chain makes it very important to improve supplier relationships as well as streamline visibility of the supply chain. As climate change impacts the world, some regions will be able to create crops that was not possible before. The company would need to strategize if there is a need to switch sourcing to countries that would be able to sustain weather conditions that are suitable for consistent supply while minimizing logistics and environmental costs.

Maintaining supply chain has always come with challenges but to make the most opportunity from the supply chain network is to respond by diversifying, negotiating contract terms, and hedging commodity prices, as well as utilizing forward contacts as Paben foods is currently doing.

Awareness and Industry collaboration (Dowling and Wit, 2019): There is also a lack of information amongst the local food industry because most climate impacts are discussed at a global scale and not at a local level. Hence there is a need for more refined data and Paben foods should collaborate with their supply chains as well as other industries such as IT, technology,

Insurance companies, research firms, to expand their horizon on the impact of climate change and become insured to sustain their future. In addition to industry and cross-industry collaboration, Paben foods together with other companies should stand together to get access to insurance solutions, information tools and give incentive to professional risk managers to utilize such information to develop financial tools that will help buffer the impacts of climate change on the industry.

R&D (Dowling and Wit, 2019): Moreover, its crucial for Paben Foods to also invest in R&D. When/if multiple supplier sources have been exhausted, Paben Foods would need to look for alternative options and sources. This would require heavy R&D investment from Paben Foods and would be specially challenging for the company as they dedicate themselves to produce high-quality products and distinguishes itself by guaranteeing fresh and authentic flavors. R&D is suggested in growing techniques, agro technology, seed varieties that can help Paben Food build current capacity.

In conclusion, the study's suggestion would be to develop a climate change adaption strategy, build a strong supply chain, and investing more awareness, industry collaboration and research & development. Paben Foods existing guidelines to maintain operational efficiency would need to align better with the recommendation of this study to sustain their future.

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