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A Data Visualization of Rubber Planting in Thailand

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***Abstract*—The rubber tree is considered one of the most important economic crops in Thailand generating a large amount of income for the country. The problem of rubber prices that have been continuously declining since 2012 is a critical issue that requires an appropriate solution. Consequently, a study to understand the demand and supply model of rubber along with data collection and visualization of rubber planting in Thailand are highly essential. A finding from this paper presents that there is an excessive supply of rubber over its demands. Accordingly, one of the proposed solutions to solve the rubber price problems is that the Thai government should have strict control over rubber planting areas in Thailand as the rules specified in agro-economic zones. Another proposed solution is that the Thai government may include some provinces in the northeast of Thailand in agro-economic zones as these areas also generate a high volume of rubber.**

***Keywords*—rubber price, data visualization, web scraping, system dynamics, causal loop diagram, agro-economic zone.**

I. INTRODUCTION

Rubber is one of Thailand's most economically important crops. There are approximately 6 million farmers and rubber-related businesses.

Thailand has been the world's number one rubber exporter since 1991. In 2009, Thailand produced 3.16 million tons of rubber (86% share of all the rubber produced in the world), which generates income for the country around 400,000 million baht per year. Most of the rubber is exported. The rest will then be used in the country. However, most of the rubber exports are in the form of primary processed raw materials with low added value such as ribbed smoked sheet, block rubber and centrifuge concentrate, thus affecting income generation into the country. [1] Most of the rubber suppliers are in Southeast Asia. The first place is Thailand (36%), the second place is Indonesia (25.9%), the third place is Vietnam (8.3%), the fourth place is China (6.2%), the fifth place is Malaysia (5.4%), and the sixth place is India (5%). However, rubber buyers are distributed in almost every region of the world. The first place is China (40.8%), the second place is EU (13.8%), the third place is USA (8.5%), the fourth place is Malaysia (8.3%), and the fifth place is Japan (5.9%). Having few large buyers of rubber creates high bargaining power. In addition, it also causes the rubber to be priced in advance. Figure 1 shows pricing structure of rubber.

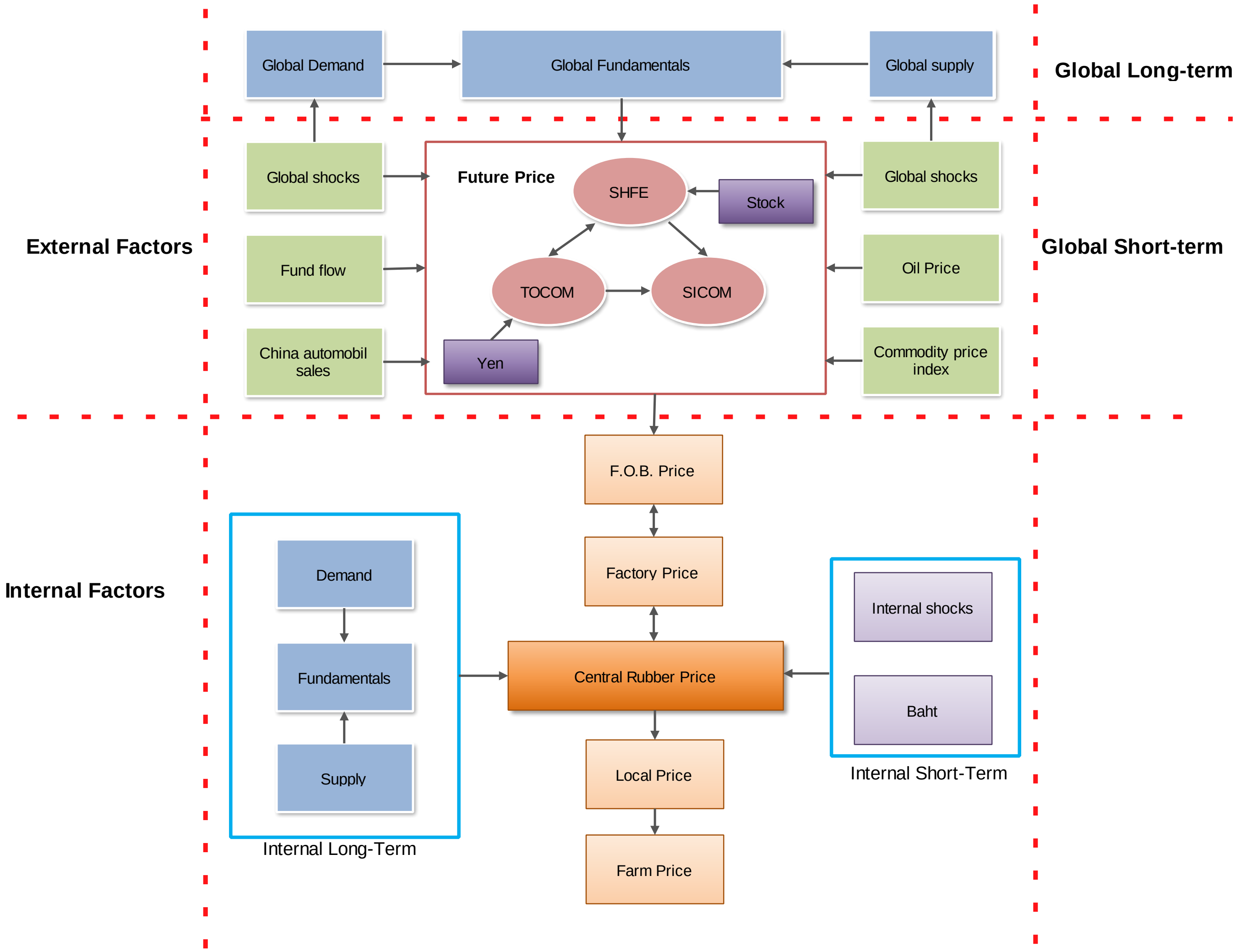

Figure 1 Pricing structure of rubber Edited from [2]

Due to rubber market structure with few traders, as well as strong dependence on export markets, Thai rubber prices are based on the world market prices, especially prices referenced from futures markets. Figure 1 shows the pricing of rubber which consists of external and internal factors. With reference to the external factors, rubber prices are primarily determined by buyers through the futures market. Generally, buyers pay strong attention to the following price movements including SHFE (Shango Futures Exchange), TOCOM (Tokyo Commodity Exchange) and SICOM (Singapore Commodity Exchange).

In addition, the rubber prices are influenced by global long-term and short-term demand and supply as well as the world oil price. Regarding the internal factor, this part will employ the price which was predefined from the first factor to determine the price of central and local markets in both long term and short term. Moreover, the amount of rubber stored in stock is an important factor which may cause the price of rubber to be high or low as well [2].

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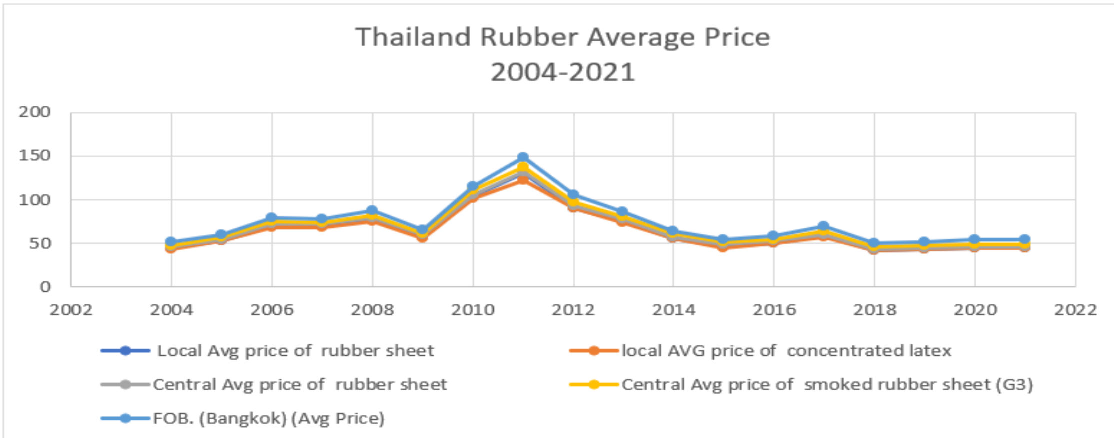

Figure 2 Thailand's rubber price from 2004 to 2021

When studying the price of Thai rubber from 2002 to 2021, as shown in figure 2, it was found that from 2004 to 2011, Thai rubber prices have unprecedentedly increased due to two main factors: 1) The demand for rubber consumption in the global market has grown exponentially; and 2) Rising oil prices cause synthetic rubber prices to rise in response to increasing petrochemical prices, resulting in higher demand for natural rubber substitutes. However, during that time, the amount of rubber was insufficient to meet the demand [2], so the government at that time had a policy to expand the area for rubber planting in addition to the original planting in the southern and eastern regions, which are the rubber planting designated areas according to agro-economic zone that has been defined [3]. The expansion of the rubber planting area as mentioned earlier led to an increase in rubber supply to the market. This caused the rubber prices to fall since the quantity supplied was greater than the quantity demanded. In addition, as other countries also expanded their rubber planting areas and the amount of Thai domestic demand continued to decrease, these also led to rubber market surplus. Moreover, the slowdown in the economy of China, a major buyer, has resulted in lower purchases from China [4], thus pushing down rubber prices. From the problems mentioned above, it may be pointed out that information is extremely important in decision making. Therefore, the presentation of information for decision-making to relevant parties such as farmers, government agencies that determine and direct the policies on rubber planting and marketing as well as related private agencies is highly essential.

This paper aimed to propose data visualization of rubber planting areas in Thailand from 2012 to 2020 in order to show how Thailand's rubber planting areas and yield per rai are. The results gained from data visualization will then be used as decision support for government agencies and private sectors in balancing between rubber planting areas in Thailand and the areas with the best yield per rai. This will cause the production of rubber in Thailand to be in line with the needs of consumers, which will ultimately result in an increase in the price of rubber in Thailand.

II. AGRICULTURAL AREAS IN THAILAND

Most of Thailand has a tropical wet and dry or savanna climate type. Therefore, the majority of Thailand has a tropical monsoon climate all year round. Summer which lasts from April until May is the hottest period. The rainy season which lasts from May until October is affected by the southwest monsoon, causing abundant rain over most of the country. Winter is from November to mid-March. During this period, the weather will be cold and dry which is affected by the northeast monsoon. An exception is the southern part of Thailand which is hot and humid throughout the year with only 2 seasons, namely summer and rainy season. Thailand is located in the position with an appropriate climate for agriculture and is also in the monsoon area with abundant rain which is suitable for cultivation. In addition, most of the soil conditions are coastal plain with alluvial soil and slightly sandy clay which are suitable for cultivation. Consequently, it is not surprising that agriculture has become main occupation in Thailand.

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The Thai government introduced agro-economic zones which are areas of agricultural production. Each area is set for specific crop production based on soil type, rainfall, temperature, economic crop, types of farming and income of farmers. The purposes of this zoning are long-term development planning in agriculture, policies formulation for promoting agricultural production, systematic agricultural marketing, efficient use of budget and time, and the most important thing is to use natural resources in generating agricultural commodities which suit to areas along with creating sustainability in the use of agricultural lands.

With reference to the criteria for determining agro-economic zones, the Office of Agricultural Economics has stated that 1) study the current crops production systems at the production volumes and market demands both within the country and abroad including their future market trends that are suitable for each agricultural product 2) analyze from the physical suitability of the areas to determine which area is suitable for which type of agriculture 3) analyze the relationship between physical and economic factors. Regarding the agro-economic zones of Thailand in 2015, there are 24 agro-economic zones [3]. Details of important agricultural products and provinces of each economic zone are shown in Table 1.

TABLE I
AGRICULTURAL PRODUCTS IN EACH ECONOMIC ZONE. EDITED FROM [3]

Important Agricultural Products	Economic Zones	Provinces
rice, cassava, cattle, buffaloes	1	Udon Thani, Nong Bua Lamphu, Nong Khai, Bueng Kan, Loei
	2	Sakon Nakhon, Nakhon Phanom, Mukdahan
	4	Khon Kaen, Kalasin, Maha Sarakham, Roi Et
rice, cassava, cattle, buffaloes, kenaf, jute	3	Yasothon, Ubon Ratchathani, Amnat Charoen
	6	Nakhon Ratchasima, Chaiyaphum
rice, corn, buffaloes	5	Surin, Buriram, Sisaket
rice, corn, soybeans, sorghum	7	Phetchabun, Lopburi, Saraburi
rice, corn, cassava, sorghum, buffaloes	8	Nakhon Sawan, Uthai Thani
rice, soybeans, peanuts, cattle, fruit trees	9	Tak, Kamphaeng Phet, Sukhothai
rice, green beans, buffaloes, cattle, tobacco, corn	10	Phichit, Phitsanulok
rice, soybeans, peanuts, tobacco, buffaloes	11	Nan, Phrae, Uttaradit
rice, cattle, tobacco, vegetables	12	Chiang Rai, Phayao, Lampang
vegetables, buffaloes, cattle, soybeans	13	Chiang Mai, Lamphun, Mae Hong Son
rice, cattle, sugarcane	14	Chainat, Suphanburi, Singburi, Angthong
rice, fruit trees, vegetables, flowering plants	15	Phra Nakhon Si Ayutthaya, Pathum Thani, Nonthaburi, Bangkok
rice, corn, sugarcane, cattle, fruit trees	16	Kanchanaburi, Ratchaburi, Phetchaburi, Prachuap Khiri Khan
coconuts, fruit trees, sea fishing, flowering plants	17	Samut Songkhram, Samut Sakhon, Nakhon Pathom
rice, cassava, buffaloes	18	Prachinburi, Sa Kaeo, Chachoengsao, Nakhon Nayok
rice, cassava, sugarcane, coconuts, sea fishing	19	Samut Prakan, Chonburi, Rayong
fruit trees, rubber, corn, cassava, sea fishing	20	Chanthaburi, Trat
rubber, coffee, cattle, coconuts, sea fishing, oil palm	21	Chumphon, Ranong, Surat Thani
rubber, cattle, rice, sea fishing, coconuts	22	Nakhon Si Thammarat, Phatthalung, Songkhla, Satun
rubber, coffee, cattle, cashew nuts, sea fishing, oil palm	23	Phangnga, Krabi, Trang, Phuket
Rubber, cattle, coconuts, fruit trees	24	Pattani, Yala, Narathiwat

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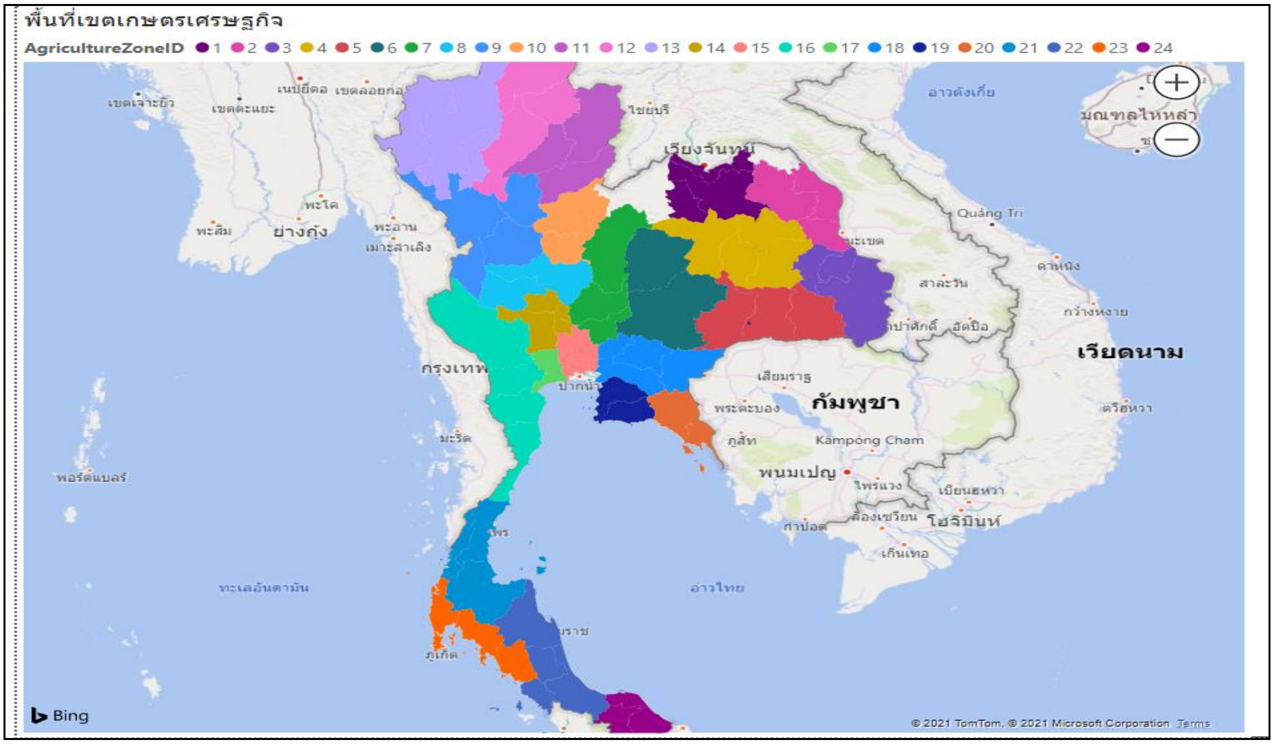

Figure 3 The 24 agro-economic zones of Thailand

III. LITERATURE REVIEW

Rubber is an economic crop which is important to the economy of the South and Thailand. Particularly latex, which is a product obtained from food pipes in the bark of the rubber tree, can be used as a raw material for making various rubber products for a wide variety of industrial uses ranging from heavy industries such as tire manufacturing to household appliances. The latex gained from the rubber tree has certain properties that synthetic rubber cannot be substituted. Therefore, natural rubber is extremely important to Thailand in many aspects including economic, social and environmental impacts. As a result, when the rubber price problems arise, a number of researches have been conducted in order to find the causes of these problems, for example:

Srisuksai [4] found that Thai rubber price has encountered enormous fluctuations. Hence, a mathematical model has been proposed to solve the problem of Thai natural rubber prices that have been continuously declining since 2012. The rubber pricing model especially Thai natural rubber was established. Vector Error Correction Model (VECM) was applied to discover the short-run relationship between WP and FP as follows:

$$\Delta FP_t = \alpha_0 + \sum_{j=1}^{\infty} \alpha_j \Delta FP_{t-j} + \sum_{h=1}^{\infty} \beta_h \Delta WP + \gamma \hat{e}_{t-1} + \varepsilon_t$$

Figure 4 Vector Error Correction Model (VECM) of price of rubber at farm gate [4]

Where WP is the rubber price in Singapore Commodity Exchange which represents the world price.

FP is the rubber price at farm gate which stands for the rubber price at local market.

As for the data collection process, Srisuksai [4] collected both primary and secondary data. Primary data collection was done using questionnaires which were designed to collect characteristics of Thai rubber farmers in various fields including general information of farmers, rubber production, rubber management, cost of rubber, rubber marketing, etc. The sampling was conducted to collect data from areas in 3 provinces in Thailand where farmers regularly cultivate natural rubber in each region, namely Bueng Kan province of the northeastern region, Chanthaburi in the east and Songkhla in the south.

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This sampling was used as a representative data to make an understanding in the general characteristics of Thai rubber farmers in the whole country. In addition, Srisuksai, P. (2020) carried out a survey to collect secondary monthly data from World Bank Commodity Price Data and Office of Agricultural Economics, Thai government between January 1999 and December 2016, (a total of 216 months).

The study from Srisuksai, P. (2020) shows that given other thins are constant, the period t-1 commodity price influences the expected commodity price and the expected profit of commodity production. In addition, the world's rubber price change in the past period causes a change in expected rubber price in the short run which also affects the expected rubber profit. This is consistent with the study results that Thai farmers normally sell their available natural rubber once the world rubber price in the past period reached the high level. Moreover, a change in price of ribbed smoked sheet 3 in SICOM has an apparently positive influence on a change in the farm price of rubber in Thailand. Furthermore, a change in the price of rubber ribbed smoked sheet in SICOM in the period $t - 1$ has a statistically significant impact on a change in the rubber price at Thai farm gate in the period t in the short run. Consequently, the rubber policy to commodity storage for the next period fluctuation should be redesigned by the government. In addition, VECM is a proper pricing model for predicting the rubber farm price in Thailand.

Meanwhile, Romprasert, S. [5] pointed out that Thailand's rubber price was apparently influenced by the agricultural futures market which was used by rubber producers to avoid risks related to rubber price fluctuations. While investors use the agricultural futures market to profit from the difference between the current and future rubber prices. The study proposed a forecasting model of futures price of ribbed smoked sheet 3 to help investors use the information obtained to make buying and selling decisions at the right time. The least mean square error was applied as a criterion for choosing the best forecasting model in the study. In addition, an analysis of factors affecting the ribbed smoked sheet 3 futures price in Thailand's futures market was also conducted. The results of the study revealed that factors affecting the price of ribbed smoked sheet 3 in the futures market was the previous monthly futures price and the oil price, which were related in the same direction. In addition, Japan's net import of natural rubber may also lead Thailand's rubber futures price trends.

IV. Research Methodology

Rubber is an important economic crop of Thailand. Thailand is the largest rubber exporter in the world, bringing in a large amount of income each year. Between 2004 and 2011, the price of rubber has unprecedentedly increased due to the rising demand for rubber in the world market. The government at that time therefore established a policy to expand the area to plant more rubber in addition to the southern and eastern regions, which were the area designated for rubber planting in the agro-economic zone. Details are shown in Table 1. This caused the amount of rubber supply to exceed the market demand and therefore affected the lower price of rubber in the end.

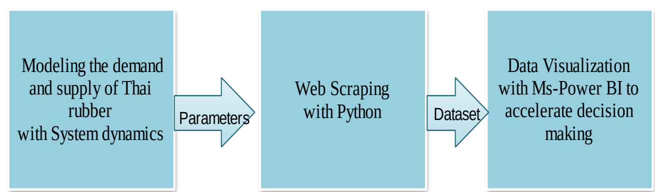

Figure 5 Conceptual research framework

This research framework was designed as shown in figure 5. The research methodology consisted of 1) Using system dynamics to present a model of demand and supply of Thai rubber prices; 2) Using web scraping with Python programming language to collect data based on the parameters of interest from the first process; 3) Using the data acquired from the second process to generate data visualization with Microsoft Power BI. The results gained from data visualization will then be used as decision support for government agencies and private sectors in balancing between rubber planting areas in Thailand and the areas with the best yield per rai. This will cause the production of rubber in Thailand to be in line with the needs of consumers, which will ultimately result in an increase in the price of rubber in Thailand.

A. Using System Dynamics Model to Analyze Supply and Demand of Thai Rubber

System dynamics is a methodology and mathematical modeling technique for framing conceptual pattern of complex matters and problems. It is presently being employed in formulating policies in several places. In addition, system dynamics is a part of systems theory as an approach to understand the dynamic behavior of complex systems. The fundamental principle of system dynamics is to identify the structure of a system with circles.

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Each circle consists of several variables which are related to one another. Sometimes a time-delayed relationship can also be found in the systems. The basic elements of system dynamics diagrams are feedback, accumulation of flows into stocks and time delays. A representation of a problem domain in system dynamics methodology may be simply commenced with a causal loop diagram [6].

From the study of the main reason that caused the price of Thai rubber to continuously decline since 2012, which has never been able to return to the high-level price as in 2011, it was found that the increasing price of rubber before 2012 resulted in the expansion of the rubber planting areas from the former areas in the southern and eastern parts of Thailand, which were classified as agro-economic zone [7]. As a result, the amount of rubber production exceeded consumer demand, causing Thai rubber price to decrease since 2012 onwards. This research applied system dynamics in analyzing the supply and demand of Thai rubber. Figure 6 presented a causal loop diagram of the supply and demand of Thai rubber.

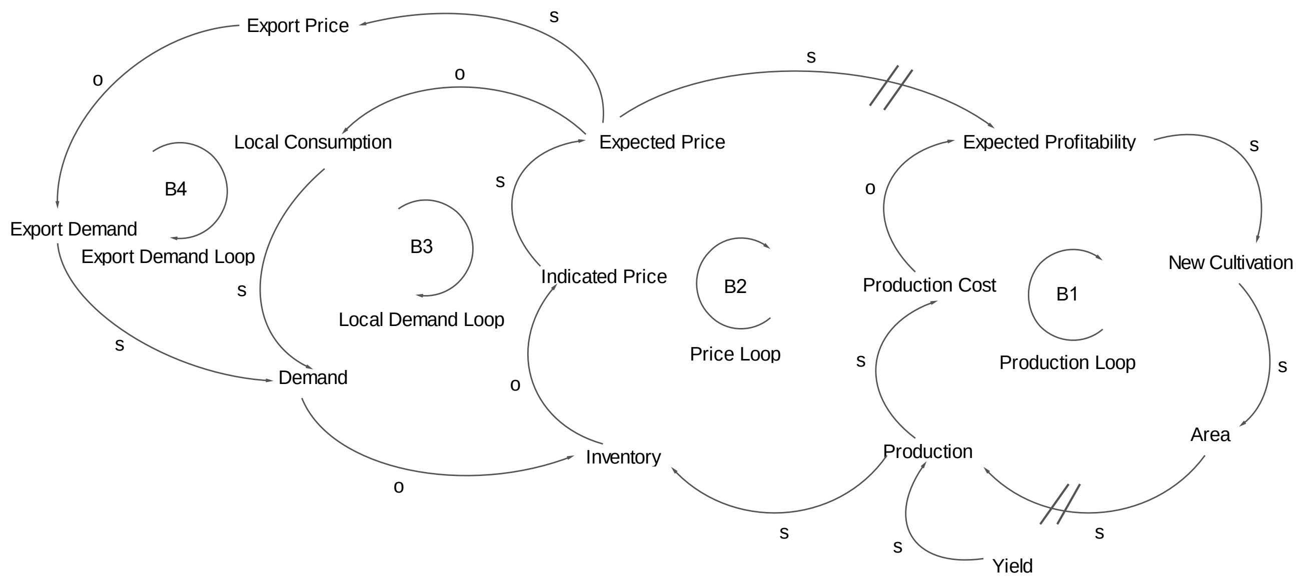

Figure 6 A causal loop diagram of the supply and demand of Thai rubber

Figure 6 presented a causal loop diagram of the supply and demand of Thai rubber which was composed of four balancing loops as follows:

1) Production Loop (B1)
   Yield →(s) Production→(s) Production Cost→(o) Expected Profitability→(s) New Cultivation→(s) Area→(s) Production
2) Price Loop (B2)
   Production →(s) Inventory →(o) Indicated Price →(s) Expected Price →(s) Expected Profitability →(s) New Cultivation →(s) Area →(s) Production
3) Local Demand Loop (B3)
   Expected Price →(o) Local Consumption →(s) Demand →(o) Inventory →(o) Indicated Price →(s) Expected Price
4) Export Demand Loop (B4)
   Expected Price →(s) Export Price →(o) Export Demand →(s) Demand →(o) Inventory →(o) Indicated Price→(s) Expected Price

where (s) represents the “same” direction of a causal link between two variables.
(o) represents the “opposite” direction of a causal link between two variables. In the analysis of the supply and demand of Thai rubber in all of the four loops mentioned above, the variables in these four loops had relationships with and influences on one another.

B. Web Scraping

Today information in the World Wide Web (www) is a huge resource which can be used in a wide variety of tasks.

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Big data analysis is vital for analyzing large amounts of rubber planting data coming from a variety of sources on the web [8]. Unfortunately, the information presented on the websites is in HTML format which is mostly unstructured and difficult to be further manipulated. Web scraping is one of the most powerful alternatives for dealing with the extraction of unstructured data in websites or web pages and converting it to structured data with no need for data copying. Web scraping can be used with many programming languages such as Python, R, JavaScript, Java, Go, and PHP. Using web scraping to extract unstructured data from websites or web pages and convert it into structured data for many uses is an important process to collect large amounts of data which can be of great benefits. For instance, it may be further used in data analysis, data visualization, or as data sets for machine learning models testing. There exist researches that use web scraping as a data extraction tool.

For example, using web scraping in extracting online food prices for research works in food prices, using web scraping in extracting COVID-19 related data, and using web scraping in extracting traveling information such as accommodation, restaurants, spas, hospitals to present information for decision-making to both government and private sectors who desire to invest in tourism [9].

For this research, web scraping with Python programming language was used to collect soil performance data and soil utilization in various crop cultivation, information on land use classification by type of cultivation in Thailand, between 2010 and 2018 at the provincial, regional and national levels [10], information on agro-economic zones of Thailand [3], and rubber planting areas in Thailand and rubber prices gathered from [11] [12] [13]. Figure 7 presents a web scraping process. To begin with, data is extracted from data sources and forwarded to the data cleaning process. The cleaned data will then be transformed into Excel format to serve as an input for data visualization process in MS Power BI.

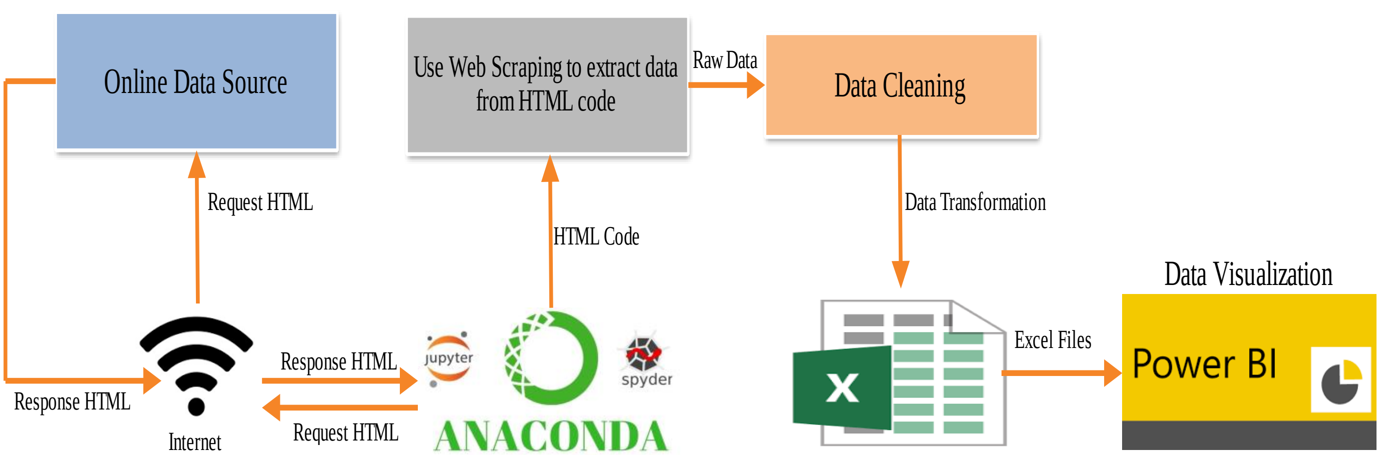

Figure 7 Web scraping process

This research has compiled data from a variety of the aforementioned sources, to acquire dimensional data that can be used to support decision-making about the true causes of the slump in rubber prices since 2012. From the analysis of the data, it was found that the yield was greater than the amount of demand for consumption due to the fact that Thailand has expanded the rubber planting areas, which were previously specified in agro-economic zones. Details of the workflow in figure 7 can be described as follows. Firstly, select data sources or websites which contain the required data.

Then survey the number of web pages to ensure that the data to be extracted is complete and not missing. Next, specify the URL of each page and use the Anaconda Navigator – jupyter tool to perform web scraping with Python by requesting HTML to the required resources. After that, the system will return a Response HTML to researchers. Take this HTML part to write commands to extract the data from. The extracted data will then be transmitted to be cleaned and transformed into Excel format to serve as an input for data visualization process in MS Power BI.

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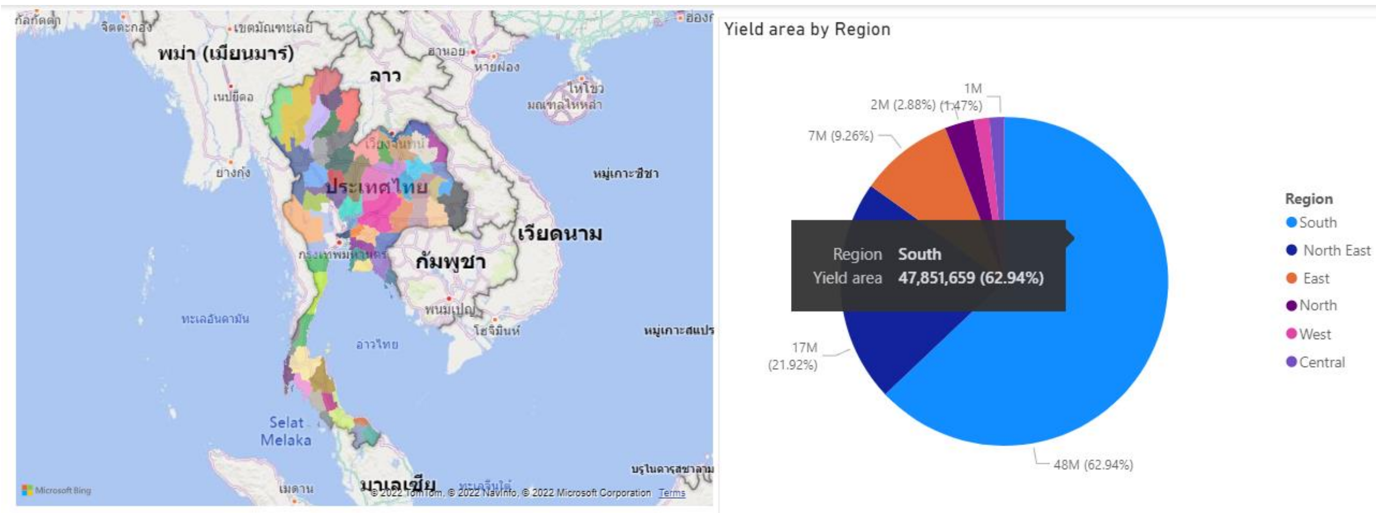
C. Data Visualization

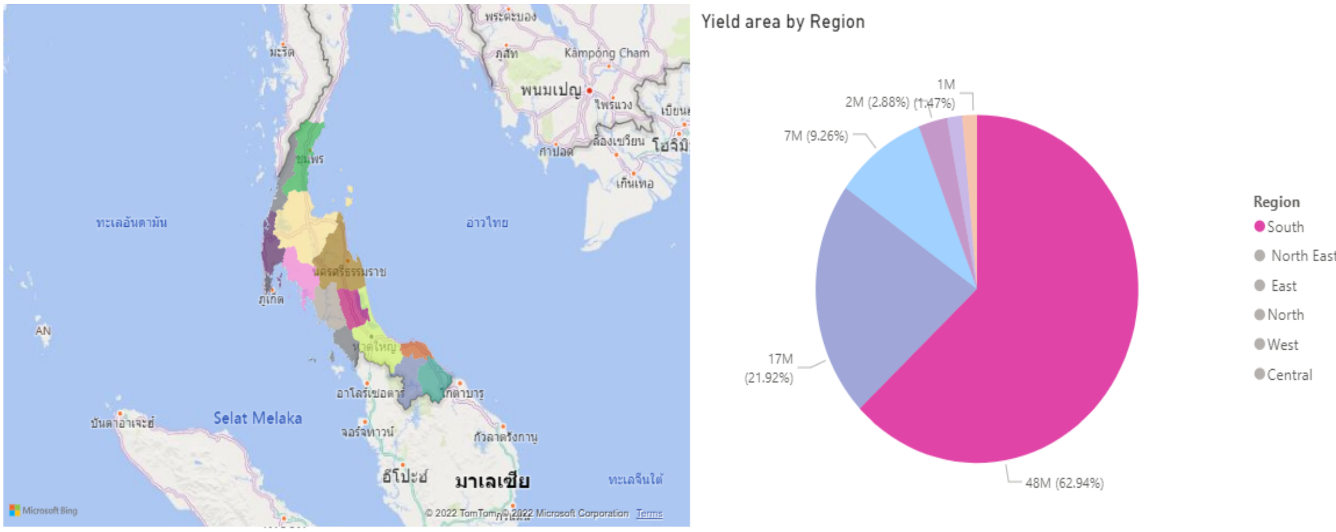
This research presents data visualization of rubber planting in Thailand from 2011 to 2018 in order to illustrate the answers to the following questions.

In what areas does rubber planting in Thailand occur? What areas are ready to yield? And what is the production volume per rai in each area?



Year	2015		2016		2017		2018		Total	
Region	Total planting	Yield area	Total planting	Yield area	Total planting	Yield area	Total planting	Yield area	**Total planting**	**Yield area**
South	14,256,430	12,051,365	14,073,390	11,949,116	13,798,707	11,867,825	13,584,115	11,983,353	**55,712,642**	**47,851,659**
North East	5,160,561	3,752,491	5,145,636	3,864,467	5,230,429	4,303,757	5,225,749	4,742,345	**20,762,375**	**16,663,060**
East	2,090,800	1,722,060	2,076,992	1,718,594	2,052,064	1,755,547	2,046,508	1,844,729	**8,266,364**	**7,040,930**
North	835,121	456,388	833,650	473,214	848,670	570,010	848,805	691,677	**3,366,246**	**2,191,289**
West	428,592	240,930	425,053	243,952	420,731	295,952	418,197	375,259	**1,692,573**	**1,156,093**
Central	368,867	202,696	378,376	217,406	501,577	313,651	502,903	385,736	**1,751,723**	**1,119,489**
Total	**23,140,371**	**18,425,930**	**22,933,097**	**18,466,749**	**22,852,178**	**19,106,742**	**22,626,277**	**20,023,099**	**91,551,923**	**76,022,520**

Figure 8 Data visualization of all rubber plantings in Thailand



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Total	**14,256,430**	**12,051,365**	**14,073,390**	**11,949,116**	**13,798,707**	**11,867,825**	**13,584,115**	**11,983,353**	**55,712,642**	**47,851,659**

Figure 9 Data visualization of all rubber plantings in the south of Thailand

Figure 8 shows a data visualization of all rubber plantings in Thailand from 2015 to 2018. It was found that all regions of Thailand have rubber plantings. The southern region is the area with the highest rubber cultivation and yield in Thailand which corresponds to the areas defined in agro-economic zones [3].

Figure 9 illustrates a data visualization of rubber plantings in the south of Thailand which can be apparently seen that every province in the southern region of Thailand has rubber planting.

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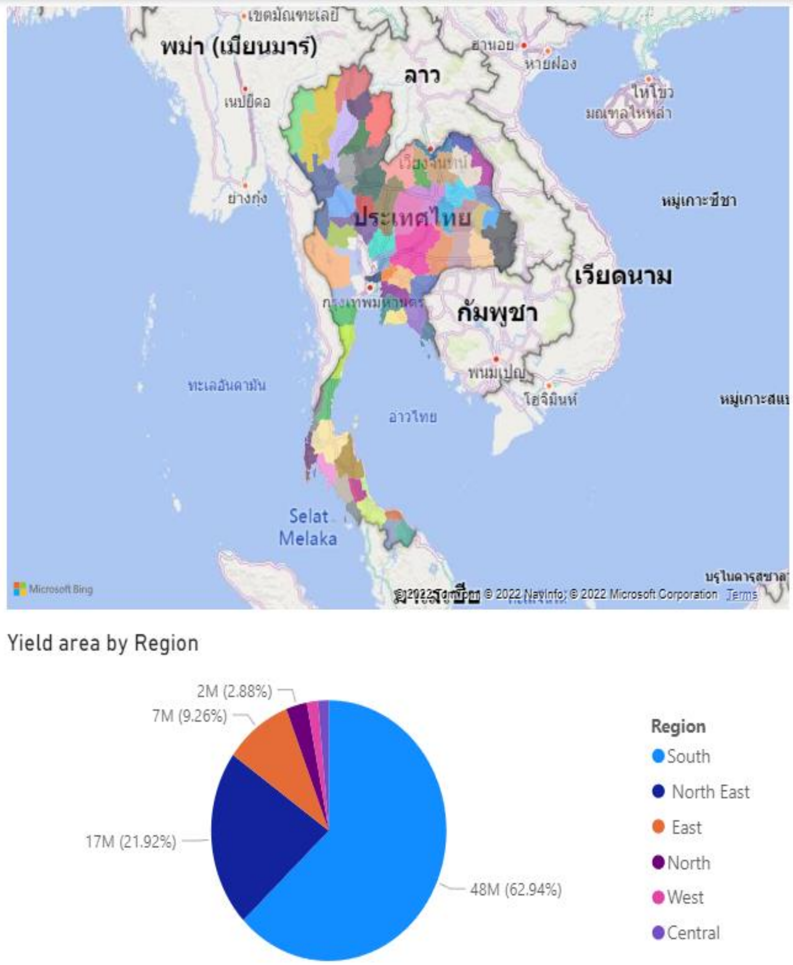

Province	Total planting	Yield area	Product/Rai
Songkhla	7,896,098	6,690,534	1,066
Krabi	2,370,609	2,089,318	1,063
Phang-nga	2,656,149	2,201,797	1,057
Surat Thani	10,020,850	8,939,320	1,046
Phatthalung	3,601,685	3,054,599	1,035
Nakhon Si Thammarat	7,250,545	6,260,239	1,030
Trang	5,959,358	4,936,699	1,024
Pattani	1,479,498	1,331,640	1,010
Satun	1,717,481	1,428,243	1,008
Chumphon	2,219,210	1,991,744	1,007
Yala	5,007,808	4,261,677	977
Narathiwat	4,026,527	3,336,587	963
Ranong	1,239,197	1,094,655	952
Bueng Kan	3,309,909	2,915,399	936
Loei	2,837,430	2,205,901	906
Nong Khai	1,083,249	924,283	889
Sakon Nakhon	1,333,957	1,079,823	874
Prachuap Khiri Khan	905,527	673,643	859
Buri Ram	911,778	737,869	846
Trat	1,364,674	1,196,927	845
Udon Thani	2,127,143	1,659,422	845
Rayong	2,472,016	2,056,451	843
Si Sa Ket	1,247,455	1,003,317	843
Surin	682,655	493,449	839
Nakhon Phanom	1,255,023	1,026,881	836
Nong Bua LamPhu	428,257	337,984	836
Kanchanaburi	554,297	368,647	832
Mukdahan	841,917	656,349	825
Chon Buri	873,513	755,677	817
Chiang Rai	1,199,776	938,265	807
Yasothon	389,031	304,810	790
Kalasin	765,196	582,616	780
Total	**91,551,923**	**76,022,520**	**50,961**

Figure 10 Data visualization of all rubber plantings in Thailand in order from the provinces with the highest yield per rai to the least

Figure 10 shows a data visualization of all rubber plantings in Thailand in order from the provinces with the highest yield per rai to the least. It was found that the province with the highest yield per rai was Songkhla. In addition, it is worth noting that of the 14 provinces in Southern Thailand, 13 were ranked as the top provinces with the highest yield of rubber per rai except Phuket since it primarily focuses on tourism industry.

However, considering the provinces in the 14th, 15th, 16th and 18th order, which are Bueng Kan, Loei, Nong Khai and Sakon Nakhon respectively, it was found that although these four provinces are in agro-economic zones 1 and 2 where their main agricultural products listed are rice, cassava, cattle, and buffaloes, they are capable to be the second to the 13 southern provinces in generating high yield per rai of rubber.

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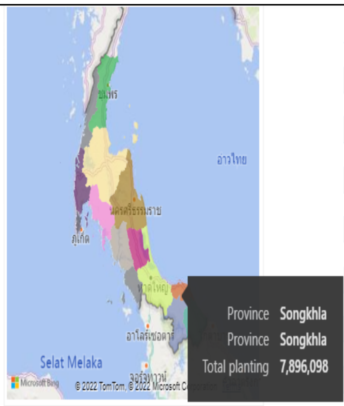
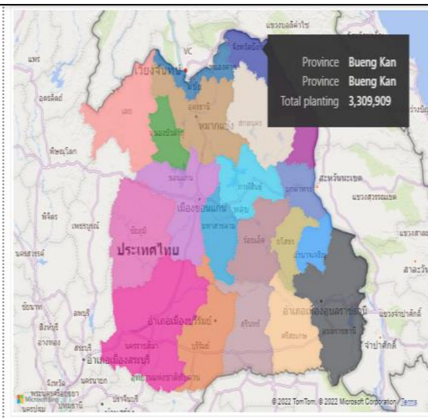


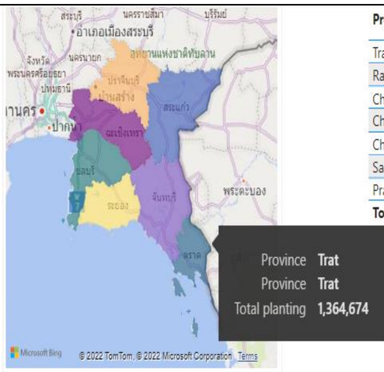
Province	Total planting	Yield area	Product/Rai
Songkhla	7,896,098	6,690,534	1,066
Krabi	2,370,609	2,089,318	1,063
Phang-nga	2,656,149	2,201,797	1,057
Surat Thani	10,020,850	8,939,320	1,046
Phatthalung	3,601,685	3,054,599	1,035
Nakhon Si Thammarat	7,250,545	6,260,239	1,030
Trang	5,959,358	4,936,699	1,024
Pattani	1,479,498	1,331,640	1,010
Satun	1,717,481	1,428,243	1,008
Chumphon	2,219,210	1,991,744	1,007
Yala	5,007,808	4,261,677	977
Narathiwat	4,026,527	3,336,587	963
Ranong	1,239,197	1,094,655	952
Phuket	267,627	234,607	764
Total	**55,712,642**	**47,851,659**	**14,002**

Southern



Province	Total planting	Yield area	Product/Rai
Bueng Kan	3,309,909	2,915,399	936
Loei	2,837,430	2,205,901	906
Nong Khai	1,083,249	924,283	889
Sakon Nakhon	1,333,957	1,079,823	874
Buri Ram	911,778	737,869	846
Udon Thani	2,127,143	1,659,422	845
Si Sa Ket	1,247,455	1,003,317	843
Surin	682,655	493,449	839
Nakhon Phanom	1,255,023	1,026,881	836
Nong Bua LamPhu	428,257	337,984	836
Mukdahan	841,917	656,349	825
Yasothon	389,031	304,810	790
Kalasin	765,196	582,616	780
Amnat Charoen	301,265	219,435	779
Ubon Ratchathani	1,816,680	1,524,512	770
Nakhon Ratchasima	213,071	137,469	745
Khon Kaen	329,849	261,595	728
Chaiyaphum	483,350	293,900	708
Roi Et	360,921	273,864	698
Maha Sarakham	44,239	24,182	645
Total	**20,762,375**	**16,663,060**	**16,118**

North-East

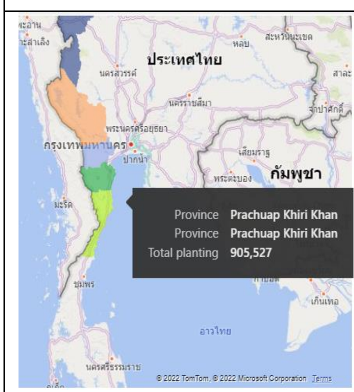


Province	Total planting	Yield area	Product/Rai
Trat	1,364,674	1,196,927	845
Rayong	2,472,016	2,056,451	843
Chon Buri	873,513	755,677	817
Chanthaburi	2,374,662	2,143,441	716
Chachoengsao	806,376	660,299	706
Sa kaeo	262,532	126,580	693
Prachin Buri	112,591	101,555	619
Total	**8,266,364**	**7,040,930**	**5,239**

Eastern

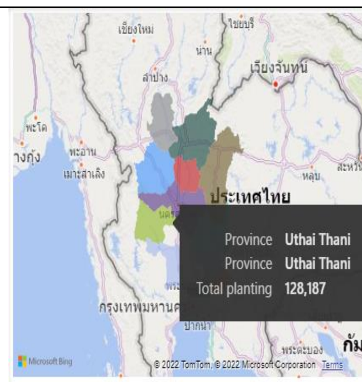
Province	Total planting	Yield area	Product/Rai
Chiang Rai	1,199,776	938,265	807
Phayao	645,878	483,532	751
Lamphun	22,508	13,998	619
Nan	1,028,554	528,509	613
Chiang Mai	103,515	72,045	575
Phrae	120,444	54,433	570
Uttaradit	85,567	41,393	489
Lampang	150,882	54,230	474
Mae Hong Son	9,122	4,884	428
Total	**3,366,246**	**2,191,289**	**5,326**

Northern



Province	Total planting	Yield area	Product/Rai
Prachuap Khiri Khan	905,527	673,643	859
Kanchanaburi	554,297	368,647	832
Phetchaburi	66,082	30,250	708
Ratchaburi	115,211	51,209	694
Tak	51,456	32,344	614
Total	**1,692,573**	**1,156,093**	**3,707**

Western



Province	Total planting	Yield area	Product/Rai
Uthai Thani	128,187	84,295	708
Kamphaeng Phet	128,051	73,667	605
Phitsanulok	924,211	683,817	598
Saraburi	10,183	5,067	575
Nakhon Sawan	41,993	17,039	574
Sukhothai	155,829	86,725	573
Suphan Buri	28,429	9,543	550
Phetchabun	300,843	144,062	537
Pathum Thani	1,644	1,252	536
Nakhon Nayok	6,584	3,508	499
Phichit	16,169	5,805	421
Lop Buri	9,600	4,709	393
Total	**1,751,723**	**1,119,489**	**6,569**

Central

Figure 11 Data visualization of planting areas, yielding areas, and yield per rai of rubber in all six regions of Thailand

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Figure 11 shows data visualization of planting areas, yielding areas, and yield per rai of rubber in all 6 regions of Thailand, with details in order from the highest to the lowest yield per rai as follows: 1) the southern region where Songkhla was the province that generated the highest yield per rai at both regional and national levels; 2) the northeast region where the highest yield per rai was in Bueng Kan; 3) the eastern region where Trat generated the highest yield per rai; 4) the northern region where Chiang Rai occupied the highest rank; 5) the western region where Prachuap Khiri Khan was at the highest rank; 6) central region where Uthai Thani held the highest rank.

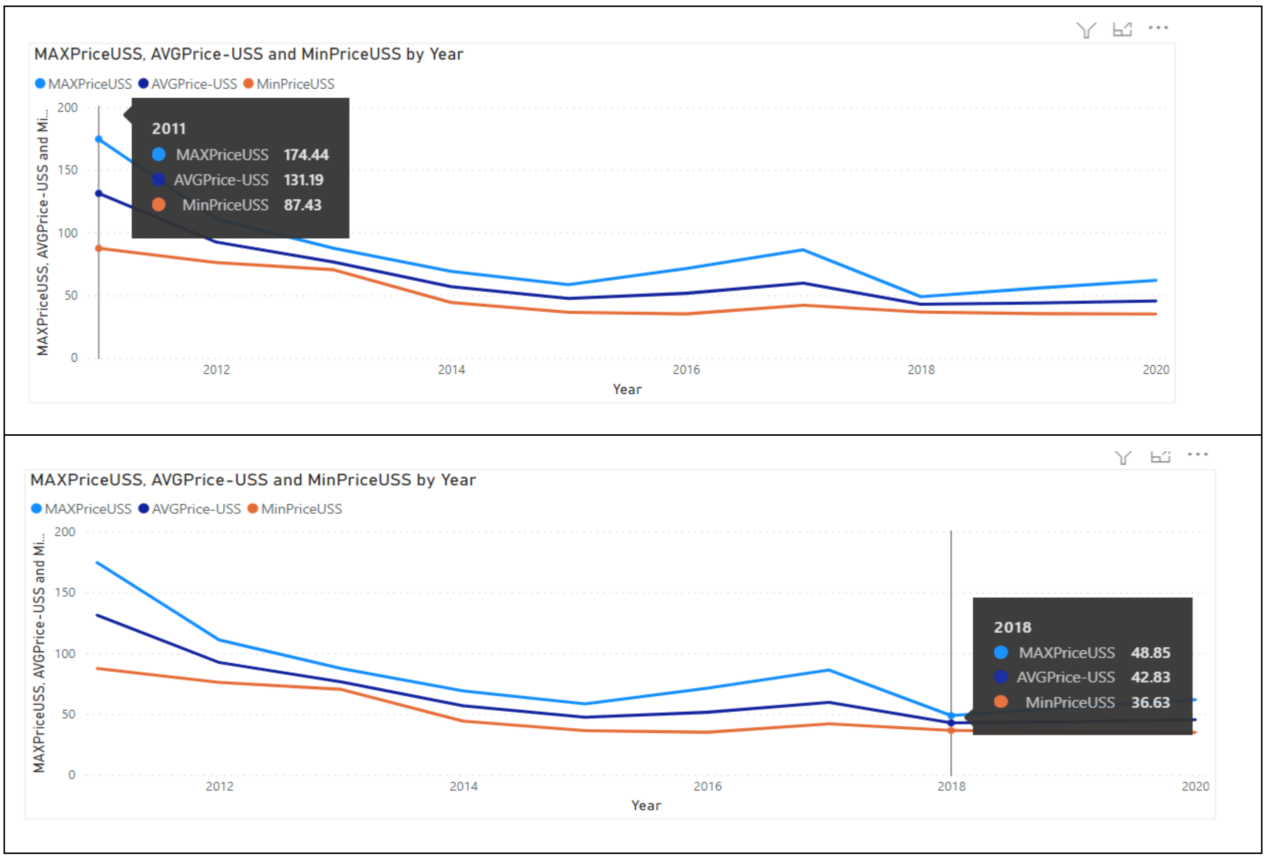

Figure 12 Data visualization of rubber prices in Thailand from 2012 to 2020

Figure 12 shows a data visualization of rubber prices in Thailand from 2012 to 2020. It was found that 2011 was the year that rubber price in Thailand reached its highest value at 174.44 baht per kilogram, while in 2018, the highest price was only 48.85 baht per kilogram which was still lower than the lowest price in 2011.

V. Discussion

In this research, data collection process was conducted by web scraping methodology with Python programming language, allowing researchers to efficiently gather large amounts of both structured and unstructured data from multiple sources in a short period of time.

This differs from the research performed by Srisuksai [4] in that his work used a questionnaire-based data collection method which may experience limitations on the amount of data that can be collected. time required, the variety of data types as well as the completeness of data. In addition, even though the Vector Error Correction Model proposed by Srisuksai [4] may be a suitable one for predicting rubber farm price in Thailand, the model was still just a general equilibrium of commodity goods which may have a limitation in analyzing rubber price which is volatile and constantly changing. Hence, system dynamics as an approach to understand the dynamic behavior of rubber supply and demand proposed in this paper may be more efficient.

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Moreover, a research conducted by [5] pointed out that Forecasting rubber price requires a large amount of data over a changing period of time to gain a reliable prediction result. This corresponds to this research which has applied a data collection technique using web scraping methodology. As a result, researchers are able to perform big data collection to provide graphical representations of information using a data visualization tool. This could eventually lead to actionable insights that can be used to support business decision-making.

VI. CONCLUSION

The problem of rubber prices in Thailand is caused by a variety of reasons. The main reason is that the number of rubber supply has exceeded the consumer demand. This was due to the increase in planting areas during the time when the price increased without a deep analysis of the consequences of oversupply. From the results of this research, it may be pointed out that currently there exists rubber planting in every region of Thailand although the Thai government has already introduced 24 distinct agro-economic zones based on soil type, rainfall, temperature, economic crop, types of farming, and income of farmers with the purposes of long-term development planning in agriculture, policies formulation for promoting agricultural production, systematic agricultural marketing as well as efficient use of budget and time. According to the criteria established in the agro-economic zones by the Thai government, the rubber planting areas in Thailand are set to be located only in the south and eastern region of Thailand. In fact, however, there exists rubber planting in every region of Thailand. Hence, the rubber supply exceeds consumer demand causing Thai rubber prices to continuously decrease. Other variables that may cause the price of rubber in Thailand to uncontrollably fluctuate include an increase of the rubber planting areas in other countries, increasing amounts of rubber stored in the warehouse and a decline of rubber demand from China. However, these are external variables that are difficult to be controlled. Therefore, according to the results of this research, the variable that can help increase rubber price in Thailand is a strict control of rubber planting areas in Thailand to be in accordance with the rules specified in agro-economic zones.

In addition The results of this study also found that the rubber planting areas that were not in agro-economic zones but was able to generate the highest yield per rai next to the 13 provinces in the south are provinces in the northeast including Bueng Kan, Loei, Nong Khai and Sakon Nakhon respectively. This information is extremely helpful in making adjustments on the agro-economic zones for rubber planting areas in Thailand to be more appropriate in the future.

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