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RESEARCH PAPER

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Climate Change Impacts on Rice Farming in Chao Phraya River Basin of Thailand from 1975 - 2015

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1. Introduction

1.1 Background of the Study

Climate change refers not only to global changes in temperature, but also changes in wind, precipitation, and seasons, the strength and frequency of extreme weather events– droughts and floods. Climate change is expected to continue for Thailand. This could affect major agriculture production, particularly rice farming, throughout the country. [1]

In Thailand, rice is farmed in both the basin and mountain areas and each faces different problems. Rice farming in Chao Phraya River Basin has been facing uncertainties in production and damage caused by natural disasters from the severe floods in 1982, 1991, 2011, 2016, and changes to water management policies and weather during 1975 -2015. Supakorn Chinwanno, the Climate Change Specialist, stated that farmers experienced unpredictable rice production, and losing investment and profits from their products during this time. [2]

1.2 Research Objectives

To further examine the challenges of rice farming in the face of climate change, this study focuses on the impacts of flooding, one of the major natural disasters affecting the Chao Phraya River Basin. Floods in this context refer to extreme situations when water from the Chao Phraya River Basin overflows its banks, usually after heavy rainfall, affecting rice crops in that area. The specific objectives of this study are:

(1) To describe the current rice farming situation in the Chao Phraya River Basin of Thailand.
(2) To review the impacts of climate change and floods on rice farming.
(3) To review adaptation policies and to identify challenges due to climate change

1.3 Research Questions

To achieve these objectives, the study focuses on the following research questions:

1. What is the current situation and the impact of climate change on rice farming in Chao Phraya River Basin of Thailand?
2. What is the current status of climate change adaptation plans for rice farming of Thailand?
3. What are the challenges for rice farming in Chao Phraya River Basin of Thailand?

1.4 Method

The methodology used in this research is based on a literature review of Thailand's official policies and official statistics from the Ministry of Agriculture and Cooperatives, the Ministry of Science and Technology, and the Ministry of Natural Resources and Environment. The paper is also based on a review of existing studies by Kasetsart University, The Thailand Research Fund (TRF), and Thailand Development Research Institute (TDRI).

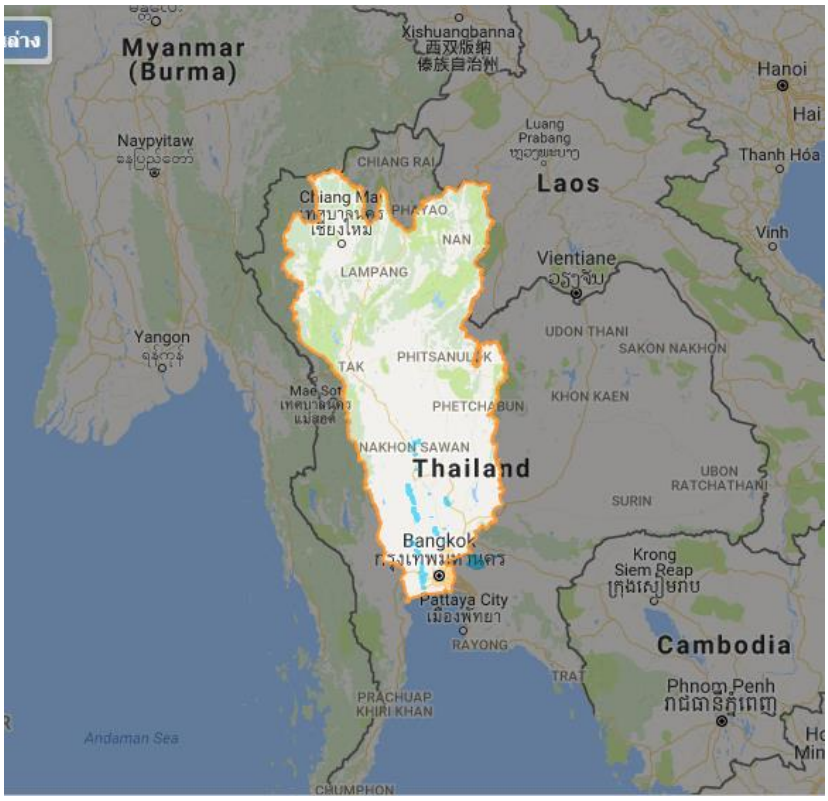
2. Overview of Climate Change, Natural Disasters and Rice Farming in Chao Phraya River Basin of Thailand - Past and Current Issues

2.1 General Information about the Chao Phraya River Basin

The Chao Phraya River Basin (CPRB) of Thailand is located in the central part of the country, as shown in Figure 1. The largest river basin in Thailand, CPRB covers approximately 35 percent of the country's total area.[3, p. 137] The CPRB is composed of four rivers originating in the northern mountains of Thailand: Ping River, Wang River, Yom River, and Nan River, all of which meet in Nakhorn Sawan Province and flow through densely populated areas southward into the Gulf of Thailand.[4, p. 367] Figure 2 shows that the basin is divided into 8 sub-basins: The Ping, Wang, Yom, Nan, Chao Phraya, Sakae Krang, Pasak, and Tha Chin Rivers. The northern region of the country, known as the upper CPRB, consists of The Ping, Wang, Yom, and Nan River, while the central region, the lower CPRB, consists of the Chao Phraya, Sakae Krang, Pasak, and Tha Chin River.[3, p. 137]

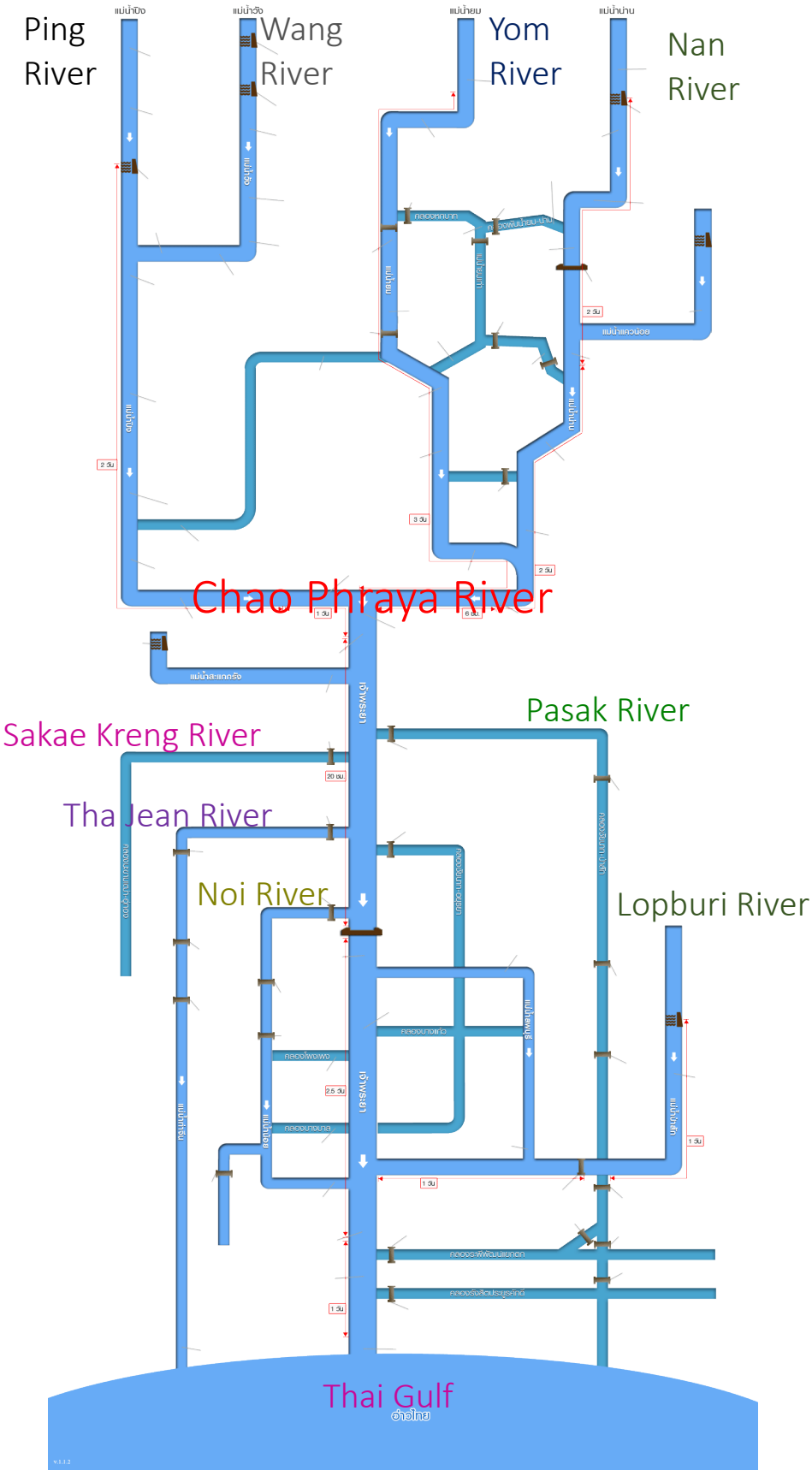
Due to the geography of the CPRB, it stores water that flows from the north. In some years CPRB is covered by floods as a result of natural disasters. The history of floods from 1900 – 2016, shows that 71 severe flood events were documented,[5, 6] some of which lasted for a month or more.[5] Crops were destroyed and the quality of the rice was reduced when the farmers could not harvest their rice in time. As an economic issue, the price of rice products decreased in some years due to lower quality. [2]

Figure 1: Chao Phraya River Basin Overview



Source: Royal Irrigation Department. 2018. [7]

Drainage



Source: Hydro and Agro Informatics Institute (HAII). 2018. [8]

2.2 Rice Farming in Chao Phraya River Basin

The major regions of the Chao Phraya River Basin include agricultural, residential and industrial areas. The main agricultural activity is rice farming which covers approximately 960,000Ha (6 million rai) of land, in which 640,000 Ha (4 million rai) are in irrigable areas. The rice growing period in Thailand lasts four months in one farming season. Farmers can grow rice three times per year or five times every two years.[2] This means that farmers need a high volume of water to grow rice every year.

The growing season starts in May and ends in September. Rice crops can also be divided into two types according to the cultivation period: (1) in-season rice, known as the "Major Rice" (May to October); and (2) off-season rice, known as the "Second Rice or Dry Rice" (November to April). There are three types of rice cropping systems as following:

1) single-cropped rice, lasting for 160-180 days (long-term rice varieties) often planted under predominantly rain-fed conditions in the lower Mekong Basin (Northeast of Thailand)

2) double-cropped rice, and

3) triple-cropped rice.

Double and triple-cropped rice use short-term varieties (90-100 days) and are mainly concentrated in the lower CPRB because the area is irrigated throughout the year [3, p. 137].

Table 1 shows the rice farming cycle for the year 2013-2015. However, the rice cycle in each season is dependent on the weather and the amount of water each year. For example, planting of "major rice" starts around June in the rainy season. In cases of severe flooding, planting may start in October. In many cases, delays prevent farmers from harvesting on time or reduce product quality, a reduction of over 15 % from the standard level.[i] [9]

Table 1. Rice farming cycle, 2013-2015

	period 2013												period 2014												period 2015											
Month	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Major rice						Planting				Harvest								Planting				Harvest								Planting				Harvest		
Dry rice											Planting				Harvest								Planting				Harvest									

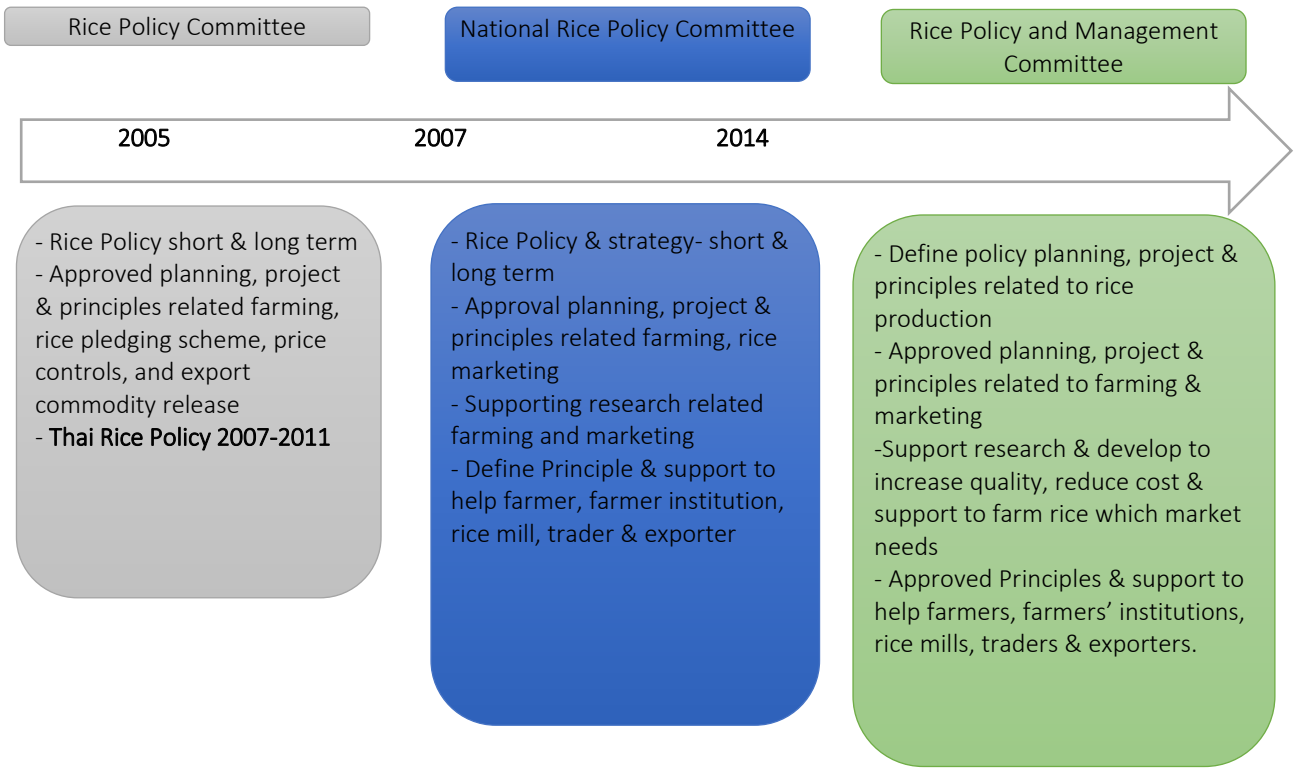
Source: Office of Agricultural Economics. 2018.

2.3 Cooperation between Farmers and the Government in Rice Farming

Even though during 1975- 2015 Thailand was on average the largest rice exporting country in the world, it did not have a specific rice farming policy until the mid-2000s. As shown in Figure 3, the first rice farming policy (covering both the long and short term) began in 2005, when a committee was established to provide advice on any subject related to rice production and products. [10]

[i] Quality factors – specific moisture content 15% m/m max Lower moisture limits should be required for certain destinations in relation to the climate, duration of transport and storage. Governments accepting the Standard are requested to indicate and justify the requirements in force in their country.

Figure 2: Evolution of the Thai Rice Policy and Committee



Source: Department of Internal Trade. 2018.

Water management in Thailand was embedded in over 50 laws involving more than 30 government authorities across 7 different ministries. There were overlapping authorities and none of the laws gave the authority to divert water for usage and none had concerns specifically with flood management. In response, the Thai government established the National Water Resource Management committee in 1989 for overarching water management and changed the policy and committee be responsible to cabinet. [11]

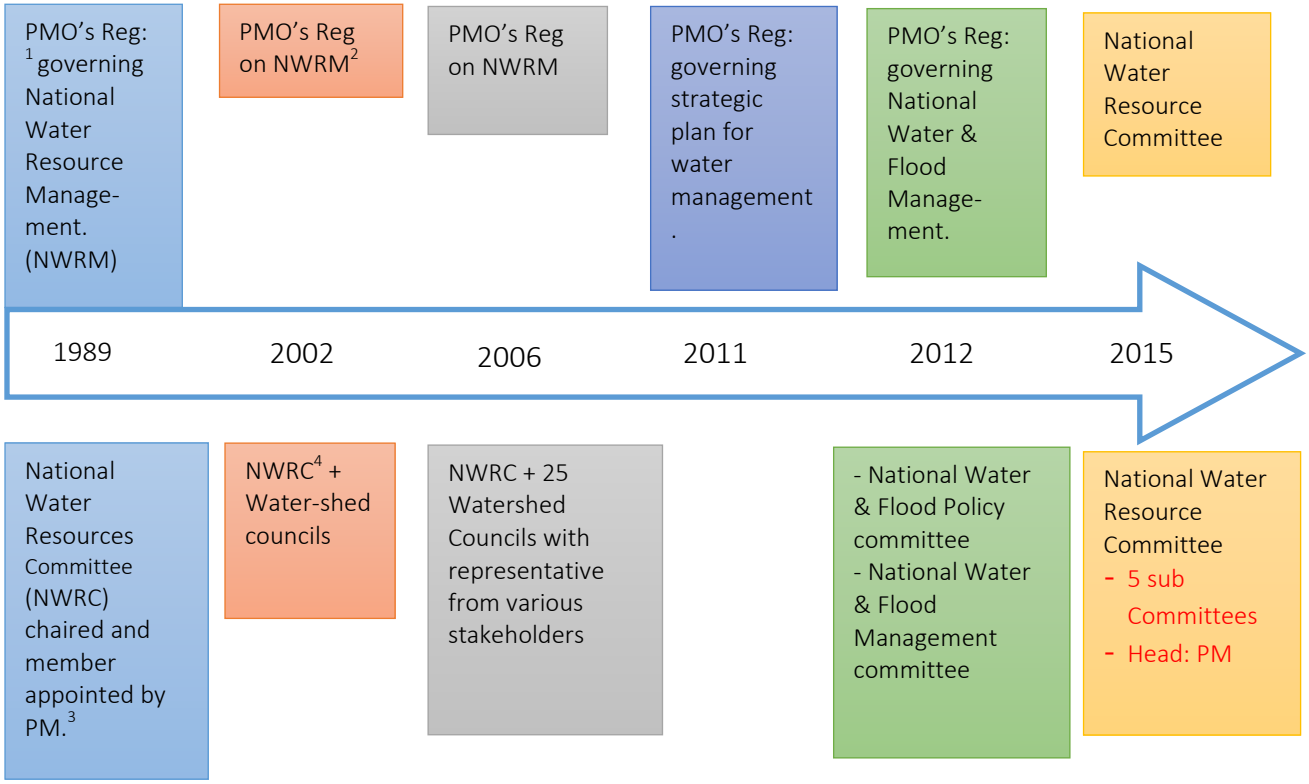
Currently, the government has established policies dealing with water management. These include support for rice farming both long term, and year-by-year policies, as responsible policies after natural disasters. The current rice farming policy No. 3 2015-2019 (Buddhist era: BE 2558 -2562) aims to encourage farmers to: 1) grow other types of crops (e.g., drought resistant) in case of drought, 2) reduce the number of times rice crops are planted per year, and 3) cooperate with one another to form larger rice farm holdings.[12]

In addition, Thailand is implementing a 12-year-Strategic Plan for Water Resources Management for 2015 – 2026 (Buddhist era: BE 2558 – 2569), which includes short, medium and long-term planning. The plan includes a strategic management plan covering flood and drought events. [12, 13]

Every year, the government is responsible for announcing the rice farming policies to farmers before the rice growing season begins. The purpose of the policy is to announce the targeted

amount of farming area which is in line with water availability and management and pricing controls. However, in some years there are timing problems between the official announcement of targets and the rice crop calendar. As a result, the government's yearly target on the size of farming area and production is not always achieved because farmers have started their farming cycle before the announcement by the government. The government's yearly target is the approximate amount of paddy rice produced in the country. This target aims to regulate over supply and market prices of paddy, and to estimate the amount of government support needed for farming in the case of disasters.

Figure 3: Evolution of the Thai Water Resource and Flood Management Institutions



Note:1: PMO's Reg: Prime Minister's Office Regulation

2. NWRM: National Water Resource Management

3. PM: Prime Minister

4. NWRC: National Water Resources Committee

Source: Deunden Nikomborirak and Kittipong Ruenthip. 2013. [13]

3. Impacts of Climate Change and Floods on Rice Farming in the Chao Phraya River Basin of Thailand.

3.1 Overview of Climate Change and Vulnerability in Thailand

Climate Change has been defined in the United Nations Framework Convention on Climate Change (UNFCCC) [14] as follows:

"Climate Change means a change of climate which is **attributed directly or indirectly to human activity** that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

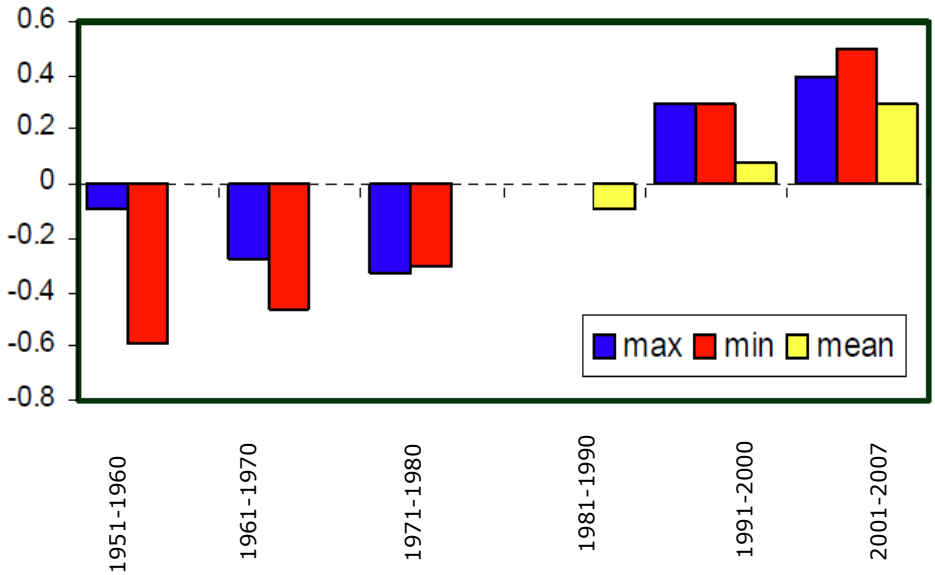
Similarly, the Intergovernmental Panel on Climate change (IPCC) gives a more detailed definition of climate change as: "Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes (operates from within the climate system, for example the change in the global energy balance due to changes in the composition of the atmosphere and greenhouse gas) or external forces (operates from outside the Earth's climate system, and includes changes in the global energy balance due to variations in the Earth's orbit around the Sun, and changes in the amount of energy coming from the Sun or Solar Variability) [15], or to persistent anthropogenic changes (resulting from or produced by human beings) in the composition of the atmosphere or in land use." [16] Greenhouse effects from Human Activities are the main reasons contributing to climate change [17, 18] which has an effect on temperature, rainfall, drought, cyclones and monsoons.

Climate Trends in Thailand: Temperature and Rainfall

Recorded temperatures and rainfall in Thailand reveal that both have increased during the last two decades as shown in Figures 4 and 5.[17, 8]

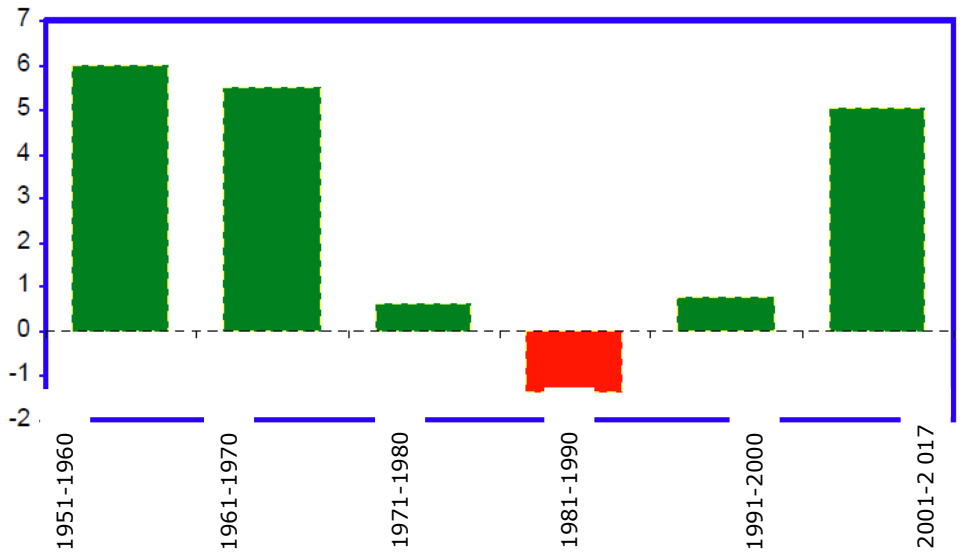
Preyachaya Klaytoun [19] found that when rice farming encounters extreme floods and high amounts of water in paddy fields of over more than 10 centimeters per week, there will be a loss of about 60% of the rice products in each flooded field.

Figure 4: Average temperatures in Thailand for 10 year periods compared with the normal level (Celsius) [18, 20]



Source: Department of Meteorological. 2018

Figure 5: Rainfall volumes in Thailand for 10 year periods compared with normal volumes [18, 21]



Source: Department of Meteorological. 2018

History, Main Causes and Effects of Floods in Chao Phraya River Basin

Between 1975 and 2015, Thailand was impacted by water related natural disasters, particularly floods and droughts. The central part of Thailand faced many flood events during this period. Table 2[20] shows the flood events and their effects on land and people's livelihoods from 1998 to 2013.

Table 1: Flood events and effects on land and human lives in the Chao Phraya River Basin, 1998- 2013

Year	Begin	Ended	Duration (days)	Area affected (km^2)	Dead	Displaced	Main cause	Magni-tude **	Damage (Thousand USD)
1988	18-Sep-88	5-Oct-88	18	243171	19	16000	Torrential rain	6.9	700
1994	3-Sep-94	18-Dec-94	107	65261	407	2000000	Heavy rain	7.1	153
1995	1-Aug-95	9-Nov-95	101	444498	260	4220000	Heavy rain	8.0	395,267
1999	25-Oct-99	9-Nov-99	16	232555	632	1114000	Tropical cyclone	6.9	265,000
2002	18-Aug-02	26-Nov-02	101	371596	65	400000	Monsoonal rain	7.9	32,000
2002	17-Sep-02	2-Dec-02	77	139683	1	3000	Monsoonal rain	7.0	
2003	12-Sep-03	12-Oct-03	31	314895	7	10000	Monsoonal rain	7.0	3,690
2004	6-Aug-04	3-Oct-04	59	378045	11	60000	Monsoonal rain	7.3	
2005	13-Aug-05	26-Sep-05	45	134287	11	119270	Monsoonal rain	7.1	
2005	23-Nov-05	12-Jan-06	51	70520	69	700000	Monsoonal rain	6.9	

2006	10-Oct-06	4-Nov-06	26	174277	0	0	Monsoonal rain	6.8	
2006	20-Aug-06	13-Dec-06	116	213081	195	2000000	Monsoonal rain	7.6	8,100
2007	5-Sep-07	10-Nov-07	67	299972	10	17000	Monsoonal rain	7.3	
2008	11-Aug-08	20-Aug-08	10	219466	130	4000	Tropical Storm Kammuri; Heavy rain	6.3	
2008	11-Sep-08	4-Oct-08	24	165834	0	0	Monsoonal Rain	6.9	8,000
2011	5-Aug-11	9-Jan-12	158	96785	790	10000	Tropical Storms, Monsoonal Rain	7.2	465,000
2013	30-Sep-13	14-Oct-13	15	312091	42	982799	Monsoonal Rain	7.0	

**Flood Magnitude = LOG*(Duration x Severity x Affected Area)

*LOG = Logarithm

Source: G.R.BRAKENRIDGE. 2018. [20]

Table 2 shows that monsoonal rain is one of the main causes of floods across the country, effecting a total area of to 444,498.3 km^2 in 1995, the largest impact as compared with other years. The highest economic effect is the 2011 event which impacted the agricultural, industrial and housing sectors.

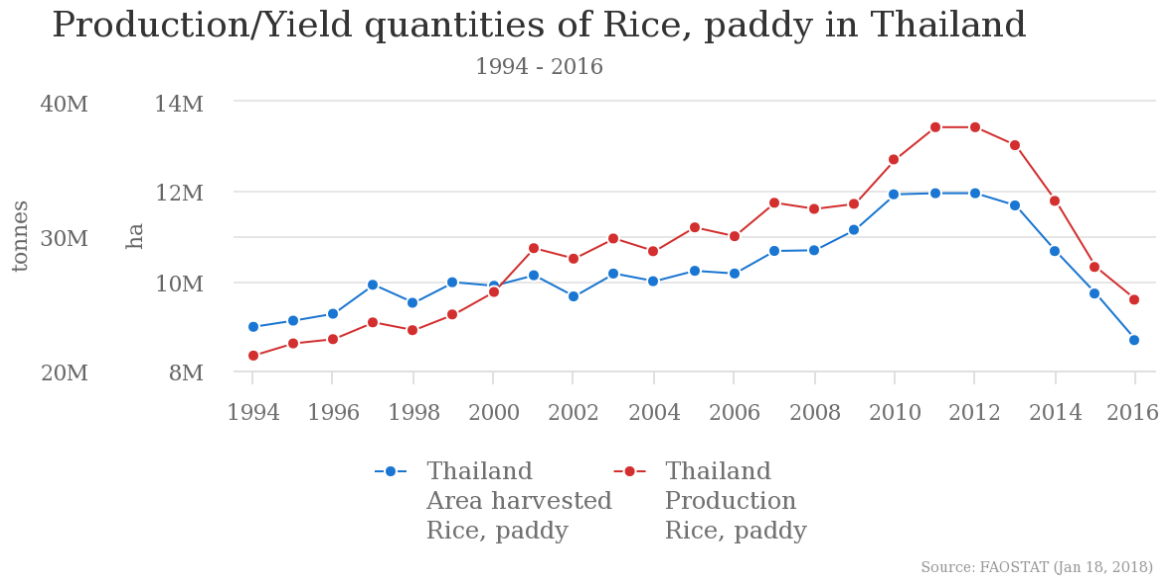
3.2 Impacts of Climate Change and Floods on Rice Farming

Most of rice fields in the CPRB are located on alluvial and flood plains which absorb water flow from the northern part of the country. However, the monsoon occurs in Thailand almost every year which can result in heavy rainfall.

3.2.1 Impacts on Production

Each year, paddy farming area and production quantity have been affected by floods. Figure 7 shows that from 1994 to 2011, both the size of the harvested area and production increase and the rice yield per hectare grew at a rate of around 2 percent on average annually. However, since 2012, the production of rice has been decreasing. The decrease in yield can be caused by many factors such as; 1) less frequent or delays in the rice farming cycle during the years of severe flooding 2) less developed equipment and technology in farming activities.

Figure 6: Major and second rice harvested area and production, 1994-2011



Source: FAOSTAT.2018.

3.2.2 Impacts on Agricultural Land

Table 3 shows the amount of agricultural land destroyed by floods in the Chao Phraya River Basin. The flood in 1994 destroyed the largest amount of agricultural land. In 1995 however, the Chao Phraya experienced one of the biggest flood events in history, affecting the largest area as compared to floods in other years; yet, the destruction of agricultural land was less than that of 1994. In 2011 while the agricultural sector experienced the largest destruction in terms of economic value, the area of destroyed agricultural land was lower than in 1999.

Table 2: Agricultural area destroyed by floods

Year	Begin	Ended	Duration (days)	Area affected (km^2)	Destroyed agriculture area (Million Rai)
1988	18-Sep-88	5-Oct-88	18	243171	NA
1994	3-Sep-94	18-Dec-94	107	65261	14,000,259
1995	1-Aug-95	9-Nov-95	101	444498	3,792,364
1999	25-Oct-99	9-Nov-99	16	232555	3,038,167
2002	18-Aug-02	26-Nov-02	101	371596	10,435,115
2002	17-Sep-02	2-Dec-02	77	139683	NA
2003	12-Sep-03	12-Oct-03	31	314895	1,595,557
2004	6-Aug-04	3-Oct-04	59	378045	3,298,733
2005	13-Aug-05	26-Sep-05	45	134287	1,701,450
2005	23-Nov-05	12-Jan-06	51	70520	NA
2006	10-Oct-06	4-Nov-06	26	174277	6,560,541

Year	Begin	Ended	Duration (days)	Area affected (km^2)	Destroyed agriculture area (Million Rai)
2006	20-Aug-06	13-Dec-06	116	213081	NA
2007	5-Sep-07	10-Nov-07	67	299972	1,617,284
2008	11-Aug-08	20-Aug-08	10	219466	6,590,655
2008	11-Sep-08	4-Oct-08	24	165834	NA
2011	5-Aug-11	9-Jan-12	158	96785	11,798,241
2013	30-Sep-13	14-Oct-13	15	312091	6,099,777

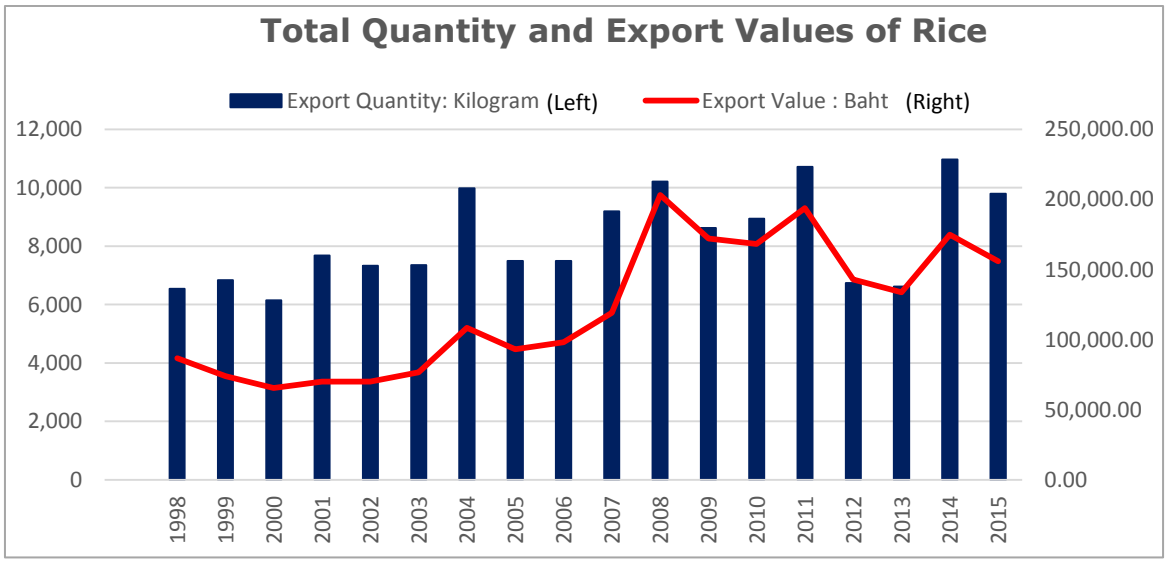
Note: NA: Data is not available

Source: Department of Disaster Prevention and Mitigation. 2018

3.2.3 Impact on Export Quantities and Values

Figure 8 shows that the export quantities as well as export values deceased sharply in 2012 and 2013. This can be explained by the effects of large flood event in 2011 resulting in the loss of rice production and damage to arable land, which further reduced the rice quantity available in the market in the following years.

Figure 7 : Export quantities and values



Source: Office of Agriculture Economics. [21]

4. Government Policies of Rice Farming and Remaining Challenges

4.1 Government Policies

4.1.1 Long Term Policies for Rice Farming

After the floods in 2011, Thailand has been more active in integrated rice farming and water management policies into long-term planning. In its yearly planning, the Government announces which areas should be used for the farming of the major rice and second rice depending on the weather forecasts.

Water management policy will focus on how to preserve water for agriculture and daily use, manage the amount of natural and irrigable water and how to manage in case of flood or droughts. Mostly, water policies focus on droughts rather than floods. In the case of floods, the government has a plan to limit water being held in dams, to control the flow of water into the gulf of Thailand and to preserve the rice farming area for monkey cheek zoning[ii] [22] to reduce the economic effects in certain areas. In some years, the implementation is not in line with the plan because the amount of water does not match the forecast. [23]

In addition, Thai government had a National Adaptation Plan for Agriculture (NAP-Ag) for 2013-2016 and is now drafting the 2nd plan for 2017-2021 (B.E. 2560-2564) and developing the NAP work plan. The plan is under the responsibility of Department of Agricultural Economics, Ministry of Agriculture and Cooperatives.[17]

The NAP-Ag plan is under the climate change master plan for 2015-2050 and 12th National Economic and Social Development Plan (2017-2021). The vision of the NAP-Ag plan states that Thailand's agriculture should be climate resistant and contribute to mitigating climate change problems under Sufficiency Economy Philosophy and the sustainable development pathways. Strategic goals in the 2017 -2021 plan include:

1) Adaptation for enhancing climate resilience
2) Sustainable development
3) Building networks and collaborations between farmer, government and stakeholder in local level, national level and international level
4) Enhancing competitiveness in the world market
5) Developing technology transforms that are environmental-friendly and have low carbon production

The plan for 2017 -2021 has three priorities for climate change adaptation:

1) Water management
2) Sustainable soil management
3) Strengthening farmers' climate resilience

Thai NAP-Ag included both mitigation and adaptation plans for agriculture by defining them as a strategic plan. Some of these plans are:

<u>Adaptation plans</u>

- Strategy no. 1 – collect and develop database, knowledge, technology and innovation for awareness in climate change adaptation
- Strategy no. 2 – increase capacity in climate change adaptation for agriculturists, agricultural institutions, and related businesses

[ii] The term 'monkey cheek' was introduced by King Bhumibol Adulyadei of Thailand as a metaphor to promote local water retention systems and is part of the 'New Theory' in Agriculture. It refers to monkeys filling up their cheeks with excess food. The food is stored and chewed and eaten later. The monkey cheek programme was initially started to solve the flood problems of Bangkok, but has subsequently been replicated all over the country, especially in the north-east

- Strategy no. 4 – increase capacity management for climate change in agriculture

Mitigation plans

- Strategy no. 3 – The Agricultural Sector shall participate to reduce the greenhouse effect and develop global environmental-friendly practices.

From NAP-Ag, 12th National Economic and Social Development Plan (2017-2021) and Government policy, Thailand has expanded the plans and strategies which aim to reduce the causes and effects of climate change.

- "Big area rice farming policy" aims to encourage farmers to cooperate with each other to farm in a large area and share water and other resources.
- "Smart farmer policy" calls for not only for the use of technology to forecast weather and market prices, but also, the use biotechnology for developing seeds and preserving crops to meet quality standards.
- "Added value rice farming policy" aims at having farmers growing added value rice that meets the customer's needs for example organic rice and high grain and healthy rice.

4.1.2 Zoning for Monkey Cheeks

The water management plan of the Ministry of Agriculture and other related agencies aims to reduce the effects of floods on economic zones in cases of natural disasters. This is accomplished by using rice farms as a flood way or as detention basins to move water to other river basins, or by waiting until the volume of water has reduced. The affected areas are usually greater than estimated because the volume of water is higher than expected which results in flash floods. Due to such events, harvesting is not possible even though the paddy is ready to be harvested and, thus, the products are destroyed.

4.2 Remaining Challenges

Despite government policies on climate change adaptation, according to Global Climate Risk Index 2018, Thailand is one of the top ten countries most affected by climate change and extreme weather from 1997 to 2016 (annual averages).Moreover, in the 2017 Index, Thailand is ranked 10th out of the top 10 countries, as shown in Table 4. This ranking shows that Thailand has not made much progress in terms of dealing with climate risk. [24, 25]

The Meteorological Department has forecasted that Thailand will have higher temperatures, and floods may affect all parts of the country.

Table 3: The Long-Term Climate Risk Index (CRI): the 10 countries mostly affected, 2017 [25]

CRI 1996-2015 (1995-2014)	Country	CRI score	Death toll	Deaths per 100 000 inhabitants	Total losses in Million US$ (PPP)	Losses per unit GDP in %	Number of events (total 1996-2015)
1 (1)	Honduras	11.33	301.90	4.36	568.04	2.100	61
2 (2)	Myanmar	14.17	7145.85	14.71	1300.74	0.737	41
3 (3)	Haiti	18.17	253.25	2.71	221.92	1.486	63
4 (4)	Nicaragua	19.17	162.90	2.94	234.79	1.197	44

5 (4)	Philippines	21.33	861.55	1.00	2761.53	0.628	283
6 (6)	Bangladesh	25.00	679.05	0.48	2283.38	0.732	185
7 (8)	Pakistan	30.50	504.75	0.32	3823.17	0.647	133
8 (7)	Vietnam	31.33	339.75	0.41	2119.37	0.621	206
9 (10)	Guatemala	33.83	97.25	0.75	401.54	0.467	75
10 (9)	Thailand	34.83	140.00	0.22	7574.62	1.004	136

Source: The Long-Term Climate Risk Index (CRI). 2018.[24]

Climate change and extreme natural disasters such as floods are to impact further farmers' livelihood. Since farmers usually have to use their traditional or previous year experience to prepare for next years' farming cycle, production outcomes are mostly unpredictable and unsatisfactory. Climate change will continue; these problems need to be addressed and adapted to improve farmers' working conditions within limited resources. Further support and appropriate options for adaptation of infrastructure, knowledge and information sharing, research and technology are important in this regard. Research studies on farming of flood and drought resistant crops are also needed as models for farmers.

5. Conclusion

This paper reviewed the current situation regarding rice farming in the Chao Phraya River Basin of Thailand, the impact of climate change and flood events on rice farming, and the climate change adaptation plan for rice farming in place for this area.

The study revealed that between 1975 and 2015, CPRB encountered many unexpected and extreme flood events. Recorded mega flood events occurred in 1975, 1978, 1983, 1988, 1993, 1995, 1996, 2001, 2002, 2006, 2010, and 2011. Mostly, the floods were caused by extreme weather and heavy rain. The flood in 1995 was ranked the highest, causing a submerged area of 444,000 km^2, while the 2011 event was the longest (158 days) and led to the largest economic losses of about USD 46,500,000. The 2011 flood in CPRB damaged not only housing, but also, more than 1.92 million hectares of land, consisting of 1.35 million hectares of rice fields which represented 12.5 percent of all cropland.[23]

The forecasted statistical analysis of maximum and minimum temperature and rainfall in Thailand after 2070 suggests that maximum temperatures will be around 40-43 Celsius and minimums will be at 13-17 Celsius. There will be increased unpredicted rainfall and monsoons which will affect farming, harvesting cycles and cause production losses.

Climate change and floods are one of the key factors that will affect farmers' lives and ways of working. Usually, farmers use their former years' experience to adapt to the change in weather and prepare for the next years' farming cycle. To be better prepared, farmers could integrate mitigation and adaptation plans including plans to identify new challenges using research and technology which would enable them to get more support from the government.

In addition, the government is engaging in developing water management strategies, rice farming policies and climate change plans. However, these initiatives require broader dissemination to ensure the public is aware of them. For the policies to be more effectively acknowledged and implemented, action can be taken to circulate the information widely to the public. All main sectors

particularly agriculture need to be incorporated into the mitigation and adaptation plans. The 2nd draft National Adaptation Plan for Agriculture, 2017-2021, calls for agriculture to become climate resilient and contribute to mitigating climate change problems under the Sufficiency Economy Philosophy and Sustainable Development pathways: emphasizes a balanced use of material resources, social capital, environmental reserves, and cultural wealth. Supporting new technology and research for development is also another choice for improving climate change adaptation plans.

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