



Rain Making

Nakanya Rodruepid

Pursuing the Bachelor of Science: Aerospace, Professional Pilot Degree

This research was conducted for an Undergraduate Honors Thesis



History of Cloud Seeding in Thailand

Cloud seeding in Thailand was started by King Bhumibol Adulyadej in November 1955. The reason that rain making is necessary for Thailand is that Thailand is an agricultural country that relies on rain to grow crops. The king saw that there was a lack of water in many parts of the country, so he needed to help his people. It took 15 years for him to gather all the information regarding the necessary chemicals and steps to make rain. He successfully discovered the chemicals that were effective in rain making and founded the Royal Rainmaking Project to conduct cloud seeding missions regularly. The government has been operating cloud seeding to help farmers ever since.

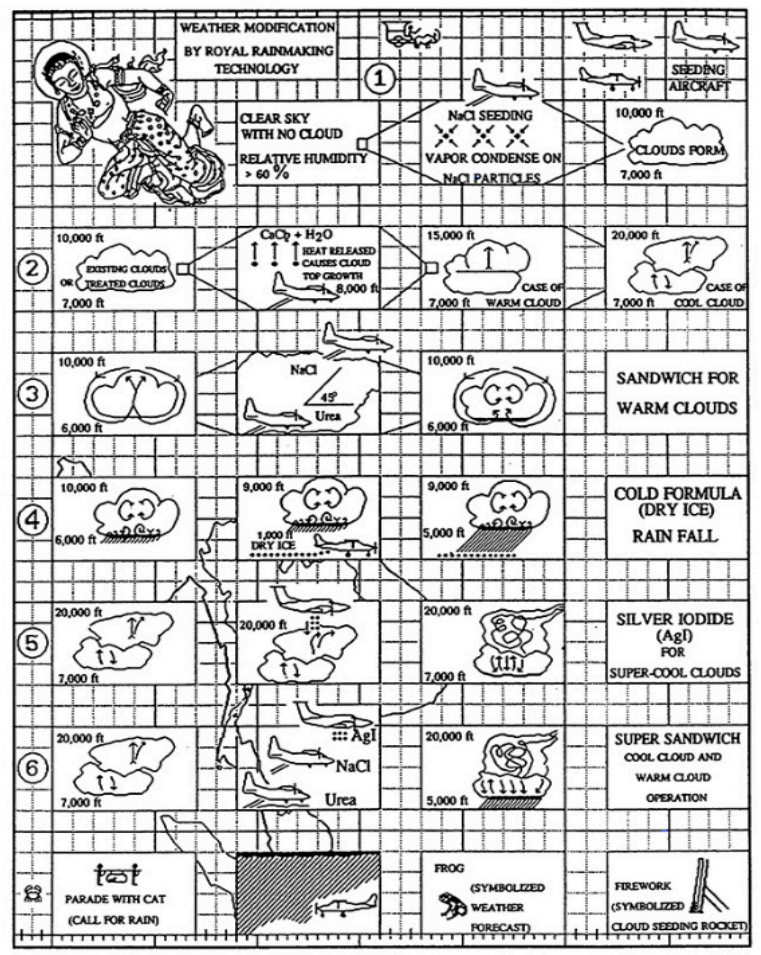
Steps to Make Rain

Multiple factors must be considered when choosing the area where the rain mission will take place:

- ❖ The main industrial crops grown in the area where the rain mission will take place. Thailand's main crops are rice, corn, cassava, and sugarcane.
- ❖ The current rainfall amount, because there might be flooding, making more rain unnecessary or even harmful.
- ❖ The local reports by the people who live in the area regarding their water situation.
- ❖ The radar to see if there was any rain in the area the night before.

Rain Making only works when there is at least 60% relative humidity. The atmospheric condition must be unstable with light wind for the chemical to create clouds. The Royal Rainmaking Project uses six steps, which were written by the king, to make rain.

Six Steps Involved in Rain Making	Definitions of Steps
Triggering	This step increases the existence of clouds.
Fattening	This step increases both the growth rate of clouds and the density of water droplets.
Sandwich Technique	This step causes the cloud base to become denser and heavier causing it to rain.
Enhancing	This step lowers the cloud base to be closer to the ground.
Attacking Cold Clouds	This step pulls small ice pellets together to create bigger ice pellets until they are heavy enough to be pulled down by gravity.
Attacking by Super Sandwich Technique	This step increases the amount and duration of rain.



What Is Rain Making?

Rain making, cloud seeding, and artificial rain are interchangeable terms and refer to the fantastic process of weather modification. Scientists use modification methods to increase the amount of precipitation by utilizing different kinds of chemicals. Although it is called rain making, it provides additional meteorological benefits. Those benefits include increasing snow and rain in addition to reducing air pollution and hail damage.

My Experience as an Intern with The Royal Rainmaking Project



This project is based on my experiences as an intern at the Thailand Royal Rainmaking Project and on my research for my honors thesis. The internship was an amazing opportunity; it provided the first-hand experience of applying my knowledge of flying. The picture on the left shows the crew making preparations for a weather mission. We flew in the helicopter to observe the weather station in northern Thailand. The picture on the right was taken after I accompanied the crew during a rain making operation.

Hypotheses and Thesis Statement

This project investigated how cloud seeding works in order to determine its economic effectiveness in Thailand.

The study thus began by exploring the cloud making process in Thailand (see left panel). The study then proceeded to evaluate the success rate of cloud seeding around the world as well as to analyze the cost of rain making and discover the yearly profit of the main industrial crops that grow in Thailand (see right panel).

Result

This study successfully collected the data necessary to solve the questions posed in this thesis. First, studies from around the world demonstrated the effectiveness of rain making in increasing rain and snow as well as in decreasing hail and pollution. Second, enough financial data was retrieved to calculate the positive financial benefits of rain making in Thailand. By gathering all of these studies together, this thesis effectively demonstrated the positive meteorological and economic effects of cloud seeding.

Success Rates of Cloud Seeding

Multiple studies have been conducted regarding the success rate of cloud seeding:

- ❖ The study “Seeding Success” was conducted in 2014 by Illawarra Mercury in the Snowy Mountains, Australia. This study concluded that the success rate of the seeding process averages about a 14% increase in precipitation.
- ❖ The study “Explained: How Successful is Cloud Seeding Technology” was conducted by the Indian Institute of Tropical Meteorology. The success rate of this experiment was 60-70%.
- ❖ CNN Business interviewed the president of Weather Modification International in the Idaho mountains. The study reported an 8-15% increase in snow, which increased the amount of water during the fall season. They received approximately a 300% return out of that investment, which is about 900 million dollars’ worth of water.
- ❖ The annual report of Thailand's Royal Rain Making Project in 2018 indicates that they have had the highest success rate out of any country that is making rain. The average success rate of the whole country is 93%.

It is impossible to compare the success rate between each country to draw a conclusion regarding which country has the highest success rate in cloud seeding. The reason is because the moisture content in the air affects the success of cloud seeding and moisture varies between the locations.

The Cost of Making Rain per Year by the Royal Rainmaking Project

The total cost per year of making rain in Thailand is approximately \$40 million. The cost for a warm cloud mission, which includes pilots, meteorologists, chemical workers, fuel, and airplanes, is estimated to be about \$3,300 per two planes to complete all three steps most commonly performed; those steps are triggering, fattening, and attacking. The table below calculates that the yearly cost to make rain in Thailand per year per acre is approximately \$4.5.

Monthly Cost (Baht)	Monthly Cost (U.S. dollar)	Successfully Cloud Seeded Area (Rai)	Successfully Cloud Seeded Area (Acre)	U.S. Dollars Spent per Acre
453,048,988	15,101,632.93	218,000,000	86,166,007.91	0.17526207
581,138,013	19,371,267.1	217,880,000	86,118,577.08	0.224937148
686,788,306	22,892,943.53	217,880,000	86,118,577.08	0.26583049
740,269,785	24,675,659.5	210,380,000	83,154,150.2	0.296745976
803,230,322	26,774,344.07	190,440,000	75,272,727.27	0.355697808
1,079,958,276	35,998,609.2	163,560,000	64,648,221.34	0.556838355
1,215,266,627	40,508,887.57	140,630,000	55,584,980.24	0.728773985
30 Baht = \$1		1 Rai = 0.395256916996 Acre		

The Economic Benefits of Rain Making Calculated per Year

Using the data produced in the above table, it is possible to calculate the yearly economic benefit of rain making in Thailand.

As the table below clearly shows, each of the crops still yields a significant benefit.

Main Industrial Crops Grown in Thailand	Profit per Rai per Year (Baht)	Profit per Acre per Year (Baht)	Profit per Acre per Year (U.S. Dollars)	Cost to Make Rain per Acre (U.S. Dollars)	Benefits per Acre (U.S. Dollars)
rice	8,040	3,177.9	105.9	4.5	101.4
corn	10,200	4,031.6	134.4	4.5	129.9
cassava	3,500	1,383.4	46.1	4.5	41.6
sugarcane	10,000	3,952.6	131.8	4.5	127.3
		1 Rai = 0.395257 Acre	30 Baht = \$1		