SUMMARY REPORT

ASEAN TRAINING ON WEATHER MODIFICATION 2019: Understanding of Cloud Nature and Weather Modification for Water Resources Management in ASEAN (ASEAN WxMod TRAINING 2019)

22 - 26 July 2019, Hua Hin, Prachuap Khiri Khan

INTRODUCTION

1. The ASEAN Training on Weather Modification 2019 (ASEAN WxMod TRAINING 2019) hosted by Department of Royal Rainmaking and Agricultural Aviation (DRRAA) of Thailand. It was held on 22 – 26 July 2019 at Amari Hua Hin, Prachuap Khiri Khan Province, Thailand. The Training comprised with 3 sessions as follows:
   Session I: LECTURE ON WEATHER MODIFICATION
   Session II: DISCUSSION ON COLLABORATIONOF WEATHER MODIFICATION

2. The ASEAN Training was attended by delegates from ASEAN Member States, including Brunei Darussalam, the Republic of Indonesia, Malaysia, the Republic of the Philippines and countries that are currently cooperating and networking in weather modification with DRRAA including Sri Lanka, Mongolia and the Republic of Korea. The invited resource persons from World Meteorological Organization (WMO), China Meteorological Administration (CMA), scientist from DRRAA and agencies which are MOU counterparts of DRRAA also attended and provided the presentation on the research supporting the Royal Rainmaking.

OPENING CEREMONY

3. Mr. Narin Songnipitkul, Deputy Governor of Phrachuap Khiri Khan Province warmly welcomed Deputy Permanent Secretary of Ministry of Agriculture and Cooperatives and all the delegates to Phrachuap Khiri Khan Province. The province is an agricultural area where the main crops are field crops, trees, rice, and vegetables. It also contains valuable livestock, such as cattle, goats, and chickens. Besides the well-known Hua Hin beach, there are plenty beautiful sandy beaches and forested mountains.

4. Dr. Surasri Kidtimonton, Director-General of Department of Royal Rainmaking and Agricultural Aviation expressed his sincere appreciation to the Deputy Permanent Secretary, Ministry of Agriculture and Cooperatives for giving the precious time to inaugurate the ASEAN Training on Weather Modification 2019.

5. He reported that DRRAA played a crucial role in drought mitigation, reservoir replenishment, disaster relief, and integrated water management policies in Thailand. Collaborating with related organizations, the DRRAA addresses the

challenges of climate change and global warming, which have led to delayed rainfall, expanded agricultural areas, and land-use changes.

To combat these challenges, the DRRAA has advanced its Royal Rainmaking Technology and focused on enhancing the effectiveness of its personnel. Furthermore, the DRRAA actively promotes international cooperation in science and technology, participating in conferences and training to further develop weather modification knowledge. This collaborative approach enables participating countries to learn from each other, refine their techniques, and ultimately enhance the effectiveness of cloud seeding technology to address environmental challenges.

6. He finally invited Mr. Meesak Pakdeekong, Deputy Permanent Secretary, Ministry of Agriculture and Cooperatives to open The ASEAN Training on Weather Modification 2019 and gave a speech that recognizing the escalating global water crisis exacerbated by climate change impacts like drought and floods, weather modification technology offers a crucial long-term solution. Thailand, under the visionary leadership of His Majesty King Bhumibol Adulyadej the Great, has pioneered royal rainmaking since 1955 to combat drought, haze, and forest fires, demonstrating its commitment to addressing water scarcity and environmental challenges.

7. Mr. Meesak Pakdeekong, took a group photo with participants of The ASEAN Training on Weather Modification 2019.

SESSION I: LECTURE ON WEATHER MODIFICATION

8. The training program was structured into 3 content areas, with the summaries of each area as follows:

1) **GENERAL BACKGROUND OF WEATHER MODIFICATION,** this course included lectures covering fundamental cloud physics, weather modification technology, cloud-aerosol interactions in weather modification, advances in weather modification research and operations, and trends and challenges in weather modification research. This provided participants with basic knowledge and understanding of weather modification and the scientific processes involved in cloud and rain formation.

2) **WEATHER MODIFICATION RESEARCH,** this course included lectures covering advances in rainfall enhancement research, research design, weather modification techniques, cloud physics knowledge for weather modification and rain formation mechanisms, data analysis, and practical training in cloud physics data measurement using numerical models. This helped participants understand cloud physics, cloud modeling, and rain formation processes from cloud formation to cloud growth, cloud dissipation, and prolonging rain duration. This knowledge enables them to conduct research to enhance weather modification efficiency in response to changing weather conditions.

3) **WEATHER MODIFICATION TECHNOLOGY,** this course included lectures covering cloud and mesoscale modeling for rain simulation, weather modification models and techniques in China, hygroscopic flare applications for weather modification, optimal particle sizes for warm cloud seeding, airborne cloud and rain process measurement, weather modification techniques and methodology for hail suppression, weather radar data development for flash flood warnings, alternative rainmaking agent development for enhanced rainmaking operations, application development for identifying suitable cloud groups for rainmaking operations, weather modification techniques and method for rainfall reduction, and Royal Rainmaking Technology: principles and operational procedures. This provided participants with knowledge and facilitated the exchange of weather modification techniques in which each country has distinct expertise, particularly alternative technologies such as rocket-based cloud seeding and ground-based generators to supplement aircraft operations with their limitations and operational constraints.

SESSION II: DISCUSSION ON COLLABORATION OF WEATHER MODIFICATION

9. The speakers and delegates from each country collaborated to exchange ideas aimed at promoting cooperation in weather modification, research, and development of weather modification technologies. This effort fosters a collaborative research and development network among ASEAN member countries and dialogue partners to enhance weather modification efficiency, prevent and address drought, mitigate disasters through integrated approaches, and manage atmospheric water at the ASEAN regional level. It also addresses current erratic weather patterns. The key takeaways are summarized as follows:

1) Conducting research requires fundamental knowledge and understanding of cloud physics, scientific processes, and rain formation processes. Weather modification faces significant limitations and challenges, particularly in developing highly efficient and effective techniques. Examples include: using hygroscopic flares with small particle sizes, lightweight, and easy transport instead of heavy powder agents requiring larger quantities; developing cold and warm cloud seeding techniques to increase rainfall; researching optimal and efficient particle sizes of the rainmaking agent; studying cloud and aerosol behavior in the atmosphere; and maximizing the use of available equipment such as weather radar and Super King Air aircraft equipped with cloud physics data measurement instruments.

2) Many ASEAN countries and dialogue partners have their own agencies responsible for weather modification operations. Each country possesses its own strengths, such as advanced equipment, cloud and rain formation models, knowledge, expertise, and experience. Leveraging these strengths through collaborative operations and research, with a clear mapping of each country's strengths, would enhance integrated work efficiency. Furthermore, such cooperation would help address the shortage of specialized research personnel.

TRAINING PROGRAM EVALUATION RESULTS

10. Survey and evaluation of training participants were conducted using QR codes to gather feedback and improve event organization. The evaluation was divided into two categories:

1) **Overall Project Evaluation**, the evaluation, conducted using a post-training assessment form, categorized satisfaction into five levels: (5) Excellent, (4) Good, (3) Moderate, (2) Fair, (1) Needs Improvement. The overall project satisfaction among participants was found to be at a 'Good' level. Detailed results are presented in the table below:

Table 1: Training Participant Feedback on Overall Project Organization

Assessment Item	Satisfaction Level (Percentage)					Average Score	Average Satisfaction Level
	Excellent (5)	Good (4)	Moderate (3)	Fair (2)	Needs Improvement (1)		
Training							
1. Public Relations	64.70	17.65	17.65			4.47	Good
2. Facilities	58.82	17.65	23.53			4.35	Good
3. Venue	70.59	11.76	17.65			4.50	Excellent
4. Food and Beverages	64.70	11.76	5.89	17.65		4.23	Good
5. Coordination and Management	64.70	17.65	17.65			4.47	Good
Experience gained from Attending Training Program							
6. Topics and Curriculum	58.82	23.53	17.65			4.41	Good
7. Duration of Each Topic Lecture	35.29	41.18	23.53			4.11	Good
8. Valuable Weather Modification Experience	76.46	5.89	17.65			4.58	Excellent
9. Networking and Future Collaboration Opportunities	76.46	5.89	17.65			4.58	Excellent
10. Value of Participation	64.70	17.65	17.65			4.47	Good
Overall Satisfaction Level of Training Participants						**4.42**	**Good**

2) **Evaluation of Content, Curriculum, and Speakers** using a post-training evaluation form at the end of each training day, with a 5-level scoring system: (5) Excellent, (4) Good, (3) Moderate, (2) Fair, (1) Needs Improvement, it was found that the participants' satisfaction with the content, curriculum, and speakers was at a 'Good' level. Detailed results are presented in the table below:

Table 2: Participants Feedback on Training Content, Curriculum and Speakers

Assessment Item	Speakers							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Content and Curriculum								
1. Relevance to Objectives	4.39	4.52	4.34	4.55	4.63	4.59	4.45	4.57
2. Interest, Modernity, and Practical Usefulness	4.42	4.53	4.32	4.55	4.66	4.35	4.36	4.36
3. Clarity and Relevance to Participants' Questions	4.30	4.52	4.13	4.43	4.58	4.53	4.36	4.29
4. Applicability to Practical Work	4.45	4.53	4.26	4.56	4.56	4.47	4.45	4.21
5. Potential for New Ideas and Research	4.36	4.54	4.19	4.47	4.58	4.53	4.36	4.5
6. Content Appropriateness for Time Allotted	4.39	4.48	4.24	4.52	4.66	4.47	4.36	4.43
Average Satisfaction (Content and Curriculum)	**4.39**	**4.52**	**4.25**	**4.51**	**4.61**	**4.48**	**4.39**	**4.39**
Speakers								
1. Subject Matter Expertise	4.57	4.55	4.42	4.69	4.78	4.59	4.45	4.5
2. Communication and Clarity	4.36	4.62	4.06	4.51	4.61	4.29	4.18	4.36
3. Presentation Materials/Aids Appropriateness	4.45	4.50	4.11	4.54	4.59	4.41	4.45	4.5
4. Qualifications and Relevance to Content	4.42	4.61	4.04	4.54	4.66	4.24	4.18	4.29
5. Positive Interaction with Participants	4.42	4.50	4.14	4.53	4.61	4.47	4.36	4.36
Average Satisfaction (Speakers)	**4.44**	**4.56**	**4.15**	**4.56**	**4.65**	**4.4**	**4.32**	**4.4**

11. List of speakers by number in Table 2, with their respective lecture topics as follows:

1) Prof.Dr. Masataka Murakami, Expert from the World Meteorological Organization, Meteorological Research Institute, Japan Meteorological Agency, Japan.

- Fundamentals of Weather Modification Science
- Advances in Precipitation Enhancement Research
- Cloud Physics Knowledge for Weather Modification and Rain Formation Mechanisms
- Cloud Seeding Model for Weather Modification

2) Dr. Thara Prabhakaran, Expert from the World Meteorological Organization, India Meteorological Department, India.

- Basic Knowledge of Cloud Physics and Weather Modification Technology
- Cloud-Aerosol Interactions in the contest of Weather Modification

- Advances in Weather Modification Research and Operations
- Trends and Challenges in Weather Modification Research
- Research Design for Weather Modification Techniques
- Data Analysis and Practical Measurement of Cloud Physics Data Using Equipment Installed on Super King Air Aircraft

3) Dr.Lou Xiaofeng, Weather Modification Center, China Meteorological Administration, People's Republic of China.

- Study of Rain Simulation using Cloud and Mesoscale Models
- Weather Modification Models and Techniques in China
- Weather Modification Techniques for Rainfall Reduction

4) Prof. Guo, X.L., Chinese Academy of Meteorological Science, China Meteorological Administration, People's Republic of China.

- Measurement of Cloud and Rain Process Data using Airborne Equipment
- Hail Suppression Weather Modification Techniques
- Weather Modification Operations Training for Hailstorm Suppression

5) Prof. Dr. Yan Yin, Nanjing University of Information Science, People's Republic of China.

- Hygroscopic Flare Applications for Weather Modification
- Optimal Particle Sizes for Warm Cloud Seeding

6) Dr. Arisa Jaiyu, Thailand Institute of Scientific and Technological Research (TISTR), Thailand.

- Development of Alternative Rainmaking Agents for Enhanced Royal Rainmaking Operations

7) Dr. Piyamarn Srisomphorn, Hydro Informatics Institute (Public Organization), Thailand.

- Development of Weather Radar Data for Flash Flood Warnings

8) Mr. Sarawut Arthayakun, Department of Royal Rainmaking and Agricultural Aviation, Thailand.

- Application Development for Identifying Suitable Cloud Groups for Royal Rainmaking Operations

Suggestions and Comments

12. 80% of the training participants expressed their satisfaction with learning from experienced weather modification experts. They also showed interest in participating in future training sessions and would recommend the program/course to other personnel in their organizations. The following is a summary of their suggestions and comments:

1) There is need for highly specialized lecture to increase the time allotted for explaining complex content, such as interpreting charts and graphs, and analyzing radar data.

2) Future speakers to be invited include Prof. Dr. Daniel Rosenfeld from the Hebrew University of Jerusalem, specializing in cloud physics; Dr. Cha Joowan from the Korea Meteorological Administration, specializing in weather modification techniques; and Dr. Lulin Xue from NCAR, specializing in rain simulation modeling and rainmaking scenarios in the United States.

3) Topics of interest for future training include alternative rainmaking substance usage, rainmaking substance management processes, operational evaluation, rainmaking flight operations, the use of ground-based microwave radiometer technology, and practical field rainmaking exercises.

ACKNOWLEDGEMENTS

13. The ASEAN Training on Weather Modification 2019 was held in the traditional spirit of ASEAN cordiality and solidarity. It was successfully completed with the participation and contribution of all delegates

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