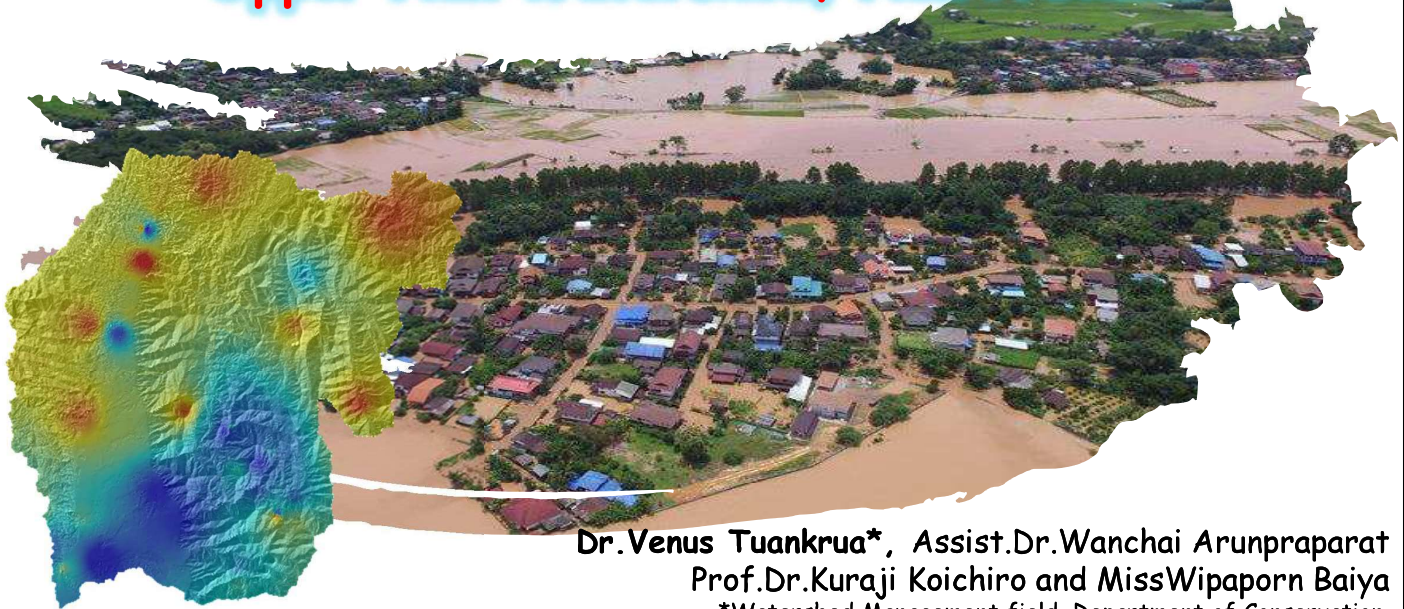# Modified Critical Antecedent Precipitation Index (MCAPI) for Flood Warnings in Upper Nan Watershed, Nan Province

Dr.Venus Tuankrua*, Assist.Dr.Wanchai Arunpraparat
Prof.Dr.Kuraji Koichiro and MissWipaporn Baiya
*Watershed Management field, Department of Conservation,
Faculty of Forestry, Kasetsart University, Bangkok, Thailand

Introduction

50 years later

In 1964, there are forest area about 4,022.31 m²

In 2013, there are forest area about 2,911.63 m²

Nan

forestry concession

1,100.68 m² = decrease 27.36%

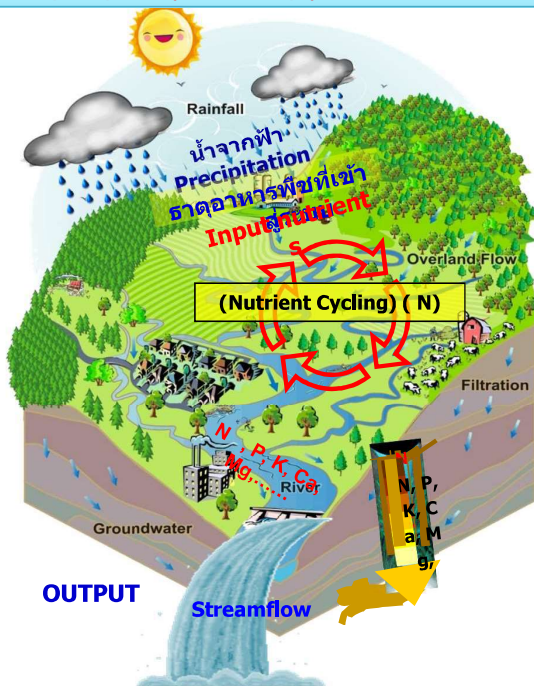shifting agriculture

Introduction

Changing structure = Changing Function

⬇

Changing Hydrology in watershed ecosystem

Rainfall
น้ำจากฟ้า
Precipitation
ธาตุอาหารพืชที่เข้า
Input ธาตุอาหาร
Overland Flow
(Nutrient Cycling) (N)
Filtration
N, P, K, C, Mg...
River
N, P, K, C, a, Mg,
Groundwater
OUTPUT
Streamflow

Forest fire
landslide
Soil erosion
haze
Cash crops
Extreme storm
Flash flood

Extreme Disaster

Dam damage

Introduction

Nan flood events #10yearschallenge

2006 — 2011 — 2018

Introduction

➢ **Kohler** first defined antecedent precipitation index (API) in the 1940s (Kohler and Linsley, 1951). The antecedent precipitation index is an *index of moisture stored within a soil mass which considers the previous and present rainfall.*

➢ *The API has been used as a reasonable way to estimate the soil water status* (Sittner et al., 1969), The critical antecedent precipitation index (CAPI) is *an index of maximum water storage* in soil depend on soil depth, bulk density and saturated soil water. <u>**It act as a flood threshold**</u>.

+ rainfall   - evaporation

CAPI	Soil water storage

Exiting API
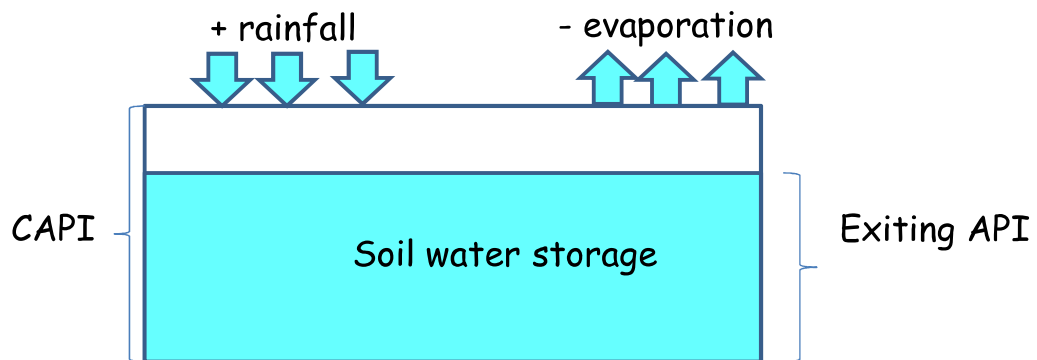
➢ **Using** in *storm rainfall-runoff modeling* (Brocca et al., 2009), also essential in *controlling runoff* (Castillo et al., 2003)

Objective

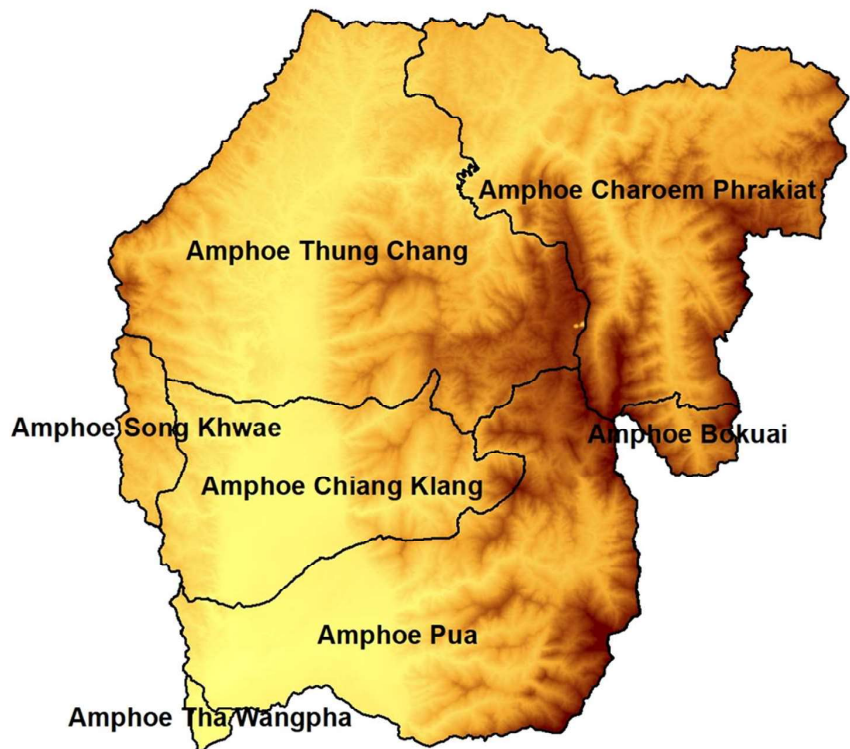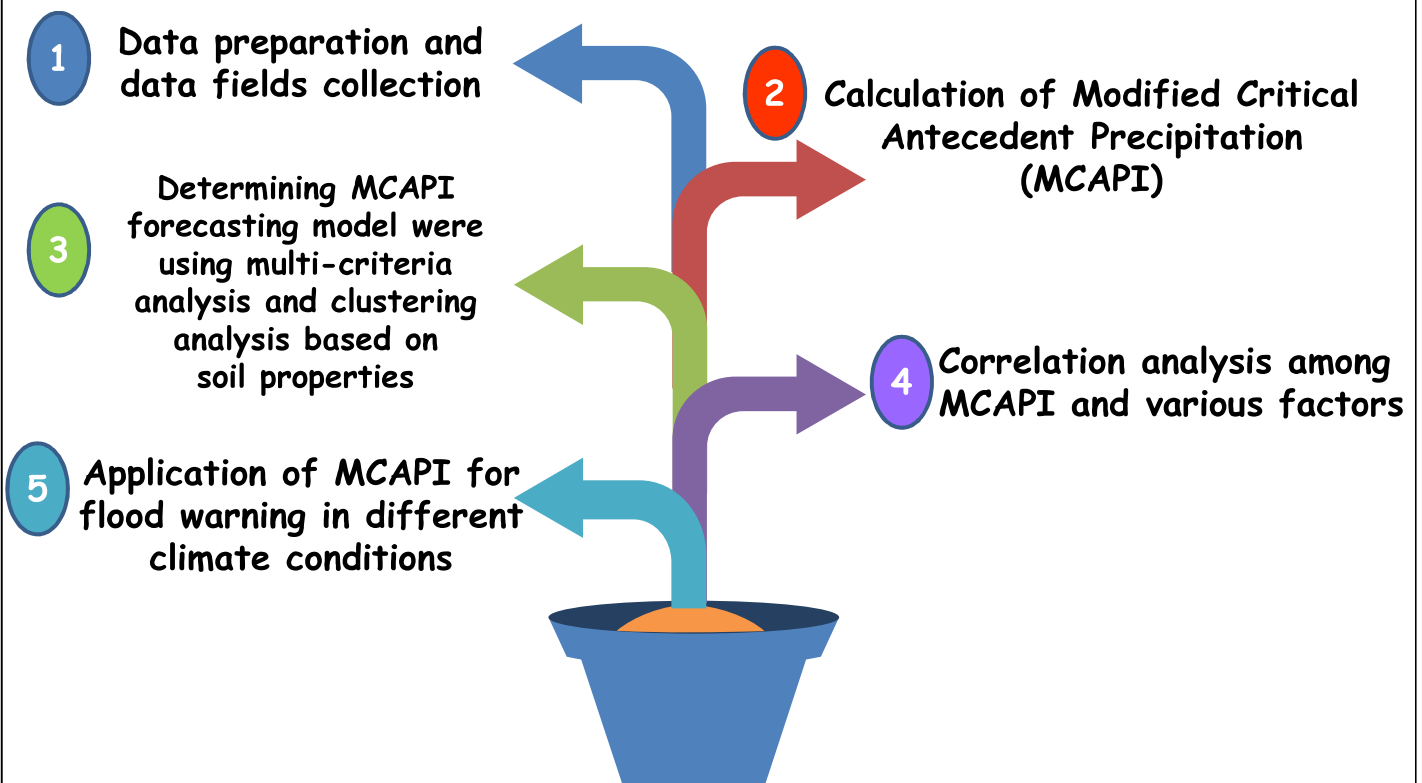|	
🌧	1. To assess Modified Critical Antecedent Precipitation (MCAPI) in upper Nan watershed
🌧	2. To analyze factors affecting with MCAPI for CAPI model modification
🌧	3. To apply MCAPI for flood warning in *different climatic conditions*

Study area

- **Upper Nan watershed** has an area of 2,220.14 km² in Nan province, Thailand.

- It has the elevation ranges from 205.77 to 1926.22 meters above sea level and average slope is approximately 34 percent.

- Most precipitation occurs from July to October in the watershed and dry period extends from December to April.

- The annual average precipitation is approximately 2,000 mm with an annual average temperature of 25.9 °C

Amphoe Charoem Phrakiat

Amphoe Thung Chang

Amphoe Song Khwae

Amphoe Bokuai

Amphoe Chiang Klang

Amphoe Pua

Amphoe Tha Wangpha

Framework

1. Data preparation and data fields collection

2. Calculation of Modified Critical Antecedent Precipitation (MCAPI)

3. Determining MCAPI forecasting model were using multi-criteria analysis and clustering analysis based on soil properties

4. Correlation analysis among MCAPI and various factors

5. Application of MCAPI for flood warning in different climate conditions

Methods

1 **Data preparation and data fields collection**

➤ *Collecting GIS data and climatic data from TMD stations and ADAPT project*

➤ *Gather field soil sample and analysis soil properties data in different land use types and different elevations.*

Infiltration capacity

Ground check : existing land use types and crop patterns of Upper Nan watershed
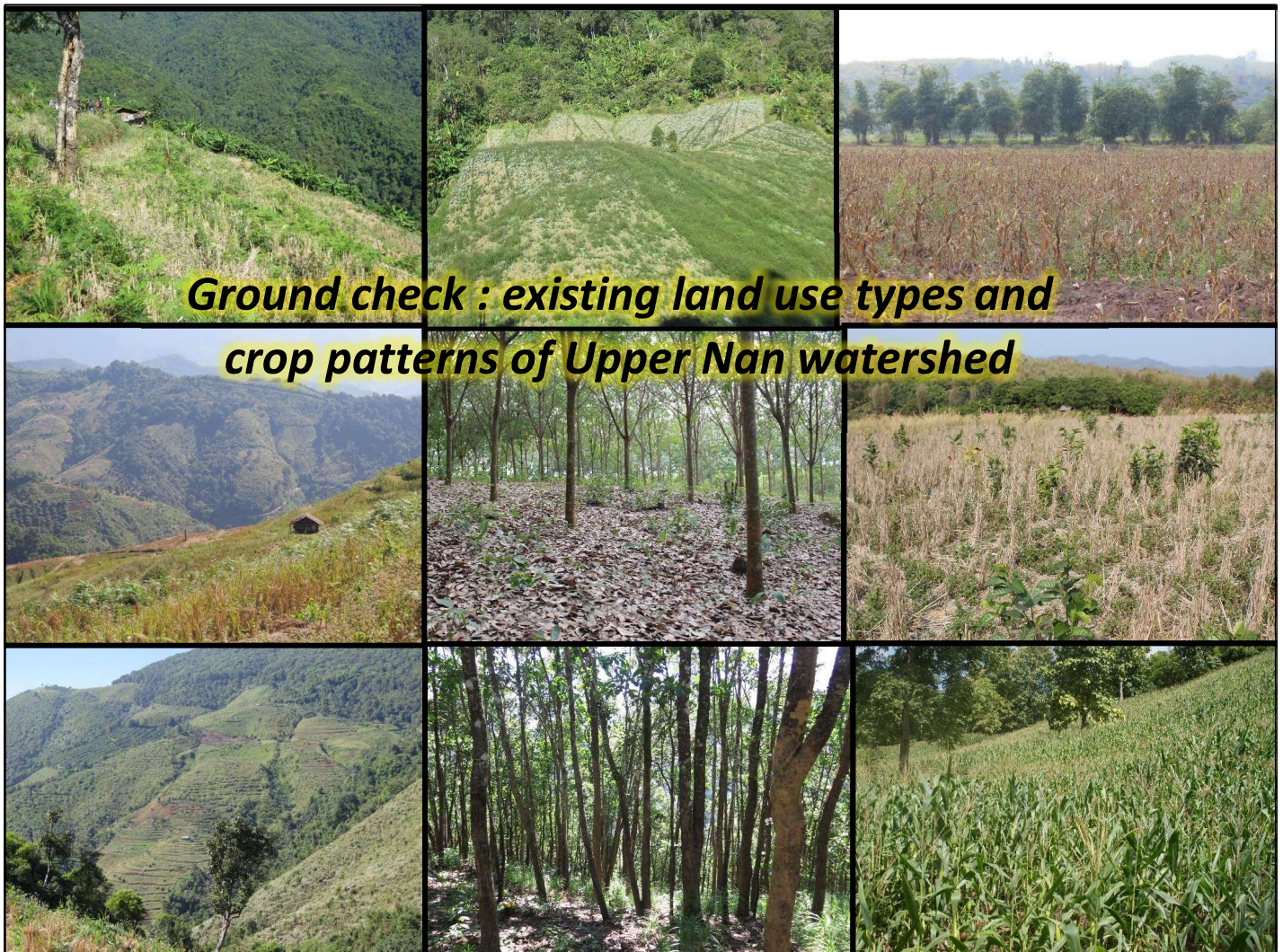
Methods

2 Calculation of Modified Critical Antecedent Precipitation (MCAPI)

➤ *Calculation Modified Critical Antecedent Precipitation (MCAPI) in each points of soil survey from follows equation;*

> ## CAPI (mm)= Saturated soil water x Soil depth

➤ *After calculation CAPI in each soil sample points, they were use to interpolate MCAPI were generated by IDW method for spatial MCAPI maps (cell sizes = 20 x 20 m).*
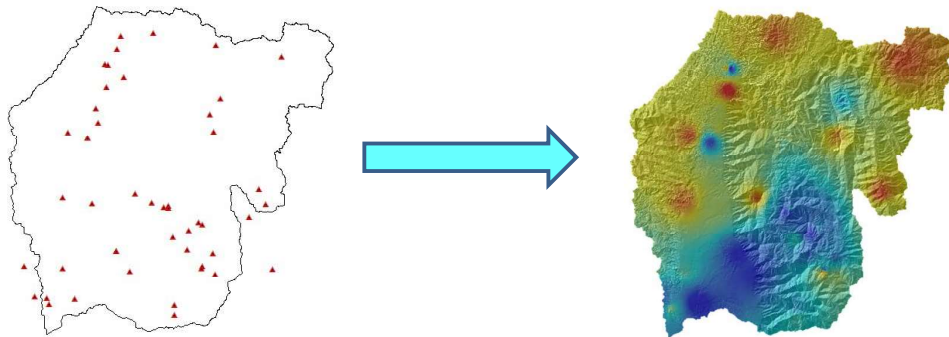
Methods

2 Application of MCAPI for flood warning in different climate conditions

➤ *MCAPI is the maximum threshold of each area, flood could be generated depend on API real time or exiting API (API_t). It was indicated situation of soil storage after evaporation. The equation was showed as follows;*

$$API_t = kAPI_{t-1} + P_t$$

(Kohler and Linsley, 1951)

When   The index of one day **t** is the index of the previous day **t −1** multiplied by the factor **k**. If rainfalls occur on day **t**, it is added to the index.
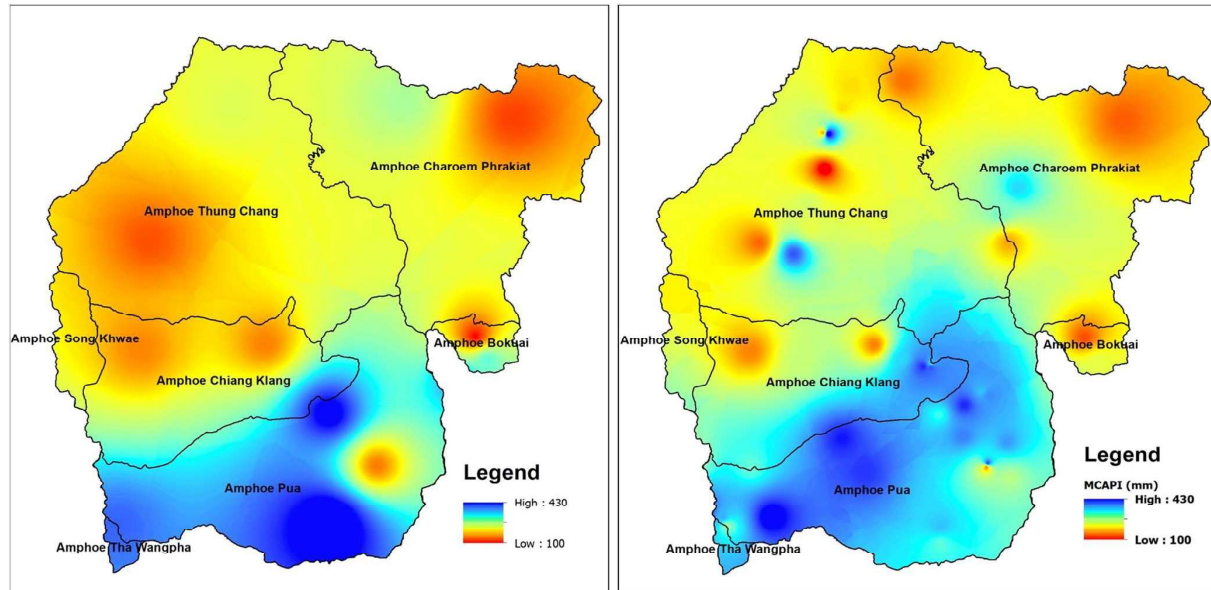
➤ *The previous flood events in upper Nan watershed were selected to use in case study for flood warning simulation;*

Event I: Flood and landslide event in Boklua district, Doi Phuka national park, Nan province during 27–29th July, 2018.

Event II: During July to September in 2011 (Strong Lanina)
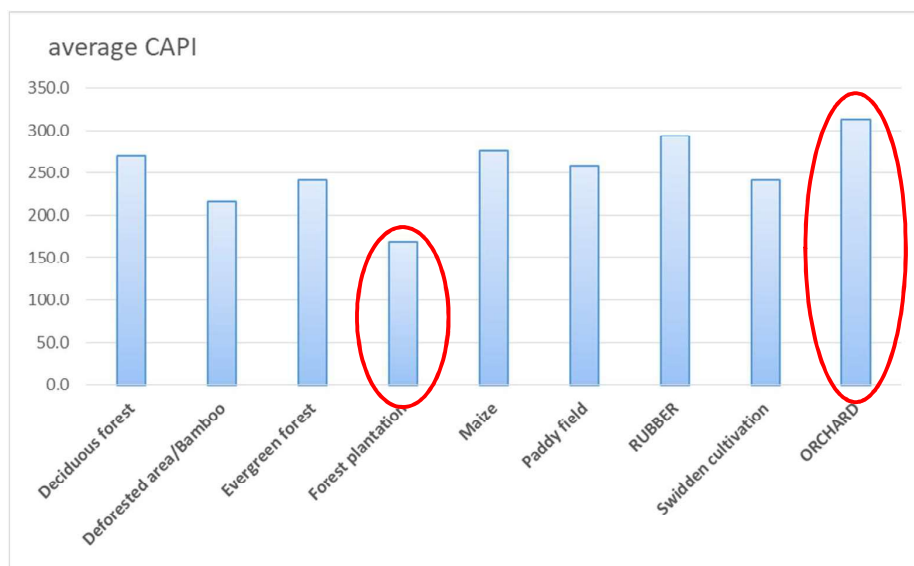
Results and discussion

1. Modified Critical Antecedent Precipitation (MCAPI)

	Old CAPI (mm)	Modify CAPI (mm)
mean	204.04	257.74
minimum	142.12	106.82
maximum	323.18	425.61

Results and discussion

2. MCAPI in different land use types

➢ The highest average CAPI was showed in orchard area as 312.713 mm because average *soil depth is quietly high* (>80 cm).

➢ In forest plantation, there was lowest CAPI because high bulk density. It could be said that less gaps in soil that influent with soil water storage capacity.
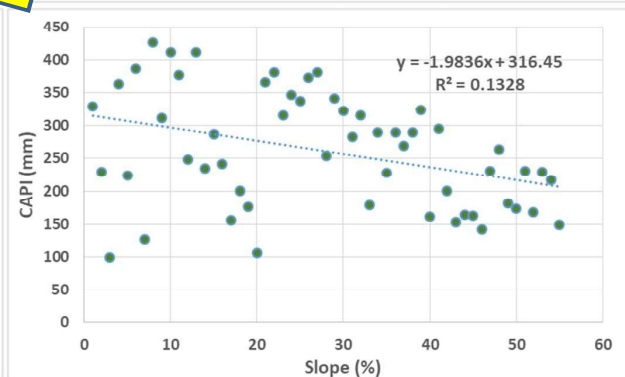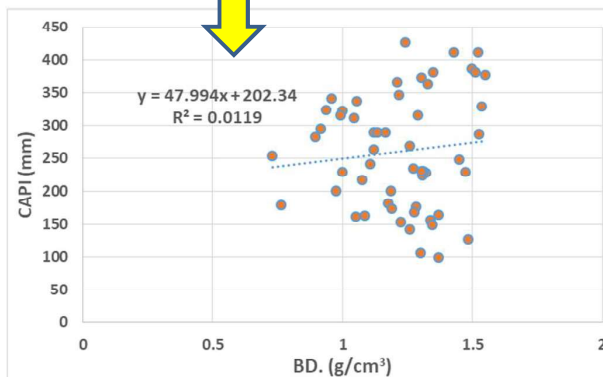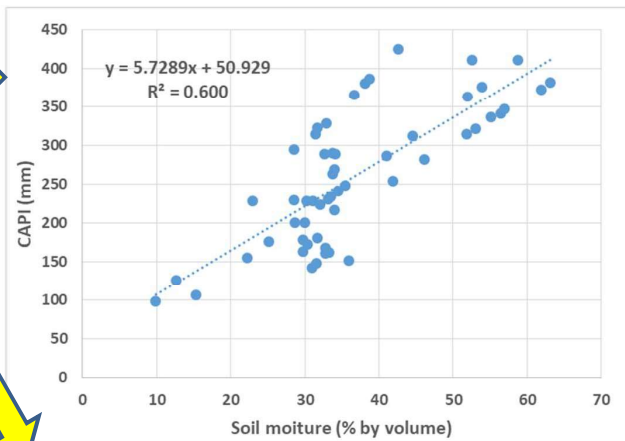
Results and discussion

3. Relationships among MCAPI and various factors

➢ The saturated soil moisture was quietly high positive relationship with CAPI (60%).

➢ The slope was quietly low negative relationship with CAPI (13%).

➢ The Bulk density was not has relationship with CAPI.

Results and discussion

3. Correlation analysis among MCAPI and various factors

correlation coefficients (r)	Slope	Bulk Density	Sat. Soil moisture	Soil depth	CAPI
Slope	1	-0.403**	0.012	0.056	-0.231*
Bulk Density	-0.403**	1	-0.566**	0.367**	0.080
Sat. Soil moisture	0.012	-0.566**	1	-0.504**	0.569**
Soil depth	0.056	0.367**	-0.504**	1	0.155
CAPI	-0.231*	0.080	0.569**	0.155	1

Remarks: ** = significant at 0.01
        * = significant at 0.05

➢ For correlation coefficients (r), it was indicated that CAPI were significant positive relationship with Soil moisture (SM) but significant negative relationship with slope percent.

➢ So, Soil moisture (SM) was significant negative relationship with bulk density (BD) and soil depth. If any area have more bulk density (BD), it will have less space for water storage in soil.

Finding

> The 3 patterns of MCAPI forecasting model were determined using multi-criteria analysis and clustering analysis based on Saturated soil moisture and bulk density.
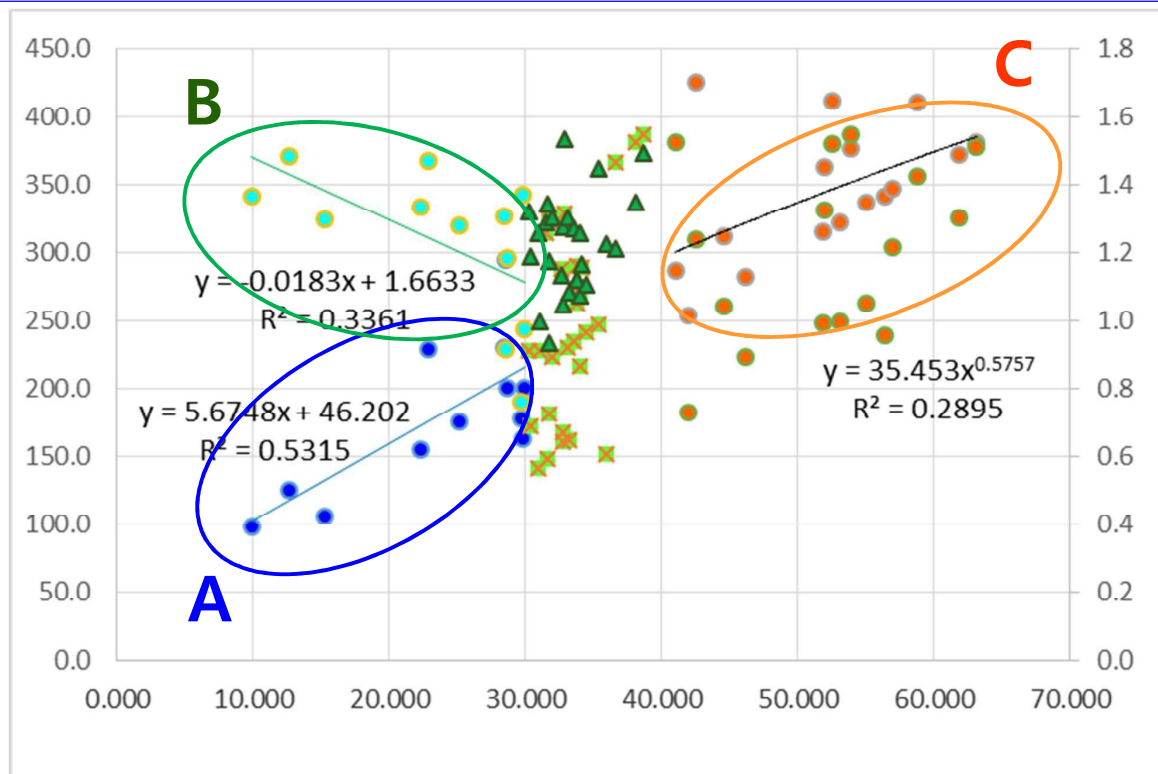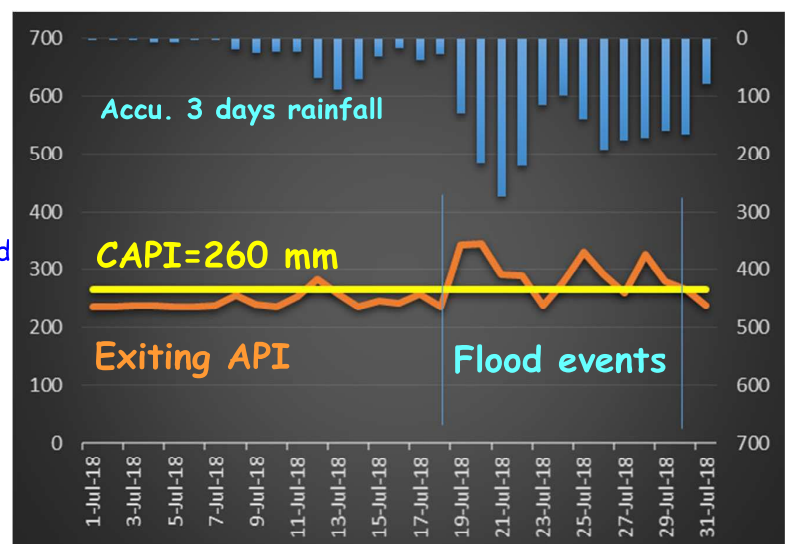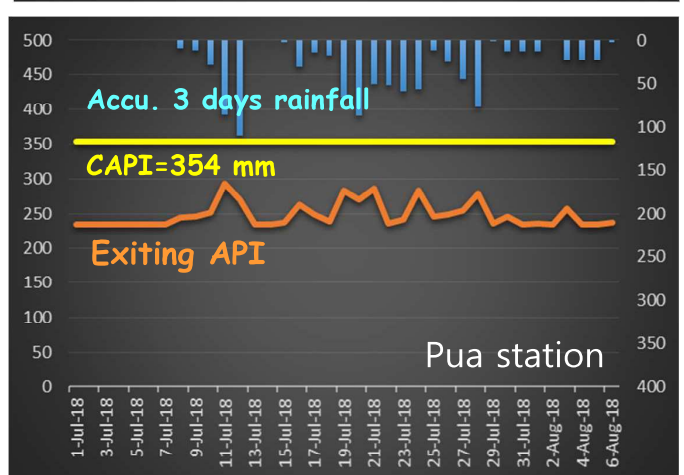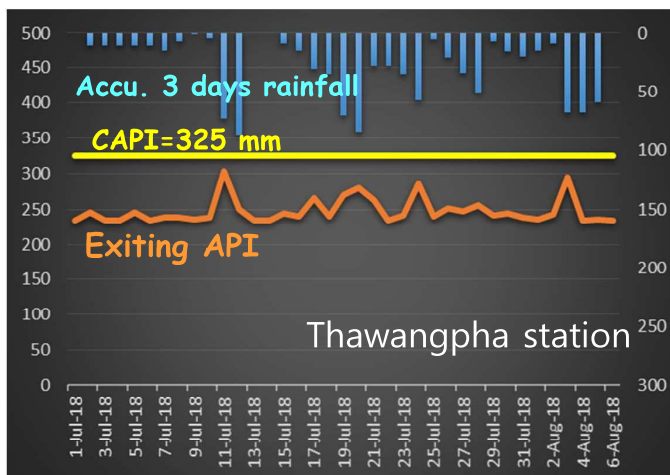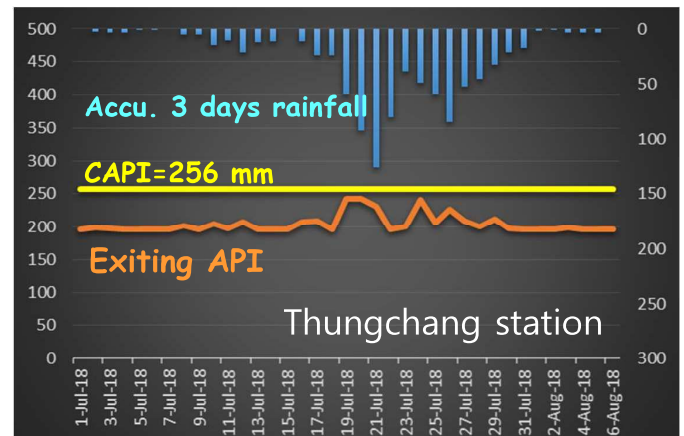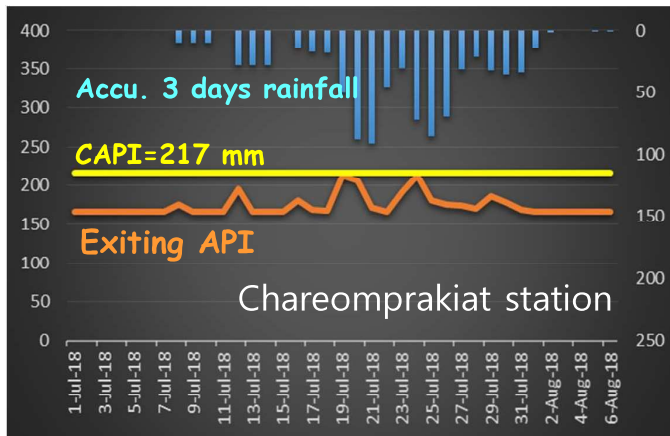

Results and discussion

3. Application of MCAPI for flood warning in different climate conditions

Event I: Flood and landslide event in Boklua district, Doi Phuka national park, Nan province during in July, 2018 (from heavy rainfall)

> The existing API (API_t) was shown that it was not greater than CAPI.
> So, CAPI in Doi phuka national park is approximately 266 mm.
> On 28 July, rainfall continue increase and API_t were more than or quite near CAPI. Flood and landslide events occurred as projected.

> ➤ When compare APIt with CAPI, other stations did not occurred flood because APIt less than CAPI.


Chareomprakiat station
(Accu. 3 days rainfall, CAPI=217 mm, Exiting API)

Thungchang station
(Accu. 3 days rainfall, CAPI=256 mm, Exiting API)

Thawangpha station
(Accu. 3 days rainfall, CAPI=325 mm, Exiting API)

Pua station
(Accu. 3 days rainfall, CAPI=354 mm, Exiting API)

Results and discussion

3. Application of MCAPI for flood warning in different climate conditions

Event II: During July to September in 2011 (Strong Lanina)

> ➤ When compare APIt with CAPI in 2011, accumulate rainfall at Doi phuka national park high increase and APIt were more than or quite near CAPI.
> ➤ Flood events occurred as projected on 20-26 August 2011.

(CAPI=260 mm, Accu. 3 days rainfall, Exiting API)
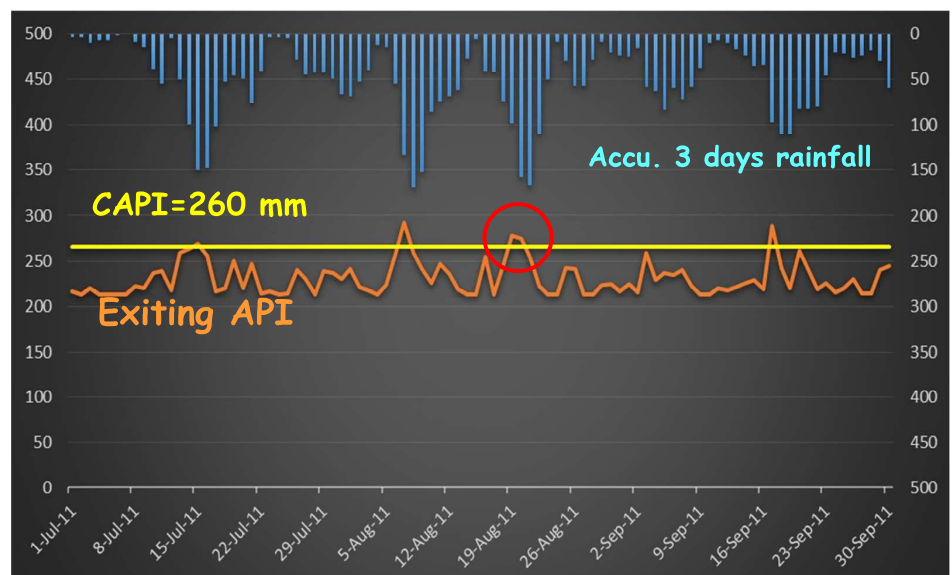
Conclusion

➢ *Average Modified Critical Antecedent Precipitation (MCAPI) was approximately 257.74 mm. It could be said that quite low moderate soil storage capacity because average bulk density was showed quite high (1.22 g/cm^3) and average saturated soil moisture was quite low (36.6% by vol.)*

➢ *The 3 patterns of MCAPI forecasting model were determined using multi-criteria analysis and clustering analysis based on saturated soil moisture and bulk density.*

➢ *When compare APIt with CAPI in 2018, accumulate rainfall at Doi phuka national park continued increase and APIt were more than or quite near CAPI. Landslide events occurred as projected. Other stations did not occurred flood because APIt less than CAPI.*

Acknowledgement

➢ Thank you ADAPT project for all supporting and research funding.

➢ Local officials of Doi Phukha national park, N an province, Department of National Parks, Wildlife and Plant Conservation for field sur vey and data collection.