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AN ANALYSIS ON DISASTERS CAUSED BY FLOOD VIA DATA FROM SENTINEL-1 SATELLITE

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Abstract- From every flood occurred in Thailand, Thai people had to encounter with damages against their assets, houses, commercial buildings, factors, and agricultural areas. Sukhothai Province is also one of those areas that have encountered with flood every year. Therefore, this study aims to analyze disasters caused by flood via data from Sentinel-1 Satellite: a case study of Sukhothai Province, Thailand. For methodology, data from Sentinel-1 Satellite in the studied areas were analyzed by using SNAP and ArcGIS program. The results of data analysis revealed that data on August 25, 2020, indicated that there was a flood area, i.e., 96.751 km^2. When comparing data on flood obtained from analyzing with data on flood obtained from Geo-Informatics and Space Technology Develop-ment Agency (GISTDA) with approximate flood areas of 106.632 km^2, it was found that difference was around 9.593%. For geography, it was also found that Sukhothai Province has a river that flew through the province from the north to the south with the approximate distance of 170 km that was considered as the cause of repeated flood, especially areas in Sri Satchanalai District, Sawankaloke District, Muang Sukhothai District, and Kongkrailat District, Thailand.

Keywords: Remote Sensing, Flood, Sentinel-1, SNAP.

1. INTRODUCTION

Natural disaster means dangers caused by nature that affect to life and living of humans. From ancient time, humans have had to encounter with the great of natural disasters. For a long period of time, humans have been trying to learn and overcome natural disasters up till now but we have never won [1]. Previously, Thailand often encountered with the problems caused by nature every tear, especially natural disasters caused by flood that has been considered as the problem causing huge damages against life and assets. In addition, it has also affected to overall economy because most victims have been farmers therefore when there has been any natural disaster, it has subsequently affected to agricultural production [2]. Each year, Thai farmers and people have encountered with the problem on flood in many provinces leading to several damages against life and assets [3, 4].

Flood in Thailand is caused by the locations of cities, i.e., most cities are located in river basins for convenience on consumption. Therefore, when those cities expand due to uncontrollable increase of populations and abnormal volume of water, those cities turn to block waterways causing some bad effects to water drainage ad damages against life and assets of local people, for example, in 2018, it was found that there were 125,716 households of all Thai people that were affected by flood calculated to be 326,072 persons with 10 dead persons [5].

Moreover, Thailand is also located in the center of Indochina Peninsula in South East Asia. Formerly, Thailand has encountered with flood in all regions throughout the country every year due to geographic factor, i.e., Thailand is located in tropical zone causing Thailand to be affected by southwest monsoon, northeast monsoon, and storms throughout the year [6, 7]. The urgent thing that cannot be missed for evaluating on damage level and severity level of flood is information or map indicating the boundaries of flood areas [8-12].

The former method was flood mapping through ground surveying but it caused high expenses and consumed time with difficulty on accessibility due to large areas of some flood areas .Therefore, remote sensing technology via data from satellite that recorded phenomena occurred on earth based on reflection of electromagnetic wave to sensor installed on the satellite [13, 14] was used along with physical model as the tools for evaluating damages caused by flood [15-20]. Data obtained from satellite could cover large areas that were hard to access properly with affordable expenses compared to ground surveying [21-25]. With all reasons as mentioned above, this research aims to analyze disasters caused by flood via data from Sentinel-1 Satellite: Case Study of Sukhothai Province, Thailand.

2. STUDY AREA AND DATA

2.1. Study Area

In this study, Sukhothai Province, Thailand (Figure 1) was selected as the studied area. Sukhothai Province, Thailand is located in the lower northern part based on administrative areas of Thailand located from Latitude

16° 34′ to 17° 46′ N and from Longitude 99° 24′ to 100° 01′ E with the approximate area of 6,596 km^2. For most geographic characteristics, they are lowland areas with northern areas as plateaus with mountain ranges to the west. The middle areas are lowlands whereas southern areas are plateaus. There is a river flowing through the province with the average distance of 170 km from the north to the south covering the areas of Sri Satchanalai District, Sawankaloke District, Muang Sukhothai District, and Kongkrailat District, Thailand. For general climate of Sukhothai Province, it is changed by effects of southwest monsoon and northeast monsoon.

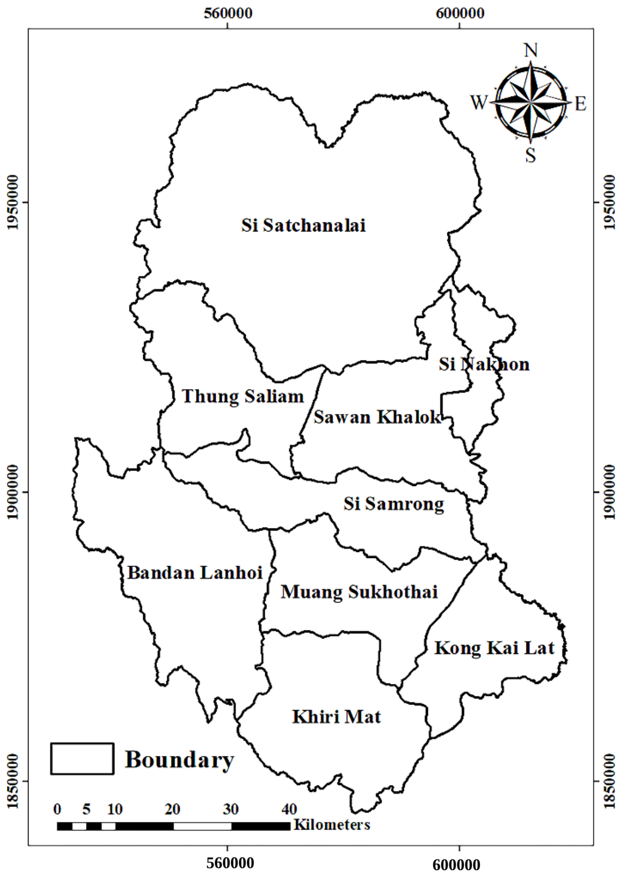


Figure 1. The study area

2.2. Data from Sentinel-1 Satellite

Sentinel-1 Satellite is and earth observation satellite of Global Monitoring for Environment and Security (GMES) under cooperation between European Commission and European Space Agency (ESA). Sentinel-1 Satellite consists of 2 satellites, i.e., Sentinel-1A Satellite that was launched into orbit on April 3, 2014 and Sentinel-1B Satellite that was launched into orbit on April 25th, 2016. They are operated in the same orbit but located in distant locations with the angle of 180°.

They are orbiting from the north to the south in the format of sun-synchronous orbit with the height from the ground of 693 km and tilt angle of 98.18°. The duration of 1 orbit is 100.7 minutes. As a result, it can orbit for 14 rounds per day with record of the same are within every 12 days. Sentinel-1 Satellite records data via C-SAR sensor system giving images in all light conditions and climates.

The mission of Sentinel-1 Satellite is surveying and observing forests, water, soil, agriculture, marine environment, mapping oil leakage, detecting vessels, and checking climate change, etc. [26].

3. METHODOLOGY

3.1. Analysis on Data from Sentinel-1 Satellite

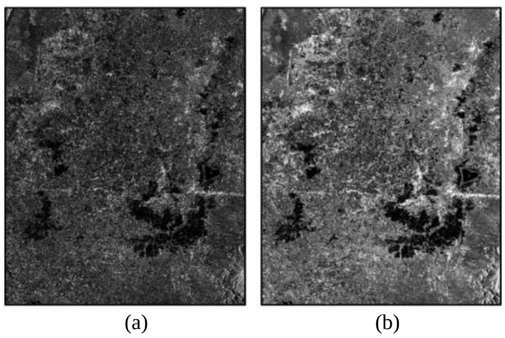
This study was conducted by using data from Sentinel-1 Satellite that recorded data on flood on August 25, 2020 of Sukhothai Province's areas from information service website of Copernicus Open Access Project created by ESA. Data were Level-1 IW GRD data with spatial resolution of 5×20 km and width of the line of 250km which were considered as data hidden with deviation. To apply to this study, it was necessary to improve quality of data from Sentinel-1 Satellite by using SNAP in order to obtain efficient results of analysis on flood areas.

Black pixels on image data from Sentinel-1 Satellite were reduced whereas SNAP contained the model for adjustment in various methods. In this study, Lee Filter Model with the image size of 9×9 or 18 pixels was utilized with mean and variance of pixels that were equal to mean of nearby areas. Variance of all pixels in selected kernel was the result representing middle pixel that was the representative of surrounding data for obtaining higher resolution (Figure 2). Equations (1)-(3) was the equation for calculating coefficient variance without any noise used in adjustment of this research [27].

$$\sigma^2 = \frac{\sigma_z^2 + \mu_z^2}{\sigma_v^2 + \mu_v^2} - \frac{\mu_z^2}{\mu_z^2} \quad (1)$$

$$k = \frac{\sigma_x^2 \mu_v}{\sigma_v^2 (\mu_z^2 / \mu_v^2) + \sigma_x^2 \mu_v^2} \quad (2)$$

$$\hat{X} = \frac{\mu_z}{\mu_v} + k(z - \mu_z)$$



(a) (b)

Figure 2. (a) Original image and (b) Image after Lee Filter Model process

(3)

For Binarization, it is the method for separating grey pixels with value from 0-255 (grayscale level) included with water areas and other areas that are not water sources. Consequently, it will give both water areas and land areas. Graph of Reflection was applied because water areas had good absorption of signal waves therefore, they reflected signal in low level. After applying this principle, threshold could be determined for separating pixels by determining low threshold as water sources. Images were separated by using white pixels (255 = water areas) and black pixels (0 = other areas).

Equation (4) [28] was used for determining condition. If Source Bands were lower than Threshold Value (Source Bands <Threshold Value) real condition or 255 (water areas) would be shown. If it was higher, false condition or 0 would be shown (other areas). Since there may be some distortion of images caused by various causes due to long distance shooting, for example, curves and earth orbits as well as satellite orbits, it was necessary to reduce geometric errors by using Range-Doppler Terrain Correction in order to show results of quality improvement of satellite as shown in Figure 3.

$$255 \times \left(Source\ Bands < Threshold\ Value \right) \tag{4}$$

where, Source Bands = Sigma0_VV

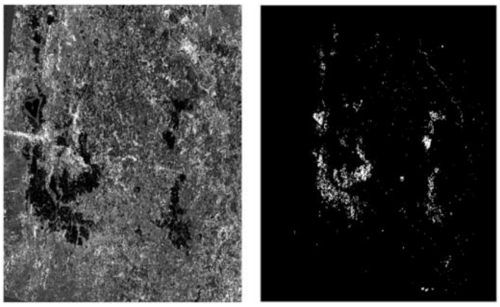


Figure 3. (a) original image and (b) image after lee filter model process

3.2. Creation of Data on Scope of Flood Areas

To create the boundaries of flood areas in this research, ArcGIS Program, educational version, as utilized by transforming improved data from Raster data to be Polygon areas for separating boundaries of flood areas clearly and compacting data structure. Moreover, obtain data files were small leading to smaller spaces for storing data. For classification, reflection of each pixel would be used.

From determining Threshold Value, division of water sources was shown in white. As a result, for correctness, reflection was determined to show data on water areas only as well as to find total water areas by creating Data Table for Geometry Calculation. Equation (5), [29], the basic calculation of area sizes, was used for finding total water areas. Lastly, the model areas that were expected to be affected by flood were created.

$$A = \frac{1}{2}\sum_{n-1}^{n}(X_{i+1} - X_i)(Y_{i+1} + Y_i) \tag{5}$$

where, n is number of vertices of polygon and (X_1, Y_1), (X_2, Y_2), …, (X_{n+1}, Y_{n+1}) = coordinates of each vertex

4. RESULT

Results of analysis on disasters caused by flood via data from Sentinel-1 Satellite: Case Study of Sukhothai Province, were shown in Figure 4. From Figure 4, it was found that, on August 25, 2020, there were around 96.751 km^2 of Sukhothai Province that were flood areas. When comparing data obtained from analysis with average flood area of 96.751 km^2 with data on flood areas obtained from Geo-Informatics and Space Technology Development Agency (GISTDA) with approximate flood areas of 106.632 km^2 (Figure 5), it was found that difference was around 9.593%. Such difference may be caused by different operations on data management and creation as well as data processing for determining the scope of flood.

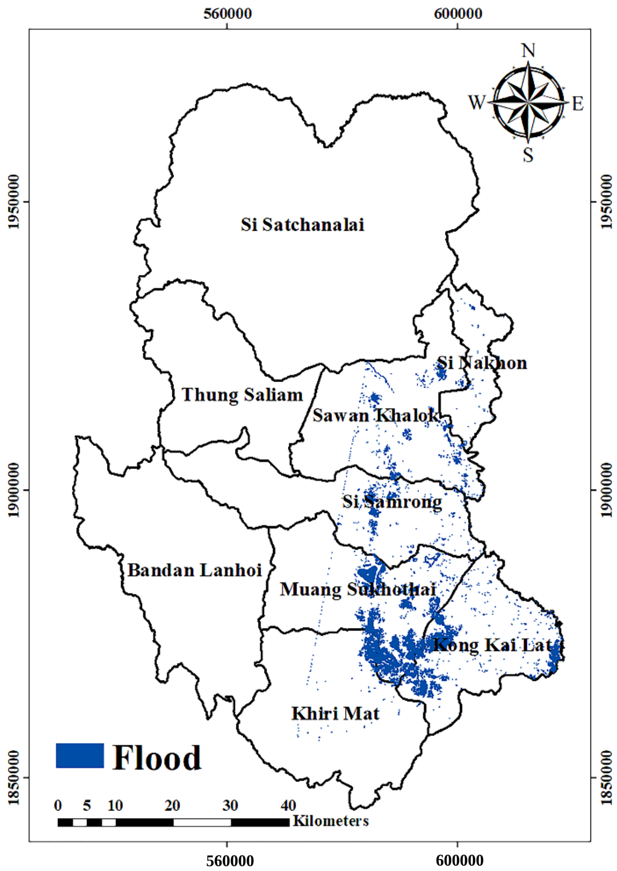


Figure 4. Flood analysis result

Rainy season in Thailand starts from the mid of May of every year to the end of October with the approximate duration of 5 months and a half. During raining season, Thailand will be affected by southwest wind or wind that was blown from Andaman Sea to most areas of Thailand causing heavy rain in all regions of Thailand. At the end of rainy season that is monsoon period, Thailand will be affected by several storms formed in South China Sea. Storms will reach Thailand when they are mild whereas some storms may move to Thailand when they are monsoon causing heavy rain, strong wind, and floor every year. Average monthly rainfall of 2020 from Sukhothai Metrology Station (Table 1) revealed that rainfall of August was 300.2 mm that was the highest level. It could be seen that such area caused flood disasters in Sukhothai, Thailand that was consistent with results of this research.

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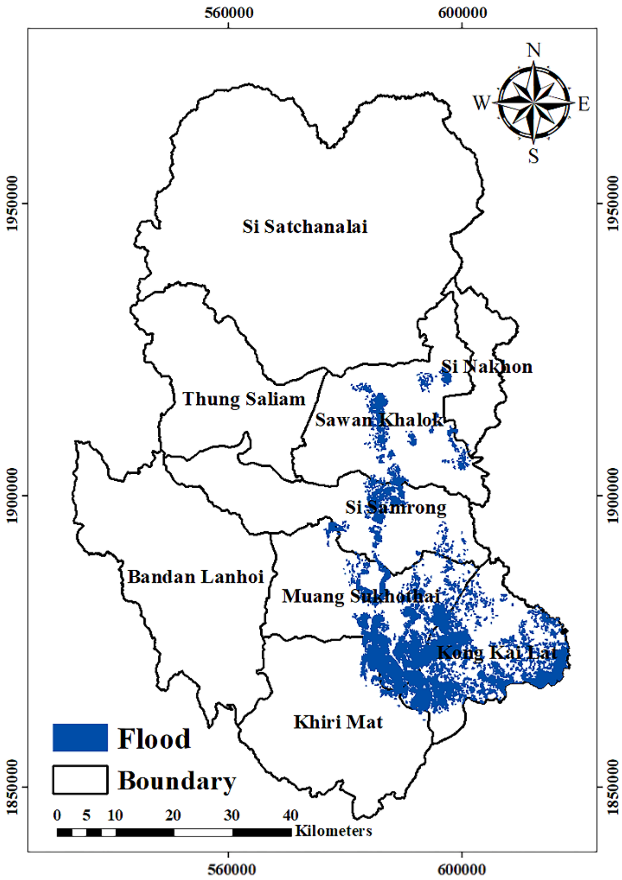

Figure 5. Flood areas obtained from GISTDA [30]

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Table 1. Average monthly rainfall of 2020 [31]

Month	Rainfall (mm)
May	65.4
June	124.2
July	35.5
August	300.2
September	234.8
October	106.5

It could be seen that such area caused flood disasters in Sukhothai that was consistent with the results of this research.

5. CONCLUSIONS

Climate change tends to push Thailand to be in risky conditions caused by effects of climate that is different from current condition, especially increase of risky conditions caused by flood that are considered as consecutive problems with huge effects against economic and social conditions of Thai land. Risky areas on flood are often river basins with density of land utilization for settlement, agriculture, industry, and transportation.

Consequently, flood in such areas can cause damages in local level and overall economic and social conditions of Thailand. From studying and analyzing disasters caused by flood via data from Sentinel-1 Satellite :Case Study of Sukhothai Province, it was found that, on August 25, 2020, flood areas in Sukhothai Province, Thailand were approximately 96.751 km^2.

In addition, it was also found that geography of Sukhothai Province, Thailand, i.e., the area with a river flowing from the north to the south with approximate area distance of 170 km, was the cause of repeated flood, especially those areas in Swankaloke District, Sri Samrong District, Muang Sukhothai District, and Kong Krailat District, Thailand. The results of this study could be applied to find tendency of flood areas for preventing, monitoring, or evacuating people promptly for reducing extensive effects.

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