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Applications of Sentinel -1 SAR Data for Flood Damage Assessment: a Case Study of Central Vietnam Flooding Event in October 2020

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Applications of Sentinel -1 SAR data for flood damage assessment: A case study of central Vietnam flooding event in October 2020

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Abstract: **Floods are one of the major devastating natural hazards around the globe. Recent development in remote sensing technology provides support in faster and low-cost analysis of flood hazards. In this study, the Sentinel-1 SAR data was used for flood mapping and damage assessment. We selected the flood event that occurred in three provinces of Central Vietnam in October 2020. Random Forest algorithm was adopted to detect and classify the inundation areas from 344 sample points of training and testing. The results showed that the inundation situation remained high throughout October and the flooded area was up to 101,000 ha. The estimation of land cover damage showed that most of the affected areas were in the cultivated land and accounted for more than 90% of the total inundated area. The results help the decision-makers for better monitoring and flood damage assessment in the Central Vietnam.**

Keywords: **Sentinel 1, flood mapping, random forest, Vietnam**

I. INTRODUCTION

Currently, remote sensing (RS) has been applied to disaster management in an extensive, efficient, and accurate way. In flood monitoring and damage assessment, remote sensing data provide a substantial contribution to minimize the impacts of floods [1]. In this study, the method of creating a flood map and assessing the flood damage based on Sentinel-1 SAR data is presented. It was applied to a historic flood event that occurred in the Central Vietnam during October 2020.

In October 2020, the Central Vietnam was directly affected by 3 consecutive large typhoons. Typhoon Linfa made its landfall in the Central Vietnam on October 11 and produced heavy rains from October 6 to October 13, followed by the Nangka typhoon on October 14 which generated heavy rainfalls till October 20. In the last week of October, the Molave typhoon made its landfall and induced heavy rainfalls till the first week of November 2020.

These typhoons caused enormous and long-term floods, along with flash floods and severe landslides. According to the report of the Vietnam disaster management authority [6], 150 people were killed or lost, and more than 220 were injured. In addition, a total of 1037 houses were damaged and 361,787 houses were inundated. These typhoons also damaged 13,804 hectares of agricultural area, 20.2 km of the dike, 116 km long canal, and 43 km long bank of river and coast.

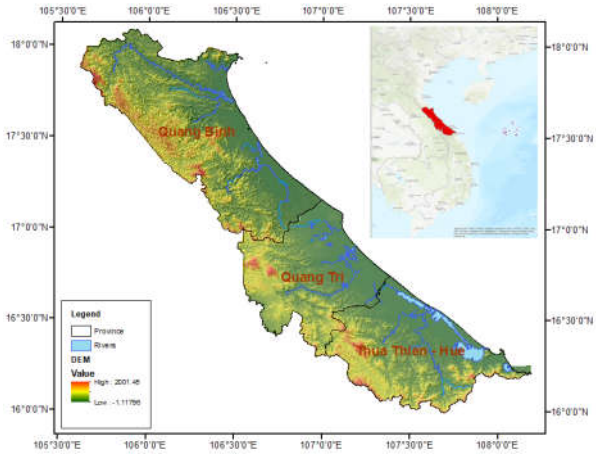

Figure 1. The location of study area includes three provinces: Quang Binh, Quang Tri, and Thua Thien Hue, which were the most affected regions due to the flood events in October 2020

Mapping the flood based on SAR images is a quick and reliable method for identifying the inundated areas [2]. With the characteristic of penetration of the cloud – cover, SAR can be operated in any weather conditions and provides timely information. By analyzing the Sentinel-1 SAR images, provided by Copernicus, near-real-time flooding maps for the Quang Binh, Quang Tri, and Thua Thien Hue provinces were prepared. These maps were sent to the local agencies during floods for assistance in the decision-making of prevention and mitigation operations.

II. METHODOLOGY

The study was designed in two phases. The first phase was to create flood maps using machine learning classifiers based on the Sentinel 1 SAR images. The second phase was to estimate the flood damage for different types of land cover (Fig. 2).

Producing the time series of flood maps was the target of the first phase. Initially, seven images of Sentinel 1 including VH and VV polarizations were collected. These images were taken on 6, 11, 18, 22, 28, and 31 October, and 4 November 2020. They were processed and analyzed to identify the variation of flooding in the study area. After reducing the radar speckle [3], the SAR images were classified into two classes, water, and non-water by the Random Forest algorithm. A total of 344 sample points were used for training and testing purposes. Then, the flood maps

were refined by excluding the permanent water, which was extracted from global surface water maps.

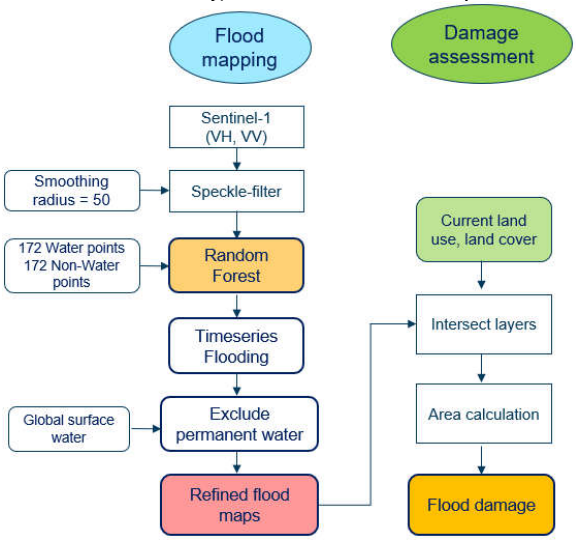

Figure 2. The workflow of flood mapping and damage assessment

In the second phase, the flood maps were intersected with the different land cover classes to identify the flood damage. The current land use map was provided by the Vietnamese Ministry of Natural Resources and Environment for the three provinces of interest. The two main classes of interest were residential and crop areas.

III. RESULTS

The flood maps for the three central provinces of Vietnam showed that the inundation situation remained high during October 2020. Inundation, which started in the early days of October, rapidly grew on 10 October and peaked on 18 October 2020. After that, floods started to decrease, but more than 20,000 ha region was inundated by the end of October (Fig. 3).

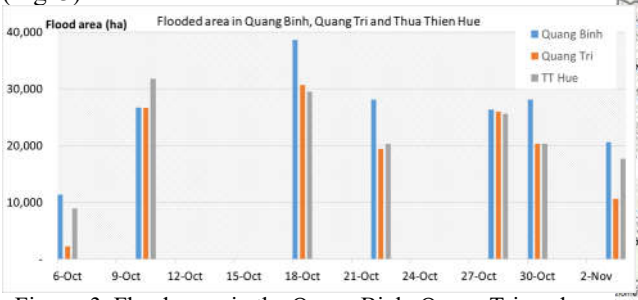

Figure. 3. Flood areas in the Quang Binh, Quang Tri, and Thua Thien Hue provinces.

The largest recorded flooded region in the Quang Binh province was found on 18 October 2020. The total area submerged in water up to 38602.6 hectares. The Le Thuy District suffered the most, up to 13611.3 ha area found to be submersed, accounting for 35.3% of the flooded area of the province. The other districts, found to be heavily inundated, were Quang Ninh, Quang Trach, and Bo Trach with flooded areas 8201.7ha, 6231.9ha and 5836.4ha respectively. The Dong Hoi City, the political and economic center of Quang Binh Province, was found with 1137.5 hectares of submersed area (Fig. 4).

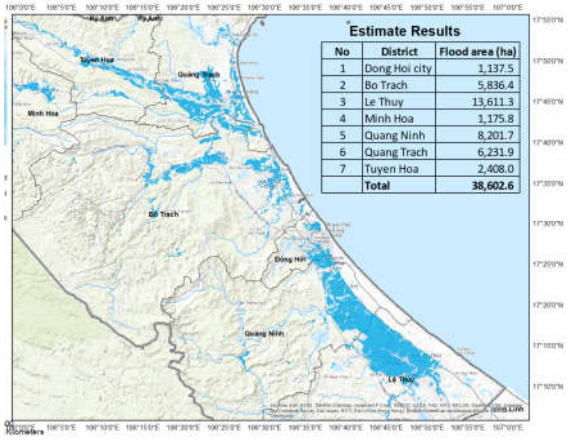

Figure 4. Flood map of Quang Binh Province on Oct. 18, 2020.

In the Quang Tri Province, the largest recorded flooding occurred on 18 October 2020, with a total area submerged in water up to 30658.9 hectares, in which the Hai Lang District was flooded the most and up to 9492.08 ha area submersed, accounting for 31.0% of the flooded area of the province. The other districts, also heavily inundated, were Trieu Phong, Gio Linh, and Vinh Linh with flooded areas of 7722.06 ha, 5097.58 ha and 4800.74 ha respectively. The Dong Ha City, the political and economic center of the Quang Tri Province, also significantly suffered with 1301.54 hectares of area flooded (Fig. 5)

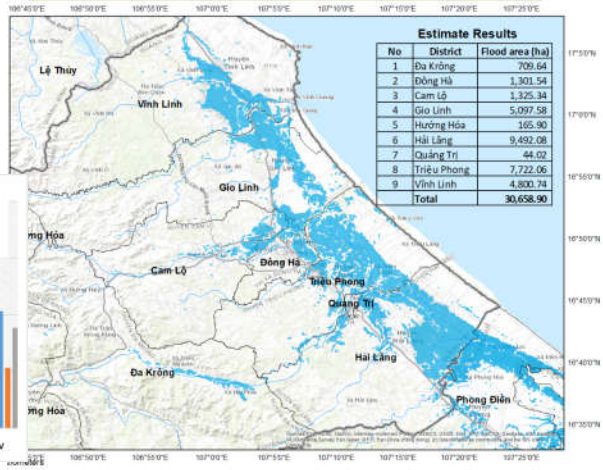

Figure 5. Flood map of Quang Tri Province on Oct. 18, 2020.

The Thua Thien Hue Province, the ancient capital of Vietnam, suffered the largest recorded flooding on 10 October 2020, with a total area submerged in water up to 31800.6 hectares. The districts in the coastal plain area had the largest affected regions, including Phu Vang, Phong Dien, Quang Dien, Huong Tra, Huong Thuy and Phu Loc districts with the flooded

areas of 7468.48 ha, 6917.09 ha, 5606.95 ha, 4085.32 ha, 3419.81 ha, and 3041.01 ha respectively. The political and economic center of the province, Hue City, also suffered floods of 912.34 hectares (Fig. 6)

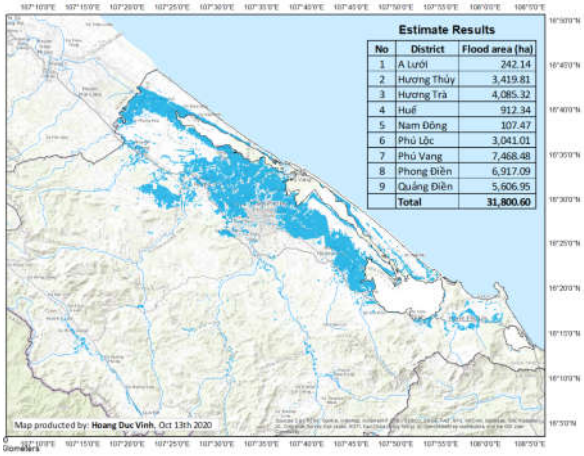

Figure 6. Flood map of Thua Thien Hue Province on Oct. 10, 2020.

The results of land cover damage estimation showed that the major affected areas were cultivated lands and accounted for more than 90% of the total inundated area. These were flat, fertile, and low elevation areas that were prone to flooding. The residential areas suffered less, but with a direct impact on people as the damage was resulted from the inundation persisted for long time. The largest inundated residential areas were up to 922.5 ha in Quang Binh; 1066.4 ha in Quang Tri and 430.2 ha in Thua Thien Hue.

IV. CONCLUSION

In the central coastal area in Vietnam, flood is one of the most frequently occurring natural disasters, which affect human and cause economic and infrastructure losses [4]. Thus, there is a need to create rapid and effective approaches for flood monitoring [5]. Based on remote sensing and GIS techniques, the flood map could be generated in response to those requirements by using the SAR imagery and Google Earth Engine online platform.

This study is a successful case of a rapid response to heavy flood in the Central Vietnam in Oct, 2020. The results of the flooding maps and damage estimates were sent to the local authorities in a timely manner and contributed to damage assessment as well as decision-making support for local disaster prevention options.

ACKNOWLEDGEMENT

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