Interferometry Synthetic Aperture Radar (InSAR) Application for Flood Area Detection Observed by Sentinel 1A

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Abstract— Almost every year, flood and landslide occur at Pangkalan Lima Puluh Kota district, West Sumatra, Indonesia. These not only destroyed the agricultural but also isolated the area. The area is essential for supporting transportation connection in the center of Sumatra. However, the handling of this issues is insufficient then scientific information is a necessity. In this research, flood monitoring data extracted using InSAR processed by SNAP Sentinel-1 toolbox. The data were provided by European Space Agency (ESA) Ground Range Detected (GRD) High-resolution, Interferometric Wide Sentinel-1A observation product in ascending and descending orbit Both co-polarization VV and cross-polarization VH of satellites detected slightly different flood covered. The cross-polarization is high sensitive than co-polarization. The result was the present great potential of SAR satellite data for detection and delimitation flood risk in the area.

1. INTRODUCTION

Flooding disaster event occurred in the most area in the world. Even in some country the tragedy has been natural phenomena in the rainy season. The flood is not only the destroyed the environmental but also in social and economic impact because the disaster is obstructing people's livelihood, break the transportation routes then the area become isolated. So, the fact requires more attention from local authorities in managing in before, during and after the geo-hazard occurrence.

In recent year, the number of disasters attacks Pangkalan Koto Baru, West Sumatra, Indonesia. Flood is one of the common tragedy that has a long history in the area. In last three-year, large-scale flooding event occurrence on November 2015, February 2016, March 3, 2017. The trend of flooding occurs at the end of the year (Oct.–Dec.) until early month on next year (Jan.–Mar.) regularly [1], because of rainfall intensity is high during the time [2]. Then the local government by BPBD (Regional Disaster Management Agency) has categorized the area into middle-high land movement and flooding [3].

For mitigation and evaluation of flood event, the Synthetic Aperture Radar (SAR) interferometry data has used to extract the information about the surface area. The data obtained from SAR satellite operation that emits the electromagnetic wave to the earth and receive its reflection [4]. The satellite can acquire data without preventing by a cloud during day and night time [5]. Then the earth surface feature can be observed correctly with high image resolution. In this case, Sentinel-1A satellite data that provided by European Space Agency (ESA) was used to extract the flood information. The data acquisition is February 20, 2017, and March 4, 2017, for before and during the inundate event respectively.

Mapping the areas that affected by flood and property damage is crucial for evaluating and preventing probability the flood disaster coming in future. In this work, we discuss the application of interferometry C-band SAR data for mapping the flood area in Pangkalan Koto Baru using Sentinel-1A images.

2. AREA OF STUDY AND SATELLITE DATASET

The study area located at 0.10°N, 100.76°E Pangkalan Koto Baru, Lima Puluh Kota district West Sumatra Indonesia. The zone is the main road connecting West Sumatra province and Riau province. This way is essential as the trade lane from both region that more than ten thousand [6] vehicle in this way every day. However, the area has a longtime history of flooding, even every year at least onetime flood occurred notice since 2011. Recently, the last large-scale flood occurred on March 3, 2017. Besides destroyed the agriculture and infrastructure also triggering the landslide in some zone. The area has high rainfall intensity along the year [1], in particular, at the end until the early month of the next year with the intensity is more than 300 mm/month [2].

Figure 1 shows the area of research on Pangkalan Koto Baru, which the red square is inhabitant area and white square is a basin that has been a control water level in the field. The most of

the field is mountainous that have valleys between them which have been inhabitant area. In the valleys passed some rivers that sometimes overflow then inundate the resident zone.

For investigation flood area and damage analyze, the Sentinel-1A (C-band) SAR data with Ground Range Detected (GRD) product format used. The mode of satellite data is Interferometric Wide (IW) with has swath width area 250 km and has a dual polarization ($VV + VH$). The GRD range-azimuth resolution is 20×22 m with pixel spacing 10×10 m [7]. The acquisition date is March 4, 2017, February 20, 2017, at 11.32 am for flood event and waterbodies respectively.

Figure 1: The study area of flooding on Pangkalan Koto Baru, West Sumatra, Indonesia. The red square is settlements area; the white square is a basin. The image captured by Sentinel-2A in July 2017.

Table 1: Satellite Sentinel-1A dataset with dual polarization ($VV + VH$) and azimuth range resolution 20×22 m.

Satellite data	Beam Mode	Type	Acquisition	Track	Orbit
S1A	IW	GRD	04-Mar.-2017	69	15541
S1A	IW	GRD	20-Feb.-2017	69	15366

3. METHODOLOGY

SAR interferometry is a technique that develops to extract information from a pair of SAR images in different time acquisition [8]. The SAR data achieved by emitting an electromagnetic wave to the earth surface with a specific frequency. The lowest frequency has high sensitivity [9] to surface feature with an accuracy of the topography and displacement in meter and millimeter respectively [10].

Flood area can be analyzed by its backscatter coefficient σ^0 [11], which has the low value than others because the satellite signal reflected away from the sensor then the area look dark in SAR images. The processing flow is shown in Figure 2.

4. RESULT AND DISCUSSION

In flood investigation, we use two satellite data, before and during the event. The data in before flood event was used to mapping the water body on the area, and comparing with flood event. To extracted water bodies and flood area information, the backscatter coefficient threshold was applied to separate water and non-water. To decide the value, statistical analyze was applied by selecting the water area. The water class, which has lowvalue backscatter coefficient than other. Furthermore, to verify the value, the histogram analyzing also was considered. The backscatter coefficient value for water is shown in Figure 3.

In Figure 3, the minimum and maximum value of the backscatter coefficient for 6022 pixels sample were selected in both basin area (B1, B2) of 0.001 and 0.0251 respectively. The coefficient value > 0.0251 correspond to land area. In this case, the time acquisition of the satellite data is in 12-hour flooding then some field less identified. Based on amplitude value for copolarization (VV) and cross-polarization (VH) the area of the study depicted in Figure 4.

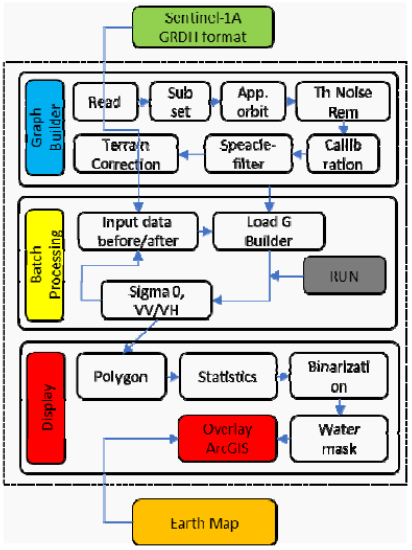

Figure 2: Flood area investigation processing flow based on SNAP software developed by ESA.

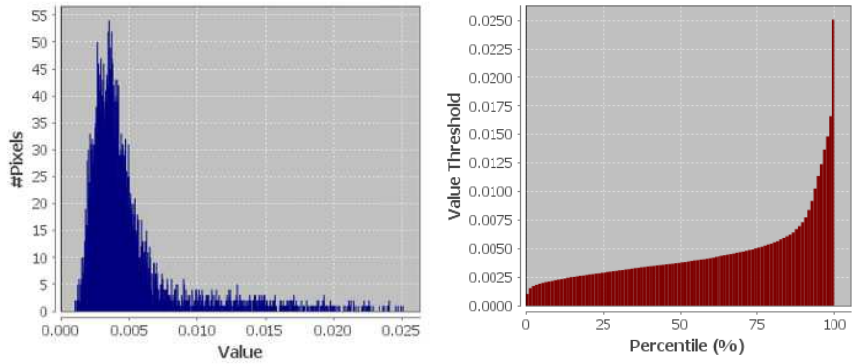

Figure 3: Statistical value of flood water backscatter coefficient for the 6022-pixel sample in Pangkalan Koto Baru basin, West Sumatra Indonesia.

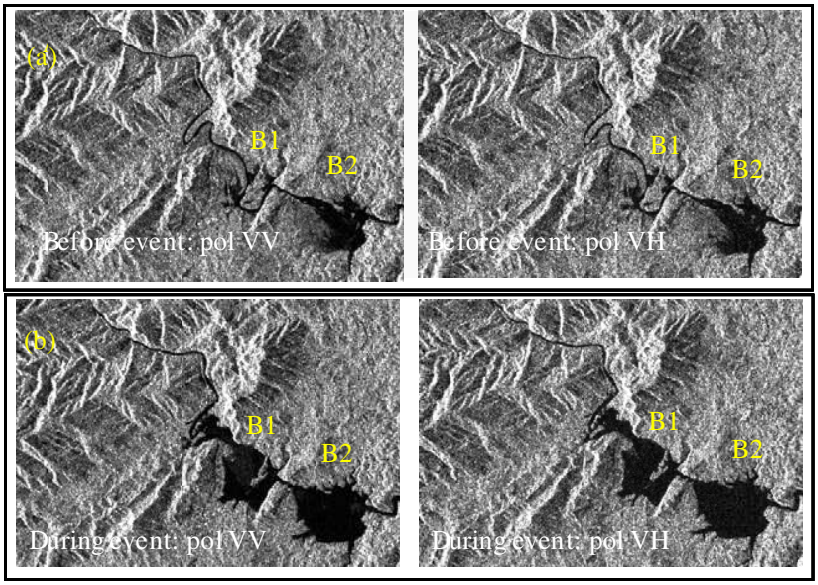

Figure 4: Images based on the amplitude value of the study area for co-polarization (VV) and cross-polarization (VH) observation. (a) SAR image before flood event (20-02-2017), (b) SAR image during flood event (04-03-2017).

Figure 4 shows the images based on the amplitude value in the study area, that observed by Sentinel-1A with co-polarization (VV) and cross-polarization (VH) before and during flooding. In basin (B1) has the land area in the center. Also basin (B2) has a half area approximately filled with water in before the event that observed by both polarization (Figure 4(a)). Wheres, during the flooding both of basin has a vast area that inundated with water (Figure 4(b)).

Figure 5 shows inundated area on Pangkalan Koto Baru, from two zones as a sample. In both sample are Pankalan Koto Baru basin and Pangkalan Sub-district center. The water bodies filled up with a yellow color and the inundated area is blue and green observed by VV and VH polarization respectively. For equal backscatter coefficient threshold value, cross-polarization VH observation has more inundated area than co-polarization VV.

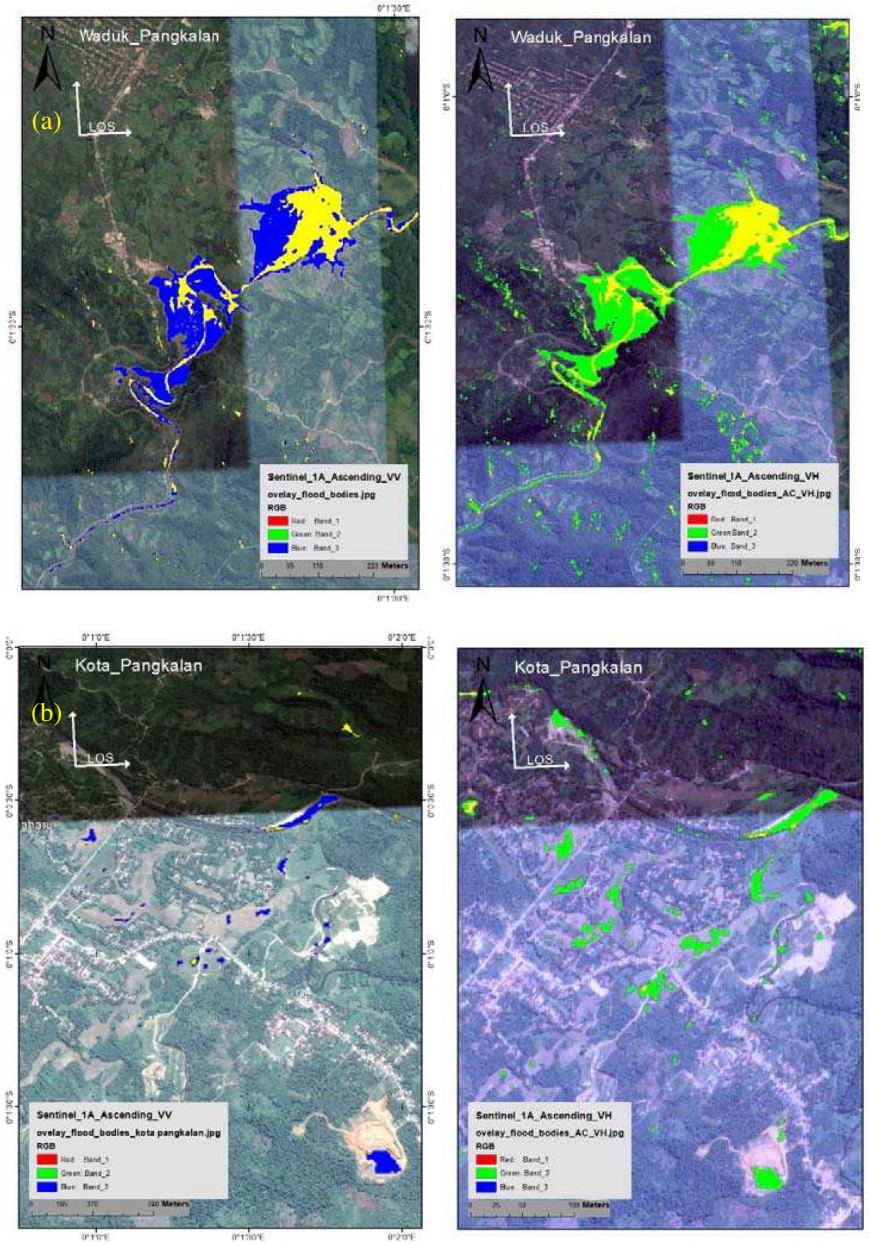

Figure 5: Overlay the flood area and the water bodies for two sample, observed by co-polarization (VV) and cross- polarization (VH): (a) Pangkalan Koto Baru basin, (b) Pangkalan Sub-district center.

5. CONCLUSION

This paper presents the capabilities of interferometry remote sensing data processed by SNAP software for detecting and managing the flooding area in Pankgkalan Koto Baru. Inhabitant area, the flood is less identified because of the acquisition time of SAR data observed after 12-hour

flooding. However, in the two basins, the inundated area is clearly observed. Interferometry SAR observation with Co-polarization VV is less sensitive to flood detection than cross-polarization VH on the area.

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