Analysis of karst potential using Landsat 8 Imaging and DEM in the District of Sampang, Madura Island, East Java

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Abstract. There has been done a research on the determination of karst potential in District of Sampang. This research aims is to analyze the presence of karst morphological potential based on Landsat 8 and DEM using several spatial analyze based on river flow maps, surface temperature, NDVI and composite band maps using ArcGis and BEAM VISAT. Then the process continued to get karst analysis map and the results are karst morphology. There are karst potency with 3 parts spread in northern, central and southern part of Sampang. Those differences are suspected because of the existence of tectonic activity and depositional process.

Keywords: *Band composite, DEM, karst, and NDVI*

1. Introduction

Karst is a morphology of carbonate rock that is lifted to the surface. Carbonates are highly susceptible to acidic water and thus dissolve to form distinctive surface features such as, in the form of basins, small hills, lost surface rivers, sediments of red clay resulting from limestone weathering that breaks into the soil and rough surface. Karst also high economic potential as a source of limestone and geological learning sites. Mapping karst areas is usually done with geological mapping of direct survey so it takes a long time. With the advance in remote sensing technology, mapping of karst areas can be done using Landsat 8 ETM+ sattelite image data to become more efficient and alternative method in Sampang District, Madura, East Java.

2. Theory

Karst is a morphology consisting of limestone and dolomite. It precipitates infiltrate the soil and flow beneath the surface to a high altitude to a lower altitude [11]. Karst contains an aquifer that can trap water in the soil. Karst can resulting in contamination of groundwater, unexpected water reserves, sinkhole formation, and underground caves. The hydrogeological characteristics of karst aquifer include evolution, heterogeneity, anisotropy, and variability. Karst evolution is made up of flowing water containing carbondioxide (CO_2) which dissolves carbonate rocks. As for heterogeneity, karst aquifer has different characteristic at every distance. In the cave, there are many quantities of water

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while on the borehole there is no water at all. Anisotropy of th aquifer depens on the orientation of geological elements, such as hydraulic conductivity tends to be high on the large fault [6].

Landsat 8 sattelite itself serves to map the entire earth every 16 days which results can be downloaded for free through the EarthExplorer website, Landsat Look Viewer, and GloVis. Landsat 8 has has two instruments namely Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) [8]. Landsat 8 measures various different frequencies along the electromagnetic spectrum where each distance is called a band. The Landsat 8 image has 11 bands of which has its own uses, such as mapping the thermal, estimating soil moisture, and distinguishing the slope of vegetation. To analyze a particular theme, a combination of bands is required (www.infogeospasial.com).

Band 1 shows dark blue and violet colors. Band 2 shows blue, band 3 show green, and band 4 shows red. Then band 5 measures colors close to the important infrared used in ecology. By somparing bands 5 with other bands, the NDVI can be created and NDVI is used in measuring plant health. Then band 6 and 7 show short waves infrared or SWIR used on wet earth and dry earth as well as on geology like rocks and soil. Then band 8 is panchromatic which works like a black and white movie instead of unifying different colors. Meanwhile the band 9 covers the layer with a wavelength of 1370 +- 10 nanometers. Then band 10 and 11 are infrared heat (thermal) or TIR measures soil tempature which is generally hotter than air temperature [7].

3.Methodology

In this research, the softwares that are used are Beam Visat 5.0 and ArcGIS 10.3. In Beam Visat 5.0, radiometric correction and band can be made to get the image that is need for further study. Images that can be created from Beam Visat 5.0 are atmospheric penetration, natural colors, or natural colors with atmospheric removal. Meanwhile, further processing can be done through ArcGIS 10.3 using the image from Beam Visat 5.0. Further processing can be done by using composition of .shp file, digital image elevation model, making river flow map, NDVI extraction and ends with a carthographic process map.

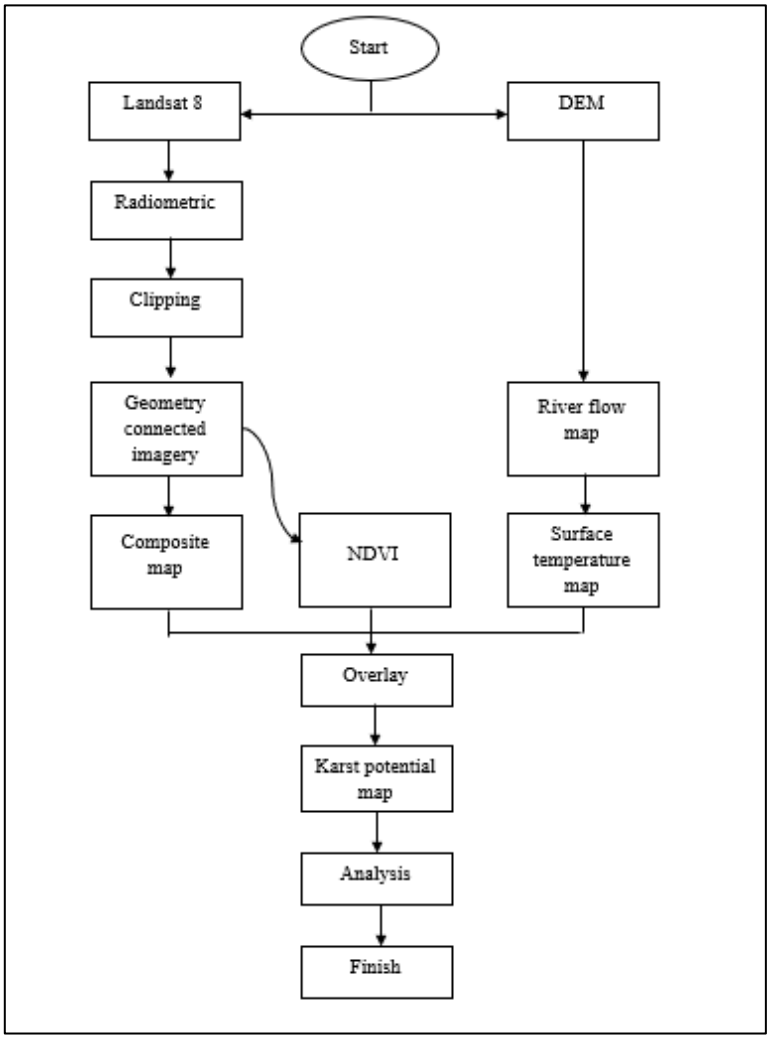


Figure 1. Workflow used in this reaearch

4.Result and Discussion

4.1 NDVI

Normalize Difference Vegetation Index (NDVI) is index of "green" vegetation of photosynthesis activity and NDVI is one of the most method used for vegatation. Vegetation that activates photosynthesis will absorb most of the red waves from the sun and will reflect near infrared waves that is higher. Vegatation that is dead or less healthy will reflect more red waves and less on near infrared waves. For karst area mapping, a review can be made areas with low vallue vegetation index. Green plants can rarely be seen in karst area due to unfavorable surface conditions fertile and rocky. On the NDVI map below, area red color represent the area with low NDVI then for yellow area is an area with medium NDVI (not high and not low) while for green area is an area with an high vegetation index. From the map can be seen that District of Sampang is an area with almost the whole part is karst morphology.

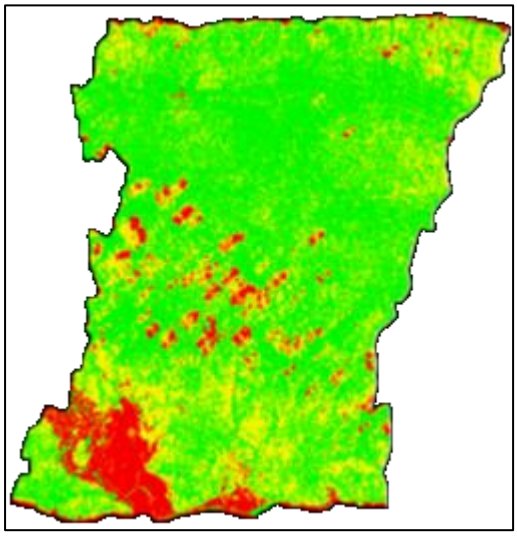


Figure 2 Normalized Difference Vegetation Index Map (NDVI)

4.2 Digital Elevation Model (DEM)

Digital Elevation Model (DEM) is a digital data to map the height of the Earth's surface shape which consists of surface coordinate points. DEM shows the height of a surface can be used to know the length of a surface and can be used to know the length and width of the river, river slope, river flow pattern, altitude an area, knowing the morphology of a basin, and determine the potential content of an area. NDVI map above shows a potential karst map of NDVI at District of Sampang, Madura. Please note that green area is an area with low NDVI values that have high karst potential with lomestone lithology. Then from the DEM data of District of Sampang obtained a contour map that shows altitude in the area of Sampang. Those contour map will be overlaid with NDVI map above.

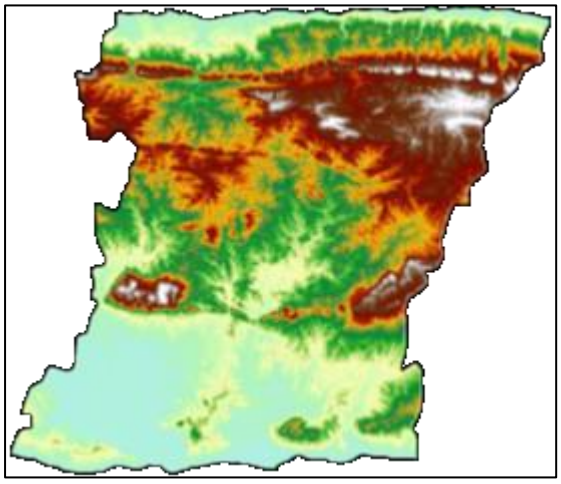


Figure 3. Digital Elevation Model Map (DEM)

4.3 Band Composite

Several composite combinations Landsat 8 images were made to interpret qualitatively. Such as band 765 atmospheric penetration, natural color, and normalized difference vegetation index. Composite band 765 (atmospheric penetration) can be used to analyze morphological formations as well as soil moisture. The morphological formation of the caves of the hollows, small hills, and open surfaces which look abrasive is show in the figure above.

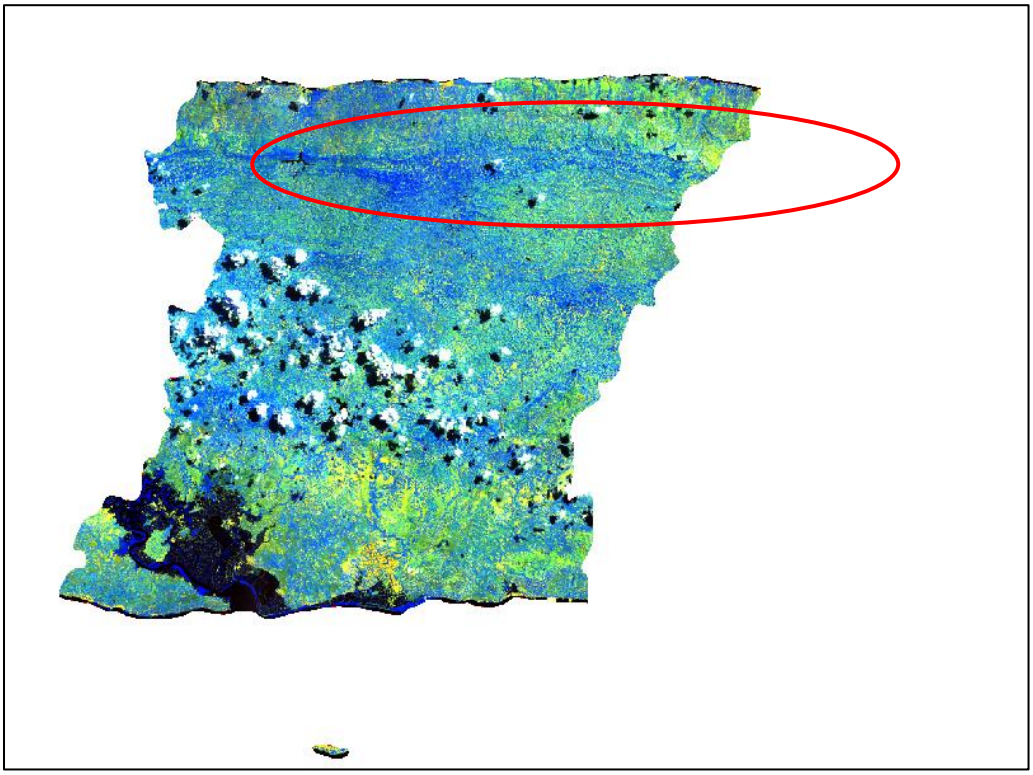


Figure 4. Atmospheric Penetration Map

The composite band (natural color) that has been processed using pan sharpening method can be used to analyze the color of sediment of red clay sediment resulted from the weathering of limestone (red circle) and bright white is the typical color of limestone quarry (yellow circle). The result of interpretation of natural color band composite is confirmed with the result interpretation from normalized difference vegetation index composite band or commonly called NDVI. NDVI has a function as a result of calculation of image algorithm to know the level of vegetation of a region.

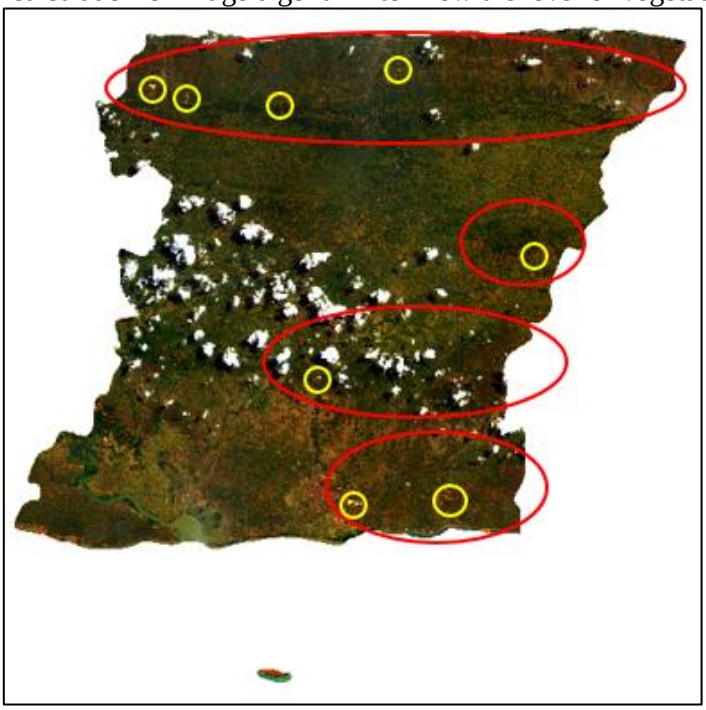


Figure 5 Natural Color Map

4.4 Potential Analysis

After processing on Landsat 8 and DEM Image, it is resulting a map above. Where the green area is an area that has the potential for karst exploration. Determination/ stipulation of the area obtained from the overlay between the digitized area of limestone formation and NDVI, and also observing on composite natural color map for validate the desired area is not affected by the cloud. Furthermore, a review of the watershed, in the karst area occurs loss of river flow on the surface. This is happening because the characteristic of limestone is dissolved by water to form the fracture and caving on the subsurface which is followed by the formation of subsurface streams in karst caves.

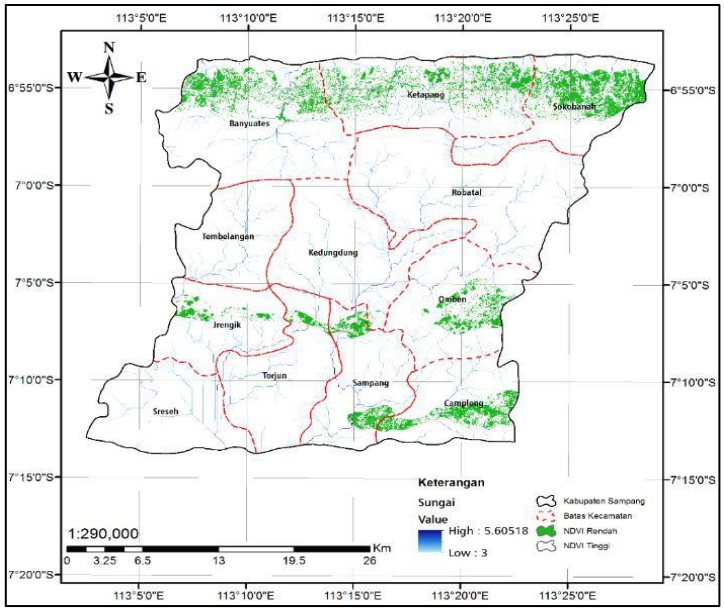


Figure 6. Karst Potential Analysis Map in Sampang, Madura

5. Conclusion

Based on analysis of karst area in Sampang Regency using Landsat 8 satellite and DEM data that have been done, resulting the conclusion that eksokarst area spread in some Subdistricts, including Banyuates, Ketapang, Sokobanah, Omben, Jrengik, Sampang, Camplong with parameter value NDVI -0.014 - 0.313, located on hilly terrain (closed contour 150 meters height in north and 50 meters in the south), the river around the area suddenly disappears, there is a layer of weathering of dark red carbonate rocks, and above the lime lithology based on geological map).

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