Utilization of Topographic Imagery using Watershed Transformation in Watersheds Prone to Natural Disasters

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Abstract*: *Indonesia is an archipelago that has abundant natural resources, however, problems arise in the process of utilizing natural resources, namely the emergence of natural disasters that have the potential to cause serious damage in several areas. The threat of floods and landslides in watersheds has become the main focus to be addressed as early as possible with the best solutions and planning. The use of topographic imaging in the field of remote sensing is one solution that is very useful in developing better natural disaster management systems. With the support of the use of the watershed transformation method, this study aims to obtain geographical situation data, both from the flow dimensions and slope conditions that affect the watershed discharge capacity. Thus, the risk of natural disasters can be minimized both from the level of material and non-material damage as early as possible.

Keywords* : *Topographic Imagery, Watershed Transformation, Watershed.

I. INTRODUCTION

Erratic weather changes and ecosystem imbalances are factors in natural disasters resulting in material loss and loss of life. The high rainfall and the difference in the time of falling rain intensity become obstacles in predicting the chances of excessive water discharge in the watershed. Disruption of the environmental balance from unfavorable community behavior such as: littering, and utilizing forest products without calculation, makes the threat of flooding can occur at any time. One of the estuaries of this danger is the watershed that functions as a gathering place and the flow of various types of water, both from urban and mountainous. Natural disasters such as floods, landslides, and other natural disasters can come at the same time.

From the existing natural phenomena, rivers as a water flow have varied shapes that are caused by nature and are not easy to describe. Streams flooding and waterfalls from a certain height are examples of illustrative forms that are difficult to describe with certainty. A deeper understanding is needed about slopes and contours around watersheds. As early prevention from the threat of natural disasters is to utilize remote sensing technology using watershed transformation.

Researchers have done a lot of research on detecting watershed surface images such as watershed Image Segmentation Technique using MATLAB [1], extraction of watershed characteristics using GIS [2], and Segmentation and classification of hyperspectral images using watershed transformation [3], Estimation of Surface using Runoff for Sub-watershed [4]. The transformation technique in the health sector has been done by researchers, including segmentation and classification of bacterial cells [5], and CT images and classification of brain tumors [6].

The physical characteristics of watersheds can be analyzed by the morphometric analysis which is useful for the fields of land use planning, soil conservation, terrain elevation, and soil erosion [7]. The database of the results of this analysis can be used as a basis for project implementation in relation to land use, water resources and climate change [8]. While the application of other methods to map natural disasters and the impact of natural disasters has been carried out such as flood mitigation [9]. While this study utilizes topographic imagery using watershed transformations in watersheds prone to natural disasters.

II. THEORY

A. Watershed Transformation

Transformation regards images as three-dimensional with gray, white and black pixel color levels. This explains the shape of the topography with various points, including the point which is a regional minimum point that is if the water drops will fall to a certain minimum position called catchment basin, the point that if the water drops will fall to one of the minimum positions is called the watershed line. Watershed is a basic tool in mathematical morphology that functions for segmentation and is often used in the field of remote sensing to determine the height or contour of an area. The topographic representation of a one-band image is shown in Figure 1 [3] and an example of watershed transformation in one dimension is shown in Figure 2 [3].

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The purpose of this segmentation algorithm is based on the concept to determine the watershed line, which is a line on the surface of the image topography. The assumption in this watershed transformation can be described as a small part or segment in the topography of the image that is considered as a hole, then assume that each hole or segment formed is filled with water to its surface to form a basin or dam that is connected to each other by the watershed boundary line. A watershed line is a boundary line that connects each basin or dam on the image topography so that segments are formed that are connected to each other. Gray level representing basin areas using the MATLAB program as shown in Figure 3. The Flow-chart of the scheme of segmentation and classification is shown in Figure 4.

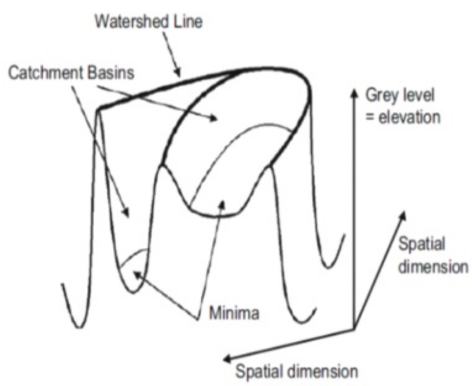

Fig. 1. Topographic representation of a one-band image [3]

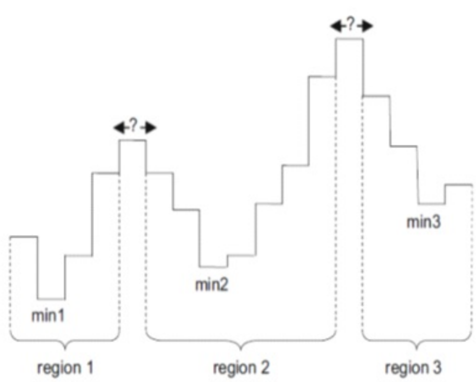

Fig. 2. Example of watershed transformation in one dimension [3]

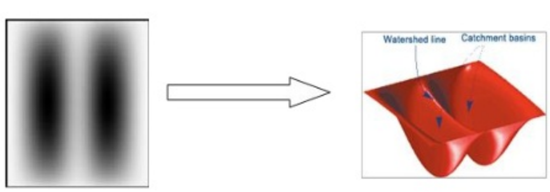

Fig. 3. Gray level representing basin areas

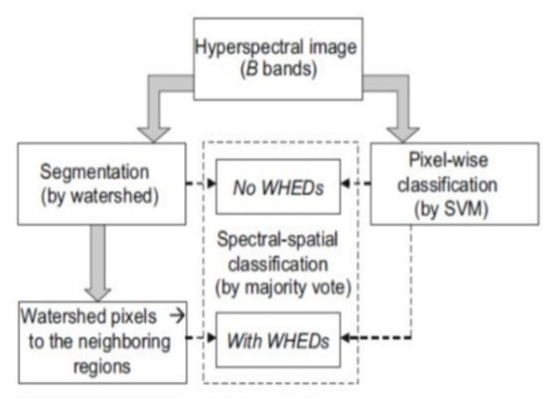

Fig. 4. The Flow-chart of the scheme of segmentation and classification

III. METHODS

In this study, the satellite imagery used was sourced from USGS/the U.S. Geological Survey which contains information about surface water in an area, with the following steps:

1. Determine the location of the satellite observation station in accordance with the data needed.
2. Record of the coordinates of the station description and then download the 30 meter DEM file as shown in Figure 5.

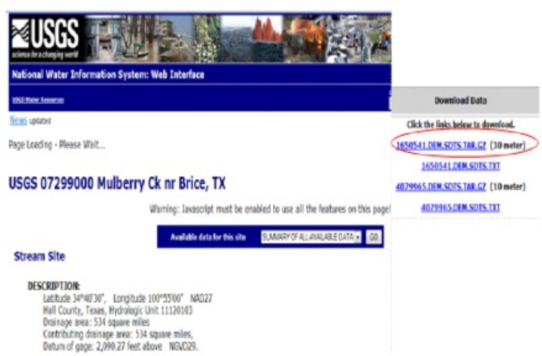

Fig. 5. The example display of downloading a 30 meter DEM file

3. The downloaded file is then extracted using the sdts2dem software so that it can be read properly in the Arc GIS software. Then the extraction results are collected in one folder, call the converted DEM file into the Arc Map by changing the color combination through the available properties. Select the desired color combination according to the purpose of slope height classification. An example of extracting files using the sdts2dem software with Arc GIS software is shown in Figure 6.
4. From the recorded station coordinates, it is then used

to change the transformation into a UTM system with zone 14 according to the location of the station point. Next, convert the DEM data format to Raster. As a complement, bring up the surface with the choice of Hillshade so that the topography is marked by different degrees of gray.

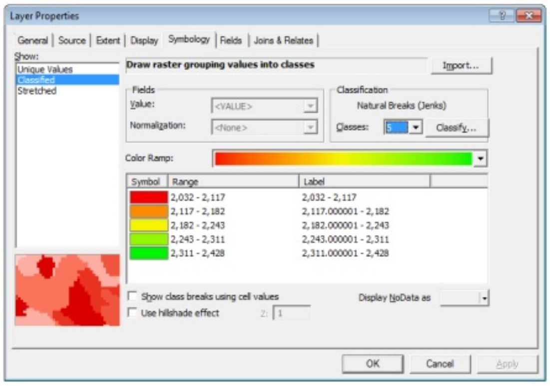

Fig. 6. Display the extracted file using sdts2dem software and Arc GIS

IV. RESULT AND DISCUSSION

In remote sensing, data recording systems using satellite sensors can be divided into two parts, namely the passive system and the active system. Both systems are very influential in the system, procedures, and data processing methods. This research uses Landsat 7 Enhanced Thematic Mapper Plus satellite imagery, 30 x 30 meter resolution, multi-time as a basic component of the passive system remote sensing data collection such as power sources, atmosphere, power interactions with objects on earth, sensors, data processing systems, and various data uses. Landsat satellite data with Return Beam Vidicon (RBV), Multispectral Scanner (MSS), and Thematic Mapper (TM) sensors.

By using image processing software such as Matlab, Erdas Imagine, ErMapper, and Arc-GIS will facilitate the image in pre-image processing and image processing, so as to improve the quality of image data. In the analysis phase, the image will issue different colors that show different heights in each region and form different slopes. Satellite imagery that is converted into grayscale images will form an area and any difference in value that will be used as a reference in the analysis of the slope of the region as shown in Figure 7, Figure 8, and Figure 9. The resulting slope image will show the slope angle in accordance with the actual contour conditions in an area.

From the results of topographic image analysis, several scenarios for prevention and mitigation in disaster-prone watersheds can also be designed, including: (1) dredging sediment in river beds so that maximum water capacity can be carried out, (2) building alternative drainage routes such as new river channels and pipelines that can prevent the burden of excessive discharge on the river, (3) provide education to the public so as not to build buildings in the water absorption area and river banks, (4) not to cut down trees in the forest without well-planned reforestation because it can trigger landslides, and (5) making retaining walls and embankments along the river. With these efforts, it is hoped that an area that is classified as disaster-prone with a large population around it, can cope with and reduce material losses and casualties. Preventing disaster is very likely to succeed if balanced with disaster resilience planning is done well.

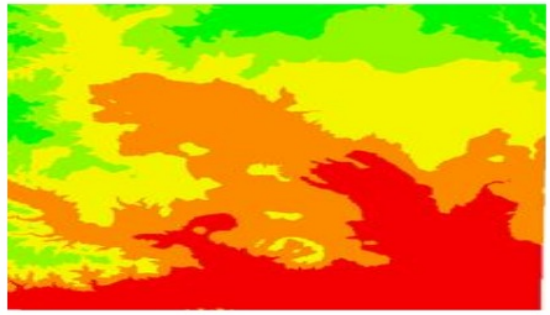

Fig. 7. Watershed Transformation Results with 30 meter DEM SRTM Data (Condition 1)

Fig. 8. Watershed Transformation Results with 30 meter DEM SRTM Data (Condition 2)

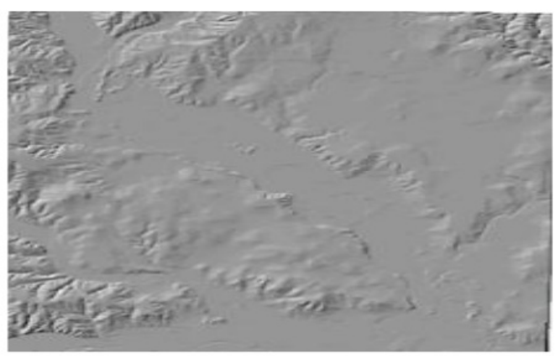

Fig. 9. Watershed Transformation Results with 30 meter DEM SRTM Data (Condition 3)

V. CONCLUSION

The use of topographic imagery as one of the innovations in remote sensing is very much needed in prevention and mitigation activities in disaster-prone watersheds because local geographical data can be known quickly and relatively easily, even though the area is difficult to reach in territorial terms. Efforts to respond to natural hazards can be done more effectively and safely so as to reduce the risk in areas that have a high level of hazard and vulnerability to disasters. This can be used as an evaluation of the ability of the system and infrastructure in disaster management that often occurs at this time.

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