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Learning invention using satellite observations to support sustainable development goals (SDG): A use case on disaster risk reduction in Sei Serelo Indonesia

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Learning invention using satellite observations to support sustainable development goals (SDG): A use case on disaster risk reduction in Sei Serelo Indonesia

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Abstract. The morphological pattern of the Sei Serelo was investigated to infer the impact of land use and climate change. Two sets of areal Landsat (1990 and 2019) identified the morphological changes to reduce the disaster risk and ideally reverse this prevailing situation. This paper presents a scalable and flexible approach to monitoring land-use change at the local level using various components of the Global Earth Observation System of Systems (GEOSS) platform. Increasing mining area has contributed to land-use change and the loss of agricultural land in many rural areas. In many cases, it worsens the poverty levels of smallholder farmers who depend on subsistence farming – an issue that Sustainable Development Goals number one seeks to address. A multi-criteria evaluation is applied using morphometric indicators, geology, and contours to identify the areas vulnerable to drainage and relief conditions. This learning invention has developed decision tools to apply GIS utilization to support disaster risk reduction. The devices are iterative and can be updated as new events occur to maximize GIS benefit, reducing disaster risk reduction and their potential consequences.

Keywords: morphometric, land-use change, SDGs, disaster risk reduction.

1. Introduction

Discussions on the relationship between Sustainable Development Goals (SDGs) and environmental assessment (EA) take various forms [1]. Most of the research on hydrological risk focuses on the risk of flooding and drought as impacts of two, so consideration is needed to design strategies and measures for reducing disaster risk (DRR) [2]. Determination of the level of integration of SDGs and EA is divided into three primary forms of integration, namely non-integration, radical integration, and partial integration, which includes six levels of integration. This research is intended to strengthen the framework of the implications for integrating the two concepts [3]. Natural conditions that have many values, which are sometimes synergistic, sometimes contradict people's lives, so that when viewed from the perspective of Sustainable Development Goals (SDGs), spatial mapping with nature's contribution to the SDGs has the potential to implement SDG strategies through the conversion of ecosystem services and land for sustainable management. However, this mapping requires a range of spatial data so that the SDGs have the potential to be in line with expectations [4].

Mapping with spatial data utilizes remote sensing data, namely satellite image data using a geographic information system (GIS) which assesses the temporal dynamics of the spatial dynamics of land cover changes in an area. It aims to understand historical events and economic policies that contributed to these changes. The analysis of land-use change aims to prevent the loss of subsistence agricultural land. This is related to the first point in the Sustainable Development Goals (SDGs) with realistic goals for people in rural areas to eradicate poverty [5]. Sustainable Development Goals (SDGs) 15.3.1. which describes progress in combating land degradation is monitored by three sub-indicators: vegetation productivity. These indicators are measured in the vegetation index using remote sensing data using a geographic information system (GIS) [6].

In the process of developing risk management, the use of geographic information systems is crucial. Geographic Information Systems (GIS) continue to build, but there are significant gaps in the risk management approach to geographic information needs, flows, and information sources. This information causes limitations on the effectiveness of management efforts in disaster risk management. Disaster risk management with geographic information systems has its concept of geographic information, namely by measuring and analyzing research capabilities in understanding, accessing, and using data on the analyzed aspects [7]. Drainage and relief parameters are very influential on the intensity of landslides. Therefore, these parameters are essential aspects that will be used in the final mapping of landslide susceptibility [8]. In this paper, the identification of areas that are vulnerable to relief and drainage conditions becomes a multi-criteria evaluation for this study.

2. Data dan methodology

This section provides background and analysis of morphometric indicators and methodology for morphometric change in each context. We use the watershed level as a case study; many morphometric parameters have been considered to fulfill the objective. The following characteristic of Earth Observation (EO) data can bring significant to support directly or indirectly target and indicator of the SDG Framework [9]:

a. Spatial resolution: This study uses data with a more detailed spatial resolution of 10 m × 10 m to describe the spatial characteristics of the watershed topography in more detail.
b. Temporal resolution: resolution by capturing data repeatedly at a specific time in the frequency of hours or days. This study uses a moderate temporal resolution, namely temporal resolution, within 16 days on Landsat data.
c. Scale: capacity on the size of the data spatially and in the field. The scale is used ranging from local to global scale in units of m or km.
d. Time-series: time in providing spatial data that is sustainable and continues to grow to start from 1972 (e.g., Landsat)
e. Multi-spectral: remote sensing methods in different wavelength ranges based on the need for spatial data (e.g., 0.64 – 0.67 for the Landsat infrared wavelength against the vegetation index).
f. Consistency: consistent availability of data and information at various scales and time
g. Complementary: data validation using additional sources such as sensor data.

2.1. Remote sensing data

This research uses Landsat 5 TM data with band math function on band 4 and band 3 on June 26, 1996, for modeling vegetation indicators in 1996 and Landsat 8 OLI/TIRS data with band math function on band 5 and band 4 combinations of band 4, band 3, and This study utilized Landsat 5 TM on June 26, 1996, on August 31, 2019, for modeling vegetation indicators in 2019. In addition to Landsat data, it also uses spatial data in the form of SRTM DEM data with a resolution of 10 m × 10 m for modeling relief and drainage conditions. This year, we used images from Goggle Maps to assess the magnitude and impact of land change after mining operations. The location of the research is shown in Figure 1.

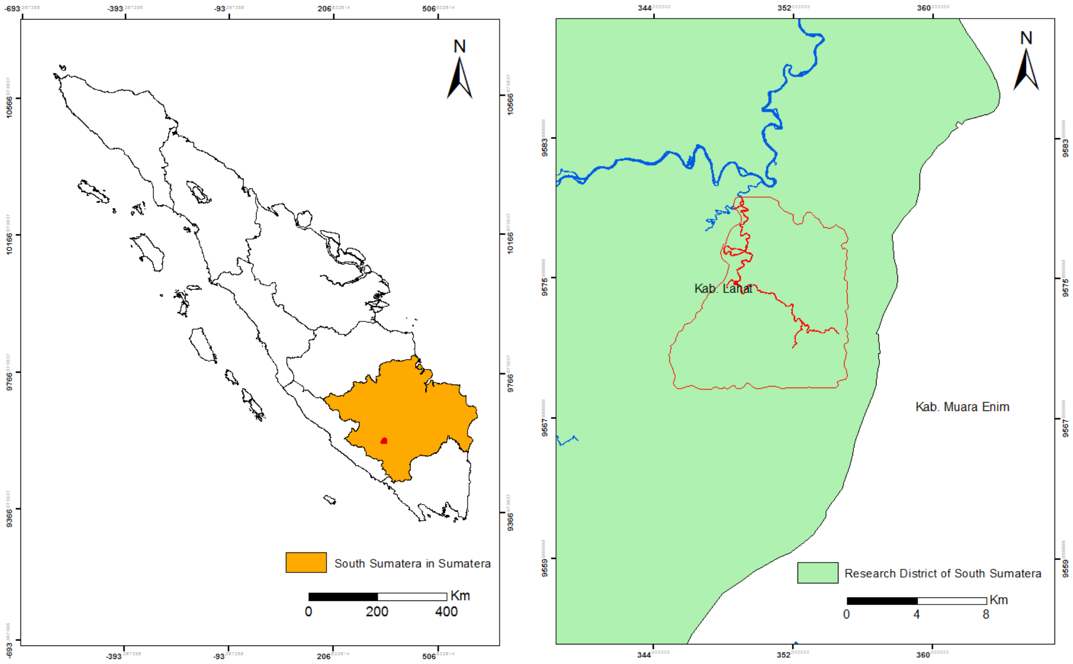


Figure 1. Location of the study area in Sei Serelo watershed, Merapi Selatan, Lahat, South Sumatera Province

2.2. Digital image enhancement and processing

We used ArcMap software in ArcGIS version 10.3 for image data processing and SRTM DEM in this research. In addition, this study's data processing and spatial data attributes were converted geographically to the Universal Transverse Mercator (UTM) coordinate system with the World Geodetic System (WGS) 84 datum.

Extraction on drainage networks is an essential data processing in this research. The processing of the drainage system and the Sei Serelo watershed in this study uses ArcGIS 10.3 with SRTM DEM data which has a resolution of 10 m. The spatial resolution of 10 m is intended to describe the topography of the watershed in detail. In addition to processing DEM data, this study also uses Landsat data to determine the characteristics of vegetation indicators.

The purpose of this study with the result in the form of a drainage diversity map, namely, to find out which areas have drainage that plays a dominant role. Sei Serelo watershed drainage density is based on morphometric indicators, including stream frequency, drainage density, drainage intensity, length of overland flow, infiltration number, bifurcation relative relief, and ruggedness index. Meanwhile, the topographic model uses relief diversity with dissection index, relative comfort, slope in degree, lineament density.

3. Results and discussion

The result obtained from 12 different indices, including morphometric indicator and relief diversity for Sei Serelo, are given in Figure 2. The explanation of indicator only selected to disaster-related based on the evaluation.

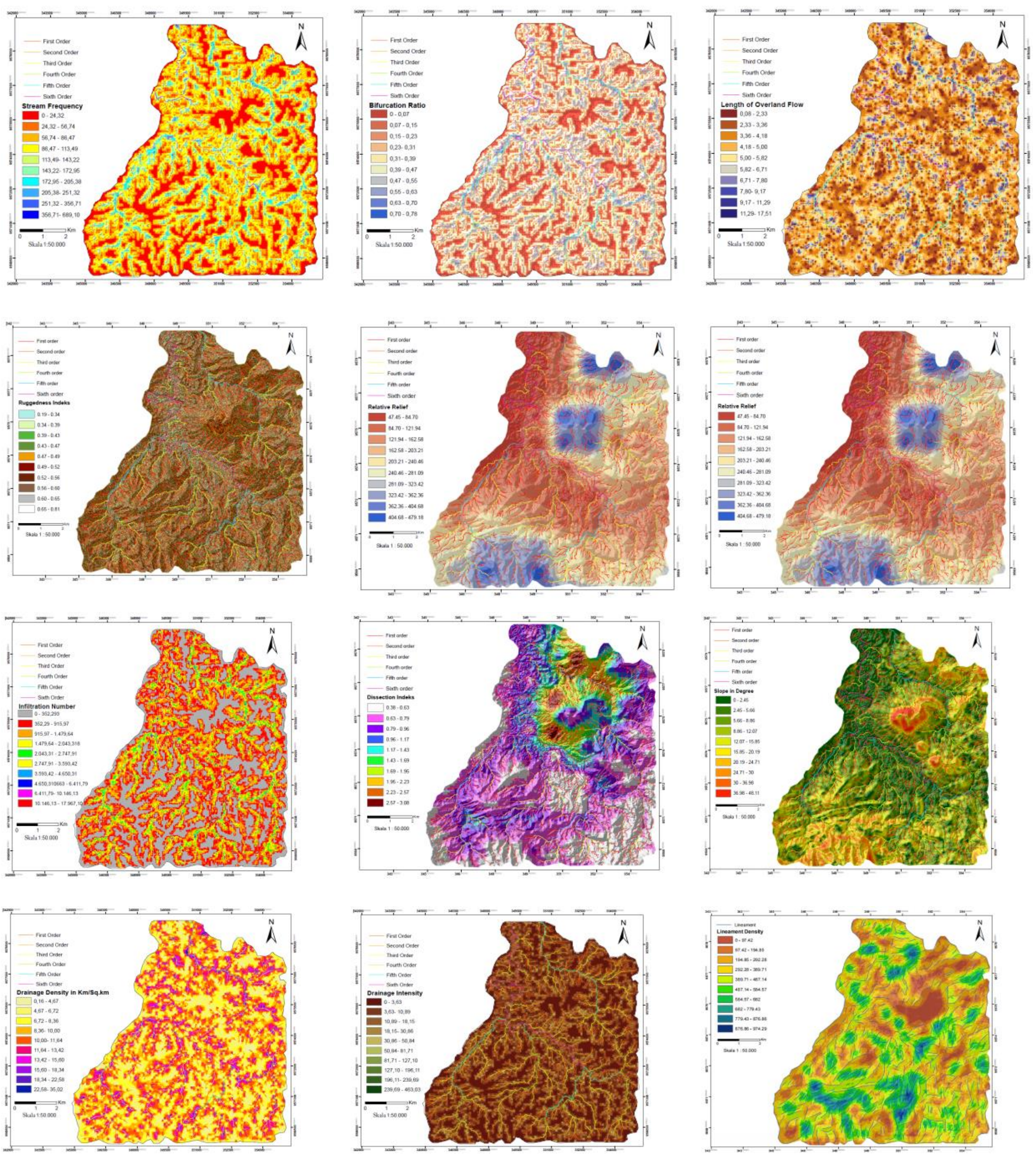


Figure 2. Morphometric indicator and relief density of Sei Serelo river basin

3.1. Morphometric indicator

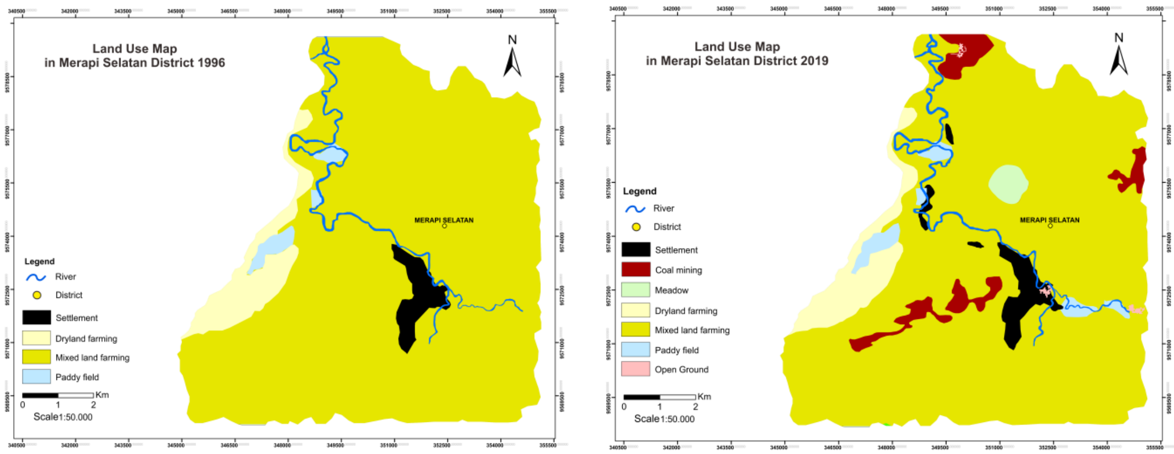
The **Stream length ratio** (Rt) indicator compares the total length of a particular river order and the total length of a subsequent river order based on the Strahler method. A high Rt value causes a high runoff rate and the possibility of flooding [10]. According to Strahler's (1952) practice, the **bifurcation ratio** (Rb) compares the number of river segments of a particular order and the number of features of a higher-order river. Therefore, while the probability of flooding is high in a watershed with a high Rb value, the rate is even lower in a low Rb value [11]. For example, the value of Rb on the Sei Serelo River has a value that varies between 0.07 to 0.90, indicating the potential for moderate flooding.

3.2. *Relief Density*

The **Drainage density** (Dd) indicator shows the relationship between the level of permeability and the potential for flooding of an area where if the level of Drainage density (Dd) is high, it means that the area has a high runoff level so that when the permeability is low, the potential for flooding is higher [12]. Based on data analysis in the research study area, some areas have high-density values. A high Dd ratio is related to low permeability values, low vegetation index, and low relief diversity values in watershed areas. The **Ruggedness number** (Rn) indicator is one of the most significant indicators on the potential for flooding [13]. If the Rn in the drainage basin increases, the flow will increase to make an area have a low flood potential. The Rn value is low so that the probability of peak flooding decreases.

3.3. *Land-use change*

Figure 3 below illustrates a diagrammatic representation of the classification results obtained from multitemporal satellite imagery. The figure also shows the magnitude of land change associated with each land use cover class identified in this study.



Land use in 1996 Land use in 2019

Figure 3. Land use and Land cover between 1996 and 2019

Table 1. Land use and land cover in km2 and their associated change

Land cover	1996	2007	2019	Change	
				1996-2007	1996-2019
River	1.03	1.06	1.10	0.03	0.07
Paddy field	1.10	1.08	1.63	-0.02	0.53
Coal mining	0.00	0.00	3.12	0.00	3.12
Settlement	1.96	2.02	2.34	0.06	0.38
Dryland farming	3.95	4.74	4.45	0.79	0.50
Mixed land farming	75.76	74.90	69.53	-0.86	-6.23
Meadow	0.00	0.00	0.88	0.00	0.88
Open ground	0.00	0.00	0.18	0.00	0.18

Table 1 presents the exact direction associated with the change, such as plantation, dryland farming, and mixed land farming decreased in each period. The above results show that all land cover except river bodies is characterized by only marginal change. All other land uses/covers have resulted in significant changes during the study period. Areas of coal mining, paddy fields, and settlements increased, with mixed land agriculture being the only land use/cover class that had to experience a substantial reduction in this period. These results can also be explained that after 2007, coal mining continued to increase while mixed land cover decreased.

3.4. Morphometric change

Various parameters of river network morphometry are seen in the previous section. Prominent river sinuses are measured for the entire watershed and straight-line segments of different lengths within the watershed. The results show that sinuosity is highly variable and that shorter segments show higher values than longer line segments, as shown in Figure 4. There is an inverse relationship between sinuosity and drainage density, although there are no data to test this.

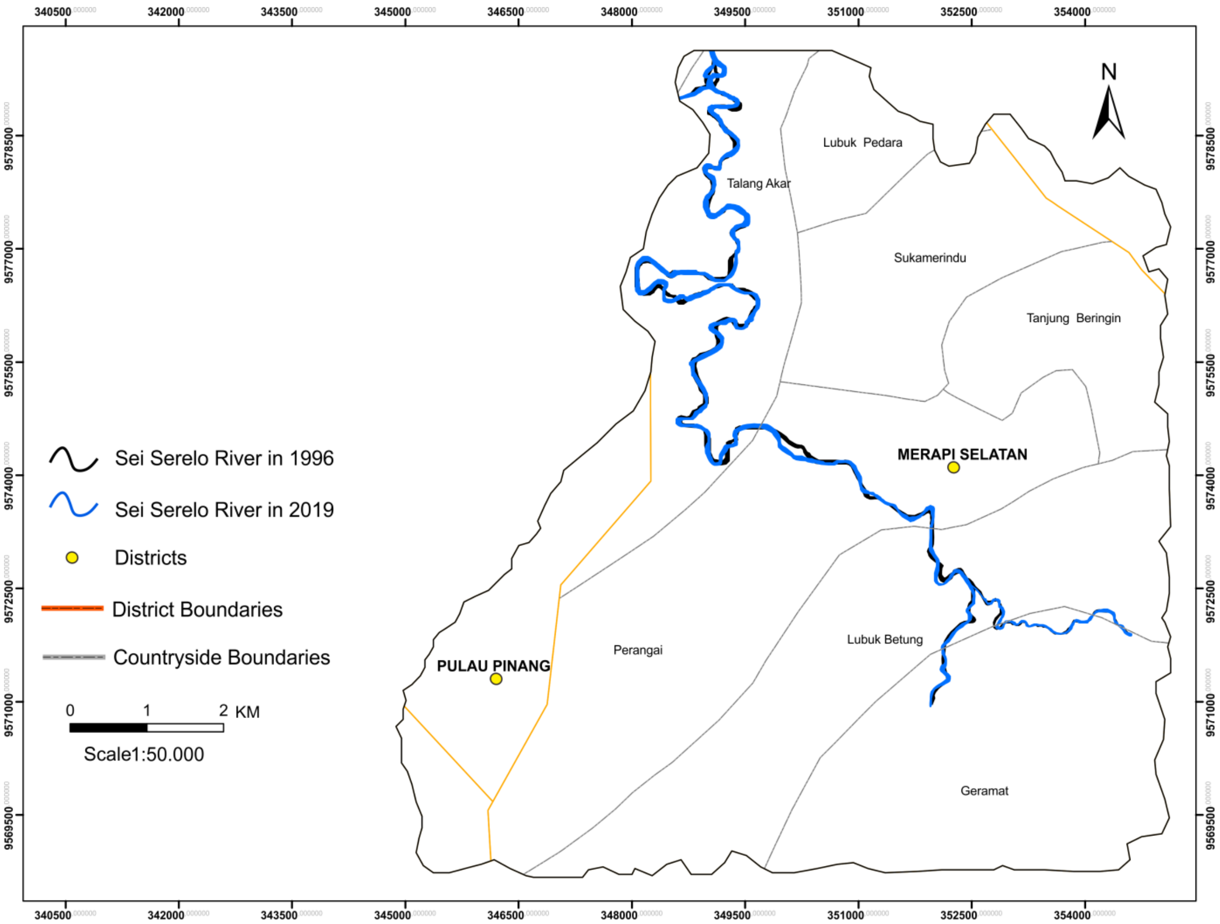


Figure 4. River sinuosity of Sei Serelo

The meandering river has dynamic evolutionary characteristics of lateral migration and longitudinal creep movement. The study of migration rates in meandering rivers has scientific and practical significance for understanding the evolutionary process. Unfortunately, river source areas are often underpopulated and lack long-term monitoring data, making estimating river bend migration rates challenging. However, studies have shown that topography can influence the changing trajectories of mountain streams and control the development of bedrock twists [14].

The mapped river bend patterns are also examined in detail in a smaller area of the watershed [15]. We identified several settlements living along the Sei Serelo River and assumed that each house could accommodate an average of four people. Small colonies are typical along the river, and we consider that some of these small settlements may be homes to members of the same family. The aim is to examine current river bends, including all topographic relief uniformly, or whether there is topographical evidence of river bend migration. As is known, the process of erosion and sedimentation directly impacts the communities along the banks of the Sei Serelo River. Communities experiencing a process of sedimentation, for example, tend to live far from rivers and in areas with lower river speeds (inner banks), thereby reducing their vulnerability to low inundation impacts.

4. Conclusions

This remarkable study uses remote sensing data from the Sei Serelo watershed in South Sumatra, which aims to show the development of settlements and mining that affect land-use changes in the area. Land-use change is an important issue that must, and land must be managed carefully to reduce disasters. In addition, this study was conducted to consider different morphometric parameters. We used morphometric parameters to describe the hydrogeomorphological characteristics of the research area. Integrated morphometric parameters to predict possible disaster vulnerability zones. This research is intended to have a deeper understanding of protecting ecosystems and an appreciation of the results of this research that can be used productively together with traditionally engineered systems for people's lives [16].

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