Mapping Land Cover and Vegetation Detection in Urban Areas

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Abstract. The increase in population has caused land use change. The development of a city has increased the need for settlements and buildings. Monitoring any land cover is essential to support environmentally based and sustainable urban planning. Medan, as one of the big cities in Indonesia, has shown development of the areas. The study aims to analyze the land cover and vegetation existence in two sub-districts of Medan. The supervised classification analysis was conducted for the year 2019. A ground check was a part of the study. There were six land cover classes found in the area: paddy fields, grass, shrubs, trees, mixed plant, and built-up land. The largest area within two sub-districts was the built-up land. The result showed that the vegetated areas within two sub-districts were fewer. There was 86% of built-up land in Medan Baru and 69.3% in Medan Selayang. Vegetation is a critical element in the urban environment. There is a need to plant trees in less vegetated areas. Green open space should be incorporated into city planning to preserve and improve the quality of the urban environment.

Keyword: Land cover, Medan, Remote Sensing, Urban, Vegetation

1 Introduction

A dense population and developed areas are within the characteristics of a city. Changes in land cover over time are prominent in a city's development. As mentioned by [1] cities as habitat mosaics in small spatial scales change through time. The development has caused the expansion of built-up areas, such as settlements and buildings. A compact vegetated land has changed into complex land cover by different uses. Environment heterogeneity was existed in cities due to

the variation within. As stated by [2], among other land surface features, the most heterogeneous landscape was the urban landscape.

The increasing population was one of the factors that led to urban area change [3]. People need land for residential and economic purposes. As stated by [1], urbanization entails numerous interacting elements of environmental change. The rapid urbanization resulted in the transition of the land cover into built-up regions [4], therefore having a significant contribution to changes [5]-[6]. Many urban studies deal with the expansion and its relation to land cover change. Those studies include urban ecology [1], urban sprawl [7]-[9], urban expansion pattern [10], trends in expansion, density, and transition [11]. Furthermore, [11] also stated that landscapes and livelihoods are affected by urban area expansion. Some of the main issues in urban are climate change [12]-[15] and environmental pollution [16]-[22]. Monitoring, as the control function of growth and development of the urban area [3], is a necessary input to urban planning. For instance, the insufficiency of urban expansion data hindered the effectiveness of land use planning [5]. It is related to how the city planner considers the environmental quality in their development plan, including the need for green open space. Particularly in developing countries, there was a shift of rural to the urban population [23]. Urban planning and management become critical in achieving sustainable development goals (SDGs) [24]. Analysis of urban sustainability is a key to the planning [25], and it needs the monitoring of urban compositions spatially and temporally. Furthermore, they can be extracted using remote sensing as widely applied [3], [26].

Remote sensing and geographic information technologies can support the data and information statistically and spatially. A study of [5] analyzes the urban land cover change to support land use planning using the multi-temporal Landsat images to explore changes [5]-[6].

Remote sensing has been used in many research including urban areas. The technology has proved to support analysis on land cover and land use detection and monitoring. According to [27] stated that remote satellite technologies, as the technique to monitor the urban area [3], have approved their ability by giving accurate and appropriate information on land use distribution. Medan Baru and Medan Selayang are developed areas within Medan city with various socioeconomic activities. Information on the vegetation and the land cover types can be used as guidance for integrated urban planning, especially in both sub-districts.

2   Research Method

2.1   Study area

The research was carried out between December 2019 and April 2020, in Medan Baru and Medan Selayang sub-districts, Medan, North Sumatra (Figure 1). Medan is the capital city of North Sumatra. It lies in 3° 30' – 3° 43' N and 98° 35' - 98° 44' E. The analysis was done in Universitas Sumatera Utara.
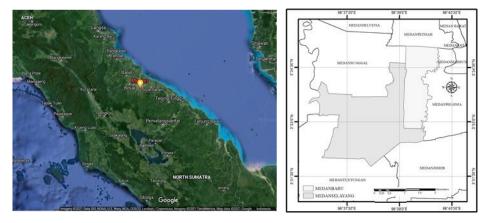
Figure 1 Research location

2.2   Data preparation

The satellite data of Landsat image 8 Operational Land Imager (OLI) (the year 2019) was downloaded from the earth explorer of The United States Geological Survey (USGS). An administration map of Medan was used to specify the study areas. Ancillary data (ground check data of land cover) was recorded using Global Positioning System. High-resolution images via Google Earth were used to give additional information on specific areas.

2.3   Land use land cover classification

ERDAS Imagine 9.1 was used for image processing. Layer stacking was applied to get a single layer. The research area was obtained by clipping the image using an administration map of Medan in ArcGIS 10.3. The maximum likelihood algorithm was used for this classification. Thus, in some mixed heterogeneous pixels, signatures had input from Google Earth which has higher resolutions satellite images. During the classification, image processing recognized the pixels which have similar spectral properties. It was done as a representation of each specific feature found [28]. Accuracy assessment was conducted to evaluate how the classification represents the real world [29], [3]. The overall accuracies of the maps that ranged between 84% - 95.7%, were considered for land cover map production [23].
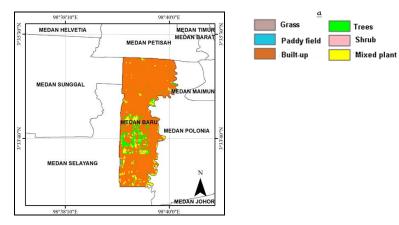
Generally, the urban areas were classified into vegetated areas and built-up areas. For detailed information, it was divided into six classes, i.e., paddy fields, trees, grass, mixed plants, shrubs, and built-up areas. Mixed plants were the term for heterogeneous vegetation, mainly crops. The built-up areas were the areas of settlements and buildings. The land cover difference depends on the specific condition of the urban areas. Some researches have divided urban areas into some classes such as vegetated areas, built-up areas, agricultural, bare, and scrublands [23]; bare land, built-up area, vegetation and water [30]; or bare soil with low vegetation density, built-up, vegetation, and water body [3].

3   Results and Discussion

3.1   Land cover types of Medan Sub-districts

Remote sensing and GIS allow conducting land cover detection and change analysis. Satellite images, including Landsat, have been widely used in urban studies [31]-[34], [6]. Many researchers studied land use land cover (LULC) using these technology [35], [29], [5], [36]-[39]. Land use and land cover could be monitored and predicted using remote sensing and GIS [40]. Also, there are many urban studies such as land surface temperature changes [2], [27], urban land cover change modeling [41], population density modeling [42], subpixel land-cover classification [43]-[44], and the study of various indices for extraction Urban Impervious Surface [45].

Within the area of 30 m as the spatial resolution of the Landsat image, there are many objects that existed in urban areas. So, it could contribute to an error in classification results. It was mentioned by [46] that the land use in urban areas is diverse and complex. There are difficulties in identifying land use and functional areas due to different definitions of similar built-up features. The ground check data can describe the objects within the areas. It was hard to find a homogenous object with big areas in urban. Most of the areas are diverse and complex, for example, houses with some trees around. The result of classification can be seen in Figure 2 and Figure 3. In both Medan sub-districts, the built-up is the largest area. The green areas are found in some places but not in large or homogeneous patterns.
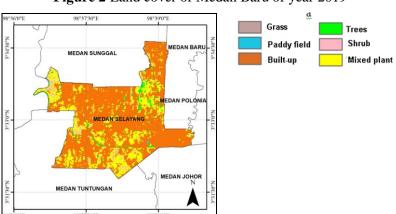

Figure 2 Land cover of Medan Baru of year 2019

Figure 3 Land cover of Medan Selayang of year 2019

It was found that 86% of Medan Baru was built-up areas in 2019. Table 1 illustrates the distribution of land cover in Medan Baru.

Table 1 Area of land use land cover in Medan Baru

Land cover	Year 2019	
	Areas (Ha)	%
Paddy field	1,0	0,2
Trees	33,4	6,1
Grass	1,5	0,3
Mixed plants	38,9	7,1
Shrub	2,1	0,4
Built-up land	473,6	86,0
Total	550,5	100

A different situation is found in Medan Selayang, which has the larger vegetated land in 2019 compared to Medan Baru. Medan Selayang is also dominated by built-up land, 69.3% of the total area. Table 2 illustrates the distribution of land cover in Medan Selayang.

Table 2 Areas of land use land cover in Medan Selayang

Land cover	Year 2019	
	Areas (Ha)	%
Paddy field	4.5	0.3
Trees	39.3	2.7
Grass	0.3	0.02
Mixed plants	355.8	24.0
Shrub	54.7	3.7
Built-up areas	1,028.5	69.3
Total	1,483.1	100.0

Changes in ecosystem patterns could be led by the change of land cover. The change of vegetated land into built-up areas will be harmful to the quality of the environment, especially with the increase of pollution by vehicles and industries. It could also affect the drinking water supply, as mentioned by [47], [53].

3.2   Vegetation existence in urban area of Medan

The high population density in Medan affects the high level of pollution and emissions due to a large number of vehicles. The existence of a green open space area could be one of the efforts to reduce emissions and air pollution that occurs in the city of Medan. In Medan Baru and Medan Selayang, there are 27 tree species found in the green open spaces and those on the roadside i.e. *Swietenia mahagoni*, *Tamarindus indica*, *Mimusops elengi*, *Gmelina arborea*, *Ceiba pentandra*, *Ficus benjamina*, *Paraserianthes falcataria*, *Polyalthia longifolia*, etc.

In some parts, communities use the land for planting mixed crops, for instance, *Zea mays*, *Saccharum officinarum*, *Manihot utilissima*, and *Cocos nucifera*. There were also some fruit

trees and oil palm found in the area. Trees are required to encounter the carbon dioxide emitted by vehicles and industries. Green space in the public area is regarded as a public good. The local municipality is responsible for providing a suitable amount and the quality of green open space [48], which has a significant role in urban areas [49]-[51] and also contributes to overcoming pollution [52]. The increase of built-up areas occurred as the change of agricultural and vegetated areas [4]. The large area of built-up land is one of the proofs of urban expansion within the research areas. Green open space should be considered in urban management and planning.

Figure 4 Visualization of some areas in Medan Baru

Figure 4 shows the existence of vegetation near the built-up land. The trees are beneficial for the environment and society (Figure 5). The improper management of the urban environment will result in the decline of environmental quality.

Figure 5 Trees existence in the research area

The need for built-up land increases along with the population. According to [27] stated that the rise of urban population and economic development could explain the growth of the urban landscape. Figure 6 illustrates the vegetation and land cover categories in the field.

Figure 6 Visualization of some areas in Medan Selayang

People tend to convert vegetated land to built-up land to accommodate the need for housing. The decrease of green areas could harm society. The local government has to give serious attention to vegetation existence, to maintain the quality of environment and life in urban areas. Due to the high conversion of green land to built-up land, the area is prone to flooding because of inefficient space usage that exceeds carrying capacity. The rapid growth of urbanized areas has also put a strain on precious land and water resources. It results in increased environmental stress. Addressing the numerous problems and conflicting interests that exist in urban and peri-urban contexts is necessary for good city planning [39]. Land cover change, as a result of urbanization, has significant consequences for society and environmental sustainability [10]. Built-up land covers the majority of the land in Medan sub-districts. There has been an increase in built-up land. It must be a shared concern among all parties so that development in this area is suitable with the environment's carrying capacity to minimize the risk of flooding and environmental harm. Land optimization through tree planting is critical for environmental quality maintenance.

Due to its combination of social and environmental characteristics, urban gardening is gaining increasing attention as a viable and socially inclusive use of urban green spaces. It is not only beneficial to the ecology but also consistent with sustainability goals [48]. Asserted by [50] that the functions of urban vegetation are strongly linked to its structure, composition, distribution, and the management criteria used. According to [48], urban gardening has grown in popularity as a financially viable and socially equitable way to utilize city green spaces. This study used Landsat image as the primary data. Landsat could be a good source for classifying the land cover in urban areas. Landsat images also used by [54] to conduct urban studies on green open space. Landsat data were analyzed to determine the effect of urban forest on the thermal environment [55]. According to [9] was also used Landsat to assess the land cover change and urban growth trend. Many studies used Landsat for land use and land cover detection and change analysis [56]-[59], [23], including in vegetation change analyse within some areas [60]-[63].

The maximum likelihood method is used to classify land cover classes [34]. Maximum likelihood is one of the most extensively used pixel-based and object-based image analysis techniques [33]. It is difficult to monitor three-dimensional urban densification using Landsat, notably its 30 m spatial resolution [57]. Statement of [3] discussed the classification error in bare soil with low vegetation density and built-up areas due to visual similarities between the two classes. Multi-spatial resolution data was also used in many studies on change analysis on land cover and land use [64]-[66].

The examination of urban expansion for effective planning and management could be accomplished through the use of an integrated strategy that incorporates remote sensing, GIS, and a matrix of urban sprawl [9]. Natural disasters and human actions are unpredictable. As a

result, cities must act more rapidly and effectively in order to foresee and mitigate connected effects and threats [67]. Urban planning integrates and balances the diverse needs and demand of all city stakeholders [48]. City planners are more concerned with the quality of life in metropolitan areas. A multidisciplinary approach is required for assessing the quality of urban life [25].

Landsat and high-resolution Google Earth imagery are used to conduct a land use and land cover analysis [23]. High spatial and spectral resolution satellite images provide more details on urban structures [31]. There are much reason why using Landsat data remains a difficult challenge in extracting information on built-up areas. One of the reasons is the spatial-temporal expression of land cover [64]. Urban management requires high-resolution maps of land usage. However, the richness and heterogeneity of metropolitan areas complicate land use mapping [31]. Due to the range of surface materials, monitoring urban expansion with medium resolution photography continues to be difficult [44].

Additional research is required to investigate the utilization of higher-resolution remotely sensed data. The high-resolution satellite image will enhance the quality of land cover maps and allow for the precise mapping of all urban classes. High-resolution photos will aid in revealing urban trends and patterns. While urban studies encompass a broad range of topics, they all share a common goal: to solve issues and create a healthy environment for man and nature. These studies include those on smart sustainable cities [25], [68], urban ecosystem services research [69]-[70], urban resilience [71], urbanization strategy and planning [69], [72].

4   Conclussions

The land cover found in Medan sub-districts was a result of land use. The sub-districts were comprised of paddy fields, trees, grass, mixed plants, and shrub, as well as built-up areas. Medan baru had a built-up area of 86.0 percent. Medan selayang had a built-up area of 69.3 percent. The high percentage of built-up land could increase the risk of lower environmental quality due to the lack of vegetation. Landsat provided information on the land cover within the urban areas. Ground check data and google earth images have become primary inputs for producing an accurate land cover map. Vegetation is present in some land cover types, including paddy fields, trees, grass, mixed plant, and shrub. Urban design should be considered green open space and tree planting to maintain the quality of the environment in medan's urban regions.

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