Assessment of land cover change over a period of five years in Deli Serdang, North Sumatra

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Abstract. Deli Serdang Regency is one of the districts in North Sumatra Province. Medan City is surrounded by Deli Serdang Regency. This study aimed to evaluate land cover changes that occurred during a period of five years (2014-2019) in Deli Serdang Regency by using a Geographical Information System (GIS). Changes in land cover are analyzed spatially using change detection available in the GIS application. Ground check is conducted to match the land cover type from the land cover map with actual conditions in the field. The land cover points taken in the field are taken using a Global Positioning System (GPS). The results showed that in a period of 5 years (2014-2019) there was a change in land use in Deli Serdang. The area of land use has increased, including: mangrove forest (5,176.57 ha to 5,645.23 ha), mining (211.93 ha to 387.47 ha), industry (2,944.64 ha to 3,316.39 ha), open land (726.12 ha to 1,063.57 ha), plantations (82,138.73 ha to 88,411.56 ha), settlements (20,537.91 ha to 21,347.85 ha), livestock (807.14 ha to 895.67 ha) and shrubs (3,761.61 ha to 3,013.33 ha). Areas of reduced land use include: dry land forest, mixed gardens, cultivation, rice fields, shrubs and ponds.

1. Introduction
Land use is required in planning land use in an area. Land is a physical environment that includes soil, climate, relief, hydrology, and vegetation where these factors affect its potential use [1]. The latest information on land conditions in Deli Serdang Regency is one of the important information needed to support government efforts to carry out spatial planning in the context of sustainable development. The trend of land use that occurs shows that development in Deli Serdang Regency will continue to increase due to population growth and existing urban developments [2,3]. Land-cover change and land-use change have different meanings. Land cover change is defined as the physical and biological changes in land cover by vegetation including water. Whereas land-use change has a more complex meaning because it also involves natural and socio-economic perspectives on changes in land use for human activities that have an impact on changes in processes that occur on the earth's surface, including biogeochemistry, hydrology and biodiversity. The dynamics of land use change often lead to changes in the quality of land including water resources due to the mismatch between land capability and its use.
The population growth which increases every year, and the intensity of development that develops in various fields will cause an increase in demand for land. This will trigger sustainable community interaction with land in meeting the needs of the surrounding community. The interaction between community and land that causes changes in land use. Therefore, an evaluation and monitoring of land change is needed so that the impacts of land change can be overcome. In addition, resource management can be planned appropriately and still refers to optimizing the benefits of resources in a sustainable manner.

The latest data and information regarding land cover changes that have occurred in Deli Serdang Regency are needed. Research on land cover change in several districts, provinces, and countries has been widely conducted [4-14]. Given the importance of data and information regarding land use changes that have occurred over a period of five years, this research is necessary. This study aimed to determine the types of land use in Deli Serdang Regency and to determine the area of land use which has increased in area and decreased in area for five years (2014-2019). The results of this study are expected to be a guideline for the Deli Serdang Regency government and other parties in regional planning.

2. Methods

This research was conducted from December 2019 to June 2020. The research location was conducted in Deli Serdang Regency (Figure 1).

![Map of Deli Serdang Regency, North Sumatra Province](image)

Figure 1. Map of Deli Serdang Regency, North Sumatra Province

Data analysis was carried out at the Forest Inventory Laboratory, Faculty of Forestry, Universitas Sumatera Utara. The materials were used in this research such as: digital map of the administration of Deli Serdang Regency, a map of the forest area of the North Sumatra Province, a 2014 land cover map...
and a 2019 land cover map. The tools used were a computer, ArcGis software, Global Positioning System (GPS) and a digital camera. Geographical information systems (GIS) with overlay techniques and change detection processes contained in GIS applications are used to analyze land use changes (2014-2019) (Figure 2) [15-21]. Reduction or increase in land cover area is done using Microsoft Office Excel. Ground check is conducted to match the land cover type from the land cover map with the actual conditions in the field. The land cover points taken in the field are collected using a GPS device. Interviews with key figures and discussions with various stakeholders were also carried out in the context of data analysis.

![Flowchart of land change analysis with change detection](image)

**Figure 2.** Flowchart of land change analysis with change detection

### 3. Results and discussion

Administratively, Deli Serdang Regency is divided into 22 districts, 394 villages [2,3]. The results of the land use map analysis show that there are 16 types of land use in Deli Serdang Regency, namely: cultivation, dryland forest, industry, mangrove forest, mixed garden, open land, paddy field, plantation,
pond, settlement, shrubs, airports, lakes, river, livestock, mining (Table 1). Land cover in Deli Serdang Regency from 2014 to 2019 was dominated by plantations followed by mixed gardens and rice fields. In Table 1, it is also seen that some land cover has increased in area and some have experienced a decrease in area.

**Table 1. Land cover in 2014 and 2019 in Deli Serdang Regency**

| Land Cover       | 2014       |   %   | 2019       |   %   |
|------------------|------------|-------|------------|-------|
| Airport          | 1,337.90   | 0.52  | 1,337.90   | 0.52  |
| Lake             | 18.17      | 0.01  | 18.17      | 0.01  |
| Mining           | 211.93     | 0.08  | 387.47     | 0.15  |
| Dryland forest   | 19,484.93  | 7.52  | 19,426.73  | 7.50  |
| Mangrove forest  | 5,176.57   | 2.00  | 5,645.23   | 2.18  |
| Industry         | 2,944.64   | 1.14  | 3,316.39   | 1.28  |
| Mixed garden     | 55,268.30  | 21.34 | 49,603.82  | 19.16 |
| Open land        | 726.12     | 0.28  | 1,063.57   | 0.41  |
| Plantation       | 82,138.73  | 31.72 | 88,411.56  | 34.14 |
| Cultivation      | 25,984.30  | 10.03 | 24,383.63  | 9.42  |
| Settlement       | 20,537.91  | 7.93  | 21,347.85  | 8.24  |
| livestock        | 807.14     | 0.31  | 895.67     | 0.35  |
| Paddy field      | 34,891.86  | 13.47 | 34,574.82  | 13.35 |
| Shrubs           | 3,761.61   | 1.45  | 3,013.33   | 1.16  |
| River            | 1,626.37   | 0.63  | 1,626.37   | 0.63  |
| Pond             | 4,023.09   | 1.55  | 3,887.05   | 1.50  |
| **Total**        | **258,939.57** | **100.00** | **258,939.57** | **100.00** |

From Table 1, it can be seen that plantation cover still dominates land cover in 2014 and 2019, even experiencing an increase in area. Plantation is all activities that cultivate certain plants on land and or other growing media in a suitable ecosystem, processing and marketing the goods and services of the plant, with the help of science and technology, capital and management to create welfare for the plantation business actors and the community. The plantations in Deli Serdang Regency are spread across almost all districts. Generally dominated by oil palm and rubber plantations. Plantation areas are characterized by the cultivation of plant species that can produce suitable spatial material at a slope level of 8-15% (sloping).

Based on Table 1, it can be seen that in 2014, plantation land cover dominated around 31.72%, followed by mixed gardens with 21.34%, paddy fields 13.47%, cultivation 10.03%, settlements 7.93%, and dry land forests 7.52% of the total land cover area in Deli Serdang Regency. In 2019, plantation land cover also still dominated around 34.14%, followed by mixed gardens 19.16%, paddy field 13.35%, cultivation 9.42%, residential 8.24%, and dry land forest 7.50% of the total land cover area in Deli Serdang Regency. The land cover of the airport, lake, and river did not change. The area of land use has increased, including: mangrove forest (5,176.57 ha to 5,645.23 ha), mining (211.93 ha to 387.47 ha), industry (2,944.64 ha to 3,316.39 ha), open land (726.12 ha to 1,063.57 ha), plantations (82,138.73 ha to 88,411.56 ha), settlements (20,537.91 ha to 21,347.85 ha), livestock (807.14 ha to 895.67 ha) and shrubs (3,761.61 ha to 3,013.33 ha). The areas of reduced land use include: dry land forest, mixed gardens, cultivation, rice fields, shrubs and ponds (reduced by 0.05%). Mixed garden has decreased in area from 21.34% to 19.16%. Paddy field has decreased in area but only 0.12% over a period of five years. Industry has also experienced a broad decline but only 0.14% over the past five years. Industrial
estates are characterized by the existence of a production process both in small quantities and in large quantities which correspond to a slope of 8-15% (flat to sloping) [22-24].

Forest area in Deli Serdang Regency, based on its function, consists of nature reserve forest, protected forest, limited production forest and permanent production forest. Nature Reserve Forest is divided into three status forest areas, namely Gunung Leuser National Park (TNGL), Nature Reserve (CA Sibolangit) and Wildlife Reserve (Wildlife Reserve Karang Gading Langkat Timur Laut). This forest area has an important value for Deli Serdang Regency as a wealth of biodiversity, conservation and a sustainable natural ecosystem cycle. Meanwhile, the function of protection forest is divided into 2 areas, namely mountainous areas (dry land forests) and coastal areas (mangrove forests). The results of an overlay of forest area maps and land cover maps, obtained information that forest reserves and protected forests are experiencing changes in land cover. Mangrove forests have turned into industry, ponds, shrubs and open land. Likewise, dry land forests that have turned into cultivation (Figure 3). The encroachment that occurs is not only for timber extraction, but also for land use in the development of economic development activities.

Land use conditions in forest areas in Deli Serdang Regency based on analysis for five years (2014-2019) show that protected forests have land use with forest vegetation only 23% of the total protected forest. Limited production forest has land use with forest vegetation 49.9% of the total limited production forest, permanent production forest has land use with forest vegetation only 5.9% of the total permanent production forest and nature reserve forest has land use with forest vegetation covering an area of 85.9% of the total forest reserve [3]. From these data it can be concluded that the function of forest areas in Deli Serdang Regency requires handling such as reforestation considering that the forest has been cleared.

Figure 3. Land use change map (2014-2019)
Based on Table 1 and Figure 3, it can be seen that changes in mangrove land cover in Deli Serdang Regency are in four Sub-districts (Hamparan Perak, Labuhan Deli, Pantai Labu and Percut Sei Tuan). In 2014, the mangrove area was 5176.56 ha, which then increased to 5645.23 ha in 2019. This increase was due to the large number of pond businesses in Deli Serdang Regency that were no longer utilized and left unused, so that the pond area grew mangrove vegetation naturally. In the details of changes in land cover, it is known that mangroves have also turned into industry, cultivation and open land, but in a small area, so that the total area shows an increase due to unmanaged ponds. The increase in population is one of the causes of changes in land use in Deli Serdang Regency. Population growth will result in increased human needs for food and other needs that can be generated by land resources. Likewise, the demand for housing and regional infrastructure. Increased population growth and increased material requirements can lead to competition in land use. Several studies have been conducted to analyze the factors causing land use change [11-14]. The causes of land use change include: (1) The high level of urbanization and the slow process of development in rural areas, (2) The increasing number of middle to upper income groups in urban areas which results in high demand for settlements (housing complexes), (3) There is a transformation in the economic structure which in turn will shift agricultural / green land activities, especially in urban areas, (4) The occurrence of fragmentation of land ownership into business units with sizes that are economically inefficient.

Change in land use is defined as a process of change from previous land uses to other uses which can be permanent or temporary and is a logical consequence of the growth and transformation of changes in the socio-economic structure of a developing community for both commercial and industrial purposes [14]. This change occurred because of the need to meet the increasing needs of the population and was related to the increasing demands for a better quality of life. In determining land use, there are four important factors that need to be considered, namely physical factors of land, economic factors, and institutional factors [11,13]. In addition, factors of social and cultural conditions of local communities will also affect land use patterns. Change in land use is change. the use or activity of a land that is different from previous activities, both for commercial and industrial purposes [14]. Changes in land use in the implementation of development cannot be avoided. These changes occur because of the need to meet the increasing needs of the population and are associated with increasing demands of a better quality of life.

4. Conclusions

There are 16 types of land use in Deli Serdang Regency, namely: Cultivation, Dryland forest, Industry, Mangrove forest, mixed garden, Open land, Paddy field, Plantation, Pond, Settlement, Shrubs, airport, lake, river, livestock, mining. In a period of five years, in Deli Serdang District, there was a change in land cover. Some have decreased in area and some have increased in area. The area of land use has increased, including: mining, mangrove forests, industry, open land, plantations, settlements and livestock. Areas of reduced land use include: dry land forest, mixed gardens, cultivation, rice fields, shrubs, and ponds. Airport, river, and lake have not changed.

References

[1] Hardjowigeno S 1993 Soil Classification and Pedogenesis (Klasifikasi Tanah dan Pedogenesis) (Jakarta: Akademika Pressindo)
[2] Statistics of Deli Serdang Regency 2019 Deli Serdang Regency in Figures 2018 Lubuk Pakam
[3] Deli Serdang Regency environmental office (Dinas Lingkungan Hidup Kabupaten Deli Serdang) 2019 (Regional Environmental Management Performance Information Document 2018) Informasi Kinerja pengelolaan Lingkungan Hidup Daerah 2018 Lubuk Pakam
[4] Rahmawaty, Villanueva T R and Carandang M G 2011 Participatory Land Use Allocation (Case Study in Besitang Watershed, Langkat, North Sumatera, Indonesia) (Germany: Lambert Academic Publishing) 199 pp
[5] Rahmawaty, Khairat N and Rauf A 2016 Integrated Approach as an Effort to Climate Change Mitigation in Land Use Change Assessment Proceedings of the National Seminar on Strengthening
Climate Change Teaching and Research: Bridging Gap Implementation of Mitigation and Adaptation Policies at National and Subnational Levels

[6] Rahmawaty, Sinaga, A and Riswan 2013 Analysis of Changes in Land Cover Area Using Geographical Information System Applications in Dolok Surungan Wildlife Forest (Analisis Perubahan Luas Penutupan Lahan dengan Aplikasi Sistem Informasi Geografis di Hutan Suaka Margasatwa Dolok Surungan) Jurnal Vegetasi X (1)

[7] Batunacun CN, Yunfeng H and Tobia L 2018 Land-use change and land degradation on the Mongolian Plateau from 1975 to 2015—A case study from Xilingol, China. Land Degradation & Development 29 6 1595-1606

[8] Rahmawaty, Y. Afiffudin, H. Kurniawan 2012 Application of Geographic Information Systems (GIS) in reviewing deployment palm oil in forest area (Aplikasi Sistem Informasi Geografis (SIG) dalam mengkaji penyebaran perkebunan kelapa sawit pada kawasan hutan). Prosiding Seminar Ilmiah dalam rangka Dies Natalis USU ke-59 (SI-DIES 2011)

[9] Han H, Yang C and Song J 2015 Scenario simulation and the prediction of land use and land cover change in Beijing, China Sustainability 7 4260–4279

[10] Biondini M and Kandus P 2006 Transition matrix analysis of land-cover change in the accretion area of the Lower Delta of the Paraná River (Argentina) reveals two succession pathways Wetlands 26 981–991

[11] Iacono M, Levinson D, El-Geneidy A and Wasfi R 2015 A Markov Chain Model of land use change Tema Journal of Land Use Mobility and Environment 8 263–276

[12] Rahmawaty, Monnica Zalukhu, Abdul Rauf 2015 Integrated Approach for Land Use Change Analysis as an Effort to Climate Change Mitigation in Medan North Sumatera Province. International Conference of Indonesia Forestry Researchers III tanggal 21-22 Oktober 2015 Bogor

[13] Pielke RA 2005 Atmospheric Science: Land use and climate change Science 310 (5754) 1625–1626

[14] Zhang M, Wang K, Chen H 2010 Impacts of land use and land cover changes upon organic productivity values in Karst ecosystems: a case study of Northwest Guangxi, China Front. Earth Sci. China 4 3–13

[15] Rahmawaty, Sembiring IEP, Batubara R and Patana P 2018 Mapping of Tree Damage Classification in the Western Part of Medan City, Green Belts Using Geographic Information System IOP Conference Series: Earth and Environmental Science iopscience.iop.org/volume/1755-1315/166

[16] Rahmawaty, Sitorus NA and Rauf A 2017 Distribution, above-ground biomass and carbon stock of the vegetation in Taman Beringin urban forest. Medan City, North Sumatra Indonesia. Malaysian Forester 80 (1): 73-84.

[17] Rahmawaty, Siti EK Syofyan A and Rauf A 2015 Integrated geographic information system and global positioning system for mapping of forest plants in supporting natural resources protection Procedia Chemistry 14 334-342

[18] Rahmawaty, Frastika S, Marpaung RME, Batubara R and Rauf A 2019 Short Communication: Use of Geographic Information System for mapping of Aquilaria malaccensis land suitability in North Sumatra, Indonesia. Biodiversitas 20 (9) 2561-2568

[19] Rahmawaty, Marpaung, RME, Rauf A, Batubara R 2020 Integrated GIS and GPS for mapping of land suitability for mulcy purpose tree species (Persea americana) at community agroforestry land in Peria-ria Village. IOP Conference Series: Earth and Environmental Science. IOP Conf. Series: Earth and Environmental Science 454 (2020) 012146. IOP Publishing. doi:10.1088/1755-1315/454/1/012146.

[20] Rahmawaty, Situmorang LKN, Rauf A, Batubara R 2020 GIS based; mapping of mulcy purpose tree species (Durio zibethinus) in Perkebunan Tambunan Village, Langkat District, North Sumatra Province, Indonesia. IOP Conf. Series: Earth and Environmental Science 454 (2020) 012147. IOP Publishing. doi:10.1088/1755-1315/454/1/012147.
[21] Rahmawaty, Rauf A, Batubara R, Frastika S 2020 Application of geographic information system for mapping of *Hevea brasiliensis* and *Aquilaria malaccensis* land suitability at Simpang Kuta Buluh. IOP Conf. Series: Earth and Environmental Science 458 (2020) 012030. IOP Publishing. doi:10.1088/1755-1315/458/1/012030.

[22] Irawan 2005 Conversion of rice field: potential impact, utilization patterns and determinant factors (*konversi lahan sawah: potensi dampak, pola pemanfaatannya, dan faktor determinan*) Forum Penelitian Agro Ekonomi 23 (Bogor: Pusat Analisis Sosial Ekonomi dan Kebijakan Pertanian)

[23] Komarsa G 2001 Analysis of the use of paddy fields and moorlands in the upper land of Cimanuk Waterhed, West Java (*Analisa Penggunaan Lahan sawah dan Tegalan di Daerah Aliran Sungai Cimanuk Hulu Jawa Barat*) Disertasi (Bogor: Institut Pertanian Bogor)

[24] Rahmawaty, Rauf A and Siregar AZ 2014 Study of the Distribution of Peatlands for Rice on the East Coast of North Sumatra (*Kajian Sebaran Lahan Gambut Sebagai Lahan Padi di Pantai Timur Sumatera Utara*) Warta Konservasi Lahan Basah Wetlands International-Indonesia 22 (3) 10-11

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