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LAND COVER CHANGE ANALYSIS TO SEDIMENTATION RATE OF RAWAPENING LAKE

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ABSTRACT: Rawapening Lake has specific biogeophysical form, biodiversity potential and socio-economic also ecological functions which are very important for people's lives and the surrounding environment. Even so, the facts showed that the activities of the population around Rawapening are growing so that problems arise in the form of environmental degradation that has continued to the present. This study aims to determine the development of land cover in the Rawapening River catchment starting from 2000, 2010 and 2019 on the sedimentation rate that occurred in Rawapening Lake. This study applies a Spatial-ecological approach by using multi-temporal remote sensing image data accompanied by field surveys and secondary data from related agencies. The tools used in this study are image processing software and Global Positioning System (GPS), while the data used utilizes RBI maps, Landsat 7 Satellite Images in 2010 and Landsat 8 in 2019. The results showed an increase in the area of developed land by 1,520.54 ha in the period 2000 - 2010 and experienced an increase again in 2019 amounting to 1,330.96 ha. The increase in the area of land developed was due to land conversion, which was largely derived from vegetation cover in the water catchment area (DTA) of Rawapening, where the impact caused by the change in land cover increased the rate of sedimentation that occurred in Rawapening Lake. Therefore, it is necessary to limit the transfer of land functions in the DTA of Rawapening so that it does not cause siltation in Rawapening Lake in the future.

Keywords: Rawapening Lake, Environmental Degradation, Land Cover Change, Water Catchment Area, Sedimentation.

1. INTRODUCTION

Rawapening is a natural lake located in Semarang Regency, Central Java Province, approximately 40 km to the south of Semarang City. Geomorphologically, Lake Rawapening is surrounded by mountains that function as water catchments area. Rawapening water catchment area has ten sub-watersheds that flow into the lake. Rawapening Lake has many functions including as a source of agricultural irrigation for Semarang Regency, Grobogan Regency and Demak Regency, downstream flood control, power plant sources, inland fishing businesses, raw water providers, and is one of the attractive tourism destinations [1]–[4].

Rawapening Lake acts as a source of life for the community because it is inseparable from the various community activities carried out in the Rawapening Sub-watershed. Community activities have increased along with the development in the Rawapening Sub-watershed area. According to Kumurur [5], to meet human interests, the environment around the lake is changed to suit the way of life and ways of living in humans, or even this area is often overhauled to accommodate various forms of human activities such as settlements, road infrastructure, household sewage, agricultural land, recreation, etc [6], [7].

Currently, Rawapening is facing the problem of environmental degradation which is quite a severe occurrence of sedimentation. The ongoing sedimentation process causes Rawapening to become shallower and narrower. This condition indicates that Rawapening water catchment area is experiencing severe ecological pressure. The amount of pressure experienced by the Rawapening region is a consequence of the large pace of regional development. Ecological pressure on this area is also exacerbated by the poor development of upstream land management systems that have an impact on the area in the form of pollution and sedimentation. In addition to having negative impacts in the form of pollution and sedimentation, hydrological changes due to human activities (development) also have other negative impacts on the region [8]–[11]. To reduce ecological pressure due to land-use change, it is necessary to monitor the progress of land-use change using effective techniques, one of them was used Landsat image.

The use of remote sensing data (Landsat imagery) is an effective and efficient means for obtaining information about land cover, including for assessing catchment areas [12]–[17]. Landsat satellite imagery has been widely used for various survey activities because it has several advantages including its excellent temporal resolution making it easy to process information on the development of land cover in an area [12], [14], [15]. This study aims to examine the development of built-up land in the Rawapening catchment area from 1990 to 2019 and then link the result to the increased sedimentation that occurred in Rawapening Lake.

2. METHOD

This research located in the Rawapening Water Catchment Area, where the area is an upstream part of the Rawapening Watershed sub-watershed. Administratively, the Rawapening River catchment area is in Semarang Regency with several sub-districts included in its territory. Water catchment area of Rawapening functions to accommodate, store and drain water that comes from rainwater to Lake Rawapening through river flow [18]. Besides, its acts as a controller of the sedimentation rate in Lake Rawapening which has so far had high sedimentation [19]. Figure 1 shows the location of the Rawapening DTA research.

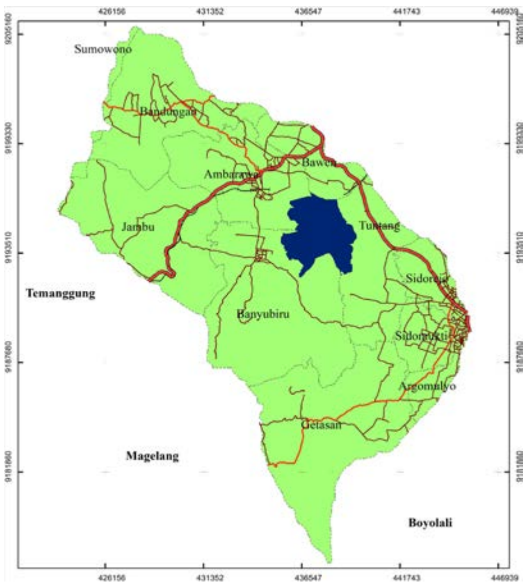

Fig. 1 Research Sites

The main data sources used are the Indonesian Earth Map (RBI) in 2000, Landsat 7 images in 2009 and Landsat 8 images in 2019 which are used to obtain time series land cover conditions. Secondary data in the form of sedimentation rate of Lake Rawapening in several years according to the time series land cover map sourced from literature studies and study results from relevant agencies.

The data processing stage begins with the preparation of the land cover map from the RBI Map, Landsat 7 and Landsat 8 imagery, where the initial stages are carried out radiometric and geometric corrections on satellite imagery. This stage is done to eliminate image distortion during the recording process [15]. Furthermore, the corrected imagery was carried out in a multispectral classification with a supervised approach to obtain maps of land cover in 2009 and 2019, whereas for maps of land cover in 2000 obtained from the generalization of land use maps from the RBI Map.

From the results of the preparation of the time series land cover map, an analysis of changes in land cover class is then carried out focusing on changes in the built land and vegetation in the Rawapening water catchment area. The analysis results of land cover changes then performed correlation to the rate of sedimentation in Lake Rawapening in a relatively close year to determine the effect of land cover changes in the water catchment area of Rawapening to the rate of sedimentation in Lake Rawapening. Figure 2 shows the research flow diagram.

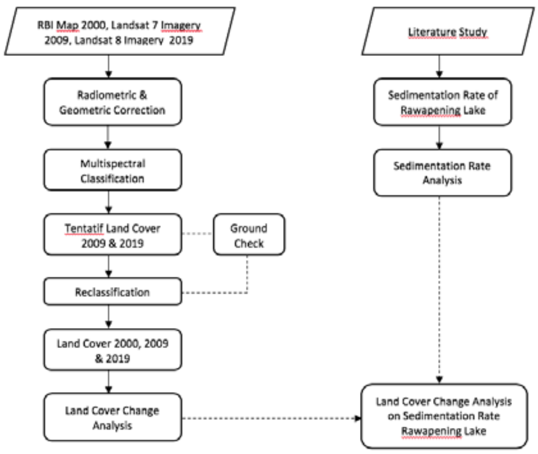

Fig. 2 Research Flow Chart

3. RESULT AND DISCUSSION

Based on the multispectral classification results with the supervised method which is then performed an interpretation accuracy test shows that the land cover in the Rawapening's water catchment area was classified into 4 (four) land cover classes consisting of built land, open land, water bodies, and vegetation. Existing land cover (2019) in the Rawapening River catchment area is dominated by open land around 9,120.61 ha (32.84%) and vegetation around 9,068.92 ha (32.65%). Open land cover consists of vacant land, dry fields, shrub/moor and fields with equitable distribution throughout the area, while for vegetation land cover consists of forest areas, mixed gardens and rice fields with clustered distribution in the west and south of the study area.

Land cover of developed/built land has an area of about 8,053.64 ha or 29% of the study area, where the developed land has a pattern of spread in areas with topography that tends to be flat and extends along a road. Most of the built land is in the form of residential buildings and a small part is in the form of industrial buildings, public facilities, also trade and service buildings. Other land cover in the form of waterbody with an area of about 1,529.68 ha (5.51%) which is Lake Rawapening. Table 1 presents the area of land cover in the water catchment area of Rawapening.

Tabel 1 Coverage of Rawapening Water Catchment Area in 2000, 2009 & 2019

Landcover	Land Cover Area (ha)					
	Area in 2000 (ha)	Percent (%)	Area in 2009 (ha)	Percent (%)	Area in 2019 (ha)	Percent (%)
Built Up	5,202.14	18.73	6,722.68	24.21	8,053.64	29.00
Open Field	10,510.57	37.84	10,144.65	36.53	9,120.61	32.84
Water Body	1,529.68	5.51	1,529.68	5.51	1,529.68	5.51
Vegetation	10,530.47	37.92	9,375.85	33.76	9,068.92	32.65

Source: RBI Map of 2000 and Multispectral Classification of Landsat 7 and Landsat 8

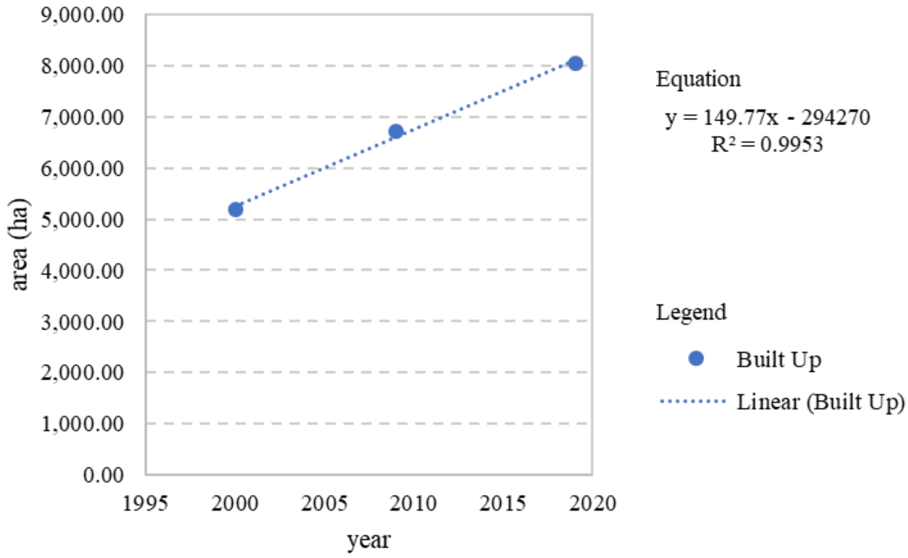

Fig.3a Trendline of Built Up Area in Rawapening DTA from 2000 to 2019

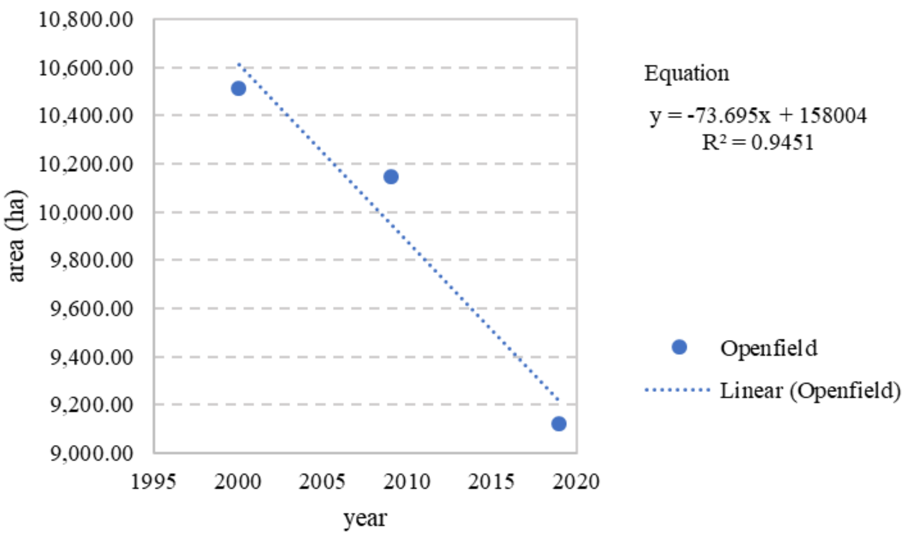

Fig.3b Open Field in Rawapening DTA from 2000 to 2019

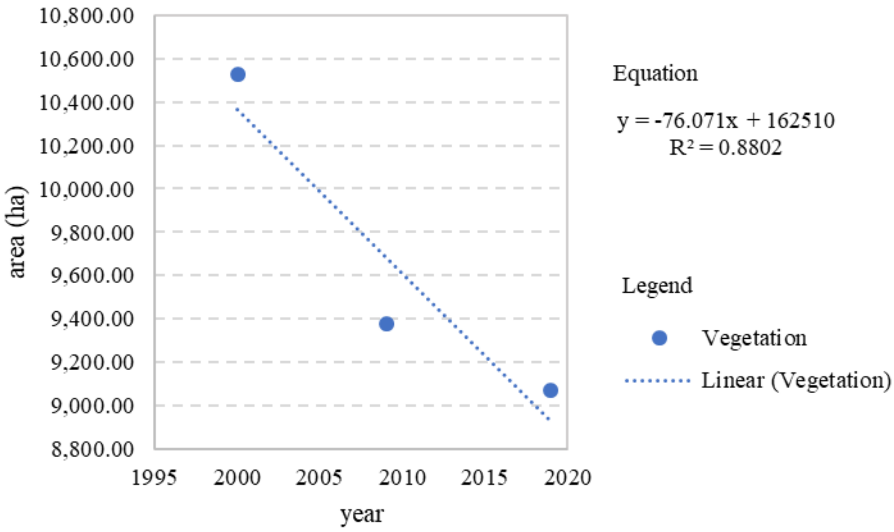

Fig. 3. Vegetation in Rawapening DTA from 2000 to 2019

Analysis of land cover change in the Rawapening DTA was carried out in 3 (three) different periods, namely in 2000, 2009 and 2019, which in this analysis was more focused on the development of built land in the study area. Land built in Dap Rawapening for each year has a large upward trend, this can be seen from the time series land cover map at the study site. Based on the 2000 RBI map the developed land has an area of around 5,202.14 ha (18.73%), where the area has increased to 6,722.68 ha (24.21%) and has increased again to 8053.64 ha (29.00%) in 2019. So, from these data, it can be concluded that an increase of 2,851.50 ha or about 10.27% in the last 19 years (2000 - 2019). An increase in the area of developed land that is not restricted can result in environmental degradation [14]. Figure 3 presents the trendline of landcover change in Rawapening DTA.

The increase in the area of built land in the Rawapening DTA in the past 19 years has resulted in a reduction in the area of other land cover as a result of land use change, where there are 2 (two) land cover classes that have been converted into land use, namely open land and vegetation. Open land has decreased in size every year, where in 2000 open land had an area of around 10,510.57 ha (37.84%), where the area decreased slightly to 10,144.65 ha (36.53%) but in 2019 the land open area experienced a significant decrease in area to 9,120.61 ha (32.84%). Whereas for vegetation land cover in 2000 has an area of around 10,530 ha (37.92%), which was reduced in 2009 to 9,375.85 ha (33.76%) and reduced again in 2019 to 9,068 ha (32.65%). The conversion of land functions in both land cover to built-up land mostly occurred in the use of fields/dry land, mixed gardens, rice fields and forest areas, where most of the land conversion functions turned into residential areas. The increase in residential areas in an area is generally caused by an increase in the number of people who need buildings for shelter [18]. Figure 4 presents the spatial distribution of time series land cover in the Rawapening DTA.

The increase of built-up land in the Rawapening water catchment area will have an impact on increasing the sedimentation rate found in Rawapening Lake. Based on the studies of Indrayati and Hikmah [20], it is stated that an increase in the area of developed land will trigger erosion of the surrounding land, which in turn will be carried by the erosion of water and settle in the estuary, where in 2001 land erosion factors affected 96.26 % of sedimentation rate in Rawapening Lake. In 2001 the total sedimentation in Rawapening Lake reached 4,111,109.10 tons consisting of 3,957,363.80 tons resulting from land erosion and 153,745.30 tons due to water hyacinth, even in 2017 sedimentation in Lake Rawapening increased to 4,215,121.59 tons [20]. Based on the trend of increasing sedimentation rates, Indrayati and Hikmah [20] predict with a systematic model using the RUSLE approach to determine the sedimentation rate in 2020, where the results of the model are estimated to be sedimentation in Rawapening Lake in 2020 could reach 4,752,961.04 tons if no preventive action is taken immediately by various parties. Therefore, it is necessary to change the management paradigm from the polarization of interests to the collaboration paradigm, so that all economic activities that support the Rawapening area can be managed comprehensively and environmental sustainability can be maintained [21].

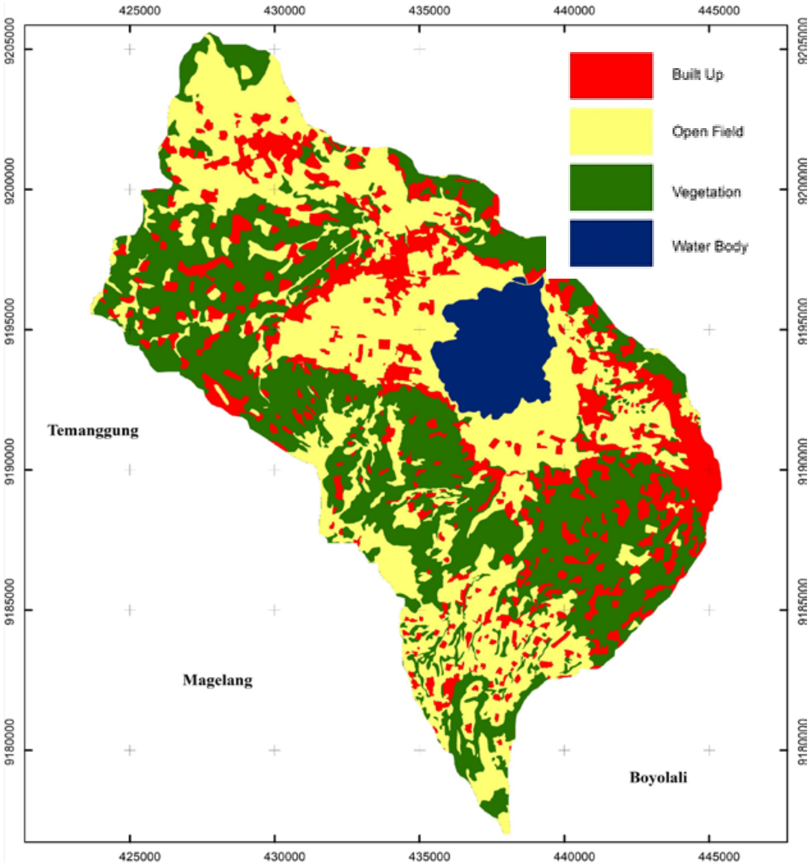

Fig.4a Land Cover Map of Rawapening Water Catchment Area in 2000

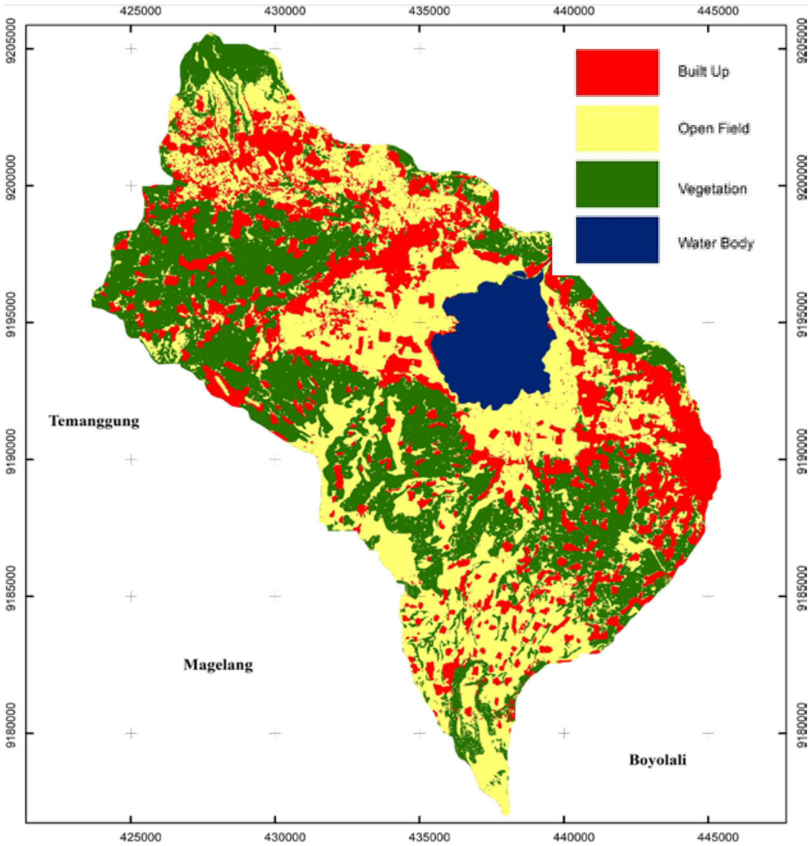

Fig.4b Land Cover Map of Rawapening Water Catchment Area in 2009

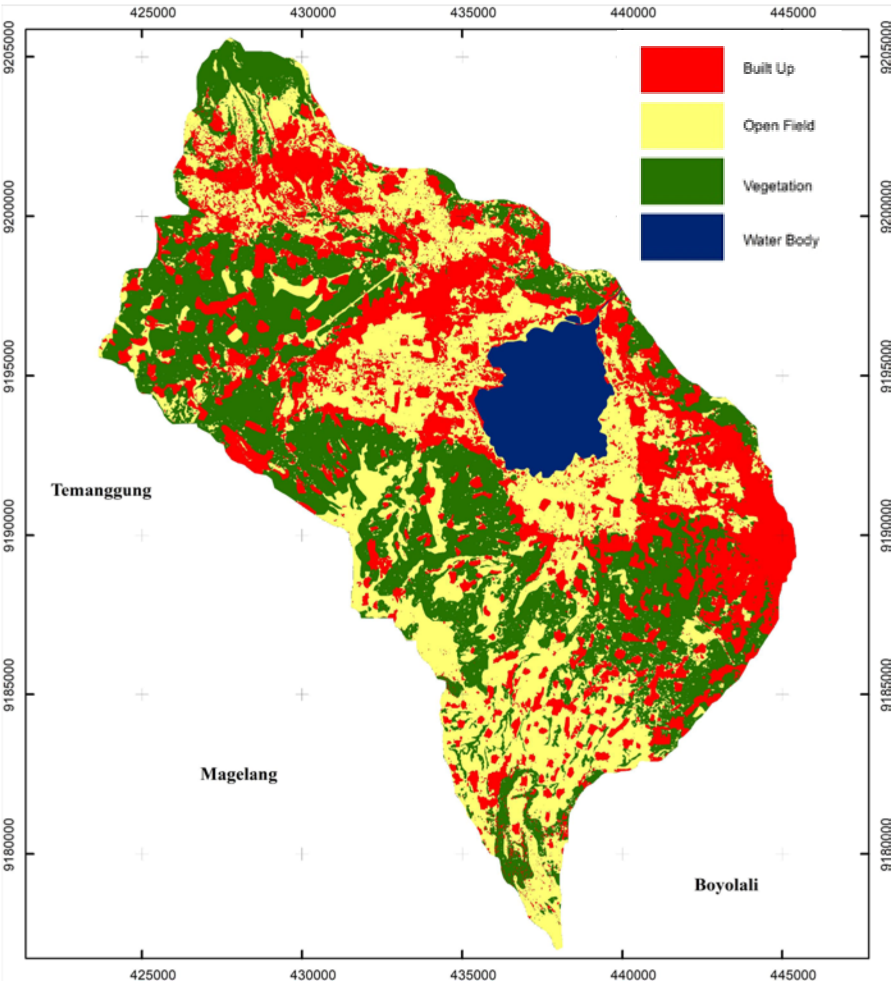

Fig.4. Land Cover Map of Rawapening Water Catchment Area in 2019
(Source: RBI Map in 2000, Landsat 7 in 2009 & Landsat 8 in 2019)

Besides, Aprilliyana [9] conveyed the results of his research that the sedimentation rate in Lake Rawapening in 1991 reached 4,084,484.59 tons, where the largest contribution of sediment came from the Parat watershed caused by land erosion in the Rawapening Watershed. Whereas in 2011 the sedimentation rate in these waters decreased to 3,688,480.45 tonnes, where this decrease was most likely due to a decrease in erosion level caused by the decrease of rainfall at most Rawapening watersheds, but for water hyacinth sedimentation continued to increase from 153,745.30 tons in 2001 to 171,349.90 tons in 2011. The rapid growth of the water hyacinth plant indicates that the fertility of waters in Lake Rawapening continues to increase, one of which is caused by sedimentation sourced from various rivers that flow into the lake [9].

In 2011 the Ministry of Environment conducted a study of the physical conditions of Rawapening Lake, where it was found that the distribution of sediment to the lake during the rainy season reached 880 kg/day and in the dry season an average of 270 kg/day at an average rate of 778.93 ton/year. Referring to that number, Rawapening Lake is included in 15 national priority lakes which will be handled together in an integrated, environmentally and sustainable manner in the period 2010 - 2014, where the determination of priority lakes is based on lake damage, lake use, strategic functions for national interests, biodiversity and the level of disaster risk [1]. Based on the results of various studies it can be concluded that the high rate of sedimentation in Rawapening Lake is caused by the erosion factor of the land in the Rawapening River Basin, where the erosion factor of the land will continue to increase if the protected and cultivated areas in the upstream area are converted into developed land. Integrated management of the various sectors of the Rawapening water catchment area is needed, especially to limit the extent of the area built in protected and cultivation areas so that the environmental balance in the area is maintained so that the sedimentation rate on Lake Rawapening does not continue to increase every year.

4. CONCLUSION

Based on the analysis of time series land cover maps sourced from the RBI map, Landsat 7 and Landsat 8 images, it concluded that the land developed in the Rawapening DTA has a trend that continues to increase every year, where from 2000 - 2009 increased by 1,520 ha and increased again in the period 2009 - 2019 amounted to 1,330.96 ha. Land cover is converted into built land in the form of open land and vegetation.

The increase in the area of developed land has an impact on the occurrence of land erosion in the Rawapening DTA, where land erosion is the main cause of sedimentation rates in Rawapening Lake. Besides, sedimentation from water hyacinth. Sedimentation rates entering Rawapening Lake in the rainy season reach 880 kg/day and 270 kg/day in the dry season with an average of 778.93 tons/year. Therefore, the high rate of sedimentation in Rawapening Lake requires integrated management by various sectors, especially to limit the conversion of land in protected and cultivated areas which can lead to increased rates of land erosion.

5. ACKNOWLEDGMENTS

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