Ecosystem services-based land use suitability analysis in East Java Province

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Abstract. Land Use planning method nowadays has been developed from many perspectives. One of the considered approaches is ecosystem based which is integrating ecosystem services in constructing land use plan scenario. The concept of ecosystem services is strictly linked to changes in land use and land cover, which affect ecosystem services, moreover this determine a decrease in global environmental and biodiversity loss. In this paper we aim to construct an ecosystem services-based industrial suitability map as an input for land use planning. The construction of ecosystem services map process involves expert judgement from stakeholders in order to know which ecosystem services classification should be taken into account in determining spatial allocation for industrial use. Furthermore, the carrying capacity map is constructed based on physical aspects such as morphology, water availability, disaster vulnerability, etc. In the construction process, stakeholders are also asked to give weight to the physical aspects, this is important since the data are then merged using weighted overlay method. The suitability map is resulted from the overlay of carrying capacity map and ecosystem services map in East Java Province scope.

Keywords: land use, carrying capacity, ecosystem services, industrial land suitability

1. Introduction

The industrial sector is one of the main sectors driving the regional economy. Therefore, the plan to develop industrial estates is one of the main focuses in the preparation of spatial plans both at the national, provincial and regency/city levels. While it is discussed in the national spatial plan, the industrial sector plan is also regulated in the National Industrial Development Master Plan (RIPIN) for 2015-2035. In the RIPIN, one of the most important points of the mission, targets, policies and industrial development strategies is to develop the central areas of industrial growth, industrial estates, and small and medium industrial centers \cite{1}. This encourages the government both at the provincial and regency/city levels to develop industrial development plans in their respective regions.

In East Java Province, the Provincial Industrial Development Plan is regulated in the provincial regulation draft on the East Java Provincial Industrial Development Plan (RPIP) for 2018-2035. In the regulation, it was explained that the focus of the RPIP was on the East Java industrial development area. Furthermore, the plan explained that industrial development in East Java is divided into 4 stages, the first stage is to build synergy between industrial development areas and between sectors. Where the purpose of this synergy is to improve production efficiency and to create environmentally friendly
industries. The second stage is to build synergy between the scale of production to strengthen the competitiveness of the industries. The third stage is industrial development directed at expanding market share, especially the expansion of exports and the fourth stage is achieving the vision of industrialization which is a world-quality industrial province [2] [3].

At present, industries in East Java Province are growing faster than national industries [2]. Industrial growth in East Java has implications for improving the economy in East Java. Based on GRDP data in 2017, it can be seen clearly that the industrial sector is the main sector contributing the largest GRDP in East Java Province amounting to 586,258.6 billion rupiahs, followed by the trade sector of 367,185.2 billion rupiahs, and the construction sector of 197,699 billion rupiahs [4].

Based on the development and contribution of the industrial sector in East Java Province, as well as the vision of the East Java Government who wants to realize the development of environmentally friendly industrial estates [5], an analysis is needed regarding the suitability of the environment-based industrial area in East Java Province. The result of this study is expected to provide input for the East Java Provincial Government in preparing their spatial plan revision, especially for the industrial sector in East Java Province. In spatial planning, the formulated and agreed strategies are run by institutions in the government. Any decision made by them are influencing the change of spatial distribution of activities. Environmental services are important elements in land use management, especially in determining the future change of land use for development purpose [6].

The ecosystems can provide a range of direct and indirect services for people and other living organisms. Moreover, climate change and human activity can influence these services, particularly land-use changes in human activity. The influence of climate variations and land-use change influence the ecosystem services, such as carbon sequestration, water flow regulation, and food and fiber production, at a variety of scales [7]. Recent issue about the use of ecosystem services is related to its dynamics in value. The use of a decentralized technology to monetize the gaining of knowledge about biodiversity is considered to be a practical way to enable a currency backed by biodiversity to play a role in the financial system. Taxonomists and ecological expertise would play important role in valuing this biodiversity and ecosystem. Furthermore, this would put biodiversity and ecosystems at the center of a financed system that reflects its value [8].

Consideration of environmental aspects in planning is important as an initial step in realizing sustainable development. In addition, consideration of environmental aspects in planning can create environmental sustainability in the development process. So far, there have been many environmental assessment techniques that can be applied, one of which is the assessment of ecosystem-based environmental services. The ecosystem services assessment is intended to know the spatial distribution and quality patterns of each ecosystem service in each ecoregion assessed by means of land cover data. Therefore, this analysis technique is considered appropriate to be included in the suitability analysis of industrial estates in East Java Province.

2. Method
The methods used in this study include the literature study, and policy review. Literature study is used to examine theories and concepts regarding ecosystem services, capabilities and land suitability, while policy review is used to review the spatial documents of East Java Province for the need to determine the location of industries in East Java. In addition, policy review is used to implement technical guidelines related to analysis techniques for ecosystem services and techniques for analyzing physical and environmental aspects in spatial planning.

The analysis technique carried out in this study is divided into several stages of analysis in accordance with the objectives to be achieved. First is land capability analysis, it is carried out by overlaying several land capability indicators obtained from technical guidelines for analyzing physical and environmental aspects in spatial planning regulated in Minister of Public Works Regulation No. 20/PRT/M/2007, this analysis obtained a map of land capability in East Java Province. Second is the analysis of ecosystem services for industrial estates, this analysis is carried out through several stages, namely the determination of the index value of ecosystem services obtained from expert assessment, where the
ecosystem services themselves are formed from overlaying ecoregion and land cover maps in East Java Province [9]. The overlay results expert judgment to provide an index of environmental services for the 23 ecosystem services. After that, several ecosystem services were selected from the 23 ecosystem services to determine the value of industrial estate ecosystem services through Focus Group Discussion (FGD) by relevant government agencies and academics. After obtaining several ecosystem services for industrial estates, the overlay technique was carried out to produce a map of the value of ecosystem services for industrial estates.

The final stage of this research is suitability analysis of industrial areas in based on ecosystem services. In this stage, overlay analysis of land capability maps and ecosystem service value map for industrial estates is carried out. The result of this analysis is land suitability map for industrial zones based on ecosystem services. The analysis stages of this study can be explained through the following diagram:

![Research analysis steps](source: Analysis, 2018)
3. Result

3.1. Land capability analysis in East Java Province

Analysis of land capability is used to determine the value of land capability of a region. The indicators used in this analysis are morological land capability units, ease of work, slope stability, foundation stability, water availability, drainage, erosion, waste disposal, and natural disasters. Each unit of land capability has its own land physical parameters within each unit analysis, and each unit of land capability has its own weight influence in influencing the results of the land capability analysis. The physical parameters used for each unit of land capability and the influence weight of each unit of land capability used are based on technical guidelines for analyzing physical and environmental aspects in the preparation of spatial plan issued by Minister of Public Works Regulation No.20/PRT/M/2007. The result of the conducted analysis can be explained as follows.

![Land Capability Map]

**Figure 2.** Land capability analysis of East Java Province  
*Source: Analysis, 2018*

| No. | Regency/City      | Land Capability (Ha) |
|-----|-------------------|-----------------------|
|     | Very Low | Low (Limited) | Moderate | Rather High |
| 1   | Bangkalan     | 0.52           | 1,716.29  | 94,188.00   | 36,171.74   |
| 2   | Banyuwangi    | 6.45           | 52,837.06  | 240,864.72  | 73,260.29   |
| 3   | Blitar        | 5.08           | 16,826.79  | 136,330.30  | 25,681.40   |
| 4   | Bojonegoro    | -              | 730.30     | 182,005.67  | 52,349.81   |
| 5   | Bondowoso     | -              | 27,687.13  | 118,784.44  | 11,848.65   |
| 6   | Gresik        | 9.12           | -          | 33,621.64   | 83,987.60   |
| 7   | Jember        | 24.93          | 71,049.97  | 237,564.37  | 28,985.31   |
| No. | Regency/City       | Land Capability (Ha) | Very Low | Low (Limited) | Moderate | Rather High |
|-----|-------------------|----------------------|----------|---------------|----------|-------------|
| 8   | Jombang           | -                    | 5,420.27 | 87,034.03     | 20,608.08 |
| 9   | Kediri            | -                    | 12,571.43| 113,361.46    | 29,430.72 |
| 10  | Kota Batu (Batu City) | -              | 6,596.84 | 12,779.58     | 406.83    |
| 11  | Kota Blitar (Blitar City) | -          | 218.67   | 4,475.30      | 2,087.18  |
| 12  | Kota Kediri (Kediri City) | -         | 1,316.12 | 2,186.63      | 2,361.46  |
| 13  | Kota Madiun (Madiun City) | -        | 39.17    | 6,950.18      | 4,335.03  |
| 14  | Kota Malang (Malang City) | -       | 121.44   | 100,417.50    | 77,418.16 |
| 15  | Kota Mojokerto (Mojokerto City) | -     | 1,191.89 | 1,340.61      | 715.65    |
| 16  | Kota Pasuruan (Pasuruan City) | -      | 232.22   | 4,475.30      | 3,709.88  |
| 17  | Kota Probolinggo (Probolinggo City) | -   | 684.53   | 4,884.24      | 4,884.24  |
| 18  | Kota Surabaya (Surabaya City) | -     | 5,821.51 | 28,263.36     | 28,263.36 |
| 19  | Lamongan          | -                    | 121.44   | 100,417.50    | 77,418.16 |
| 20  | Lumajang          | -                    | 30,921.57| 118,976.40    | 33,451.20 |
| 21  | Madiun            | -                    | 7,911.10 | 77,663.57     | 27,768.80 |
| 22  | Magetan           | -                    | 10,165.58| 48,165.93     | 13,695.47 |
| 23  | Malang            | 19.37                | 63,196.99| 257,809.43    | 32,351.83 |
| 24  | Mojokerto         | -                    | 15,473.59| 70,283.41     | 14,399.48 |
| 25  | Nganjuk           | -                    | 8,709.10 | 87,932.50     | 34,526.95 |
| 26  | Ngawi             | -                    | 3,637.41 | 83,262.54     | 54,932.72 |
| 27  | Pacitan           | 6.05                 | 80,639.87| 64,346.55     | 1,270.33  |
| 28  | Pamekasan         | -                    | 4,133.40 | 58,657.21     | 17,938.24 |
| 29  | Pasuruan          | -                    | 23,052.24| 97,669.29     | 31,178.46 |
| 30  | Ponorogo          | -                    | 30,048.35| 92,997.43     | 21,612.21 |
| 31  | Probolinggo       | -                    | 35,671.64| 110,946.69    | 29,724.46 |
| 32  | Sampang           | -                    | 3,101.24 | 101,689.53    | 19,901.86 |
| 33  | Sidoarjo          | -                    | 24,346.30| 74,879.04     | 32,628.62 |
| 34  | Situbondo         | -                    | 34,957.47| 100,161.71    | 33,572.80 |
| 35  | Sumenep           | 75.20                | 4,578.36 | 155,646.14    | 51,196.91 |
| 36  | Trenggalek       | 47.47                | 34,860.84| 88,570.15     | 3,978.04  |
| 37  | Tuban             | -                    | 2,795.71 | 140,897.78    | 56,514.11 |
| 38  | Tulungagung       | 2.38                 | 9,243.74 | 74,879.04     | 32,628.62 |

Source: Analysis, 2018

Based on the analysis, it can be explained that in general the ability of land in East Java Province is very supportive to be used as a built-up area. From the total land area in East Java, 87.73% or about 4,282,768 hectares have moderate land capability - rather high, which means that the land capability class can be used as a built area, while the remaining 12.27% has very low land capability classes - low (limited), which means the land capability class is very suitable for non-built land or protected areas.

In more detail, the results of the analysis of land capabilities for each region (regency/city) in East Java show that almost all regencies/cities in East Java have a land capabilities class that can be used as a built area. For example, the Blitar City, Mojokerto City, Pasuruan City, Probolinggo City, Surabaya City, and Sidoarjo Regency, 100% of the area has a moderate-to-rather high land capability class that is suitable to be developed as a built area. Whereas for regencies/cities that have land capability classes very low - limited (limited) are, Pacitan Regency with a proportion of 55.14% of the total area, Batu...
City with a proportion of 33.35% of the total area, and Trenggalek Regency with proportion of 27.39% of the total area. This means they are not suitable to be used as a built area. Spatially the distribution of land capabilities in East Java can be explained in Figure 1.

3.2. Ecosystem services value analysis of industrial area in East Java Province

To map ecosystem services in an ecoregion, a method of valuing ecosystem services is carried out using proxy landuse. Based on the land cover map, the ecosystem service index of each class the total ecosystem service index can be calculated and (Mashita, 2012). Moreover, the pattern of spatial distribution and quality of each ecosystem service in each ecoregion discussed by means of land cover.

In this study, the process of analyzing the value of ecosystem services for industrial area is carried out through several stages, first is to assess each ecosystem service through expert judgment, from the expert's assessment spatial distribution and quality pattern of each ecosystem service can be mapped through the ecosystem services index. the second step is to select several ecosystem services that affect the carrying capacity and capacity of the industrial area. In this stage, FGDs are conducted with the government and academics to determine the carrying capacity of the capacity of the ecosystem service-based industrial area. Based on the results of the FGD, there are 7 ecosystem services that have influence on industrial areas, which are: (1) climate controlling ecosystem services, (2) water flow and flood management ecosystem services, (3) air quality maintenance ecosystem services, (4) natural pollination controlling ecosystem services; (5) recreation and ecotourism ecosystem services; (6) natural aesthetics ecosystem services; (7) biodiversity-supporting ecosystem services.

After preparing data on 7 ecosystem services that affect the carrying capacity and capacity of the industrial area, then an overlay analysis is conducted to obtain the overall value of ecosystem services for the industrial area. The results of the overlay analysis for the value of industrial area ecosystem services can be explained as follows.

Figure 3. Map of ecosystem services for industrial estates in East Java Province

Source: Analysis, 2018
Table 2. Industrial ecosystem services distribution of each Regency/City in East Java Province

| No. | Regency/City            | Industry Area Ecosystem Services Class (Ha) |
|-----|-------------------------|--------------------------------------------|
|     |                         | Very Low | Low | Moderate | High | Very High |
| 1   | Bangkalan               | 3,390.79 | 10,205.74 | 70,609.75 | 47,545.36 | 255.20 |
| 2   | Banyuwangi              | 179,571.47 | 571.01 | 29,105.72 | 137,962.03 | 19,716.75 |
| 3   | Blitar                  | 37,252.07 | 3,980.71 | 54,010.71 | 83,026.47 | 568.08 |
| 4   | Bojonegoro              | 97,546.97 | 21,465.58 | 20,087.65 | 95,887.72 | 50.30 |
| 5   | Bondowoso               | 63,003.65 | 134.25 | 23,239.78 | 63,807.69 | 8,134.85 |
| 6   | Gresik                  | 21,646.36 | 21,177.93 | 44,487.95 | 39,748.01 | - |
| 7   | Jember                  | 123,537.41 | 1,229.72 | 46,252.23 | 154,692.91 | 11,800.32 |
| 8   | Jombang                 | 25,730.41 | 714.55 | 23,090.37 | 63,349.33 | 177.72 |
| 9   | Kediri                  | 2,310.91 | - | 36,749.06 | 93,865.57 | 1,639.08 |
| 10  | Kota Batu (Batu City)   | 10,900.17 | - | 2,796.52 | 6,041.63 | 44.93 |
| 11  | Kota Blitar (Blitar City) | - | - | 2,002.28 | 1,376.24 | - |
| 12  | Kota Kediri (Kediri City) | 301.51 | - | 3,163.00 | 3,316.64 | - |
| 13  | Kota Madiun (Madiun City) | - | - | 2,373.64 | 1,303.93 | - |
| 14  | Kota Malang (Malang City) | - | - | 1,189.54 | 866.71 | - |
| 15  | Kota Mojokerto (Mojokerto City) | - | - | 1,189.54 | 866.71 | - |
| 16  | Kota Pasuruan (Pasuruan City) | 6.94 | 1,555.77 | 1,248.52 | 1,130.87 | - |
| 17  | Kota Probolinggo (Probolinggo City) | - | - | 2,963.14 | 2,604.89 | - |
| 18  | Kota Surabaya (Surabaya City) | 45.56 | 20,554.46 | 10,908.83 | 2,562.22 | - |
| 19  | Lamongan                | 32,204.87 | 13,267.30 | 55,585.77 | 76,801.85 | 95.71 |
| 20  | Lumajang                | 59,987.41 | 1,263.21 | 20,674.34 | 93,712.47 | 7,708.90 |
| 21  | Madiun                  | 47,614.17 | 339.29 | 17,870.04 | 46,998.62 | 521.36 |
| 22  | Magetan                 | 7,604.08 | 228.69 | 26,414.24 | 37,086.76 | 251.14 |
| 23  | Malang                  | 111,631.63 | 5,623.76 | 82,461.70 | 146,239.21 | 7,390.00 |
| 24  | Mojokerto               | 28,011.89 | 1,371.12 | 21,008.26 | 49,205.51 | 559.68 |
| 25  | Nganjuk                 | 51,302.12 | 265.90 | 21,377.90 | 58,187.09 | 35.55 |
| 26  | Ngawi                   | 45,960.23 | 3,108.50 | 29,284.51 | 62,919.44 | 33.48 |
| 27  | Pacitan                 | 2,341.20 | 15,830.79 | 28,528.30 | 82,371.40 | 14,779.88 |
| 28  | Pamekasan               | 1,042.52 | 11,539.19 | 54,246.83 | 13,830.24 | - |
| 29  | Pasuruan                | 31,821.08 | 2,042.91 | 34,361.48 | 79,508.37 | 4,166.16 |
| 30  | Ponorogo                | 50,046.25 | 4,206.39 | 36,771.11 | 52,099.49 | 1,092.20 |
| 31  | Probolinggo             | 58,403.57 | 284.33 | 24,774.38 | 82,096.04 | 10,784.47 |
| 32  | Sampang                 | 792.43 | 10,704.65 | 75,064.78 | 37,959.04 | 119.30 |
| 33  | Sidoarjo                | 302.75 | 15,040.09 | 27,550.01 | 31,018.12 | - |
| 34  | Situbondo               | 84,833.15 | 315.15 | 17,663.97 | 59,227.19 | 6,652.40 |
| 35  | Sumenep                 | 77,168.15 | 26,104.29 | 68,609.10 | 38,473.35 | 120.68 |
| 36  | Trenggalek              | 63,188.77 | 12,027.68 | 19,704.07 | 31,018.12 | 1,470.42 |
| 37  | Tuban                   | 56,733.85 | 11,386.96 | 64,902.06 | 67,002.60 | - |
| 38  | Tulungagung             | 41,149.05 | 3,540.31 | 26,997.60 | 44,631.76 | 431.48 |

Source: Analysis, 2018
Based on the analysis, it can be explained that in general the condition of ecosystem services for industrial area in East Java is distributed in each class starting from the very low level of ecosystem services - low, medium, and high - very high. Ecosystem services class very low - low has a proportion of 33.94% of the total area of East Java or around 1,438,182 hectares, moderate ecosystem services class has a proportion of 23.26% of the total area of East Java or about 1,136,318 hectares, and high ecosystem services class - very high has a proportion of 42.80% of the total area of East Java or around 2,091,041 hectares.

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More detail, regencies/cities that have a very low - low ecosystem service class with a large proportion, among others are the Surabaya City with a proportion of 60.46% of the total area, Trenggalek Regency with 59.03% of the total area, and Bojonegoro Regency with 50.63% of the total area. Whereas for regencies/cities that have high - very high ecosystem services with a significant proportion, among others are Pacitan Regency with a proportion of 67.54% of the total area, Kediri Regency with a proportion of 61.47% of the total area, and Jombang Regency with proportions 56.19% of the total area. Spatially, the distribution of industrial area ecosystem services in East Java can be explained in Figure 3.

3.3. Ecosystem services-based industrial area suitability analysis in East Java Province

In this study, industrial area suitability analysis is obtained from the results of overlaying land capability map and ecosystem service value map for industrial area in East Java Province. Technically, the two maps will be given weight for each class. For land capability maps, each class starts from very low - very high, will be given influence weight 1 - 5, while for ecosystem services maps in industrial area will be given a weight of 5 - 1 for each class of ecosystem services ranging from very low classes - very high. For ecosystem services map, the assumption of the highest (score 1) to lowest (score 5) weight is given because regions with high levels of ecosystem services have high environmental service value, so that the utilization is more suitable for the protection of the area not to be used as a built-up area, especially as industrial area. So, the higher the value of ecosystem services in an area the smaller the influence to be used as a built-up area. The results of the suitability analysis based on ecosystem services in East Java can be explained as follows.

Table 3. Distribution of industrial area suitability in each Regency/City in East Java Province

| No. | Regency/City      | Industry Area Ecosystem Services Class (Ha) |
|-----|------------------|---------------------------------------------|
|     |                  | Very Inappropriate | Not Suitable | Moderate Suitability | Suitable | Very Suitable |
| 1   | Bangkalan        | 106.88             | 4,213.58    | 105,783.51           | 21,902.87 | -             |
| 2   | Banyuwangi       | 37,338.73          | 170,083.97  | 143,978.41           | 15,525.86 | -             |
| 3   | Blitar           | 5,111.47           | 40,358.31   | 119,369.91           | 13,998.36 | -             |
| 4   | Bojonegoro       | 270.78             | 97,474.03   | 111,177.10           | 26,116.29 | -             |
| 5   | Bondowoso        | 14,780.92          | 63,818.74   | 76,424.48            | 3,296.08  | -             |
| 6   | Gresik           | 9,357.37           | 11,776.78   | 54,630.83            | 51,023.15 | 272.11        |
| 7   | Jember           | 53,062.44          | 93,299.28   | 175,564.76           | 15,586.13 | -             |
| 8   | Jombang          | 3,695.95           | 23,718.81   | 74,123.83            | 11,523.79 | -             |
| 9   | Kediri           | 5,334.57           | 24,767.56   | 110,276.23           | 14,985.26 | -             |
| 10  | Kota Batu (Batu City) | 5,534.19         | 6,274.86    | 7,757.91             | 216.28    | -             |
| No. | Regency/City                  | Industry Area Ecosystem Services Class (Ha) |
|-----|------------------------------|---------------------------------------------|
|     |                              | Very Inappropriate | Not Suitable | Moderate Suitability | Suitable | Very Suitable |
| 11  | Kota Blitar (Blitar City)    | -                 | -            | 2,032.24             | 1,346.27 | -             |
| 12  | Kota Kediri (Kediri City)   | 149.05            | 204.29       | 4,794.73             | 1,633.09 | -             |
| 13  | Kota Madiun (Madiun City)   | -                 | -            | 1,864.04             | 1,813.54 | -             |
| 14  | Kota Malang (Malang City)   | -                 | 0.51         | 7,376.34             | 3,947.54 | -             |
| 15  | Kota Mojokerto (Mojokerto City) | -             | -            | 1,695.59             | 360.67   | -             |
| 16  | Kota Pasuruan (Pasuruan City) | -             | -            | 1,217.69             | 2,717.47 | 6.94          |
| 17  | Kota Probolinggo (Probolinggo City) | -             | -            | 2,866.36             | 2,701.67 | -             |
| 18  | Kota Surabaya (Surabaya City) | -             | -            | 4,811.93             | 29,219.38 | 39.78        |
| 19  | Lamongan                     | 4.47             | 32,322.11    | 111,600.03           | 34,028.87 | -             |
| 20  | Lumajang                     | 21,726.57        | 51,456.20    | 101,551.83           | 8,611.74  | -             |
| 21  | Madiun                       | 1,958.72         | 51,317.10    | 49,328.27            | 10,739.38 | -             |
| 22  | Magetan                      | 3,033.07         | 7,986.41     | 52,782.02            | 7,783.40  | -             |
| 23  | Malang                       | 36,513.24        | 100,238.40   | 198,368.06           | 18,226.61 | -             |
| 24  | Mojokerto                    | 13,419.44        | 16,789.04    | 62,011.66            | 7,936.34  | -             |
| 25  | Nganjuk                      | 4,871.13         | 49,855.23    | 64,520.09            | 11,922.11 | -             |
| 26  | Ngawi                        | 1,880.63         | 45,433.86    | 76,813.40            | 17,178.27 | -             |
| 27  | Pacitan                      | 579.00           | 62,426.66    | 71,182.11            | 9,663.79  | -             |
| 28  | Pamekasan                    | 16.93            | 1,216.05     | 59,281.77            | 20,144.02 | -             |
| 29  | Pasuruan                     | 11,403.22        | 32,319.53    | 94,785.20            | 13,369.91 | 22.13         |
| 30  | Ponorogo                     | 13,308.69        | 46,610.29    | 70,188.06            | 14,108.41 | -             |
| 31  | Probolinggo                  | 19,551.78        | 59,110.01    | 89,487.15            | 8,193.85  | -             |
| 32  | Sampang                      | 105.64           | 1,941.46     | 103,673.83           | 18,829.43 | 89.85         |
| 33  | Sidoarjo                     | -                | -            | 38,204.35            | 35,476.26 | 233.89        |
| 34  | Situbondo                    | 19,289.55        | 83,707.83    | 58,492.27            | 7,202.21  | -             |
| 35  | Sumenep                      | 780.41           | 74,289.61    | 93,925.16            | 40,402.61 | 1,077.77      |
| 36  | Trenggalek                   | 13,101.03        | 62,553.97    | 43,992.01            | 7,762.06  | -             |
| 37  | Tuban                        | 243.30           | 56,863.55    | 119,831.73           | 23,086.90 | -             |
| 38  | Tulungagung                  | 3,898.19         | 40,968.06    | 54,122.41            | 17,761.55 | -             |

Source: Analysis, 2018

Based on the analysis, it can be explained that in general the suitability of ecosystem service-based industrial area in East Java is dominated by the moderate class with a proportion of 53.62% or 2,619,887 hectares, meaning that this suitability class can still be used as an industrial area with certain amount of engineering techniques and accompanied by a study of environmental impacts. Industrial area suitability with very inappropriate - not suitable class have a proportion of 35.08% of the total area of East Java. This can be interpreted that the land suitability class is not suitable to be used as an industrial area because it has many physical boundaries such as high slope, low soil structure, susceptibility to disasters,
and others, and the area in this suitability class has a high value of ecosystem services that must be protected. Industrial area suitability with suitable - very suitable class have a proportion of 11.30% of the total area of East Java or around 552,083 hectares. This means that the land suitability class has low physical and environmental services limitations to be developed as industrial area.

In more detail, the results of the suitability analysis of ecosystem service-based industrial land that has the appropriate proportion of industrial area suitability classes - very suitable is Surabaya City with 85.88% of the total area, Pasuruan City with 69.11%, of the total area, Madiun City 49.31% of the total area, Probolinggo City 48.52% of the total area, Sidoarjo Regency 48.31% of the total area, Gresik Regency 40.37% of the total area, Blitar City 39.85% of the total area, and Malang City 34.86% of the total area. Whereas for regencies/cities dominated by very low - low industrial land suitability, among others are Situbondo Regency with proportion 61.06% of the total area, Batu City with proportion 59.69% of the total area, and Trenggalek Regency with proportion 59.38 % of the total area. Spatial distribution of the ecosystem service based industrial land suitability class for each Regency/City in East Java can be explained through Figure 4.

![Figure 4. Suitability Map of Ecosystem Services-Based Industrial Land in East Java Province](source: Analysis, 2018)

4. Conclusion

In principle, many methods and approaches can be used in determining the suitability of industrial area, one of which is the ecosystem services approach. The suitability of industrial services based on ecosystem services is considered very good to be used in determining the suitability of industrial land because with this approach we can examine environmental aspects both physically and based on ecosystem services deeper in determining the industrial area.

Based on the results of the suitability analysis of ecosystem service-based industries in East Java Province, the result is that almost all regencies/cities in East Java Province have land suitability potential
to be developed as industrial area. Spatially, it can be explained that almost all East Java Province have industrial area suitability with moderate class suitability. Furthermore, for high to very high industrial land suitability classes tend to be in the North East Java Region such as Gresik Regency, Surabaya City, Sidoarjo Regency, Pasuruan City and Probolinggo City. In addition, several other regencies/cities which are also dominated by high industrial land suitability classes to very high levels are Madiun City, Blitar City and Malang City.

Finally, the results of this study are expected to be input for the Government in determining the industrial area in East Java Province. In addition, it is expected that a study of economic, infrastructure, social and cultural aspects can be collaborated with the results of this study in order to obtain a more accurate suitability industrial area determination.

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