The Impact of The Land-Use Changes on The Water Carrying Capacity in Kajen, Indonesia: A Spatial Analysis

A. Pugara¹, B. Pradana¹, and D. A. Puspasari¹

¹Diponegoro University, Indonesia

Email: ade.pugara@live.undip.ac.id

Abstract. Kajen Sub-District is the Capital of the Pekalongan Regency. This area is the center of activity that grows to be the urban area with trading and services as the economic pole. The trading and services activity is escalating inherent with the existence of IAIN and UNDIP campuses. The new campus increasing the need for a dormitory or housing and facilities area. Its result of land conversion in vegetation and agriculture. This spatial and development planning above contain in the Pekalongan Regency spatial document years 2020 – 2040. According to that document, the built-up area is predicted to be 50 % growth by the end of the planning period. The study regarding the influence of the land-use changes on the water carrying capacity in Kajen is conducted with the deductive–quantitative method. The deductive is begin to form theoretical synthesis about the themes and then search the empirical fact to compare. The quantitative approach means the data of the study is can be count rationally. The analysis tools of the study are spatial analysis and correlation. The study aims to examine the influence of the land-use change on the water carrying capacity and the most significant land use which influences it. The result of the study it the most influencing land use in water carrying capacity is a settlement with an 8.7-point level of correlation. The settlement appears from the agricultural land conversion, especially dry land and paddy field.

Keywords: water carrying capacity, land conversion, deductive-quantitative research

1. Introduction

Kajen is the capital city of the Pekalongan Regency. As the capital city, many important activities are carried out in this area including government, trade and services, and settlements. Even though it is an urban area, Kajen still has large production forests and agricultural areas. Based on the Spatial Planning of Pekalongan Regency in 2020-2040, it is identified that in 2020, the area of production forest in Kajen District is about 2,882.83 Ha. The production forest in Kajen District is concentrated on the southern side of the area and is known as the center of sengon and pine production. On the other hand, agricultural land, especially crops agriculture, has an area of 4,698.21 Ha. This land is located in the central to the northern part of Kajen District and is even in the surrounding area of the government office. The large vegetation cover area has a role to support the water reservoir and catchment area performance.

Based on the spatial planning, in 2040 the crops agriculture area will decrease and become 3,846.38 Ha. Meanwhile, production forest is projected to have the same area. On the other hand, the existence of a settlement area is predicted to increase by 829.21 Ha. The settlement areas have a quite high coefficient of water runoff than agriculture. Hence, the land-use change in spatial plans influences water availability and water carrying capacity [1]. Thus, the hypothesis is the changes in spatial use in the
Pekalongan Regency spatial plan will influence the carrying capacity of water. Based on that, this study will examine how the impact of land-use changes on the condition of water carrying capacity in Kajen District and what land use has the most influence on it.

2. Data and Methods

2.1 Data

In 2020, Kajen District has several types of land uses, namely production forests, industrial areas, conservation zones, waters, and settlements. The production forest area in Kajen District has a total area of about 2,882.83 Ha. The largest one is in Linggosari Village, which is about 1,222.48 Ha. The use of industrial land in Kajen is only found in Rowolaku village, which is about 2.55 Ha. Meanwhile, the green zone or conservation zone has an area of 10.95 Ha and it is spread over several villages. On the other hand, the statement area is about 879.56 Ha. The largest settlement area is in Kajen Village, which is 72.37 Ha. Meanwhile, the population in 2020 in Kajen District is around 58,805 people. The largest number is in Gejlig Village, which is 5,441 people. In detail, the population and land use area of Kajen District in 2020 can be seen in Table 1.

In 2040, based on the Pekalongan Regency spatial plan for 2020 – 2040, it is identified that the production forest area is projected to have a fixed area. Meanwhile, the industrial area is planned to increase in the area of 0.92 Ha which is located in Tanjungkulon Village. On the other side, the Settlement area reached 1,708.77 Ha. Among this area, Gejlig Village has the largest area of 173.61 Ha. Besides that, the use of agricultural land specifically crops have decreased significantly to 3,846.38 Ha. Meanwhile, the population in 2040 in Kajen District is around 79,201 people. The largest number is in Gejlig Village, which is 7,329 people. The projected population and land use area in Kajen District in 2040 can be seen in Table 2.

2.2 Method

The research regarding “The Influence of The Land-Use Changes on The Water Carrying Capacity in Kajen” was conducted by a deductive – quantitative – rationalistic paradigm. Deductive research means that the research starts from general theory then is clarified through findings in the field specifically. Quantitative means that this research uses quantitative analysis and data based on the numbers calculated and measured. While rationalistic means that the syllogism of the research variables has an element of rationality in a concrete causal relationship [2].

This research has a focus on the carrying capacity of water. The carrying capacity of water is calculated through a comparison between water availability and water demand. In this case, the availability is calculated through rainfall data, runoff coefficient, and land use. Each land use has a specific runoff coefficient [3]. Meanwhile, water needs are calculated by estimating the water needs for the population, agriculture (food and livestock) as well as water needs for industry. The following is the calculation formula [4].

\[ DDA = \frac{SA}{DA} \] \( \text{(1)} \)

\[ DDA = \text{Carrying Capacity of Water} \]

\[ SA = \text{Water Availability} \]

\[ DA = \text{Water Needs} \]

\[ SA = 10 \times C \times R \times A \] \( \text{(2)} \)

\[ 10 = \text{Conversion Factors} \]

\[ C = \text{Runoff coefficient} \]

\[ R = \text{Precipitation Intensity} \]

\[ A = \text{Land Use Area} \]

\[ DA = (N \times KLHA) + KAP + KAIND \] \( \text{(3)} \)

\[ KLHA = \text{Water Needs of People} \]

\[ KAP = \text{Water Needs of Plant} \]

\[ KAIND = \text{Water Needs of Industry} \]
| Village        | Population (2020) | Production Forest | Industry | Conservation Zone | Waterbody | Settlement | Agriculture |
|----------------|-------------------|-------------------|----------|--------------------|-----------|------------|-------------|
| Brengkolang    | 713               | 683.01            | 0.00     | 0.00               | 0.00      | 10.82      | 60.51       |
| Gandarum       | 5,003             | 0.00              | 0.00     | 0.17               | 0.00      | 67.44      | 185.30      |
| Gejlig         | 5,441             | 0.00              | 0.00     | 0.00               | 0.00      | 66.56      | 361.30      |
| Kajen          | 4,589             | 0.00              | 0.00     | 1.63               | 0.00      | 72.37      | 77.12       |
| Kajongan       | 1,469             | 0.00              | 0.00     | 0.00               | 0.00      | 16.07      | 139.75      |
| Kalijoyo       | 2,134             | 60.77             | 0.00     | 0.00               | 0.00      | 34.03      | 269.35      |
| Kebonagung     | 4,056             | 0.00              | 0.00     | 1.91               | 0.00      | 60.99      | 157.80      |
| Kutorejo       | 2,145             | 0.00              | 0.00     | 0.00               | 7.14      | 29.11      | 128.56      |
| Kutorojo       | 1,381             | 709.03            | 0.00     | 0.00               | 0.00      | 28.06      | 112.53      |
| Linggosari     | 1,712             | 1,222.48          | 0.00     | 0.00               | 0.00      | 29.62      | 313.01      |
| Nyamok         | 3,238             | 0.00              | 0.00     | 5.09               | 0.00      | 69.04      | 112.14      |
| Pekiringanageng| 1,405             | 3.79              | 0.00     | 0.00               | 0.00      | 20.36      | 479.57      |
| Pekiringanalit | 3,284             | 0.00              | 0.00     | 0.00               | 3.20      | 41.79      | 157.18      |
| Pringsurat     | 1,510             | 42.78             | 0.00     | 0.00               | 0.00      | 16.95      | 326.20      |
| Rowolaku       | 1,978             | 0.00              | 2.55     | 0.88               | 0.00      | 34.71      | 170.71      |
| Sabarwangi     | 1,158             | 0.00              | 0.00     | 0.00               | 0.00      | 23.69      | 197.88      |
| Salit          | 1,971             | 0.00              | 0.00     | 0.00               | 0.00      | 23.12      | 192.10      |
| Sambiroto      | 2,457             | 0.00              | 0.00     | 0.00               | 0.00      | 36.57      | 203.55      |
| Sangkanjoyo    | 1,575             | 0.00              | 0.00     | 0.00               | 8.21      | 23.25      | 163.57      |
| Sinangohpreneng| 2,013             | 0.00              | 0.00     | 1.28               | 0.00      | 28.98      | 160.35      |
| Sokoyoso       | 1,060             | 0.00              | 0.00     | 0.00               | 0.00      | 19.04      | 95.78       |
| Tambakroto     | 1,901             | 160.97            | 0.00     | 0.00               | 2.54      | 28.82      | 244.42      |
| Tanjungkulan   | 1,803             | 0.00              | 0.00     | 0.00               | 0.00      | 34.24      | 149.76      |
| Tanjungsari     | 3,234             | 0.00              | 0.00     | 0.00               | 0.00      | 36.70      | 78.87       |
| Wonorejo       | 1,574             | 0.00              | 0.00     | 0.00               | 4.82      | 27.22      | 160.90      |
| Total          | 58,805            | 2,882.83          | 2.55     | 10.95              | 25.91     | 879.56     | 4,698.21    |

Table 1. Population and Land Use of Kejan in 2020
Table 2. Projected Population and Land Use of Kajen in 2040

| Village               | Population (2040) | Production Forest | Industry | Conservation Zone | Settlement | Agriculture |
|-----------------------|-------------------|-------------------|----------|-------------------|------------|-------------|
| Brengkolang           | 960               | 683.01            | 0.00     | 0.00              | 12.85      | 58.48       |
| Gandarum              | 6,738             | 0.00              | 0.00     | 0.00              | 96.47      | 156.44      |
| Gejlig                | 7,329             | 0.00              | 0.00     | 0.00              | 173.61     | 254.24      |
| Kajen                 | 6,180             | 0.00              | 0.00     | 2.23              | 113.68     | 35.20       |
| Kajongan              | 1,979             | 0.00              | 0.00     | 0.44              | 21.70      | 133.68      |
| Kalijoyo              | 2,874             | 60.77             | 0.00     | 0.00              | 59.89      | 243.50      |
| Kebonagung            | 5,463             | 0.00              | 0.00     | 0.00              | 161.66     | 59.03       |
| Kutorrejo             | 2,889             | 0.00              | 0.00     | 12.24             | 61.96      | 90.60       |
| Kutorojo              | 1,861             | 709.03            | 0.00     | 0.00              | 21.70      | 118.89      |
| Linggosari            | 2,305             | 1,222.48          | 0.00     | 0.00              | 39.71      | 302.92      |
| Nyamok                | 4,361             | 0.00              | 0.00     | 1.17              | 151.20     | 33.90       |
| Pekiringanageng       | 1,893             | 3.79              | 0.00     | 0.00              | 25.09      | 474.84      |
| Pekiringanalit        | 4,423             | 0.00              | 0.00     | 8.40              | 141.59     | 52.17       |
| Pringsurat            | 2,033             | 42.78             | 0.00     | 1.63              | 18.26      | 323.26      |
| Rowolaku              | 2,664             | 0.00              | 2.55     | 0.00              | 74.19      | 132.10      |
| Sabarwangi            | 1,560             | 0.00              | 0.00     | 0.00              | 45.43      | 176.20      |
| Salit                 | 2,655             | 0.00              | 0.00     | 0.00              | 90.96      | 124.26      |
| Sambiroto             | 3,310             | 0.00              | 0.00     | 0.00              | 59.86      | 180.26      |
| Sangkanjjoyo          | 2,121             | 0.00              | 0.00     | 13.43             | 33.67      | 147.93      |
| Sinangohprendeng      | 2,711             | 0.00              | 0.00     | 2.98              | 35.95      | 151.68      |
| Sokoyoso              | 1,428             | 0.00              | 0.00     | 0.87              | 21.35      | 92.60       |
| Tambakroto            | 2,560             | 160.97            | 0.00     | 5.73              | 28.41      | 241.65      |
| Tanjungkulon          | 2,428             | 0.00              | 0.92     | 0.75              | 100.35     | 81.99       |
| Tanjungvari           | 4,356             | 0.00              | 0.00     | 0.00              | 83.17      | 32.40       |
| Wonorejo              | 2,119             | 0.00              | 0.00     | 8.74              | 36.04      | 148.16      |
| Total                 | 79,201            | 2,882.83          | 3.47     | 58.62             | 1,708.77   | 3,846.38    |

3. Results and Discussion

The land-use changes in Kajen District occurred significantly in settlement areas with an increase of about 829.21 Ha. A very large increment in area is in Gejlig and Kebonagung Village, which is 107.06 Ha and 100.68 Ha. Meanwhile, the conservation area increased by 47.67 hectares which were implemented on the river border. On the other side, paddy fields have a significant reduction, namely as low as 851.83 Ha. The biggest reduction is in Gejlig Village, which is 107.06 Ha. This condition means that most of all agricultural land is converted into settlements. In detail, Table 3 explains the land-use change in Kajen District from 2020 to 2040.

Refer to Table 3, the production forest land in the southern region tends to be maintained to strengthen ecotourism in the Linggosari area and its surroundings. This is because the forest area is a tourist attraction for the development of natural cafes that are interested in the younger generation. Meanwhile, the industrial area increased by 0.92 Ha in Tanjungkulon Village. The addition of this industrial area is relatively small considering that the investment target of Pekaloangan Regency is in the coastal area.
The largest land-use change is from rice fields to settlements. The need residential land is used for housing and supporting facilities. This is necessary considering that Kajen District is the area used for the relocation of the IAIN Pekalongan Main Campus and the location of the UNDIP Perkalanongan campus. The existence of higher education activities increases the need for housing and supporting infrastructure. The following is a map of land-use change in the Kajen District.

Refer to Figure 1, it is identified that the use of settlement has a significant development in the middle area of Kajen District. This central area includes Gejlig Village, Kebonagung Village, and Kajen Village. These three areas are an agglomeration of the urban area of the Kajen Sub-district. On the other hand, Kajen Village is a location where the Pekalongan Government office is located. Thus, its strategic aspect causes a high attraction of activity and occupancy. Meanwhile, Gejlig Village is located on the west side of the government office and has become a strategic destination for the expansion of settlement activities. While Kebonagung village has a focus on developing settlements to support higher education activities at IAIN Pekalongan.

Table 3. Land Use Change in Kajen in 2020 – 2040

| Village       | Production Forest | Industry | Conservation Zone | Waterbody | Settlement | Agriculture |
|---------------|------------------|----------|-------------------|-----------|------------|-------------|
| Brengkolang   | 0.00             | 0.00     | 0.00              | 0.00      | 2.03       | -2.03       |
| Gandarum      | 0.00             | 0.00     | -0.17             | 0.00      | 29.03      | -28.86      |
| Gejlig        | 0.00             | 0.00     | 0.00              | 0.00      | 107.06     | -107.06     |
| Kajen         | 0.00             | 0.00     | 0.60              | 0.00      | 41.31      | -41.92      |
| Kajongan      | 0.00             | 0.00     | 0.44              | 0.00      | 5.63       | -6.07       |
| Kalijoyo      | 0.00             | 0.00     | 0.00              | 0.00      | 25.85      | -25.85      |
| Kebonagung    | 0.00             | 0.00     | -1.91             | 0.00      | 100.68     | -98.77      |
| Kutorejo      | 0.00             | 0.00     | 12.24             | -7.14     | 32.85      | -37.96      |
| Kutorojo      | 0.00             | 0.00     | 0.00              | 0.00      | -6.36      | 6.36        |
| Linggosari    | 0.00             | 0.00     | 0.00              | 0.00      | 10.09      | -10.09      |
| Nyamok        | 0.00             | 0.00     | -3.92             | 0.00      | 82.16      | -78.24      |
| Pekiringanageng | 0.00             | 0.00     | 0.00              | 0.00      | 4.73       | -4.73       |
| Pekiringanalit| 0.00             | 0.00     | 8.40              | -3.20     | 99.80      | -105.01     |
| Pringsurat    | 0.00             | 0.00     | 1.63              | 0.00      | 1.31       | -2.94       |
| Rowolaku      | 0.00             | 0.00     | -0.88             | 0.00      | 39.48      | -38.61      |
| Sabarwangi    | 0.00             | 0.00     | 0.00              | 0.00      | 21.74      | -21.68      |
| Salit         | 0.00             | 0.00     | 0.00              | 0.00      | 67.84      | -67.84      |
| Sambiroto     | 0.00             | 0.00     | 0.00              | 0.00      | 23.29      | -23.29      |
| Sangkanjoyo   | 0.00             | 0.00     | 13.43             | -8.21     | 10.42      | -15.64      |
| Sinangohprendeng | 0.00             | 0.00     | 1.70              | 0.00      | 6.97       | -6.67       |
| Sokeyoso      | 0.00             | 0.00     | 0.87              | 0.00      | 2.31       | -3.17       |
| Tambakroto    | 0.00             | 0.00     | 5.73              | -2.54     | -0.41      | -2.77       |
| Tanjungkulan  | 0.00             | 0.92     | 0.75              | 0.00      | 66.11      | -67.77      |
| Tanjungsari    | 0.00             | 0.00     | 0.00              | 0.00      | 46.47      | -46.47      |
| Wonorejo      | 0.00             | 0.00     | 8.74              | -4.82     | 8.81       | -12.73      |
| Total         | 0.00             | 0.92     | 47.67             | -25.91    | 829.21     | -851.83     |
Based on the population of Kajen Sub-district in 2020, the area of agricultural land for crops and industrial area, it is estimated that the water needs for the people are about 2,575,647.87 m³, the need for water for crops is 573,490.51 m³ and the need for water for industrial activities is 547,500 m³. On the other hand, the water availability in Kajen is based on a calculation is about 79,553,176.83 m³. Thus, in aggregate, the water carrying capacity of Kajen District is at number 22. It means that the availability of water can still support these activities even at a scale of 22 times the existing volume. In detail, the water carrying capacity of each village in 2020 can be seen in Table 4.

Refer to Table 4, the largest carrying capacity of water is in Brengkolang village, which is 152. Brengkolang village still has production forest land use which is around 688 Ha, On the other side, the existing settlements are only 10.82 Ha. This condition causes water infiltration rates and water purification ecosystem services to remain high. Moreover, the type of rural settlement has the characteristics of low density, semi-permanent buildings, and low building coefficients. On the other hand, the smallest water carrying capacity is in Rowolaku Village, which is worth 4. Rowolaku Village has a fairly large industrial and residential area. This causes a high enough water required to support these activities.

Meanwhile, in 2040, the water demand for the population is 3,469,024.24 m³. The need for water for agriculture is 11,564.98 m³. Moreover, the water demand for industrial activities is 821,250.00 m³. On the other hand, the water availability in Kajen is based on a calculation is about 92,458,430,27 m³. Thus, in aggregate, the water carrying capacity of Kajen District is at number 21. This value means that the availability of water can still support activities with a volume of more than 21 times of current activities. The existence of production forest land in the Kajen District makes the carrying capacity of water still high. The existence of production forest has high infiltration and water storage capacity. The availability of this water can flow through the surface or underground to the zone below [5]. This is slightly different from the use of agricultural land. Although it has good vegetation cover, water consumption for plant growth, especially crops make its role smaller than production forests in water conservation [6]. In detail, the water carrying capacity of each village in 2040 can be seen in the following Table 5.
Table 4. The Carrying Capacity of Water in Kajen 2020

| Village        | Water Needs  | Water Supply | CCoW |
|----------------|--------------|--------------|------|
|                | People       | Plant (Agriculture) | Industry |             |
| Brengkolang    | 31,216.79    | 177.22       | 4,722,715.20 | 151         |
| Gandarum       | 219,131.31   | 539.06       | 3,074,785.28 | 14          |
| Gejlig         | 238,334.90   | 3,752.08     | 4,746,300.48 | 20          |
| Kajen          | 200,979.98   | 225.18       | 2,140,237.12 | 11          |
| Kajongan       | 64,362.70    | 377.77       | 1,650,154.56 | 25          |
| Kalijoyo       | 93,474.98    | 522,812.67   | 3,589,292.93 | 6           |
| Kebonagung     | 177,655.08   | 453.78       | 2,698,005.12 | 15          |
| Kutorejo       | 93,957.26    | 370.16       | 2,021,330.88 | 21          |
| Kutorojo       | 60,504.44    | 220.54       | 5,703,150.53 | 94          |
| Linggosari     | 74,972.90    | 2,825.00     | 10,615,167.74 | 136         |
| Nyamok         | 141,834.69   | 323.42       | 2,434,736.32 | 17          |
| Pekiringanageng| 61,556.70    | 990.38       | 5,016,678.34 | 80          |
| Pekiringanalit | 143,851.51   | 466.12       | 2,413,586.56 | 17          |
| Pringsurat     | 66,116.45    | 752.62       | 3,703,394.11 | 55          |
| Rowolaku       | 86,635.35    | 390.25       | 547,500.00  | 2,367,932.16 | 4 |
| Sabawangi      | 50,727.28    | 11,414.53    | 2,355,931.20 | 38          |
| Salit          | 86,328.44    | 17,992.12    | 2,288,094.72 | 22          |
| Sambiroto      | 107,636.53   | 6,526.57     | 2,656,177.92 | 23          |
| Sangkanjoyo    | 68,966.30    | 486.02       | 2,279,448.64 | 33          |
| Sinangohprendeng| 88,169.88 | 474.20       | 2,104,040.00 | 24          |
| Sokoyooso      | 46,430.58    | 271.48       | 1,285,100.16 | 28          |
| Tambakroto     | 83,259.38    | 588.37       | 3,908,432.06 | 47          |
| Tanjungkulon   | 78,962.68    | 408.62       | 2,095,147.20 | 26          |
| Tanjungsari    | 141,659.32   | 231.44       | 1,461,738.24 | 10          |
| Wonorejo       | 68,922.45    | 480.92       | 2,221,599.36 | 32          |
| **Total**      | **2,575,647.87** | **573,490.51** | **547,500.00** | **79,553,176.83** | **22** |

Based on Table 5, the largest water carrying capacity is in Brengkolang Village and the lowest is in Rowolaku Village. The same as in 2020. However, at the village level, there is a shift in the value of the carrying capacity of water. In Brengkolang Village, the carrying capacity of the floodwaters was 113 or decreased by 37 points. While in Rowolaku Village, the carrying capacity of water increased by 1 point to a value of 5. This was influenced by changes in agricultural land and increased conservation land (especially river borders). In aggregate, the carrying capacity of water in Kajen District decreased to 21 in 2040 from the previous 22 in 2020. An illustration of the fluctuation of water carrying capacity in the Kajen District can be seen in Figure 2.
capacity, which is as follows:

Table 5. The Carrying Capacity of Water in Kajen 2040

| Village               | Water Needs | Water Supply Availability | CCow |
|-----------------------|-------------|---------------------------|------|
|                       | People      | Plant (Agriculture)       |      |
| Brengkolang           | 42,044.48   | 176.69                    | 4,783,352.64 | 113 |
| Gandarum              | 295,138.11  | 552.29                    | 3,662,669.44 | 12  |
| Gejlig                | 321,002.55  | 756.67                    | 6,329,592.32 | 20  |
| Kajen                 | 270,690.89  | 127.40                    | 2,905,836.48 | 11  |
| Kajongan              | 86,687.22   | 423.24                    | 1,773,608.96 | 20  |
| Kalijoyo              | 125,897.25  | 678.08                    | 4,029,101.57 | 32  |
| Kebonagung            | 239,275.63  | 215.47                    | 4,187,931.84 | 17  |
| Kutorejo              | 126,546.81  | 328.76                    | 2,375,159.04 | 19  |
| Kutorojo              | 81,490.71   | 330.44                    | 5,711,539.65 | 70  |
| Linggosari            | 100,977.62  | 862.27                    | 10,839,106.62 | 106 |
| Nyamok                | 191,030.77  | 123.73                    | 3,723,604.80 | 19  |
| Pekiringanageng       | 82,907.94   | 1,057.78                  | 5,142,372.42 | 61  |
| Pekiringanalit        | 193,747.12  | 190.37                    | 3,753,221.12 | 19  |
| Pringsurat            | 89,049.27   | 782.81                    | 3,774,408.83 | 42  |
| Rowolaku              | 116,685.25  | 359.11                    | 2,995,365.76 | 5   |
| Sabarwangi            | 68,322.29   | 575.58                    | 2,709,188.80 | 39  |
| Salit                 | 116,271.89  | 450.26                    | 3,230,472.64 | 28  |
| Sambiroto             | 144,970.80  | 565.32                    | 3,071,356.80 | 21  |
| Sangkanjoyo           | 92,887.60   | 539.95                    | 2,303,321.92 | 25  |
| Sinangohprendeng      | 118,752.05  | 549.27                    | 2,290,096.64 | 19  |
| Sokoyoso              | 62,535.26   | 304.14                    | 1,375,579.84 | 22  |
| Tambakroto            | 112,138.31  | 692.47                    | 3,938,419.58 | 35  |
| Tanjungkulon          | 106,351.29  | 266.11                    | 3,065,559.36 | 8   |
| Tanjungsari           | 190,794.56  | 115.98                    | 2,174,039.04 | 11  |
| Wonorejo              | 92,828.55   | 540.79                    | 2,313,524.16 | 25  |
| **Total**             | **3,469,024.24** | **11,564.98** | **821,250.00** | **92,458,430.27** | **21** |

Based on Figure 2, 15 villages have decreased water carrying capacity. The biggest decrease was in Brengkolang Village, which was 37 points. On the other hand, 8 villages have increased water carrying capacity. The biggest increase was in Kalijoyo Village, which was 26 points. Meanwhile, there are two villages whose water carrying capacity remains. Based on the facts of land-use change and water carrying capacity in 2020 and 2040, it can be formulated the effect of land-use change on water carrying capacity, which is as follows:
Refer to Figure 3, that changes in land use for settlements, industry, and agriculture have a positive correlation to the reduction of water carrying capacity in Kajen District. Settlements have a correlation of 0.87 to the reduction in water carrying capacity. While industrial land use has a correlation of 0.76 to the decrease in water carrying capacity. Meanwhile, the use of agricultural land has a correlation of 0.65 to the decrease in water carrying capacity. This means that the use of residential land has the greatest influence in reducing the carrying capacity of water in the Kajen District. Apart from the built-up land cover, the population's water needs make residential lands have the greatest influence. Meanwhile, industrial land use has a positive but moderate effect on the decrease in water carrying capacity. This influence is due to the high coefficient of the basic building in the industrial area. While on agricultural land, the need for water for plant growth and production causes this land to have a role in reducing water carrying capacity. Agricultural activities do develop plants as their core business, but agriculture that has high productivity requires a lot of water. This condition increases demand and reduces water availability [7]. Increased economic activity results in increased demand for water resources and
increases runoff [8]. This increase in runoff will be useless if there is no water body as a reservoir. [9]. This is the reason why although water runoff has increased due to the increase in settlements and industry, the carrying capacity of water in the Kajen District has decreased.

On the other side, the use of production forest land, conservation land, and waterbody harm the decrease in water carrying capacity. It means if these areas become larger, the carrying capacity of water is also improved. Production forest land use has a correlation of -0.77 with a decrease in water carrying capacity. Even though it is a production forest, the quality of water infiltration on this land is still high. However, when production forest land is converted into other types of agricultural land, its support for water availability also decreases [10].

On conservation land in Kajen District, there is a correlation of -0.52. This is because conservation zones have ecosystem services for ecological maintenance including water purification and availability. Especially in the river border zone. This area not only serves as a reservoir of water but also maintains its quality. The availability of usable water should be measured not only based on the amount but also the quality, area, and direction of water flow [11].

Meanwhile, the waterbody in the form of a pond and so on has an effect of -0.1 on the decrease in the carrying capacity of the water. This condition is because the waterbody is adaptive as a reservoir for water runoff. The results of this water reservoir can be used as a source of surface raw water. So, if the area of land for water storage decreases, the carrying capacity of the water will decrease too. This relates to the ability of the land to hold water. Not all basins can hold water permanently to be used as a raw water source. If there is an area with a semi-permeable basin on the ground, then the amount of water runoff due to productive activities can be accommodated and can relatively support the availability of water [12].

4. Conclusion

Kajen District is the capital of the Pekalongan Regency. As a capital city, activities are identified as urban characteristics such as settlements, industry, and others. Pekalongan Regency itself has formulated a spatial plan for the Pekalongan Regency area for 2020 – 2040. In the plan, it is projected that the land-use area will be in 2040. Changes in land use occur in residential, agricultural, industrial, and conservation areas. The biggest change is the residential area from 879.56 Ha to 1,708.77 Ha in 2040. This increase in area is 829.21 Ha or almost double the area in 2020. This increase in a residential area is also inseparable from the existence of the UNDIP Pekalongan campus and IAIN Pekalongan which requires support for residential activities and supporting facilities. Meanwhile, agricultural land was also reduced by 851.83 Ha. From this point of view, it is indicated that most of the crops agricultural areas have turned into residential areas. Moreover, the industrial area also increased by 0.92 Ha. The addition of this industrial area is a sign of urban development in the Kajen District.

In terms of water carrying capacity, there is an aggregate change from number 22 to number 21 or a decrease of 1 point. However, when viewed at the detail of the village, the changes occurred quite significantly. There is Brengkolang Village which experienced a decrease in water carrying capacity by 37 points. On the other hand, there is also Kalijoyo Village which has increased its carrying capacity by 26 points. Based on the analysis, it is known that this land-use change influences the water carrying capacity condition. Based on the correlation, changes in residential land have the greatest influence with a correlation number of 0.87. This indicates that settlements have a significant influence on changes or reductions in water carrying capacity. This is because living activities require water for bathing, washing, cooking, and other activities. In addition to settlements, industry, and agriculture also have a large influence, although not as significant as settlements. On the other side, the production of forest land has a major influence in maintaining the carrying capacity of water. The effect is 0.77. From this fact, vegetation cover has an important role in the hydrological cycle. Thus, in a built area, it is necessary to have green open space for environmental balance, especially the carrying capacity of water.
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6. References

[1] Asdak C 2006 Daya dukung sumberdaya air sebagai pertimbangan penataan ruang J. Teknol. Lingkung. 7
[2] Sarwono J 2006 Metode penelitian kuantitatif dan kualitatif
[3] Suripin 2004 Sistem Drainase Perkotaan yang Berkelanjutan (Yogyakarta: Andi)
[4] Menteri Negara Lingkungan Hidup 2009 Peraturan Menteri Negara Lingkungan Hidup Nomor 17 Tahun 2009 Tentang Pedoman Penentuan Daya Dukung Lingkungan Hidup Dalam Penataan Ruang Wilayah
[5] Qi P, Xia Z, Zhang G, Zhang W and Chang Z 2021 Effects of climate change on agricultural water resource carrying capacity in a high-latitude basin J. Hydrol. 597 126328
[6] Daneshi A, Brouwer R, Najafinejad A, Panahi M, Zarrandian A and Maghsood F F 2021 Modelling the impacts of climate and land use change on water security in a semi-arid forested watershed using InVEST J. Hydrol. 593 125621
[7] He L, Du Y, Wu S and Zhang Z 2021 Evaluation of the agricultural water resource carrying capacity and optimization of a planting-raising structure Agric. Water Manag. 243 106456
[8] Magri A and Berezowska-Azzag E 2019 New tool for assessing urban water carrying capacity (WCC) in the planning of development programs in the region of Oran, Algeria Sustain. Cities Soc. 48 101316
[9] Wang J, Mu X, Chen S, Liu W, Wang Z and Dong Z 2021 Dynamic evaluation of water resources carrying capacity of the Dianchi Lake Basin in 2005–2015, based on DSPERM framework model and simulated annealing-projection pursuit model Reg. Sustain. 2 189–201
[10] McGinn A J, Wagner P D, Htike H, Kyu K K and Fohrer N 2021 Twenty years of change: Land and water resources in the Chindwin catchment, Myanmar between 1999 and 2019 Sci. Total Environ. 798 148766
[11] Wu L, Su X, Ma X, Kang Y and Jiang Y 2018 Integrated modeling framework for evaluating and predicting the water resources carrying capacity in a continental river basin of Northwest China J. Clean. Prod. 204 366–79
[12] Bonansea M, Bazán R, Germán A, Ferral A, Beltramone G, Cossavella A and Pinotti L 2021 Assessing land use and land cover change in Los Molinos reservoir watershed and the effect on the reservoir water quality J. South Am. Earth Sci. 108 103243