Geosfera Indonesia
p-ISSN 2598-9723, e-ISSN 2614-8528
available online at : https://jurnal.unej.ac.id/index.php/GEOSI
Vol. 7 No. 2, August 2022, 150-164

https://doi.org/10.19184/geosi.v7i2.32085

Research Article

Land Use Change Analysis to Springs Conditions in Gunungpati Sub-District, Semarang City

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ARTICLE INFO

Article history

Received :
29 June 2022

Revised :
3 August 2022

Accepted :
16 August 2022

Published :
28 August 2022

ABSTRACT

Semarang City has the fastest development in Central Java Province, where the activities are no longer centralized but have expanded to the upper part of the region. The ongoing development certainly impacts changes with the increasing area of built-up land that converts to another cover, such as vegetation. The phenomenon impacts the balance of the environment, one of which is the source of springs. Therefore, this study aims to map the spatial distribution of the springs and identify their physical quality. A quantitative approach was used with spatial analysis. Meanwhile, data collection techniques used document research, high-resolution image interpretation and field surveys. Field surveys were conducted to test the accuracy of land use maps and measurements of discharge, temperature, pH and brightness of the springs. The results showed that there is a change in land use from 2016 - 2021 with an increase in settlements of around 77.25 hectares and commercial service buildings by 178.79 hectares. For land use with the largest decrease in area, agricultural land covers and mixed garden/vegetation covers an area of 207.01 and 50.57 hectares. There were 114 springs at the research site, of which 5% of the springs had a relatively large discharge above 10 liters/second, while the other 47% had a small discharge. For pH conditions, there were 6 springs with a pH value of less than 6. Land use change from vegetation to flying land impacts the reduction of the water supply in the soil. The impact can be seen by the non-production of several springs, where 21 springs have not been discharged. In conclusion, there is a change in land use with an increase in built-up from 2016 - 2021 by 256.04 hectares. The increase in built-up is partly in conservation areas, hence damaging several springs.

Keywords : Land use change; Springs conditions; Gunungpati Sub-District

1. Introduction

Semarang City is the area with the fastest development in Central Java Province. Besides being the provincial capital, the strategic location of the area with PANTURA Road makes the region to experience very rapid progress in development (Arsandi et al., 2017; Pigawati et al., 2019; Kelly-Fair et al., 2022). This can be seen in the increasing density of built-up land, specifically in the lower part of Semarang, which is the center of government and economy (Wijaya et al., 2018;Pigawati et al., 2019 ;Wahyudi et al., 2020). This phenomenon has an impact on decreasing environmental quality, characterized by high air temperatures, floods, and tidal decreasing the level of environmental comfort (Sunaryo et al., 2018; Sejati et al., 2020; Putra & Pigawati, 2021; Hanafi et al., 2021). This allows some residents to access the upper Semarang area with better environmental quality. One area accessed and developed in recent years is Gunungpati Sub-District (Dewi & Rudiarto, 2013), where there is the Semarang State University (Unnes) which continues to develop with various public infrastructures.

The increasing number of residents who began to access the upper Semarang area impacted land use changes in the region, specifically the Gunungpati Sub-District area (Juhadi et al., 2021; Kelly-Fair et al., 2022). The existence of the Unnes campus located in Sekaran Village makes the area have infrastructure, including public facilities and trade and service buildings. During 2005 - 2010 there was an increase in residential land in the sub-district area of 122.33 hectares and an increase again from 2010 - 2017 to 297.54 hectares (Nugraha & Sidiq, 2019). The increase in built-up land in the form of settlements and trade buildings will certainly convert other land use, such as plantations, rice fields, moorings and several other uses, which can result in a further decrease in the balance of the life-sustaining environment (Subiyanto & Fadilla, 2018; Nugraha & Sidiq, 2019; Juhadi, ae al, 2021).

Land use changes occur on non-productive, productive and conservation areas. In conservation areas, it can impact environmental degradation and sustainability of water resources. This occurs because part of the southern Gunungpati Sub-District area is at the foot of Mount Ungaran, largely dominated by conservation and catchment areas. The loss of conservation areas can certainly affect the management of water resources, such as the availability and condition of springs used to inhabit daily needs by residents (Sanjoto, 2020; Narendra et al., 2021; Rambey et al., 2021). Springs is groundwater found below the surface in water-saturated rocks (aquifers). It causes water to appear on the ground surface due to geological processes. Based on data from the Semarang City Agriculture Office, in 2021, there are 84 springs located in the sub-district that used to support agricultural activities.

Research related to changes in land use in Gunungpati Sub-District has been carried out several times because this area has a relatively dynamic development. However, identification of the spatial distribution and condition of springs has not been conducted. This research identifies the effect of land use changes on the consistency of springs at the research site yet to be studied. Based on the description of the problem, it is appropriate to conduct an inventory of the springs' distribution and condition and identify land use changes that can threaten the consistency of springs in the sub-district. Remote Sensing Technology (RS) combined with Geographic Information Systems (GIS) can be utilized to support these activities. It can determine the spatial distribution and condition of the springs and identify the consistency that can potentially be affected by land use changes.

2. Methods

2.1 Study Area

The research location used was the Gunungpati Sub-District area in the upper part of Semarang City. The selection of the location is more based on the number of springs still producing and the development of built-up land with the potential to threaten the existence and consistency of the springs. The Figure 1 presents the research location.

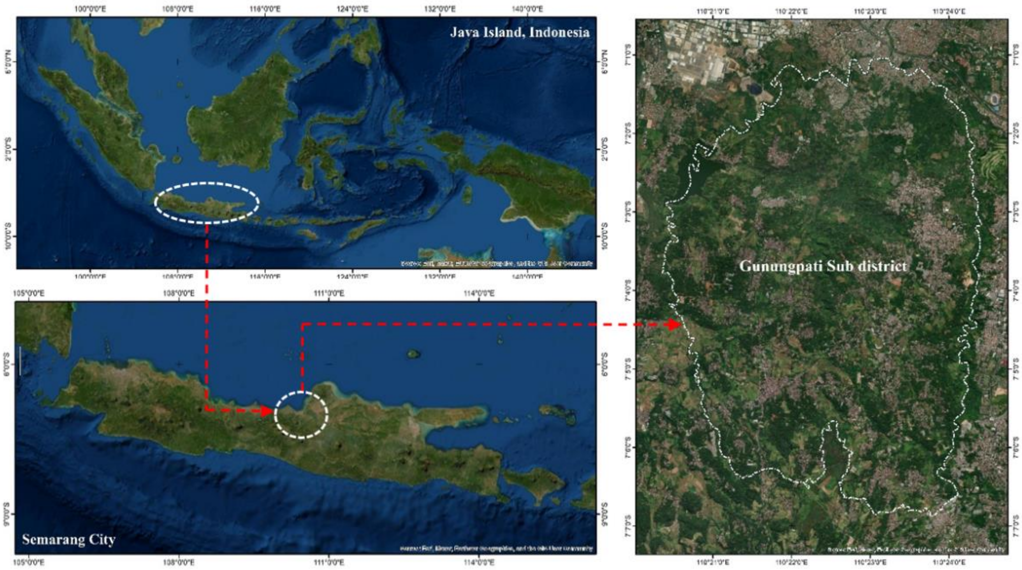


Figure 1. Research sites

2.2 Acquisition of Satellite Imagery Data

This stage is carried out to obtain imagery data used in preparing land use maps for the time series of the research area. The image used is high-resolution imagery recording in 2016 and 2021, where the 2016 and 2021 image using data from google earth and a digital globe, respectively, and both are geometrically corrected before interpretation. Furthermore, the image data is conducted pre-processing, consisting of geometric correction and cropping to improve quality and focus more on the research area (Ramadan et al., 2018; Mhangara & Mapurisa, 2019).

2.3 Visual Interpretation

Land use maps were obtained from on-screen digitizing results of geometrically corrected digital imagery of the 2016 and 2021 recording globes. Furthermore, from the existing land use map in 2021, a test was conducted using the confusion matrix method to determine the level of accuracy of the land use map compiled.

2.4 Ground Check

Ground checks were conducted to test the accuracy of interpretation of land use samples, where 51 locations were surveyed. In addition, field survey activities are also carried out by observing and measuring several physical parameters of water quality, such as discharge measured by a current meter, pH measured by pH meters, and the level of turbidity from the observations in the field.

Data techniques include spatial analysis used to map the distribution of springs at the research site. Furthermore, hydrological analysis is also used to assess the quality of water physical parameters from observations and measurements, including turbidity, discharge and pH conditions. The next thematic data analysis uses overlay with Geographic Information System (GIS) technology on two-time series land use maps, hence, the land use changes can be seen during 2016 – 2021. The Figure 2 presents the stages carried out in research activities.

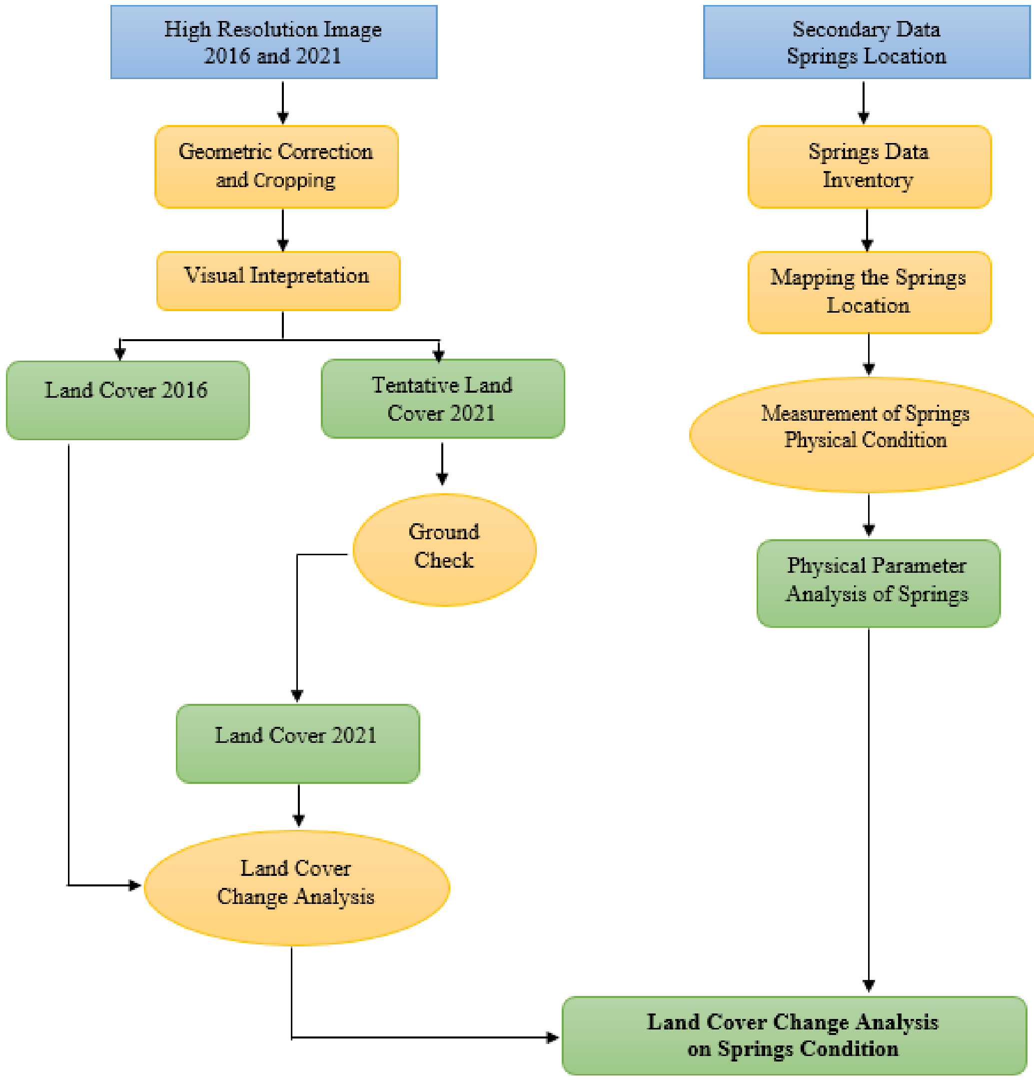


Figure 2. Research flowchart

3. Results and Discussion

3.1 Land Use Change

Existing land use in 2021 at the research location in Gunungpati Sub-District was obtained from visually interpretation high-resolution images guided by 9 elements (Martuti et al., 2020; Janah & Nugraha, 2021). Based on the results, 5 classes of land use in the region were obtained, including settlements, agricultural land, mixed gardens/vegetation, service/commercial buildings and open land. Furthermore, the tentative map was tested for accuracy with a confusion matrix approach by taking about 51 samples proportionally distributed in each class. The calculation of the level of mapping accuracy with a confusion matrix of 51 land use samples resulted in a figure of 93.95%, thereby citing the one submitted (Congalton, 2019), which stated that the minimum limit of accurate test results is 85%. The tentative land use map compiled can be carried out for subsequent analysis. The Table 1 presents the map accuracy test calculation resulting from interpreting the imagery at the research site.

Table 1. Land use map accuracy test

	Object					Omission	Total	Mapping Accuracy (%)
	ST	AL	MG	SB	OP			
ST	9					0	9	100
AL		12			1	1	13	92.30
MG		2	12			2	14	85.71
SB				6		0	6	100
OP			1		9	1	9	90
Commission	0	2	1	2	2			Overall Mapping Accuracy (%)
Total	9	14	13	8	8		102	93.95

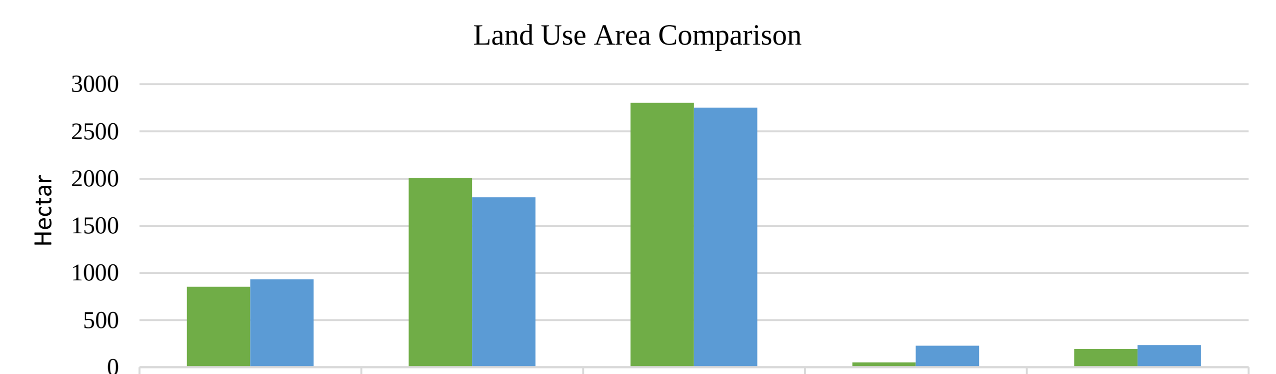
* ST: Settlement., AL: Agriculture Land., MG: Mixed garden/vegetation., SB: Service/Commercial Building., OP: Open field

Land use maps were prepared using a time series approach in 2016 and 2021. The making of the two land use maps aims to be analyzed. The map was obtained from the global digital image interpretation results, while the 2016 land use map was obtained from the google earth imagery interpretation. Before interpretation of the two images, geometric corrections were conducted to place the position of the pixels according to the object (Janah & Nugraha, 2021; Prasetyo et al., 2018).

Based on the interpretation results, information was obtained related to land use with the largest area at the research site, namely mixed gardens/vegetation of 2,750.89 hectares in 2021, which increased to 51.57 hectares in 2016-2021. It has an important role in maintaining the balance of the microclimate and increasing the potential of groundwater. Therefore, the preservation of vegetation is very important to maintain (Armstrong et al., 2016; Nunes et al., 2018). The location of Gunungpati Sub-District at the foot of Mount Ungaran with relatively undulating topography, makes part of the protected area to limit the conversion from vegetation to built-up land (Darniyus et al., 2020; Prihanto et al., 2020; Juhadi et al., 2021). Furthermore, there is agricultural land with a fairly large area of around 1801.71 hectares in 2021, where in 2016 it was 2008.72, indicating a decrease of 207.01. In detail, Table 2, Figure 3, and Figure 4 present the area and changes in land use at the research site in a time series.

Table 2. Land use in 2016 and 2021

Land Cover	2016 (ha)	Percent (%)	2021 (ha)	Percent (%)
Settlement	854.72	14.45	931.97	15.76
Agriculture land	2008.72	33.97	1801.71	30.47
Mixed garden/Vegetation	2802.46	47.40	2750.89	46.52
Service/Commercial building	51.19	0.86	229.98	3.88
Open field	195.26	3.29	198.80	3.34
Total	5912.35	100.00	5912.35	100.00



	Settlement	Agriculture land	Mixed garden/Vegetation	Service/Commercial building	Open field
2016	854,72	2.008,72	2.802,46	51,19	195,26
2021	931,97	1.801,71	2.750,89	229,98	236,13

Figure 3. Chart of land use area comparison

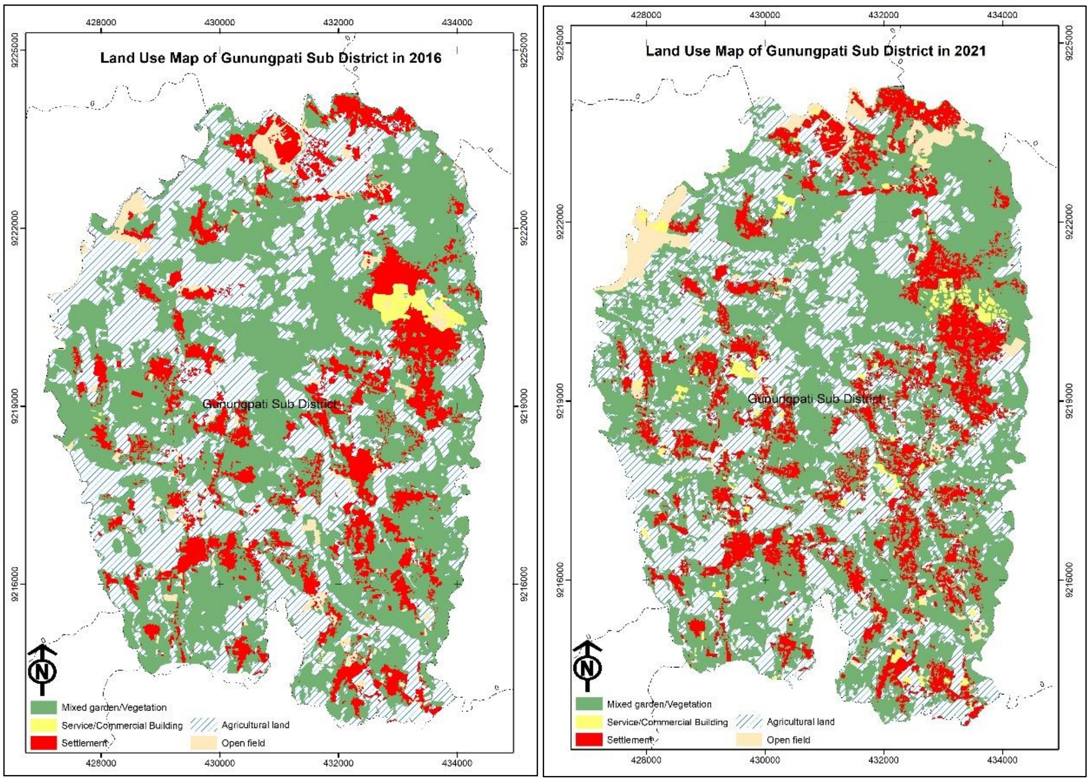


Figure 4. Land use map in 2016 and 2021

The next land use at the research site with a relatively dynamic development is built-up land consisting of settlements and service/commercial land. During 2016 - 2021, the development of settlements in the region increased by 77.25 hectares, while service/commercial buildings increased by 178.79 hectares. The built-up land in service/commercial buildings mostly occurs around Semarang State University, with an elongated pattern along Jalan Taman Siswa. These buildings provide services in the form of goods and services, specifically to students. As for the growth of buildings in the form of settlements, it is more developed in several urban villages with a distance of 3-5 km from Universitas Negeri Semarang. The Figure 5 presents the spatial distribution of land use in Gunungpati Sub-District in a time series.

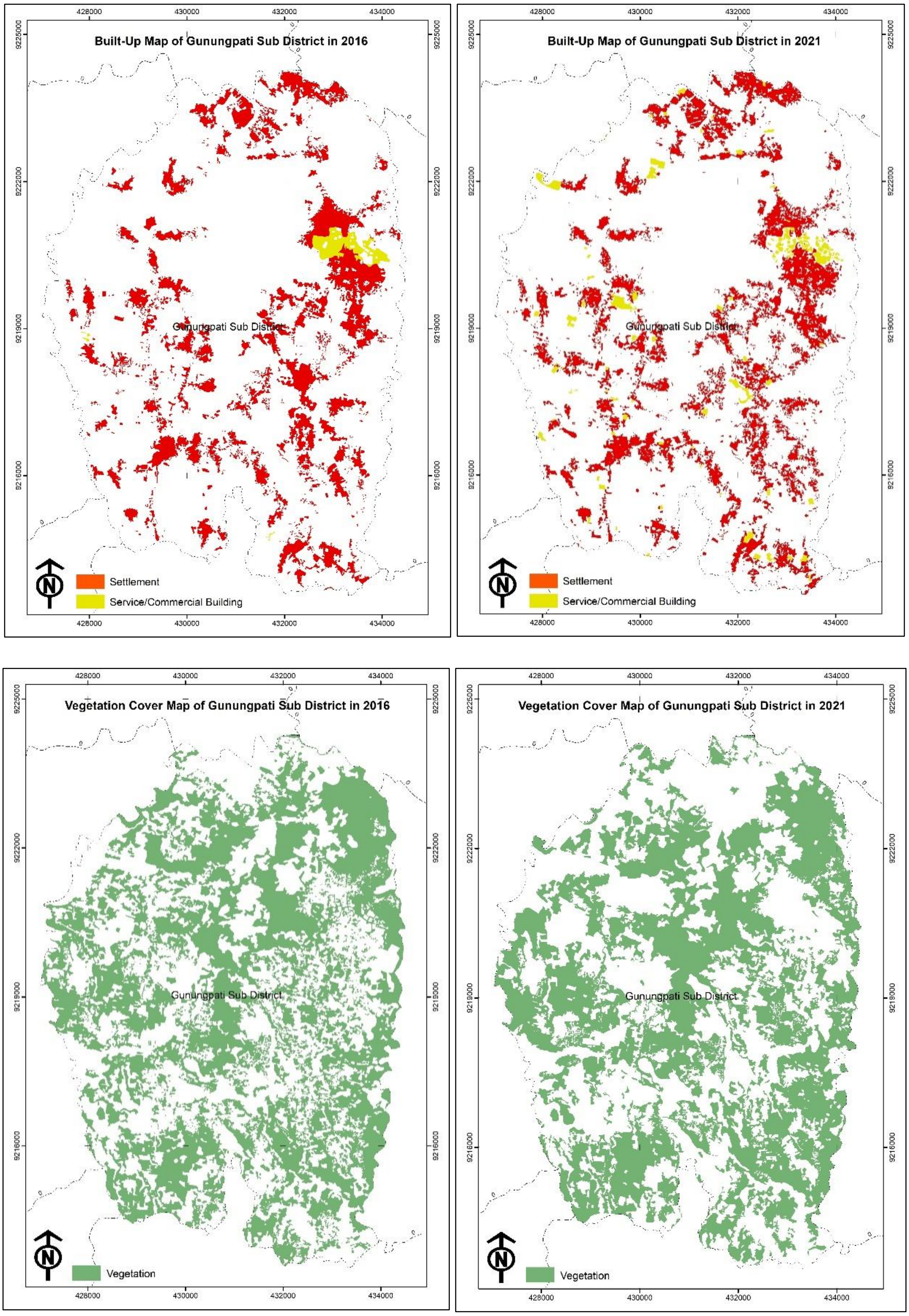


Figure 5. Built-up and vegetation cover time series in 2016 - 2021

3.2 Spatial Distribution of Springs

The spatial distribution of springs at the research site was obtained from a ground check using the participatory approach of several community leaders. Based on the results of the ground check, a total of 114 springs were obtained under various conditions and their use. The most springs were found in Pakintelan and Ngijo Villages with 17 and 13 springs. Figure 6 and Figure 7 present the distribution of springs in each village in the research location.

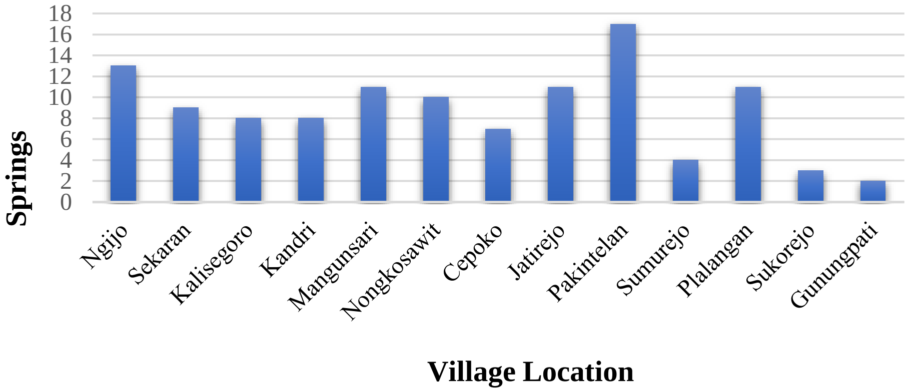


Figure 6. Springs distribution in each village

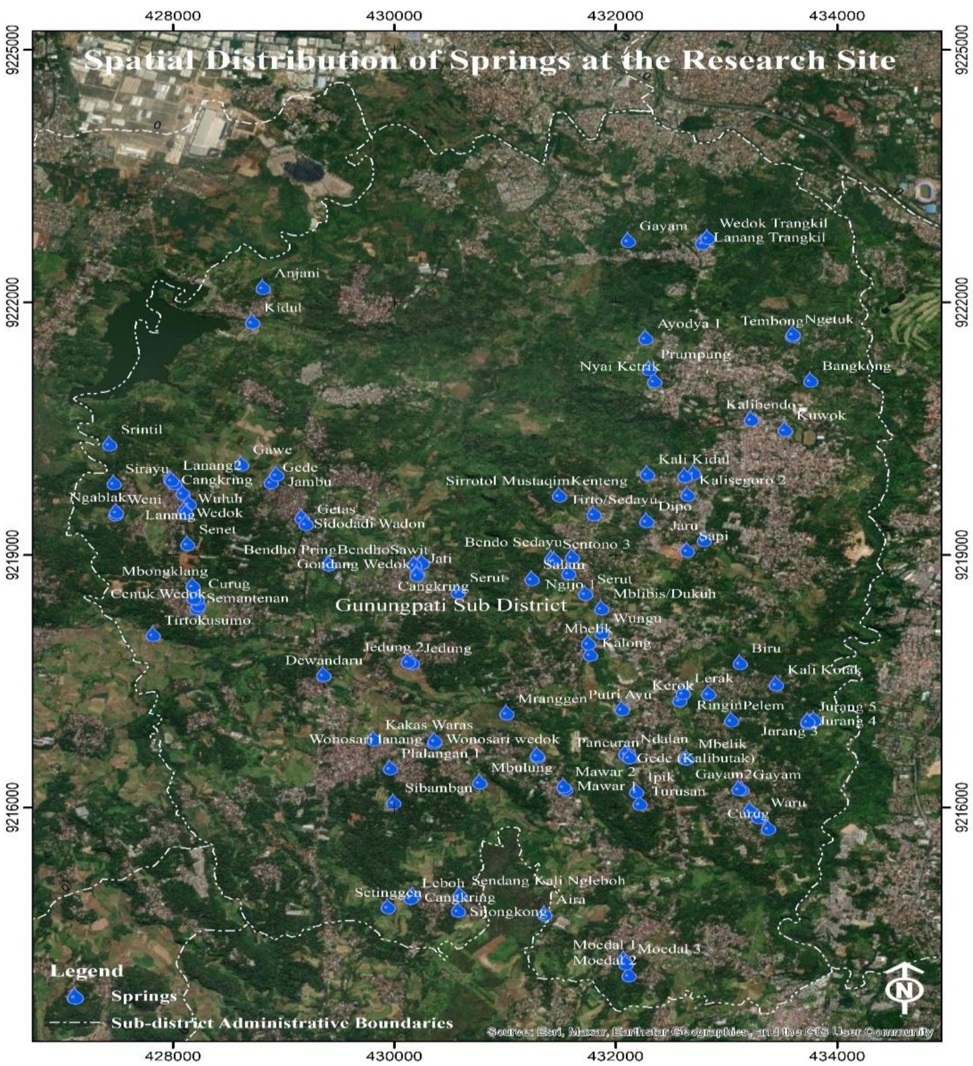


Figure 7. Spatial distribution of springs

The field survey activities also aim to obtain the physical condition of each spring, including the discharge measured by a current meter, pH measured by a pH meter, and the turbidity level from the field. The results of debit measurements obtained 5% of springs with a relatively large discharge above 10 liters/second, including Mbibis, Bangkong, Moedal 2, and Tembong spring. The Moedal 2 spring has a very large discharge and is one of the main sources of PDAM Tirta Moedal Semarang City. The discharge from these springs is relatively consistent for the whole year. As for the water temperature ranges from 26-29°C, while the pH ranges from 5-7, where several springs have a low value of less than 6. These include the Ngetuk ai, Nyai Ketrik, Kalisegoro 1, Jaru, Mbelik and Kalisegoro spring 2. Spring water with a pH below 6 is not recommended to be consumed by residents (Othman et al., 2013; Suryaputra et al., 2021). The next physical parameter is the turbidity level, where most of the springs have clear water (70%) and a small part (8%) that has relatively turbid water. Residents have mostly used Spring water with clear water to meet household needs and drinking water sources, such as Gede spring in Kandri Village and Bahurekso spring in Pakintelan village. The clarity of the spring is affected by the condition of the surrounding vegetation (Ansari et al., 2021; Pei et al., 2022; Krogh & Pomeroy, 2019). The Table 3 presents the results of measurements of pH, temperature and turbidity of the springs.

Table 3. The results of measurements about pH, temperature, and turbidity of the springs

No	Springs	Debit (liter/second)	Temperature (°C)	pH	Turbidity
1	Mblibis	11.04	28	6.5	Moderate
2	Nyai Ketrik	-	28	5.5	Clear
3	Tembong	56.70	27	6.5	Clear
4	Ngetuk	9.04	27	5.0	Clear
5	Persen 3	3.53	27	6.5	Clear
6	Ayodya 1	11.20	31	6.5	Clear
7	Bangkong	42.90	27	6.5	Clear
8	Dungrancak/Sekargading	6.00	27	6.5	Clear
9	Jaru	-	26	6.0	Clear
10	Kali Kidul	1.68	27	6.5	Moderate
11	Sapi	0.48	28	6.0	Cloudy
12	Kalisegoro 1	4.00	26	5.5	Moderate
13	Bendo Sedayu	0.72	28	7.0	Moderate
14	Sentono Wadon	0.49	27	7.0	Clear
15	Sentono 3	1.76	27	7.0	Clear
16	Sentono Lanang	1.08	28	6.5	Clear
17	Salam	0.50	29	6.5	Cloudy
18	Prumpung	0.64	29	7.0	Clear
19	Kalong	-	27	6.5	Cloudy
20	Ngijo 1	0.36	26	6.5	Moderate
21	Serut	-	29	6.5	Moderate
22	Mbelik	-	27	6.0	Cloudy
23	Kalisegoro 2	0.03	27	6.0	Cloudy
24	Putri Ayu	5.16	27	6.5	Moderate
25	Ndalan/Lanang	0.98	27	6.5	Moderate
26	Gede (Kalibutak)	-	27	6.5	Moderate
27	Pancuran	0.77	26	7.0	Clear
28	Turusan	0.79	26	6.5	Clear
29	Ipik	0.13	26	6.5	Clear

30	Mawar 1	1.04	26	6.5	Clear
31	Mawar 2	0.11	26	6.5	Cloudy
32	Sidodadi Wadon	1.50	25	7.0	Clear
33	Sidodadi Lanang	28.26	27	7.0	Clear
34	Gede	0.94	26	7.0	Clear
35	Jambu	0.50	26	7.0	Clear
36	Getas	-	27	6.5	Cloudy
37	Gondang	0.52	29	6.5	Moderate
38	Gondang Lanang	0.02	27	6.5	Moderate
39	Sawit/Cilik	0.02	27	6.5	Clear
40	Bendho	1.80	27	7.0	Clear
41	Wedok Domili	4.64	27	6.5	Clear
42	Lanang Domili	2.16	27	6.5	Clear
43	Jati	-	28	6.5	Cloudy
44	Cangkring	0.24	27	6.5	Clear
45	Serut	0.64	27	7.0	Moderate
46	Cenuk Wedok	1.14	27	6.5	Clear
47	Cenuk Lanang	-	-	-	-
48	Semantenan	0.70	27	7.0	Moderate
49	Curug	1.68	27	6.5	Moderate
50	Kalipandan wedok	-	-	-	Moderate
51	Mbongklang	0.08	27	6.5	Moderate
52	Tirtokusumo	-	27	6.5	Clear
53	Srintil	0.45	26	6.5	Clear
54	Sumbersari	-	26	6.5	Moderate
55	Lanang	0.14	27	6.5	Moderate
56	Wedok	0.11	27	6.5	Clear
57	Wuluh	0.32	27	6.5	Clear
58	Weni	2.48	27	6.5	Clear
59	Senet	0.18	26	7.0	Clear
60	Ngablak	0.07	27	7.0	Currently
61	Sirayu	1.35	27	7.0	Clear
62	Indulsari	0.33	26	7.0	Clear
63	Cangkring	0.03	27	7.0	Clear
64	Lanang 2	0.14	29	7.0	Clear
65	Kali Kotak	-	26	7.0	Cloudy
66	Biru	0.45	26	7.0	Clear
67	Pelem	0.03	26	7.0	Clear
68	Kerok	0.02	26	7.0	Clear
69	Bulungan	0.42	26	7.0	Clear
70	Ringin	0.04	29	7.0	Clear
71	Waru	0.05	27	7.0	Moderate
72	Curug	0.09	27	7.0	Moderate
73	Gayam	0.19	27	6.5	Moderate
74	Gayam 2	-	26	7.0	Clear
75	Mbelik	-	-	-	-
76	Moedal 1	-	-	-	-

77	Moedal 2	13.70	-	-	-
78	Moedal 3	-	-	-	-
79	Aira	-	25	7.0	Moderate
80	Plalangan 1	3.60	27	7.0	Cloudy
81	Sibamban	-	28	7.0	Clear
82	Cangkring	-	28	7.0	Cloudy
83	Leboh	0.56	28	7.0	Clear
84	Sendang Kali Ngleboh	0.71	27	6.5	Clear
85	Sijongkong	0.27	27	7.0	Clear
86	Mbulung	3.10	27	7.0	Clear
87	Wonosari lanang	0.04	27	7.0	Clear
88	Wonosari wedok	0.89	28	6.5	Clear
89	Kakas Waras	4.01	27	7.0	Clear
90	Setinggen	0.67	28	7.0	Clear
91	Lanang Trangkil	3.41	26	7.0	Clear
92	Wedok Trangkil	3.45	27	6.5	Clear
93	Dipo	2.20	27	7.0	Clear
94	Kenteng	0.96	27	7.0	Clear
95	Tirto/Sedayu	-	-	-	-
96	Gawe	2.00	28	7.0	Moderate
97	Kidul	0.75	28	7.0	Clear
98	Anjani	0.02	27	7.0	Moderate
99	Mranggen	-	28	7.0	Clear
100	Wungu	-	28	6.5	Cloudy
101	Bendho Pring	-	-	-	-
102	Jedung	0.18	26	6.5	Cloudy
103	Kuwok	2.00	28	7.0	Clear
104	Kalibendo	4.99	28	7.0	Clear
105	Dewandaru	0.47	28	7.0	Clear
106	Sirrotol Mustaqim	0.31	26	7.0	Clear
107	Gayam	-	27	7.0	Clear
108	Jurang 1	0.84	28	7.0	Clear
109	Jurang 2	4.93	28	7.0	Clear
110	Jurang 3	3.50	29	7.0	Clear
111	Jurang 4	0.39	28	7.0	Clear
112	Jurang 5	0.70	28	7.0	Clear
113	Lerak	-	28	7.0	Cloudy
114	Jedung 2	0.75	28	7.0	Clear

Figure 8. Condition and measurement of physical parameters of springs
(Source: Ground check, 2021)

3.3 Land Use Changes to Spring Conditions

Land use change at the research site in 2016 - 2021 showed a significant increase in built-up land, whereas, for settlements, there was an increase of 77.25 hectares, and commercial service buildings increased by 178.79 hectares. One of the land uses that are converted into built-up land is a mixed garden/vegetation of 50.57 hectares, with a potential area of rainwater infiltration that can increase the quantity and quality of groundwater. Therefore, when the vegetation area is converted into built-up land, it will have an impact on reducing the water supply in the soil (Suryaputra et al., 2021; Lo et al., 2021). The impact of this phenomenon can be seen in the non-production of several springs. The results of field surveys showed that 21 springs have not issued discharges.

Based on the observations in the field, there are several springs around residential areas with damaged and unkempt conditions. Therefore, residents no longer use them because the discharge is small. The water quality is not good, such as Kalikotak, Semantenan, and Indulsari springs, which located in Pakintelan, Cepoko, and Jatirejo Villages, respectively. Several springs are threatened due to the development of settlements, such as Curug, Kalipandan Wedok, Kelicenuk Pria, and Kalicenuk Wanita springs in Cepoko Village. The existence is threatened due to the clearing of residential land. In general, springs located around residential areas will continue to be threatened because they do not have a good water catchment area to support groundwater and also various activities of residents, such as throwing garbage to make the spring water dirty (Masitoh & Rusydi, 2020; Lo et al., 2021). Therefore, public awareness is needed to maintain environmental sustainability by not converting massive land use changes, and stricter regulations are needed to preserve springs at the research site (Hermanto & Nugroho, 2021; Angi et al., 2021).

4. Conclusion

This study showed that there is a change in land use from 2016 – 2021. This is indicated by an increase in the area of settlements and commercial service buildings by around 77.25 hectares and 78.79 hectares, respectively, and also a decrease in agricultural land and mixed gardens/vegetation area of 207.01 hectares and 50.57 hectares. Furthermore, there are 114 springs in the research location, of which 5% have relatively large discharges above 10 liters/second, including Mbibis (Dusun), Bangkong, Moedal 2, and Tembong springs, while the other 47% have a small discharge. Most of the physical conditions of the springs are still relatively good. Changes in land use from flying land vegetation impact the reduced air supply in the soil. The impact of this phenomenon has been seen by the non-production of several springs, where the survey results showed that 21 springs have not issued a discharge, hence, residents no longer use them.

Conflicts of Interest

The authors declare no conflict of interest.

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