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Original Article

Vegetation Density Change Due to Landslides in Sadu Village, Soreang Subdistrict, Bandung Regency

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Abstract. *The landslide that occurred in Sadu Village, Soreang Subdistric, Bandung Regency, West Java resulted changes density of vegetation on the last 3 years, that is on year 2019-2022. Analysis change land use employ Landsat 8-Oli imagery done for identify wide change land use occurring in the region cases study based on multitemporal data as well as land area data obtained. This research aims for analyze change in vegetation density to change land use in Sadu Village on 2019-2022. As for this research processing Landsat 8 image data interpretation with using the NDVI (Normalized Difference Vegetation Index) method. Test accuracy image in this study used for look accuracy classified image and field data. The results that is, research Accuracy Test Landsat image classification land use obtain results by 90 % (2019) and 86.6 % (2022) and study related to the results of changes in land use in 2019 and 2022 which showed that there was a change in vegetation to non-vegetation in the form of built-up land of 16 Ha, then the results of changes in vegetation density in the results for 2019 and 2022 show that the density of quite dense vegetation has increased by 78 Ha and the dense vegetation category has decreased by 88 Ha. It shows that exists change use occurring land on three year final form land area forest to agricultural land and built-up land, apart from that there was an avalanche disaster which reduced the denser vegetation area because it was eroded by the avalanche*.

Keywords: Landsat Imagery, Land Use, Vegetation Density

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1. Introduction

Change land use is something thing that has character dynamic along with growth quality and quantity the human. Change land use occurring in the region development high population like city needed in depth monitoring of order conversions occurring land could controlled to use minimize impact social economy and environment. Thapa & Bahuguna (2021) concludes that change land use or land cover show change generated environment by consequence anthropogenic and natural. However, factor the most decisive change use as well as land cover and size until pattern is growth resident, which is dynamic and sustainable. Use occurring land in line with the more increasing increase total later residents impact on need to more land high. Effort monitoring related change land use needed information as well as data from land use the from period time to time.

Enhancement total resident is wrong one problem that becomes reason lack of room in a region. This thing happened because no evenly spread population and growth residents in the region. Growth continuing residents increases, as well activity development in various field will cause increasing need land. This will later encourage the conversion of green vegetation into non-green vegetation. In general, the biggest factor in speed controller and pattern change land use is primarily human depends on characteristics social, economic and political them (Alam et al., 2020). Development region Sadu village and its surroundings in general no only for development center identical area with drip weight on development non-agricultural only, but also developed becomes center

development trade, education, agriculture and services, the effect makes the vegetation density to low. In general, vegetation density is the percentage of a species of vegetation or plants that live in a certain area. The vegetation index is one of the parameters used to analyze the condition of the vegetation of an area. The index has a variety of algorithm variations. The vegetation index is also an image transformation method based on spectral data that is widely used not only for observing plants but for various other purposes related to vegetation density. One of them is to obtain an overview of the availability of green open space in an area (Wahrudin et al., 2019).

Information as well as sensing data far have very role urgent to use extraction from land use urban. In assessing the development of changes in built-up land using multispectral classification, it aims to classify the land cover of the study area. Image data sensing far like landsat 8 OLI is wrong one frequent image data used in researching about change land use somewhere region. This is because Landsat 8 has the advantages you can do recording region on surface earth with scope more big or more broad, besides that landsat 8 also has temporal, spatial resolution as well as good radiometric, recording on each appearance the topography on the surface earth could distinguished with displayed through color, and each classification or visible identification on surface earth can too distinguished through long the waves that are on Landsat 8 (Aldhshan & Shafri, 2019). Use of image data sensing far like image satellite very support monitoring development in one area. With using image data the We can get change data as well as land use somewhere region with desired coverage where. Muldiana et al. (2016), concluded with use image Landsat 8 for analysis change land use quite valid, this is because the accuracy of the data obtained from image landsat reach 90%. Image data extraction with use classification multispectral like Supervised Maximum Likelihood could minimize error in classification with permanent take into account mark than average as well diversity between class and between channel. Like the research done Chess et al. (2015), concluded that classification supervised maximum likelihood is referring classification on values every pixel the object has categorized as or made on the research sample from each each object land cover. Classification maximum likelihood based on probability that something pixels including in class certain. The purpose of this study is to analyze vegetation density change due to landslides in Sadu Village, Soreang Subdistrict, Bandung Regency. It is hoped that this research can help the government, the community, and future researchers as supporting data for sustainable landslide control.

2. Methods

In this research, use a regional research sample with vegetation density class in Sadu Village, Soreang Subdistrict, Bandung Regency. This research use Landsat 8 image data interpretation method using the NDVI (Normalized Difference Vegetation Index) method. Normalized Difference Vegetation Index (NDVI) is calculation image used for knowing level greenish vegetation. NDVI can shows the related parameters with vegetation, including: biomass foliage green, area foliage green which is value that can be estimated for distribution vegetation. Index give number between -1 and 1 that represents density cover vegetation. kindly general index close to 1, that is vegetation dense and less from zero represents water and clouds. Algorithm in application sensing far for measure level greenish vegetation with utilise wave infrared close and wave red (Putri, Sukmono and Sudarsono, 2018).

With the NDVI method, the research location will be described by the greenness of the vegetation. The research sample points were taken using the area sampling technique to check the level of truth in the distribution of vegetation density in Sadu Village in Landsat 8 imagery for 2019 and 2022 with the distribution of vegetation density in the field using Google Earth Pro. The data analysis technique used in this research uses data analysis techniques with spatio-temporal analysis models, namely analysis techniques using GIS studies or Geographic Information Systems. The spatial and temporal analysis was carried out by using multi-temporal or time data.

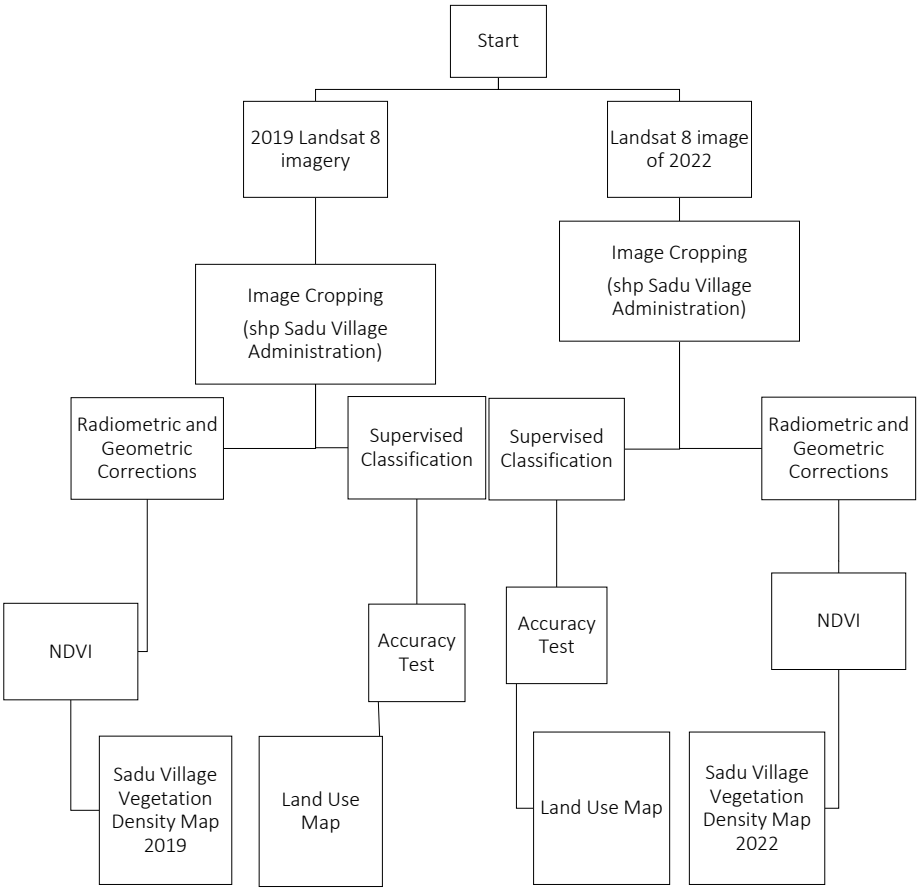

Fig. 1 Data Processing Flowchart

3. Results and Discussion

The research location for changes in vegetation density due to landslides that is in Sadu Village. Geographically, Sadu Village is one of the villages in Soreang Subdistrict, Bandung Regency, West Java. Soreang Subdistrict based on astronomical location, is at latitude or latitude -7.025202 and longitude or longitude 107.5259078.

A. Image Processing

Data collection can be done with image processing steps as follows:

a. Image data source

The image used in this study uses 2 Landsat 8 satellite images with different years. The first image was taken on 09 November 2019 and the second image on 02 August 2022.

b. Image data import

Extract the data that has been downloaded on the USGS site then import the B1-B7 data into the ENVI application.

c. Geometric Correction

Geometric correction is a process to improve the position of the image to match the coordinates in the field. In this geometric correction it is also necessary to pay attention to the RMSE value of less than 1 so that the results are better and successful in making corrections.

d. Radiometric Correction

Radiometric correction is used to correct pixel values that do not match the spectral reflection value of the actual object.

e. Image Cropping

Image cropping is carried out after the correction stage is complete so that image cropping is carried out according to the Sadu Village administrative boundaries.

f. Calculation of Vegetation Index Algorithm

The vegetation index used is NDVI with an algorithm:

$$\mathbf{NDVI} = \frac{\mathbf{NIR} - \mathbf{RED}}{\mathbf{NIR} + \mathbf{RED}}$$

Explanation:
NDVI = Normalized Difference Vegetation Index
NIR = Near Infrared Bands (Band 4)
Red = Band Red (Band 3)

The NDVI Landsat Image Processing results are then classified into 5 classes of vegetation density. The classification method used is supervised classification. With a range of NDVI values as follows:

Table 1
The Range Of NDVI Values In The Study Area

Classification of Vegetation Density	NDVI Value Range	Classification of Vegetation Density Type of Land Use
Cloud	-0.2 to -0	Not Water-Vegetated, Clouds
No Vegetation	- up to 0.21	Trade Center, Industrial Area, Dense Settlement
Sparse Vegetation	0.21 to 0.42	Settlements, Football Fields, Vacant Land
Moderate Vegetation	0.42 to 0.63	Fields, Shrubs, Plants
Dense Vegetation	0.63 to 85	Forest

Source: NDVI Classification in Sunaryo & Iqmi 2015.

g. Image Classification

Image classification is done by dividing the image classification into 5 classes namely Cloud, Non Vegetation, Not Dense, Fairly Dense, Dense.

h. Accuracy Test

ccuracy test is carried out to test the classification results with a certain accuracy. Accuracy test is carried out to test the classification results with a certain accuracy. The accuracy test carried out in this study is to use an error matrix table. The matrix test carried out is to compare the two data obtained from the sample points that have been classified with the sample points using Google Earth Pro. Test accuracy for test results classification multispectral on image sensing far currently a lot apply method with using independent data, and calculations accuracy consider side map generator (producer's accuracy) and sides map user (user's accuracy). Accuracy producer obtained from results for total that pixel classified in a manner Correct for each category with total pixels on each training set. Accuracy counted with share total classified pixels in a manner Correct for each category with total whole classified pixels on that category (Lillesand et al., 2015). Whereas accuracy whole obtained with share total whole classified pixels in a manner Correct with total whole pixels reference.

B. Sample Accuracy Test Results on 2019

In this study, 30 sample points were used for the entire research area which included 3 land uses, namely (Settlements, Rice Fields and Forests) with the results of the sample accuracy test in table 2 and a map for 2019 as follows:

Table 2
Sample Accuracy Test on 2019

Field Category	Category Interpretation Results			Row totals
	Ricefield	Built up Land	Forest	
Ricefield	8	2	-	10
Built up Land	-	10	-	10
Forest	1	-	9	10
Column Totals	10	11	9	30

Mapping Accuracy				Accuracy of Interpretation Results
Producer's Accuracy	Error Omission	User Accuracy	Error Omission	
8/10=80%	20%	8/10=80%	20%	(8+10+9)/30=90%
10/11=90.909%	9.10%	10/10=100%	0%	
9/9=100%	0	9/10=90%	10%	

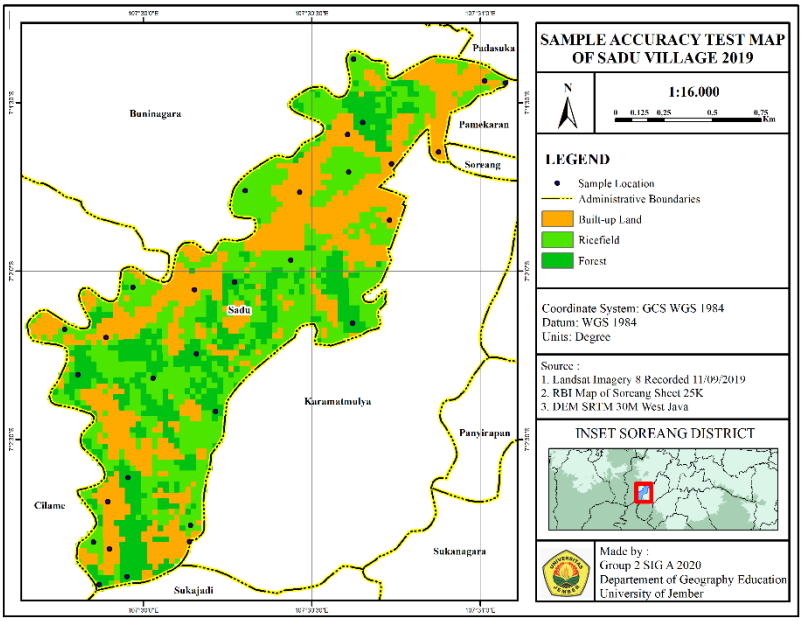

Fig. 2 Sample AccuracyTest Map on 2019

Test accuracy results classification density vegetation due to the landslide disaster in Sadu Village for knowing level accuracy results classification image with reality actually on the ground. Table 2 shows from 30 point taking sample in the field produce overall average accuracy/overal accuracy of 90%. Overall accuracy is calculated sum of the diagonals divided with point totals observation (8+10+9)/30x100%=90%. More he explained served in Table 2 above, based on the results of the accuracy test performed using 30 samples test obtained accuracy as big 90% on the 2019 sample suitability test map in Sadu Village, Soreang Subdistrict, Bandung Regency. The largest field category in 2019 was built up land, thus showing a high category of interpretation results. Based on results test accuracy interpretation value is obtained accuracy for whole sample is by 90% so results interpretation image and field accuracy about density vegetation could accepted because level accuracy expected interpretation is as big 85% meanwhile results test accuracy get value 90%. From the results test classification land suitability accuracy mapping lowest that is on rice fields that have mark accuracy 80%, meanwhile mark highest there is on forest that has mark 100% accuracy. Accuracy whole results classification (Overall Accuracy) of 90%.

C. Sample Accuracy Test Results on 2022

In this research, 30 sample points were used for the entire research area which included 3 land uses, namely Settlements, Rice Fields, and Forests with the results of the sample accuracy test in the form of table 3 and a map for 2022 as follows:

Table 3
Sample Accuracy Test on 2022

Field Category	Category Interpretation Results			Row totals
	Ricefield	Built up Land	Forest	
Ricefield	9	1	-	10
Built up Land	-	10	-	10
Forest	3	-	7	10
Column Totals	12	11	7	30

Mapping Accuracy				Accuracy of Interpretation Results
Producer's Accuracy	Error Omission	User Accuracy	Error Omission	
9/12=75%	25%	9/10=90%	10%	(9+10+7)/30=86.6%
10/11=90.909%	9.10%	10/10=100%	0%	
7/7=100%	0	7/10=70%	30%	

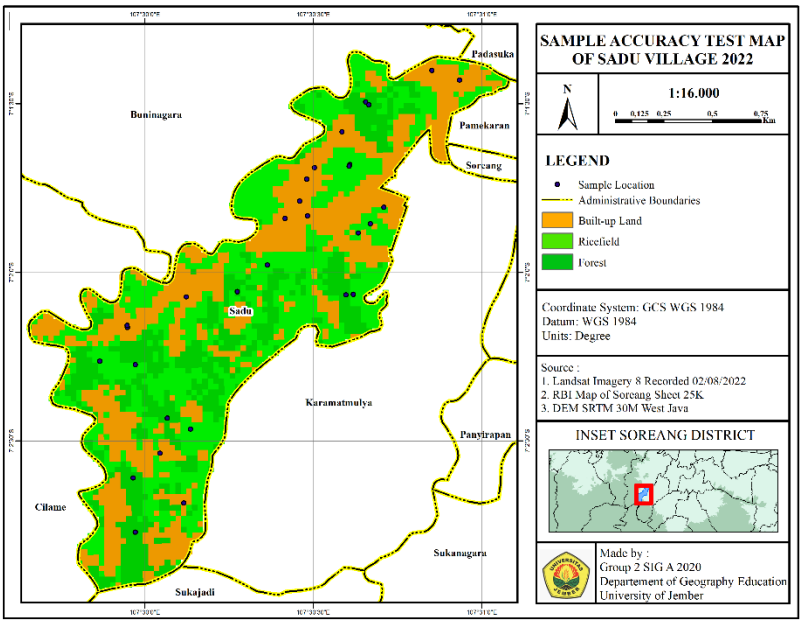

Fig. 3 Sample Accuracy Test Map on 2022

Next is the sample suitability test in Sadu Village, table 3 it shows that from 30 sampling points in the field it produces an overall average accuracy of 86.6%. Overall accuracy is calculated by the sum of the diagonals divided by the total observation points (9+10+7)/30x100%=86.6%. More details are presented in table 3 above, based on the results of the accuracy test carried out using 30 test samples, an accuracy of 86.6% was obtained on 2022 sample suitability test map in Sadu Village, Soreang Subdistrict, Bandung Regency. The largest field category in 2022 is built up land, thus showing a high category of interpretation results. From the test results land suitability classification the lowest mapping accuracy is in rice fields which have an accuracy value of 75%, while the highest value is found in forests which have an accuracy value of 100%. The accuracy of all classification results (Overall Accuracy) is 86.6%.

D. Land Use Results and Anal0ysis on 2019

The 2019 land use map was obtained from the results of supervised classification in Envi 4.5 and then processed using ArcMap to be digitized so that the area of each land use was obtained. The following is a table of the results of the land use area of Sadu Village in 2019.

Table 4
Land Use Area on 2019

No.	Type Land Use	Area (Ha)	Percentage (%)
1.	Ricefield	107	41.63
2.	Forest	55	21,4
3.	Settlement	95	36.97
	Amount	257	100.00

Sadu Village is wrong one village affected by the landslide disaster in Soreang Subdistrict, Bandung Regency. Table 4 shows the results land use shows that obtained results as following, type land in rice field classification 107 Ha or 41.63%, an area of forest 55 Ha or 2 1.4%, and settlements wide 95 Ha or 36.97%, with the total area of land use in Sadu Village on 2019 is 257 Ha. region Sadu village is dominated by paddy fields, this is because the Sadu Village area is far from the center of government, so that the land is still widely used for paddy fields. Figure 4 shows the land use map of Sadu Village on 2019.

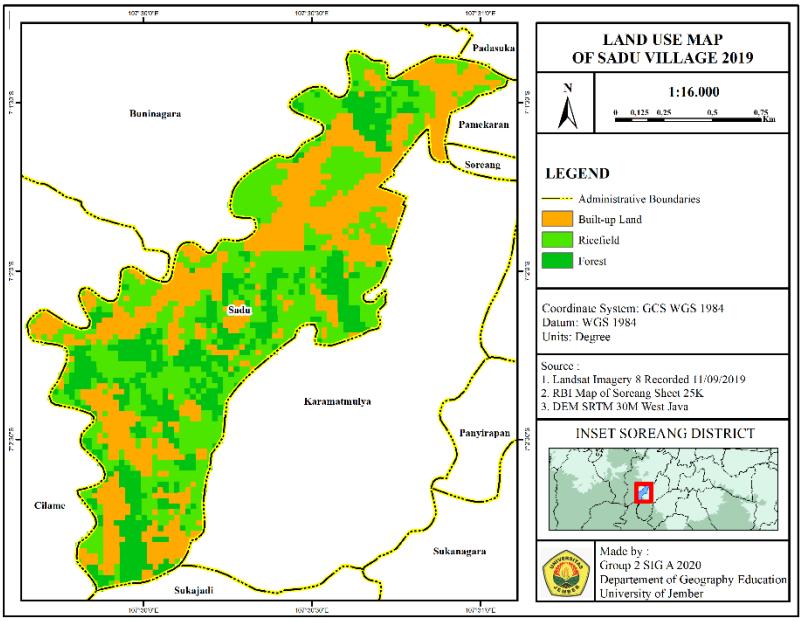

Fig. 4 Sadu Village Land Use Map on 2019

The map above is the 2019 Sadu Village Land Use Map, the map above can be analyzed based on the legend, there are village administrative boundaries, built up land, forests and rice fields. In the north we can find a lot of built up land. In addition, the distribution of rice fields is still evenly distributed in the Sadu Village area. Forest land is also very spread out

E. Land Use Results and Analysis on 2022

The map of land use on 2022 is obtained from the results of supervised classification in Envi 4.5 and then processed using ArcMap to be digitized so that the area of each land use is obtained.

Table 5
Land Use Area on 2022

No.	Type Land Use	Area (Ha)	Percentage (%)
1.	Ricefield	139	54, 09
2.	Forest	39	15,11
3.	Settlement	79	30, 74
	Amount	257	100.00

Table 5 shows the results land use of Sadu Village on 2022 where obtained results as following, type land in rice field classification 139 Ha or 54.09%, an area of forest 39 Ha or 15.11%, and settlements wide 79 Ha or 30.74%, with the total area of total land use in Sadu Village on 2022 is 25.8 Ha. Figure 5 shows the oeta of land use in Sadu Village on 2022.

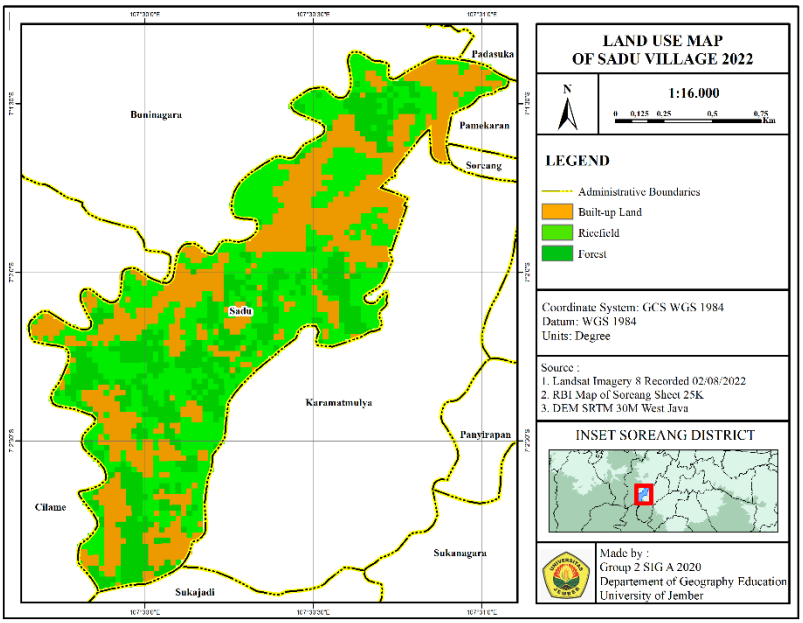

Fig. 5 Land Use Map of Sadu Village on 2022

Next, the results of the 2022 Sadu Village Land Use Map, as the previous map on 2019. Based on the image above, we can observe that the distribution of settlements in Sadu Village on 2022 has not changed much. From this description, we can observe that the built up land in Sadu Village is spread out in the northern part. It's just that the distribution of rice fields on 2022 is wider as well as the forest area is also getting smaller. This could have occurred due to many underlying factors, as increasing population growth rates so that there is a lot of need for residential land.

F. Results and Analysis of Land Use Change on 2019-2022

Table 6

Changes in Land Use Area on 2019-2022

No.	Type Use Land	Area (Ha) 2019	Area (Ha) 2022	Change	
				Increase	Reduce
1	Ricefield	107	139	32	
2	Forest	55	39		16
3	Settlement	95	79		16
	Amount	257	257	32	32

The processing resultsin Table 6, results and Analysis of Changes in Land Use for 2019-2022 show that there are types of land use, paddy fields, forests, and settlements. In the table for 2019, the types of land use are 107 Ha of paddy fields, 55 Ha of forest, and 95 Ha of settlements. The total area of land use on 2019 is 257 Ha. Whereas on 2022, there will be several changes in the type of land use including 139 Ha of rice fields, 39 Ha of forest, and 79 Ha of settlements. The total area of land use on 2022 is 257 Ha. In this case we can conclude that in the span of three years there has enough change in the area of land use in Sadu Village. The increase in the area of land use is found in the type of paddy field land use of 33 Ha, while in forests and settlements there is a reduction of 16 Ha for each type of land use

G. Results and Analysis of Vegetation Density on 2019

The results of image processing to identify vegetation density using the NDVI transformation are obtained in table 7, where it is listed in the vegetation density table in Sadu Village on 2019 with a fairly high vegetation density.

Table 7
NDVI Area on 2019

No.	Information	Area (Ha)	Percentage (%)
1.	Non-Vegetation	9	3,5
2.	Sparse Vegetation	69	26.85
3.	Moderate Vegetation	87	33.85
4.	Dense Vegetation	92	35,8
	Amount	257	100.00

Furthermore, regarding the level of vegetation density which is quite high in Sadu Village on 2019 which has been transformed using NDVI obtained various levels, namely non-vegetation with an area of 9 Ha, Sparse vegetation with an area of 69 Ha, moderate vegetation 87 Ha, dense vegetation 92 Ha with a total of 257 Ha. This can be seen in the NDVI classification results map in Figure 6 it is dominated by dark green with a value of 92 Ha, belonging to a high density level.

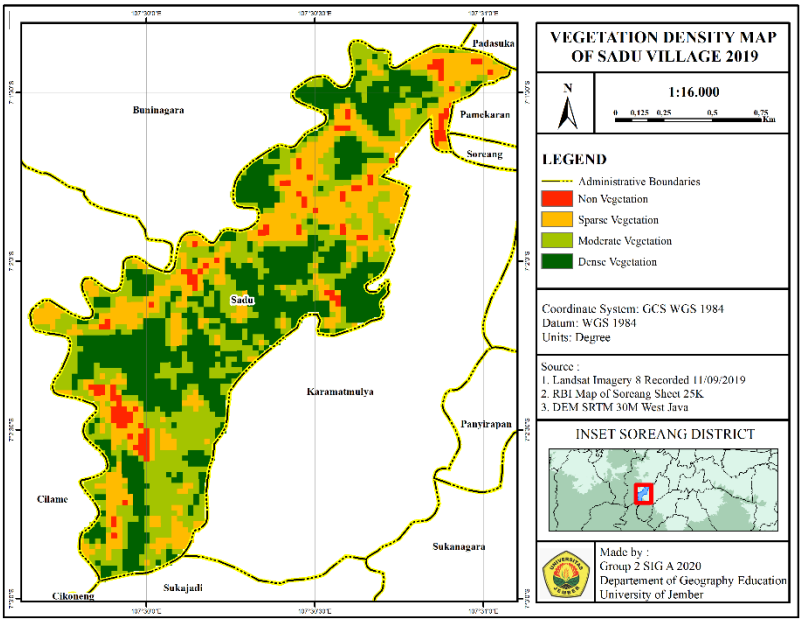

Fig. 6 Sadu Village Vegetation Density Map on 2019

Level density tall vegetation could is known based on Sadu Village NDVI classification map results on 2019. Visible that on the map more dominated by color green old included on land forest with density vegetation high, visible spread vegetation still including on sufficient spread equally on every area in the Sadu Village. On the map with color green young could categorized as as land paddy field, where on 2019 land rice fields still no many but its spread enough evenly. Non vegetation land could categorized as as land awakened like settlement, where no enough many land awakened on 2019 with region that is not have level density vegetation in build up land area.

H. Results and Analysis of Vegetation Density on 2022

Table 8.
NDVI Area on 2022

No.	Information	Area (Ha)	Percentage (%)
1.	Non-Vegetation	1	0.39
2.	Sparse Vegetation	87	33.85
3.	Moderate Vegetation	165	64.2
4.	Dense Vegetation	4	1.56
	Amount	257	100

Furthermore, regarding the level of vegetation density which is quite dense in Sadu Village on 2022 which has been transformed using NDVI obtained various levels, namely non-vegetation with an area of 1 Ha, sparese vegetation with an area of 87 Ha, moderate vegetation 165 Ha, dense vegetation 4 Ha, with a total of 257 Ha. This can be seen in the NDVI classification results map in figure 7 dominated by light green with a value of 165 Ha, belonging to a fairly high density level, and a quite different comparison on 2019.

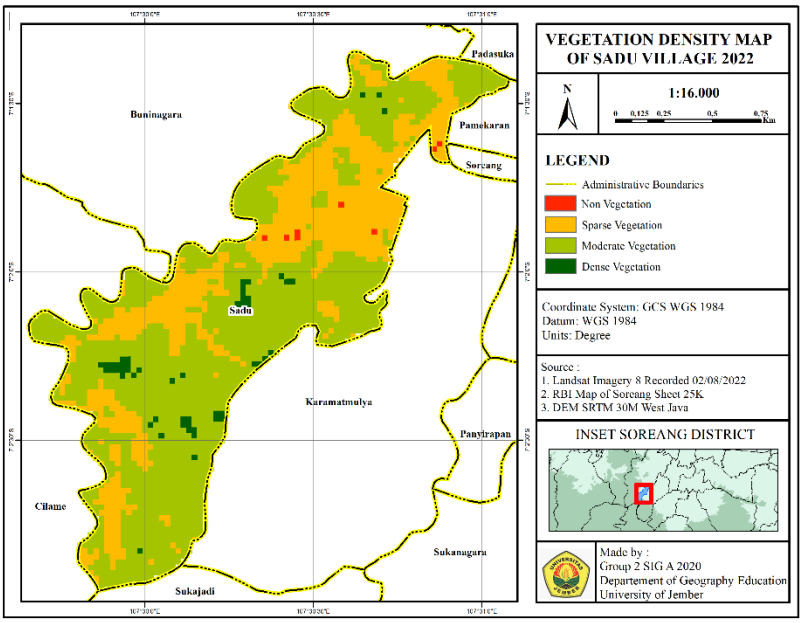

Fig. 7 Sadu Village Vegetation Density Map on 2022

Level density tall vegetation could is known based on Sadu Village NDVI classification map results on 2022. Visible that on the map more dominated by color green youth included on land rice fields with density vegetation dense enough, see spread vegetation on land rice fields still including on sufficient spread equally on every area in the Sadu Village. On the map with color green old could categorized as as land forest, where on 2022 land forest no many with level spread no equally only on part lower just. Non vegetation land could categorized as land awakened like settlement, where enough many land awakened on 2022 with region that is not have level density vegetation on build up land area.

I. Results and Analysis of Changes in Vegetation Density on 2019-2022

Table 9.
Area of Change in Vegetation Density on 2019-2022

No.	Information	Area (Ha) 2019	Area (Ha) 2022	Change (Ha)	
				Increase	Reduce
1	Non-Vegetation	9	1	-	8
2	Sparse Vegetation	69	87	18	-
3	Moderate Vegetation	87	165	78	-
4	Dense Vegetation	92	4	-	88
	Amount	257	257	96	96

Based on results analysis change density vegetation on 2019 and 2022 got classified on Table 9. Got is known ratio density with two different year that is on non vegetation have change with reduced by 8 Ha, sparse vegetation plus 18 Ha, moderate vegetation increased by 78 Ha, and level density vegetation reduced by 88 Ha. Level density vegetation experience change on 2022, this is due by factor change land vegetation becomes build up land even rice fields land, so that will result decrease level density vegetation like on 2019

4. Conclusion

Change land use based on extraction image landsat 8-OLI in Sadu Village, Soreang Subdistrict, Bandung Regency is classified becomes 3 class land use that is built up land, ricefields and forests. Class land use with change area the most is ricefield land with a total increase in area of use the land wide 39 Ha of wide use of ricefields on 2019 in Sadu Village. Results the show that there is exists change land use in the form of a forest become agricultural land that causes agricultural land the more tall whereas land forest the more reduced. Change build up land which also increases influenced by enhancement total the population in Sadu Village is increasing at the same time the occurrence of a landslide disaster in Sadu Village which then eroded some of the vegetation area. Changes in vegetation density on 2019-2022 in Sadu Village. The biggest change in area is the high level of vegetation density reduced by 88 Ha. Level density vegetation experience change on 2022, this is due by factor change land vegetation in the form of predominantly forest turned into land rice fields, so that will result decrease level density vegetation on 2019.

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References

Alam, A., Bhat, M. S., & Maheen, M. (2020). Using Landsat satellite data for assessing the land use and land cover change in Kashmir valley. *GeoJournal*, *85*, 1529-1543.. https://link.springer.com/article/10.1007/s10708-019-10037-x

Aldhshan, S. R., & Shafri, H. Z. M. (2019). Change detection on land use/land cover and land surface temperature using spatiotemporal data of Landsat: a case study of Gaza Strip. *Arabian Journal of Geosciences*, *12*, 1-14. https://link.springer.com/article/10.1007/s12517-019-4597-4

Bashit, N., Prasetyo, Y., & Suprayogi, A. (2019). Klasifikasi Berbasis Objek untuk Pemetaan Penggunaan Lahan menggunakan Citra SPOT 5 di Kecamatan Ngaglik. TEKNIK, 40(2), 122-128. https://ejournal.undip.ac.id/index.php/teknik/article/view/23050

Catur, U., Susanto, S., Yudhatama, D., & Mukhoriyah, M. (2015). Identifikasi Lahan Tambang

FADILAH, S. R. (2018). Ekstraksi Data Kedalaman Menggunakan Data Citra Landsat-8. Jurnal Online Mahasiswa (JOM) Bidang Teknik Geodesi, 1(1).

Mahdiyyah, N. D. (2019). Dampak pertumbuhan penduduk terhadap alih fungsi lahan pertanian di Kabupaten Cirebon tahun 2010-2016. REKA GEOMATIKA, 2019(1). https://ejurnal.itenas.ac.id/index.php/rekageomatika/article/view/3706

Muldiana, A. (2016). Pemanfaatan Citra Landsat Untuk Analisis Penggunaan Lahan Di Kabupaten Garut Jawa Barat (Doctoral dissertation, Universitas Indonesia).

Putri, D. R., Sukmono, A., & Sudarsono, B. (2018). Analisis Kombinasi Citra Sentinel-1a dan Citra Sentinel-2a untuk Klasifikasi Tutupan Lahan (Studi Kasus: Kabupaten Demak, Jawa Tengah). Jurnal geodesi undip, 7(2), 85-96. https://ejournal3.undip.ac.id/index.php/geodesi/article/view/20660

Rebo, P., & Timur, K. J. (2015). Identifikasi Lahan Tambang Timah Menggunakan Metode Klasifikasi Terbimbing Maximum Likelihood Pada Citra Landsat 8 https://core.ac.uk/download/pdf/291853643.pdf

Susanti, Y., Syafrudin, S., & Helmi, M. (2020). Analisa Perubahan Penggunaan Lahan Di Daerah Aliran Sungai Serayu Hulu Dengan Pengginderaan Jauh dan Sistem Informasi Geografis. In Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning (Vol. 16, No. 1, p. 265). https://jurnal.uns.ac.id/prosbi/article/view/38366

Susanti, Y., Syafrudin., & Helmi, (2019) MAnalisa Perubahan Penggunaan Lahan Di Daerah Aliran Sungai Serayu Hulu Dengan Pengginderaan Jauh dan Sistem Informasi Geografis. *Jurnal Pendidikan Biologi*. 13(1), 23-30.

Thapa, R., & Bahuguna, V. (2021). Monitoring Land Encroachment and Land Use & Land Cover (LULC) Change in The Pachhua Dun, Dehradun District Using Landsat Images 1989 and 2020. JGISE: Journal of Geospatial Information Science and Engineering, 4(1), 71-80. https://jurnal.ugm.ac.id/jgise/article/view/64857

Wahrudin, U., Atikah, S., Al Habibah, A., Paramita, Q. P., Tampubolon, H., Sugandi, D., & Ridwana, R. (2019). Pemanfaatan Citra Landsat 8 untuk identifikasi sebaran kerapatan vegetasi di Pangandaran. Geodika: Jurnal Kajian Ilmu dan Pendidikan Geografi, 3(2), 90-101. https://www.academia.edu/download/74338581/pdf_18.pd