Jurnal Pengabdian Magister Pendidikan IPA

Original Research Paper

Study of Land Use Change Map in the Irrigation Areas of Gebong and Sesaot, West Lombok Regency

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DOI : https://doi.org/10.29303/jpmpi.v6i4.6259
Sitasi: Suripto., Sugiarta, L. A., Anggraeni, J. D., & Jupri. (2023). Study of Land Use Change Map in the Irrigation Areas of Gebong and Sesaot, West Lombok Regency. *Jurnal Pengabdian Magister Pendidikan IPA*, 6(4)

Article history
Received: 27 Agustus 2023
Revised: 10 November 2023
Accepted: 20 November 2023

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Abstract: The conversion of an area's land cover can provide social and economic benefits for the area but also often has important impacts on the environment. Thus, knowledge and skills in reading land cover change maps from satellite images are very important for Environmental Science students. Work practice for students of the Mataram University Environmental Studies Program was carried out at the West Lombok PUPR Service with the aim of increasing knowledge and skills about reading, analyzing and interpreting land cover change maps through geographic information systems, especially for the irrigation areas of Gebong and Sesaot, West Lombok. Work practice was carried out using lecture, simulations, and practice with assistance methods The results show that participant was proficient in reading, analyzing and interpreting land cover change maps using both the maxilum likelihood method and the manual digitization method. From the results of work practices using the maximum likelihood and manual digitization method, it was known that in the Gebong irrigation area from 2018 to 2023 there will be a reduction in the area of 3% (3%) of paddy fields, 1% (4%) of vegetated land, and an increase of 3 (8%) of built-up land. In the Sesaot irrigation area, there was a reduction in the area of vegetated land by 10% (6%), an increase in the area of rice fields by 8% (3%), and built-up land by 2% (2%). It had been confirmed that the built-up land in the two irrigation areas consists of residential and industrial lands.

Keywords: Irrigation areas, land use map, manual digitization and maximum likelihood methods

Introduction

Land is a very vital natural resource for humans. Changes in land use can be caused by factors such as population growth, regional expansion or development. West Lombok Regency with an area of 923.06 km2 has 10 sub-districts and its population in 2020 was 724,744 people, with a density of 808 people/km2 (Darmawan, Puspaningsih & Saleh, 2017). The district continues to experience development and a relatively large increase in population every year, causing land conversion to occur. The existence of land conversion or changes in land cover in irrigation areas can provide social and economic benefits for the region. Converting agricultural land into industrial or residential land can increase income and employment opportunities for local communities. However, besides that, changes in land cover in irrigation areas can have a significant impact on the environment. For example, changing the use of agricultural land to non-agricultural land can reduce the availability of water for irrigation, disrupt natural ecosystems, and reduce agricultural

productivity. Until 2021, the agricultural sector will still support the economy of West Lombok. The contribution from the agricultural sector is the largest compared to 16 other sectors (Darmawan *et al*, 2017; Suripto, Kurniawan, & Mashadi, 2022; Virgota & Farista, 2023).

Irrigation areas are a very strategic agricultural resource. Studying changes in land cover in irrigation areas can help in managing water resources, such as determining the water needs of rice fields, identifying patterns of water percolation and seepage, and calculating soil layer changes. Study of land cover changes in irrigation areas can help in sustainable irrigation planning and management. Knowledge and skills to identify changes in land cover can make it easier to identify potential problems such as decreasing water quality, soil erosion and increasing demand for water, so that appropriate steps can be taken to maintain the sustainability of the irrigation system (Darmawan *et al.*, 2017; Suripto *et al.*, 2022).

Based on the background of the problem above, practical work activities for students of the Environmental Science Study Program at Mataram University were carried out at Dinas PUPR of West Nusa Tenggara Province. The aim of this practical work is to improve skills in reading, analyzing and interpreting land use change maps through the application of a geographic information system, especially for the irrigation areas of Gebong and Sesaot, Regency of West Lombok.

Method

Student practical work activities have been carried out for two months, June-July 2023 at the Public Works and Spatial Planning Departement (Dinas PUPR) of West Nusa Tenggara Province in three stages, namely briefing, practice and reporting.

The briefing stage was carried out using lecture, discussion and simulation methods. The media used were audio-visual tools, whiteboards, computers and internet facilities. The material provided includes searching for regional map data through satellite imagery services, data processing using software programs according to the study objectives, and interpretation of data processing results using the maximum likelihood method and manual digitization method.

The practical stage was carried out using mentoring methods by tutors from Dinas PUPR of West Nusa Tenggara Province and supervisors from Mataram University. The practical material given to participants is as follows:

- Coordination with observers in each irrigation area that is the target of the study;
- Preparation of data on the Gebong and Sesaot irrigation areas of West Lombok from satellite image data regarding administrative area boundaries and environmental variables, such as roads, rivers, non-built land, built-up land and agricultural land. The working guidance is provided in accordance with the modified working method from Adhiatma, Lubis & Widiatmaka (2020), Akbari (2014), Angin & Sunimbar (2021), Nur, Syahreza & Syamsidik. (2021).
- Validate maps from satellite imagery by making direct visits to the field, according to the work method of Awaliyan & Sulistioadi (2018), Arisanto, Artika & Utami (2018), Marlina (2022), Suripto *et al*. (2022) and Virgota & Farista (2023).
- Satellite image data processing was carried out using the ArcGIS 10.8 program. using the maximum likelihood method and manual digitization method as a comparison to determine the occurrence of land conversion. Guidance was provided according to the working methods of Arifin, Hakim, Indarto and Mandala (2020), Indarto, Nadzirah and Belagama (2020) and Putri, Sudarsono and Sukmono (2018). Land change analysis was carried out on Sentinel 2A image data in 2018 and 2023. Guidance was provided in accordance with the work method of Adhiatma, Lubis and Widiatmaka (2020), Nur *et al*. (2021) and Putri *et al*. (2018).
- Interpret the results of data analysis. Interpretation guidelines modified from Adhiatma *et al*. (2020), Suripto *et al*. (2022) and Virgota and Farista (2023).

In general, the stages of student practical work can be seen in Figure 1.

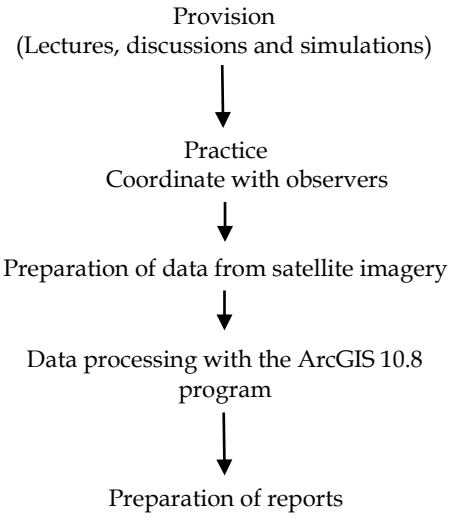


Figure 1. Flow chart of practical work activities observing land conversion in irrigation areas of Gebong and Sesaot, West Lombok

Results and Discussion

Study area

The areas for this study were the Irrigation areas of Gebong and Sesaot in West Lombok Regency, Province of West Nusa Tenggara. An overview of the area and position of the two irrigation areas on Lombok Island can be seen in Figure 2.

Gebong Irrigation Area was located in Narmada District, West Lombok Regency. The Gebong Irrigation Area is one of the areas in the Babak watershed. Gebong Dam has an irrigation service area of 2,161 Ha. The main water source for this irrigation area comes from the Babak River.

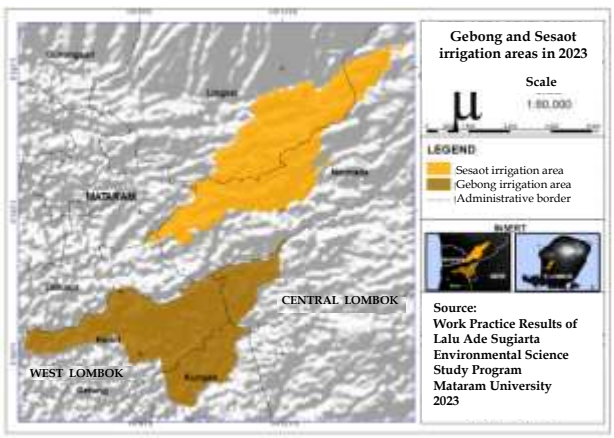


Figure 2. Position of the Gebong Irrigation Area and the Sesaot Irrigation Area on Lombok Island

The Sesaot Irrigation Area was located in Sesaot Village, Narmada District, West Lombok Regency. The Sesaot Irrigation Area has a river as a water source for irrigating forests, rice fields and other agricultural land. The Sesaot Irrigation Area drains a land area of 1195 ha.

Change of land use in Gebong irrigation area

Data on land conversion (land use changes) was obtained using two methods, namely the Maximum Likelihood (Supervised) method and the Manual Digitization method. The types of land use or land cover types were observed include non-built land and built-up land. Non-built land consists of empty land, rice fields and non-rice vegetated land, while built-up land consists of residential land and industrial land.

Land conversion or changes in land use in the Gebong Irrigation Area, West Lombok from 2018 to 2023 which were observed using the two methods above can be seen in Table 1, Figures 3 and 4.

Based on the land cover and land use classification categories by Karina & Kurniawan (2019) and Adhiatma *et al.* (2020), land cover tends to be in the higher category, namely land cover/ land use order.

Table 1. Composition of the area of built-up land cover, rice fields and vegetation in the West Lombok Gebong Irrigation Area in 2018 and 2023 according to the maximum likelihood (1) and Manual Digitization Methods (2).

			Method	
			(1)	(2)
Vegetation	2018	ha	283.57	230.02
		%	13	10
	2023	ha	277.26	139.54
		%	12	6
Ricefield	2018	ha	1527.07	1519.23
		%	69	68
	2023	ha	1462.35	1446.61
		%	66	65
Built-up land	2018	ha	414.22	475.97
		%	18	22
	2023	ha	485.23	639.03
		%	22	29
Total	2018	ha	2224.86	2225.22

supervised		%	100	100
	2023	ha	2224.84	2225.18
		%	100	100
Irrigation Area of Gebong	2018	ha	2225.62	2225.62
		%	100	100
	2023	ha	2225.62	2225.62
		%	100	100

This is because the lower categories will indicate land use that can differentiate one type of land cover according to existing land use. Adhiatma et al. (2020) have also stated that changes in land cover occur due to conditions or events that influence the use or activities on a land. Conditions or events on the land differ between previous activities and current activities. There are also changes in land use that are not detected through this program, for example residential land becomes industrial land, which remains one type of land cover, namely built-up land or grassland to bush land remains the same type of cover, namely vegetated land.

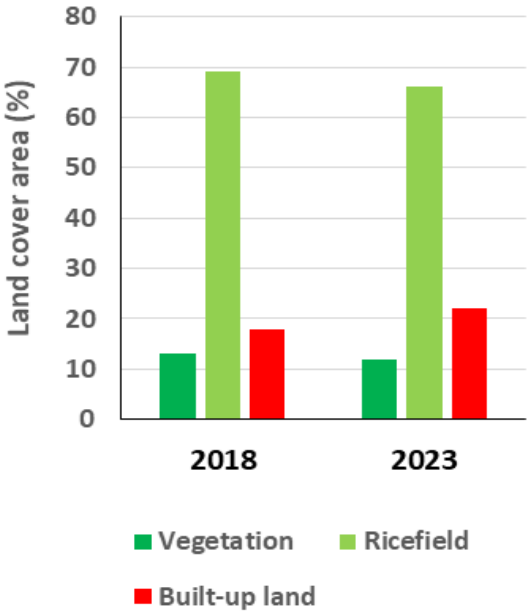


Figure 3. Observation results of land conversion in the West Lombok Gebong Irrigation area using the Maximum Likelihood method

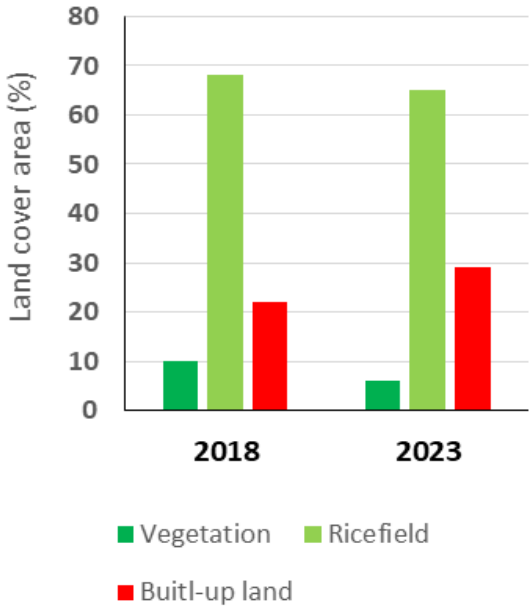
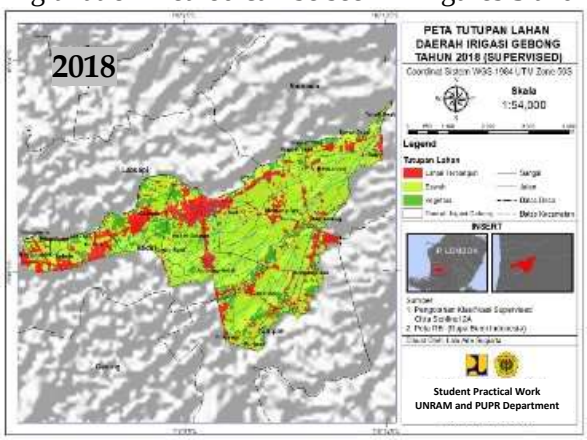


Figure 4. Observation results of land conversion in the Gebong Irrigation Area, West Lombok using the Manual Digitization method

A map depicting land conversion (changes in land area for each type of land use) from 2018 to 2023 in the Gebong Irrigation Area, West Lombok, which is the result of observations using the Maximum Likelihood method and Manual Digitization method can be seen in Figures 5 and 6.



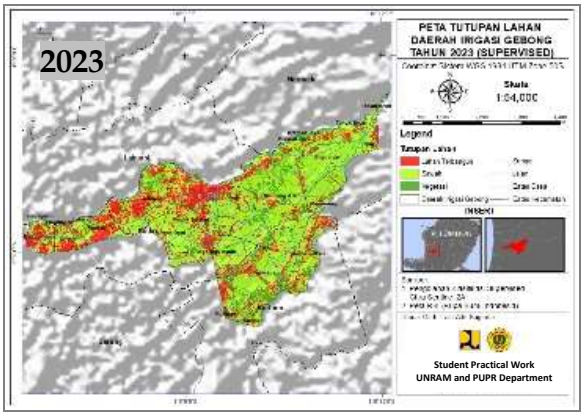
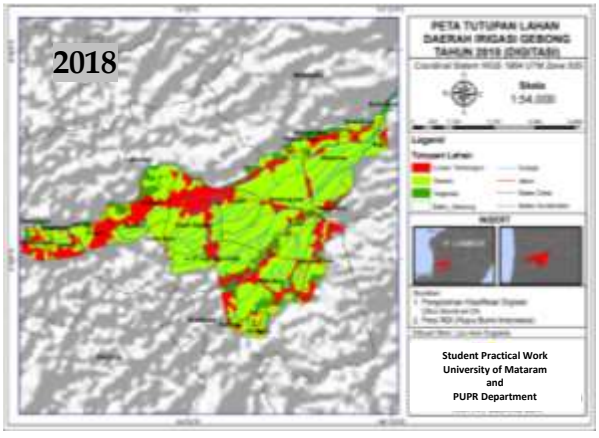


Figure 5. Land cover map of the West Lombok Gebong Irrigation Area in 2018 and 2023, results of observations using the Maximum Likelihood method

The results of data analysis from satellite imagery using the two methods above show that there is a change in land use from 2018 to 2023 in the Gebong Irrigation Area, West Lombok, namely a reduction in the area of vegetated land and ricefields and an increase in the area of built-up land.

Although based on direct observations in the field, vegetated land and rice fields have decreased because the land has been converted into asphalt roads. The vegetated land mentioned above actually consists of two sub-types, namely shrub land and grassland.

Likewise, the increase in the area of built-up land is actually largely due to the increase in the area of land that has been converted into paved roads.



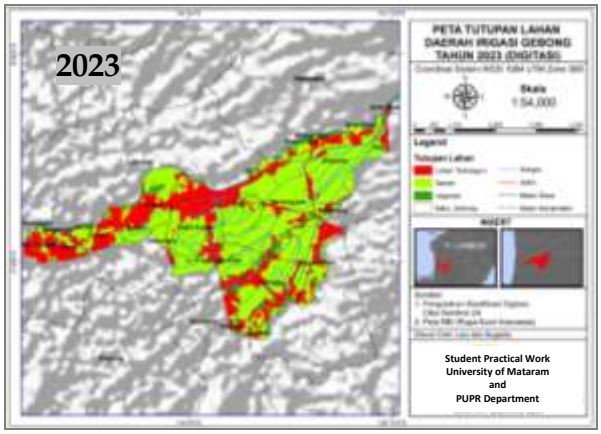


Figure 6. Map of land cover in the Gebong Irrigation Area, West Lombok in 2018 and 2023, results of observations using the Manual Digitization method

The quantity of land conversion or change in area of each type of land use in the Gebong Irrigation Area, according to the two methods can be seen in Table 2.

Table 2. Changes in land cover area 2018 - 2023 in the Gebong irrigation area, West Lombok.

Land cover type	Maximum likelihood method	Manual digitization method
Vegetated land is not rice fields	Decreased 1%	Decreased 4 %
Ricefield	Decreased 3%	Decreased 3%
Built-up land	Increased 3%	Increased 8%

Meanwhile, land change patterns in the Gebong irrigation area according to the results of analysis using the Maximum Likelihood method can be seen in Tables 3 and 4.

Table 3. Changes in land cover in DI Gebong 2018-2023 according to the Maximum Likelihood method

		2023			
		LT	S	V	Total
2018	LT	267.07	133.57	12.90	413.54
	S	183.92	1195.39	146.49	1525.80
	V	33.85	132.28	116.83	282.96
	Total	484.83	1461.24	276.22	2222.29

Table 4. Results of analysis of land cover changes in the Gebong irrigation area 2018-2023 using the Maximum Likelihood method

Tahun 2018		Tahun 2023		Perubahan		
				Type	ha	%
LT	414.22	LT	485.23	LT-LT	267.07	12
LT	414.22	S	1462.35	LT-S	133.57	6
LT	414.22	V	277.26	LT-V	12.90	1
S	1527.07	LT	485.23	S-LT	183.92	8
S	1527.07	S	1462.35	S-S	1195.39	54
S	1527.07	V	277.26	S-V	146.49	7
V	283.57	LT	485.23	V-LT	33.85	2
V	283.57	S	1462.35	V-S	132.28	6
V	283.57	V	277.26	V-V	116.83	5

According to the maximum likelihood method, the total land cover change in the Gebong Irrigation Area from 2018 to 2023 is 2222.29 ha. The biggest change in land cover that occurred was rice fields, namely from an area of 1525.80 ha reduced to built-up land covering an area of 183.92 ha, to vegetated land covering an area of 146.49 ha.

The results also show that rice fields have increased by 1195.39 ha. The area of change in rice fields from 2018 to 2023 is -64.56 ha, meaning that the area of rice fields decreased by 64.56 ha. Built-up land increased by 71.29 ha and vegetated land decreased by 6.74 ha. The accuracy (Kappa) of the supervised classification of the Gebong Irrigation Area is 0.95 (accurate) (Table 5), so the resulting map can be used.

Table 5. Accuracy test of Supervised Gebong Irrigation Area

	LT	**S**	**V**	**Total**	**UA**	**Kappa**
LT	10	0	0	10	1	0
S	0	10	0	10	1	0
V	0	1	9	10	0.9	0
Total	10	11	9	30	0	0
PA	1	0.91	1	0	0.97	0
Kappa	0	0	0	0	0	0.95

The pattern of land change in DI Gebong and its area according to the results of the analysis using the Manual Digitization method can be seen in Tables 6 and 7.

Table 6. Changes in land cover in the Gebong irrigation area 2018-2023 according to the Manual Digitization method

		2023			
		LT	S	V	Total
2018	LT	430.61	40.89	4.36	475.85
	S	156.42	1330.37	32.38	1519.18
	V	51.74	75.28	102.77	229.78
	Total	638.76	1446.54	139.51	2224.81

Table 7. Results of analysis of land cover changes 2018-2023 in the Gebong Irrigation Area using the Manual Digitization method

2018		2023		Change		
					ha	%
LT	475.97	LT	639.03	LT-LT	430.61	19
LT	475.97	S	639.03	LT-S	40.89	2
LT	475.97	V	639.03	LT-V	4.36	0
S	1519.22	LT	1446.61	S-LT	156.42	7
S	1519.22	S	1446.61	S-S	1330.37	60
S	1519.22	V	1446.61	S-V	32.38	1
V	230.02	LT	139.54	V-LT	51.74	2
V	475.97	S	639.03	V-S	75.28	3
V	475.97	V	639.03	V-V	102.77	5

According to the Manual Digitization method, the total land cover change in DI Gebong from 2018 to 2023 was 2224.81 ha. The largest change in land cover occurred in rice fields, namely from an area of 1519.18 ha reduced to built-up land covering an area of 156.42 ha and becoming vegetated land covering an area of 32.38 ha.

The results also show that rice fields experienced an increase in area of 1330.37 ha. The area of change in rice fields from 2018 to 2023 was -72.64 ha, meaning that the area of rice fields decreased by 72.64 ha. Built-up land increased by 162.91 ha and vegetated land decreased by 90.27 ha.

Land conversion in the Sesaot Irrigation Area

Land conversion or changes in land use in the West Lombok Sesaot Irrigation Area were also observed from satellite image data for 2018 and 2023 and analyzed using the Maximum Likelihood method and Manual Digitization method. Data on land cover area based on land conversion from 2018 to 2023 in the Sesaot Irrigation Area, West Lombok can be seen in Table 8, Figures 6 and 7.

Table 8. Composition of land cover area in the Sesaot Irrigation Area in 2018-2023 according to (1) Maximum likelihood method and (2) Manual digitization method.

			Methods	
			(1)	(2)
Vegetation	2018	ha	862.64	817.66
		%	38	36
	2023	ha	641.55	679.79
		%	28	30
Ricefield	2018	ha	1112.99	913.60
		%	48	40
	2023	ha	1281.54	989.98
		%	56	43
Built-up land	2018	ha	319.97	564.89
		%	14	24
	2023	ha	372.50	626.25
		%	16	27
Total supervised	2018	ha	2294.7	2296.15
		%	100	100
	2023	ha	2295.59	2296.02
		%	100	100
Sesaot irrigation area	2018	ha	2296.56	2296.56
		%	100	100
	2023	ha	2296.56	2296.56
		%	100	100

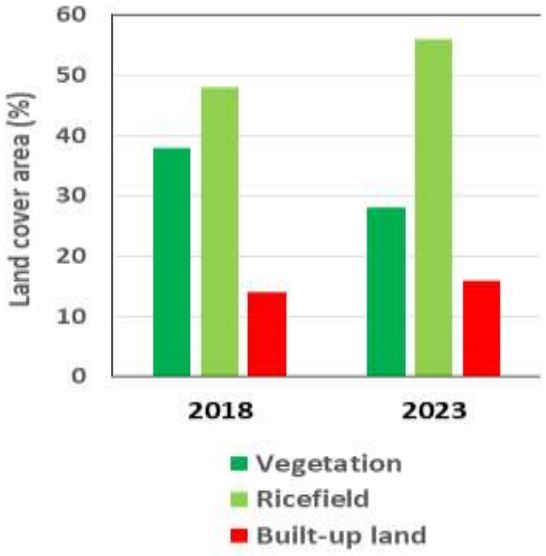


Figure 6. Changes in land cover area in the Sesaot Irrigation Area according to the Maximum Likelihood Method

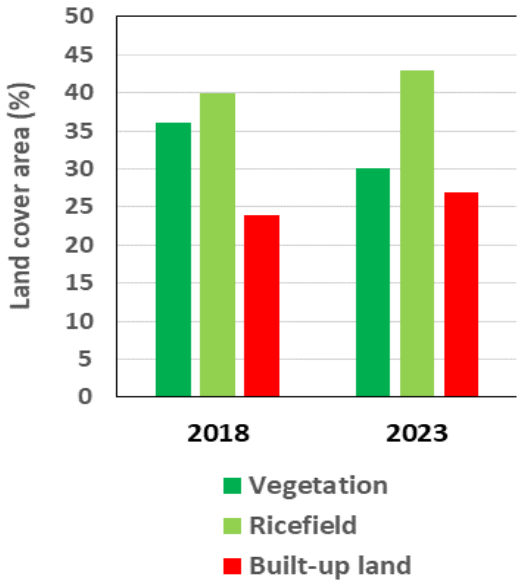
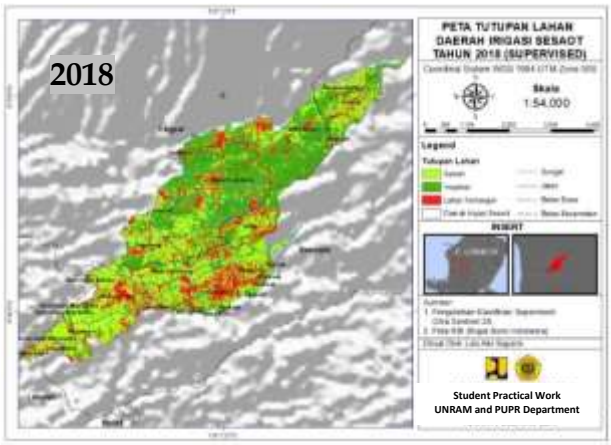


Figure 7. Changes in land cover area in the Sesaot Irrigation Area according to the Manual Digitization Method

Maps of land conversion from 2018 to 2023, especially built-up land, vegetated land and rice fields in Sesaot irrigation area according to the two methods above can be seen in Figures 8 and 9.



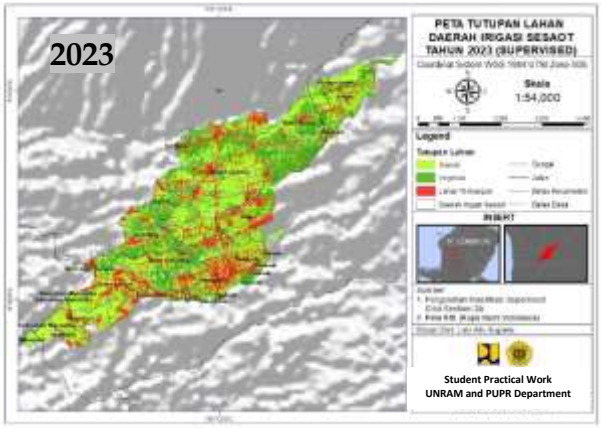


Figure 8. Map of land cover in the Sesaot Irrigation Area, West Lombok in 2018 and 2023, results of observations using the Maximum Likelihood method

These results indicate that in the Sesaot Irrigation Area, West Lombok, land conversion had also occurred in 2023 from the previous land cover map in 2018. These land use changes were a reduction in the area of vegetated land and an increase in the area of rice fields and an increase in built-up land, both according to the maximum likelihood method and the manual digitization method.

Changes in land use within the same sub-type, for example grass land and bush land were not readable. This reduction in the area of vegetated land is not due to it being turned into rice fields but rather because it is turning into built-up land (Table 9).

Table 9. Changes in the area of non-built up land and built up land from 2018 to 2023 in the Sesaot Irrigation Area, West Lombok.

	Maximum likelihood method	Manual digitization method
Vegetated land	Reduced 10%	Reduced 6%
Ricefield land	Increased 8%	Increased 3%
Built-up land	Increased 2%	Increased 3%

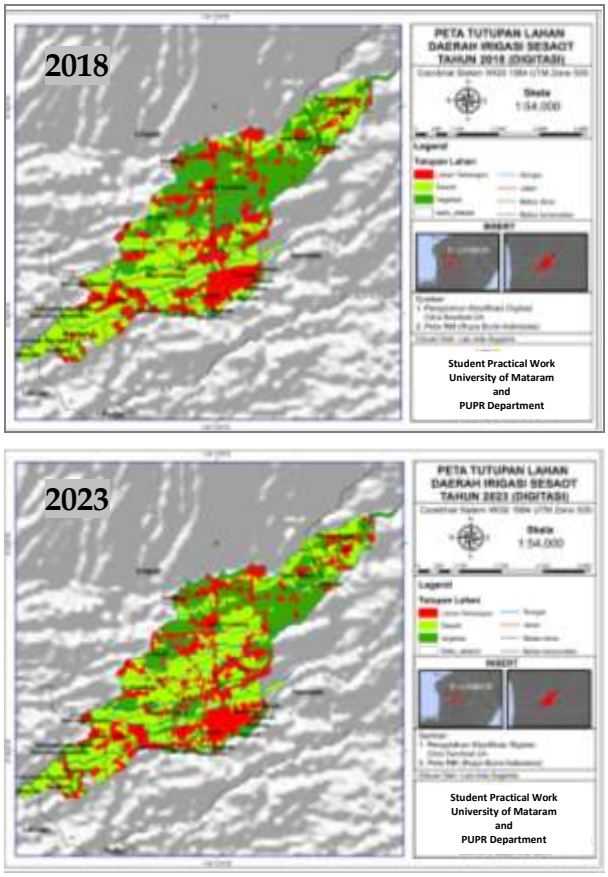


Figure 9. Map of land cover in the Sesaot Irrigation Area, West Lombok in 2018 and 2023, results of observations using the Manual Digitization method

The pattern of changes in land use in the Sesaot Irrigation Area and its area according to the results of analysis using the Maximum Likelihood method can be seen in Tables 10 and 11.

Table 10. Changes in land cover in the Sesaot Irrigation Area 2018-2023 according to the Maximum likelihood method

		2023			
		LT	S	V	Total
2018	LT	204.10	101.01	14.62	319.73
	S	139.80	795.13	176.61	1111.54
	V	28.15	383.93	449.39	861.47
	Total	372.05	1280.08	640.62	2292.75

Table 11. Results of analysis of land cover changes 2018-2023 in the Sesaot Irrigation Area using the Maximum Likelihood method

2018		2023		Change		
					ha	%
LT	319.97	LT	372.49	LT-LT	204.10	9
LT	319.97	S	1281.54	LT-S	101.011	4
LT	319.97	V	641.55	LT-V	14.62	1
S	1112.99	LT	372.49	S-LT	139.80	6
S	1112.99	S	1281.54	S-S	795.13	35
S	1112.99	V	641.55	S-V	176.61	8
V	862.64	LT	372.49	V-LT	28.15	1
V	862.64	S	1281.54	V-S	383.93	17
V	862.64	V	641.55	V-V	449.39	20

According to the maximum likelihood method, the total land cover change in the Sesaot Irrigation Area from 2018 to 2023 was 2292.75 ha. The biggest change in land cover occurred in rice fields, namely from an area of 1111.54 ha reduced to built-up land covering an area of 139.80 ha, to vegetated land covering an area of 176.61 ha. The results also show that rice fields have increased by 795.13 ha. The area of change in rice fields from 2018 to 2023 was 168.54 ha, meaning that the area of rice fields increased by 168.54 ha. Built-up land increased by 52.32 ha, part of which was an expansion of the asphalt road and vegetated land decreased by 220.85 ha.

The accuracy (Kappa) of the supervised classification of the Sesaot Irrigation Area was 0.85 (accurate)(Table 12), so that the resulting map can be used.

Table 12. Supervised accuracy test results for the Sesaot Irrigation Area

	S	**V**	**LT**	**Total**	**UA**	**Kappa**
S	10	0	0	10	1	0
V	3	7	0	10	0.7	0
LT	0	0	10	10	1	0
Total	13	7	10	30	0	0
PA	0.77	1	1	0	0.9	0
Kappa	0	0	0	0	0	0.85

According to the manual digitization method, the land change pattern of the Sesaot Irrigation Area and its area according to the results of the analysis using the Manual Digitization method can be seen in Tables 12 and 13.

Table 12. Changes in land cover of the Sesaot Irrigation Area 2018-2023 according to the Manual Digitization method

		2023			
		LT	S	V	Total
2018	LT	446.70	74.78	43.30	564.78
	S	102.31	664.37	146.59	913.27
	V	77.10	250.63	489.80	817.53
	Total	626.12	989.77	679.69	2295.57

Table 13. Results of land cover change analysis 2018-2023 Sesaot Irrigation Area using the Manual Digitization method

2018		2023		Change		
					ha	%
LT	564.89	LT	626.25	LT-LT	446.70	19
LT	564.89	S	989.98	LT-S	74.78	3
LT	564.89	V	679.79	LT-V	43.30	2
S	913.60	LT	626.25	S-LT	102.31	4
S	913.60	S	989.98	S-S	664.37	29
S	913.60	V	679.79	S-V	146.59	6
V	817.66	LT	626.25	V-LT	77.10	3
V	817.66	S	989.98	V-S	250.63	11
V	817.66	V	679.79	V-V	489.80	21

According to the Manual Digitization method, the total change in land cover that occurred in the Sesaot Irrigation Area from 2018 to 2023 was 2295.57 ha. The largest change in land cover occurred in rice fields with an area change of 913.27 ha, which turned into built-up land covering an area of 102.31 ha, and rice fields became vegetated land covering an area of 146.59 ha. Rice fields increased by 664.37 ha. The area of change in rice fields from 2018 to 2023 was 76.5 ha, meaning that the area of rice fields increased by 76.5 ha. Built-up land experienced an increase in area of 61.34 ha, while vegetated land experienced a reduction in area of 137.84 ha.

Conclusion

In the Gebong Irrigation Area from 2018 to 2023, according to the Maximum Likelihood method, there was a reduction in the area of 3% of paddy fields, 1% of vegetated land, and an increase

of 3% in the area of built-up land, while according to the Manual Digitization method there was a reduction in the area of 3% of paddy fields and 4% % of vegetated land, as well as an 8% increase in built-up land area.

In the Sesaot Irrigation Area from 2018 to 2023 according to the Maximum Likelihood method there was a 10% reduction in the area of vegetation land, an increase in the area of 8% of rice fields and 2% of built-up land, while according to the Manual Digitization method there was a reduction in the area of 6% of vegetation land, an increase in area of 3 % rice fields and 2% built-up land.

Acknowledgments

This student work practice was carried out in collaboration between the Dean of the Faculty of Mathematics and Natural Sciences, Mataram University and the Head of the Departemen Public Works and Spatial Planning of West Nusa Tenggara Province.

Thanks were also expressed to the satellite image observers at the West Lombok PUPR Service Office, on behalf of Mrs. Ida Sulyaningsih, SE. (Kediri Irrigation Observer) and Mr. Effendi Sugiarto, ST. (Narmada Irrigation Observer), who had accompanied the observations in the field.

Referensi

Adhiatma, R., Lubis, I., & Widiatmaka. (2020). Perubahan dan prediksi penggunaan/penutupan lahan di Kabupaten Lampung Selatan. *Journal Of Natural Resources And Environmental Management*, 234-246.

Adhiatma, R., Lubis, I., & Widiatmaka. (2020). Klasifikasi tutupan lahan menggunakan Supervised Machine Learning pada citra satelit menggunakan Google Earth Engine. *E-Proceeding Of Engineering*, 3278-3287.

Akbari, F. R. (2014). *Analisa Perubahan Tutupan Lahan Di Daerah Aliran Sungai Dengan Menggunakan Klasifikasi Terbimbing Dan Algoritma Ndvi Pada Citra Landsat 8* . Surabaya: Department Of Geomatics Engineering Faculty Of Civil Engineering and Planning Sepuluh Nopember Institute Of Technology.

Amarrohman, F. J., Rahmah, A. N., & Subiyanto, S. (2020). Pemodelan perubahan penggunaan lahan dengan Artificial Neural Network (ANN) di Kota Semarang. *Jurnal Geodesi Undip, 9*, 197-206.

Angin, I. S., & Sunimbar. (2021). Analisis perubahan penggunaan lahan Kota Kupang Nusa Tenggara Timur Tahun 2010-2018 (Studi Kasus Di Kecamatan Kelapa Lima, Oebobo dan Kota Lama). *Jurnal Geoedusains*, 36-52.

Arifin, F. F., Hakim, F. L., Indarto, I., & Mandala, M. (2020). Aplikasi Citra Sentinel-2 untuk pemetaan tutupan dan peruntukan lahan pada iingkat desa. *Jurnal Geografi*, 189-201.

Arisanto, A., Artika, I. K., & Utami, W. (2018). Aplikasi citra satelit penginderaan jauh untuk percepatan identifikasi tanah terlantar. *Bhumi*, 54-68.

Awaliyan, M., & Sulistioadi, Y. B. (2018). Klasifikasi penutupan lahan pada Citra Satelit Sentinel-2a dengan Metode Tree Algorithm. *Hut Trop*, 98-104.

Darmawan, A. R., Puspaningsih, N., & Saleh, M. (2017). Kajian perubahan tutupan lahan dengan menggunakan metode Multi Layer Perceptron dan Logistic Regression di Taman Nasional Gunung Ciremai. *Media Konservasi*, 252-261.

Indarto, Nadzirah, R., & Belagama, H. R. (2020). Pemetaan lahan sub-optimal berbasis nilai Ndvi Sentinel 2a: Studi pendahuluan. *Jurnal Presipitasi, 17*, 194-205.

Karina, R. K., & Kurniawan, R. (2019). Identifikasi penggunaan lahan menggunakan citra satelit Landsat 8 melalui Google Earth Engine. *Seminar Nasional Official Statistics 2019*, 789-805. Retrieved From Www.Indonesia-Geospasial.Com.

Marlina, D. (2022). Klasifikasi tutupan lahan pada Citra Sentinel-2 Kabupaten Kuningan dengan Ndvi dan Algoritme Random Forest. *String (Satuan Tulisan Riset dan Inovasi Teknologi)*, 41-49.

Nur, I. R., Syahreza, S., & Syamsidik. (2021). Pemanfaatan Citra satelit Google Earth untuk penilaian progres pemulihan lahan pasca 15 tahun dsunami Aceh Di Kecamatan Lhoong, Aceh Besar. *Jurnal Rekayasa Elektrika*, 62-69.

Putri, D. R., Sudarsono, B., & Sukmono, A. (2018). Analisis kombinasi Citra Sentinel-1a dan Citra Sentinel-2a untuk klasifikasi tutupan lahan (Studi kasus: Kabupaten Demak, Jawa Tengah). *Jurnal Geodesi Undip, 7*, 85-96.

Suripto, Kurniawan, W. & Mashadi, U. (2022). Mapping of evacuation paths and gathering points in efforts to reduce disaster risk in Taman Baru Village Sekotong West Lombok to create a disaster-responsive village. Jurnal Pengabdian Magister Pendidikan IPA. 5(3):169-172.

Virgota, A., & Farista, B. (2023). Identification and Mapping of Landslide-Prone Areas in the Meninting Watershed Area, West of Lombok. Jurnal Biologi Tropis, 23(1), 382–391.