Journal of Infrastructure Planning and Engineering (JIPE)

Journal homepage: https://ejournal.warmadewa.ac.id/index.php/jipe

Application of normalized difference vegetation index in classifying land cover change over Bangli regency by using Landsat 8 imagery

Putu Aryastana[1,2*], Maria Imaculata Goran Mosa[3], Wayan Widiana[3], I Made Eryana Eka Putra[3], Gede Rustiawan[3]

[1]International Ph.D. Program in Environmental Science and Technology (University System of Taiwan), National Central University, Taoyuan, 32001, Taiwan (R.O.C.)
[2]Department of Civil Engineering, Warmadewa University, Denpasar, 80235, Indonesia
[3]Master Program of Infrastructure and Environmental Engineering, Postgraduate Program, Warmadewa University, Denpasar, 80235, Indonesia
*aryastanaputu@g.ncu.edu.tw

Received on 21 February 2022, accepted on 28 March 2022, published on 18 April 2022

ABSTRACT

The information on land cover changes is very important in regional spatial planning. Remote sensing technology can minimize the cost and time in analyzing land cover changes. Normalized Difference Vegetation Index (NDVI) is a vegetation index that combines red and near-infrared channels so that it can provide approximate information about land cover in an area. The objective of this study is to extract land cover change information from Landsat 8 images based on NDVI values in Bangli Regency in 2015 and 2021. The classification method used to estimate the type of land cover is supervised classification. The results reveal the decrease of the land cover in the category of water body, sand, dry land/soil, rice fields, and vegetation, which are 1.62%, 14.14%, 7.93%, 8.63%, and 2.45%, respectively, while an increase in the settlement category by 30.12%. The overall accuracy of land cover classification result based on NDVI value is 86.54%.

Keywords: Bangli, classification, Landsat, NDVI

1 Introduction

The information of land cover classification is essential and useful to society, researchers, stake-holder, and government to decide on regional spatial planning [1, 2], the study of climate change, comprehension of human and environment interaction [3-5], and disaster prevention [6]. The continuous land cover change is affected biodiversity, environmental conservation, and fertilization of the soil. Therefore, the changes of land cover have been considered to use in the inventory of the previous, current, and future natural resources [2].

Analysis of land cover change information using traditional measurement requires very high time, cost, and resources. Remote sensing technology based on satellite imagery is one of the most effective and efficient alternatives in extracting information on land cover changes in an area where it is very difficult to obtain in situ observation data in time series [7, 8]. The reliable information of the surface variable can be provided by satellite imagery on a global scale, time series, and real-time [9]. Landsat datasets that have several surface variables and can be obtained free of charge are possible to be used in analyzing land cover changes both regionally and globally [10, 11]. Landsat 8 Operational Land Imager (OLI) is the latest product from the Landsat mission to provide surface reflectance data that can be used to extract land cover information by combining different channels. The capability Landsat 8 Oli has to provide high spatial resolution (30 m), multispectral images (11 spectral bands), and time series (April 2013 - present) data can be used to determine land use or land cover change. The distribution of information on land cover categories in large areas can be determined through digital classification techniques, although the availability of ground truths is still limited [8]. The land cover category in a pixel can be determined by digital classification techniques such as supervised, unsupervised, and hybrid classification [12]. In

general, for interpreting the changes of land use or land cover, supervised classification techniques are often used [13, 14].

The vegetation index is the result of radiometric measurements that combine two or more surface reflectance wavelengths, especially in the infrared and visible channels. Qualitative and quantitative studies in analyzing, monitoring, and evaluating vegetation cover in an area using the vegetation index have been carried out since the 1960s [15]. Several vegetation indices that can be used in the analysis, monitoring, and evaluation of land cover or land-use changes include Enhanced Vegetation Index (EVI), Leaf Area Index (LAI), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Soil-Adjusted Vegetation Index (SAVI). The NDVI is the most widely implemented vegetation index approach in the analysis and evaluation of land cover changes [16, 17]. Therefore, the current study used NDVI to analyze the land cover changes using two-interval Landsat 8 OLI imageries.

In the past decades, several pieces of research have been done to analyze, interpret, and assess the land cover or land use over the various region implemented the NDVI method derived from Landsat 8 images. For example, in [18], investigated land cover types by using NDVI extracted from the surface and top of atmosphere reflectance over China and Korea. Other works [19-21] classified land cover types into three successively low dense vegetation, moderate dense vegetation, and high dense vegetation, based on their NDVI value. Their study highlights that land cover changes can have different results depending on the type of classification algorithm and the NDVI index combination. In [22], determined the density of vegetation based on NDVI value into four categories is non-vegetation, sparse-vegetation, moderate-vegetation, and dense-vegetation over Srinagar district, Kashmir, India between 2001 and 2017. They found the vegetation cover was decreased around 55.56% from 2001 to 2017. Moreover in [23], examined the characteristics of green open space over the Denpasar region by classifying the NDVI value extracted from Landsat 8 OLI. However, as far as we know, no study has analyzed the land cover change classifications by applying NDVI with Landsat 8 over the Bangli regency.

The main objective of the current study is to extract the information of the spatial-temporal change of vegetation and land cover changes over Bangli regency between the period 2015 and 2021 by using imagery Landsat 8 OLI. The rest of this article is arranged as shown: section 2 presents the study area, dataset, and detail of methods used in the current study. Section 3 describes the results and discussion which concern vegetation and land cover changes. In the end, section 5 represents the conclusion of this article.

2 Data and Methods

2.1 Study area

The study area is Bangli regency located in Bali province with latitude ranging from 8°8'30" S to 8°31'07" S and longitude varying between 115°13'43" E and 115°27'24" E (Figure 1). The area of the Bangli regency is about 9.24% of Bali province or 520.81 km^2 [24]. Based on data from the Central Bureau of Statistics from 2009-2016, the average population growth rate in the Bangli regency is 0.57%. This regency features complex terrain varying between 100 to 2152 meters from sea level and mountain area (Mount Batur) in the north part [24]. The temperature in this regency is ranging from 15° to 30° [24]. Bangli regency as a part of Bali Island experiences a tropical-monsoon climate and suffers heavy rainfall from December to February [25].

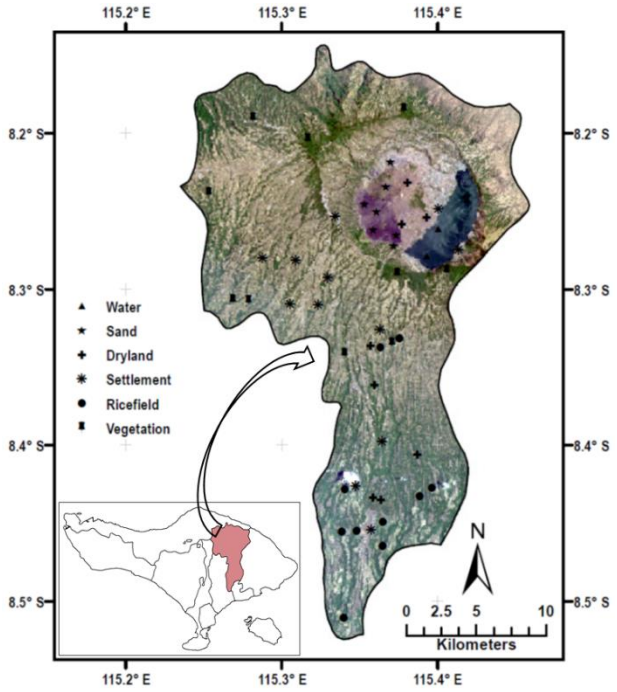

Figure 1. Map of Bangli regency including the sample of each land cover type on band composite of red, green, and blue Landsat 8 image.

2.2 Datasets

Two interval images of level 2 Landsat 8 OLI were used in this study. These images are available online at the United States Geological Survey (USGS) site (https://earthexplorer.usgs.gov/). Landsat 8 OLI characterized by 30 m spatial resolution. The dataset did predominantly not have influence by cloud (less than 10% of cloud cover) and good quality over the study area (Figure 2). The current study selected two imagery for analysis on 2 June 2015 and 18 October 2021. The border area of the Bangli regency was downloaded from the Indonesian geospatial portal (https://tanahair.indonesia.go.id/portal-web).

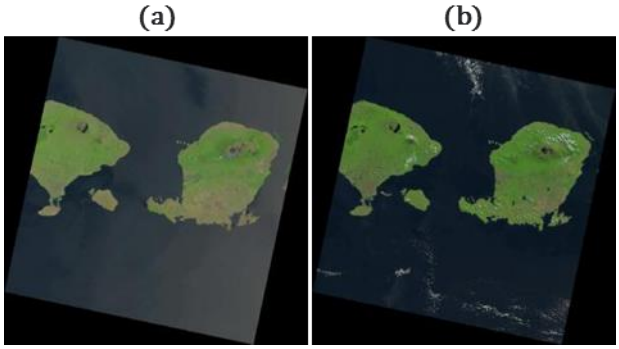

Figure 2. Landsat 8 images level 2: (a) 2 June 2015; (b) 18 October 2021

3 Methods

This study has calculated the land cover changes based on surface reflectance Landsat 8 image in 2015 and 2021 by using NDVI value. The NDVI can be calculated using surface reflectance of near-infrared (NIR) and red bands of Landsat 8 images. The expression of NDVI is as follows [21]:

$$\text{NDVI} = \frac{\text{NIR-red}}{\text{NIR-red}} \quad \text{..... (1)}$$

The NDVI value is span from -1 to 1. A high NDVI value represents a high density of vegetation, while a low NDVI value indicates a low density of vegetation. The negative value of NDVI represents the water body.

The land cover classification was divined by the supervised classification method. Vegetation cover was divided into four classes, namely non-vegetation, low denseness, moderate denseness, and high denseness, respectively [22]. A total of six classes were selected for land cover classification consisting of water body, sand, dry land/soil, settlement, rice field, and vegetation. The total number of samples for training and testing is 24 and 26 samples, respectively. Table 1 represents the distribution of samples for each classes.

Table 1. The distribution of training and testing samples

Classification	Number	
	Training	Testing
Water body	1	2
Sand	3	4
Dry land/soil	4	4
Settlement	6	6
Rice field	5	5
Vegetation	5	5
Total	24	26

The accuracy evaluation of the results of land cover classification is a crucial stage to determine the level of accuracy so that later these results can be used as correct data [21]. Several previous studies have recommended that the minimum level of accuracy in the analysis of land cover and land use is 85% [21, 26, 27]. In this study, the level of accuracy is calculated using a categorical matrix that compares the suitability of the classification of pixels with ground truth samples that have been verified in the field. The assessment indices used in the present study are user accuracy, producer's accuracy, and overall accuracy. The user accuracy represents the ratio between the number of models classified correctly and the total of model data in the same class [28]. Producer's accuracy is the ratio between the number of ground truth classified correctly and the total of ground truth data for that class [28]. Overall accuracy represents the ratio between the total of model classified correctly for each class and the overall of sample.

4 Results and Discussions

The spatial distribution of vegetation and land cover changes were identified based on NDVI values extracted from Landsat 8 in 2015 and 2021. Figure 3 shows the spatial distribution of NDVI value over Bangli regency in 2015 and 2021. The interval NDVI value of 2015 is between -0.059 and 0.576, while in 2021 it ranges from -0.031 to 0.547. The NDVI value in the current study has met the standard NDVI value range from -1 to 1 [21]. The percentage change in the maximum NDVI values from 2015 to 2021 is 5.04%, this indicates that there is no significant change in the NDVI value from 2015 to 2021. The interval of NDVI value in this study is in agreement with the results of a previous study that found the interval NDVI value extracted from Landsat 8 image in 2020 over the Eastern Ghats of India is between -0.05 and 0.51 [8]. The highest NDVI value indicated the high denseness of vegetation, while the lowest represent the water body. In Figures 3a and 3b (deep blue color), it can be seen that the water body very clearly represents Lake Batur in Bangli Regency which is located close to Mount Batur.

The classification of vegetation density and land cover was derived from NDVI value by using supervised classification with 24 training samples. The vegetation density was divided into four classes, namely non-vegetation, low denseness, moderate denseness, and high denseness, respectively. Non-vegetation indicates water body, sand, dry land/soil. Low denseness represents settlement, moderate denseness indicates rice field, and high denseness represents vegetation. The NDVI value range for each class is < 0.19, 0.19-0.299, 0.30-0.35, and >0.35, respectively. Figures 4a and 4b present the geographical distribution of vegetation density over the Bangli regency in 2015 and 2021. The differences in vegetation cover are clearly in the non-vegetation category (brown color) which can be seen in the area around Mount Batur and Lake Batur, as well as in southern Bangli.

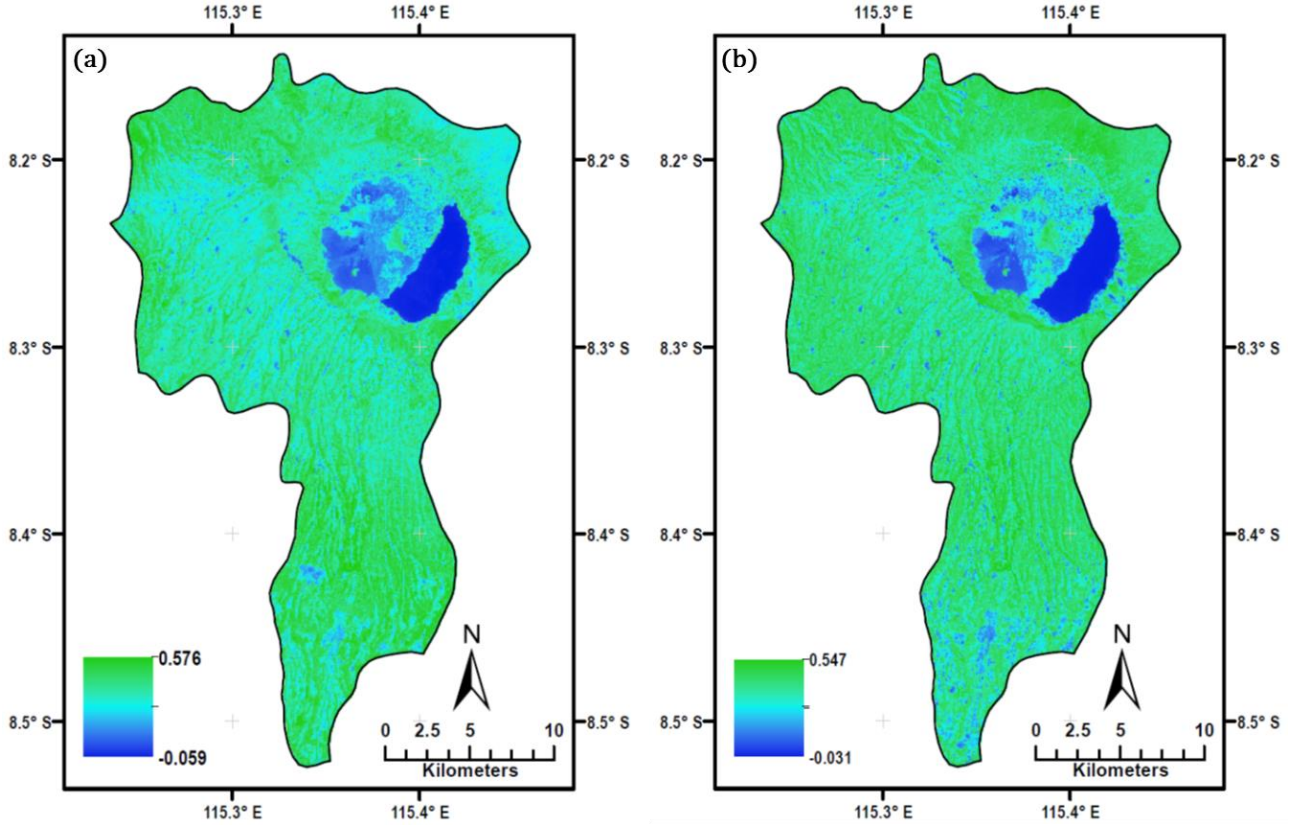

Figure 3. Variation NDVI value over Bangli regency: (a) 2015; (b) 2021

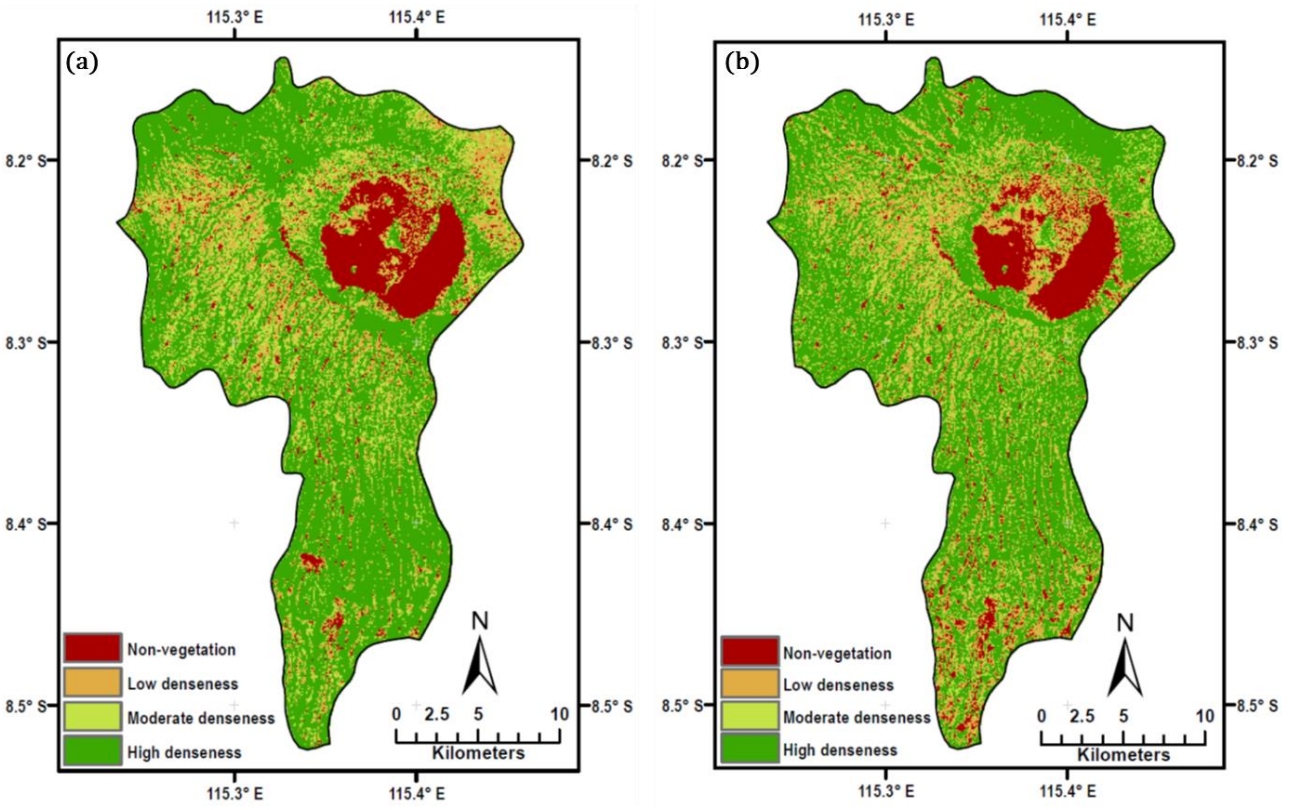

Figure 4. Vegetation density classification over Bangli regency: (a) 2015; (b) 2021

The estimated vegetation cover changes over the Bangli regency are presented in Table 2. Non-vegetation occupied the smallest portion in the Bangli regency and is predominantly situated in the area of Batur Lake and Mount Batur. The highest portion of vegetation classes is high denseness which is around 57%-58% of the total area of the Bangli regency. Non-vegetation, moderate denseness, and high denseness vegetation were decreased from 2015 to 2021 by 7.71%, 8.63%, and 2.45%, respectively. However, the high-density vegetation was increased by 30.12%.

Table 2. The vegetation density distribution and changes

Vegetation density	Area (km^2)		Change (%)
	2015	2021	
Non-vegetation	55.05	50.80	-7.71
Low denseness	66.26	86.21	30.12
Moderate denseness	96.01	87.73	-8.63
High denseness	303.54	296.11	-2.45

Based on NDVI values in the two-interval images was applied supervised classification approach was to classify the land cover changes. Figure 5a and 5b show the spatial distribution of land cover classification over the Bangli regency in 2015 and 2021, respectively. The distribution of water bodies, sand, dry land/soil, settlement, rice field, and vegetation reflect the actual land cover situation in the Bangli regency based on visual observation using the very high-resolution images of Google Earth. The distribution of vegetation was distributed in almost all of the study regions, whereas the sand and water body were mainly distributed in the mountain regions. Significant changes in land cover from 2015 to 2021 are very clearly shown in the successive classifications of sand, soil, settlements, and vegetation, while for water and rice fields the changes were not significant in Figure 5. The area distribution of land cover categories such as water body, sand, dry land/soil, settlement, rice field, and vegetation are presented in Table 3.

Table 3. The land cover distribution and changes

Land cover classification	Area (km^2)		Change (%)
	2015	2021	
Water body (W)	14.05	13.83	-1.62
Sand (S)	12.35	10.60	-14.14
Dry land/soil (D)	28.65	26.37	-7.93
Settlement (ST)	66.26	86.21	30.12
Rice field (R)	96.01	87.73	-8.63
Vegetation (V)	303.54	296.11	-2.45
Total	520.85	520.85	

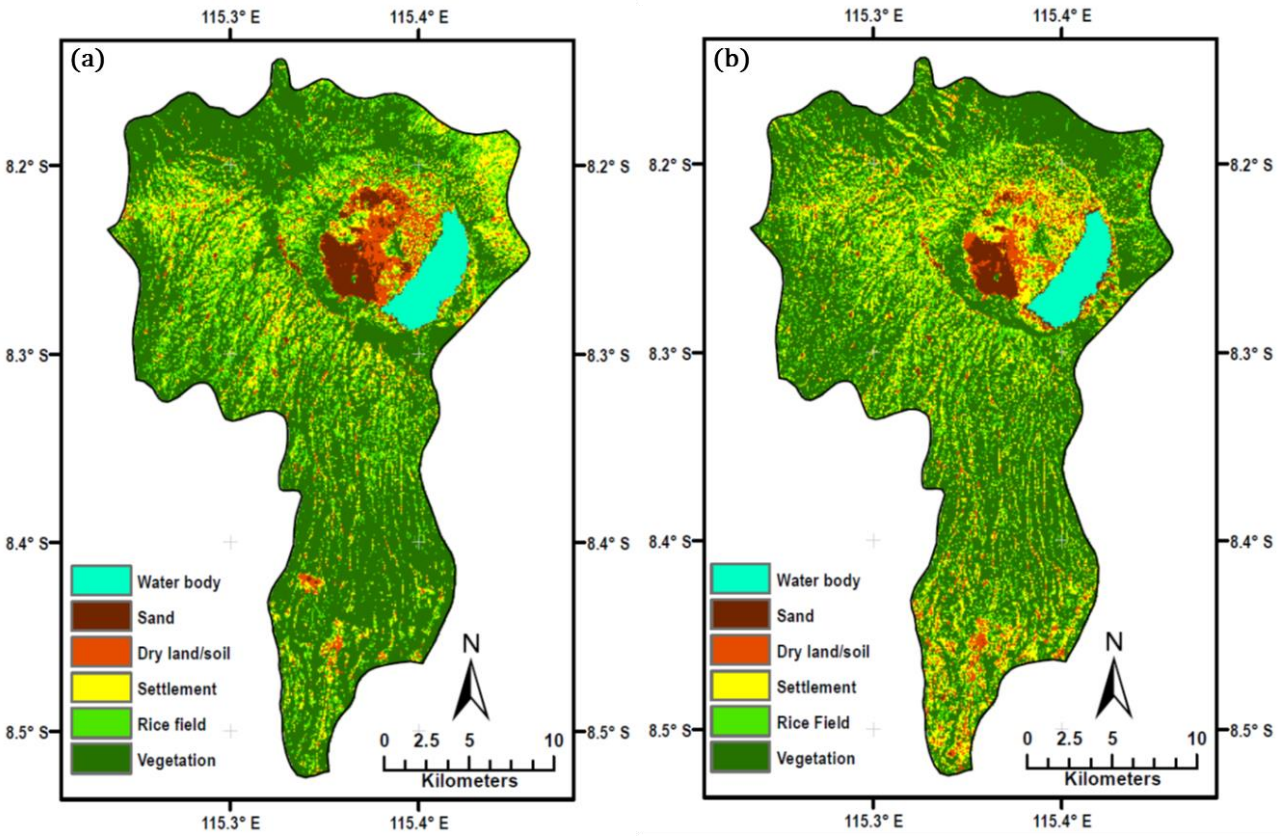

Figure 5. Land cover classification over Bangli regency: (a) 2015; (b) 2021

Land cover categories of water body, sand, dry land/soil, rice field, and vegetation were decreased from 2015 to 2021 by 1.62%, 14.14%, 7.93%, 8.63%, and 2.45%, respectively. However, the category of settlement was increased by 30.12% from 2015 to 2021. The decreasing area of the water body is may due to some areas of the lake has been changing to dry land and settlement, while the reducing area of sand is possible because of the sand mining activities around Mount Batur. The decreasing area of rice fields and vegetation is may due to the increase in the area of settlements associated with the annual increase of population in the Bangli regency and also the development of several tourist attractions. The increase of settlement area has partially occurred in the southern part of the Bangli regency, which is the center of the city and government. The total area of the Bangli regency based on the Central Bureau of Statistics is 520.8 km^2. The total area of land cover in the current study is 520.85 km^2. The difference is only 0.05 km^2 (0.009%), this indicated our result is rational.

Preliminary monitoring reveals that the classification outcomes for various arrangements were reasonable. The categorical matrix for quantitative evaluation for the performance of land cover classification results using Landsat 8 OLI was examined by using 26 testing samples. The user accuracy (UA), producer's accuracy (PA), and overall accuracy (OA) for 2015 and 2021 are exhibited in Table 4.

Table 4. The categorical matrix of accuracy assessment

		Ground truth						Total
		W	S	D	ST	R	V	
Model	W	4	0	0	0	0	0	4
	S	0	7	1	0	0	0	8
	D	0	0	7	1	0	0	8
	ST	0	0	2	10	0	0	12
	R	0	0	0	0	9	1	10
	V	0	0	0	0	2	8	10
Total		4	7	10	11	11	9	52
UA (%)					88.06			
PA (%)					88.60			
OA (%)					86.54			

The UA, PA, and OA for the land cover categories are 88.06%, 88.60%, and 86.54%, respectively. This result indicates the performance of land cover classifications was all adequate because the comprehensive accuracies are greater than 85 % [21, 26, 27].

5 Conclusion

In the current study, the Landsat 8 OLI imagery in 2015 and 2021 were utilized as a data source to examine NDVI value. The supervised classification method was implemented to classify the vegetation density and land cover category. The main conclusion of this work is a decrease a land cover from 2015 to 2021 in the category of water body, sand, dry land/soil, rice fields, and vegetation, which are 1.62%, 14.14%, 7.93%, 8.63%, and 2.45%, respectively. But on the other hand, there was an increase in the settlement category by 30.12%. Moreover, the overall accuracy of land cover classification result based on NDVI value is 86.54% which is presented that the results were reasonable.

The current study confirms that using the Landsat 8 OLI provides a reasonable result on land cover in time series that can be utilized as advice to the government to decide for land development and management. In the future study, it needs to compare the land cover by using Landsat 8 OLI imagery with other products such as Sentinel 2.

References

[1] G. Suresh, V. Ramasamy, V. Meenakshisundaram, R. Venkatachalapathy, and V. Ponnusamy, "Influence of mineralogical and heavy metal composition on natural radionuclide concentrations in the river sediments," *Applied Radiation and Isotopes*, vol. 69, no. 10, pp. 1466–1474, Oct. 2011, doi: 10.1016/j.apradiso.2011.05.020.

[2] C. B. Pande, K. N. Moharir, and S. F. R. Khadri, "Assessment of land-use and land-cover changes in Pangari watershed area (MS), India, based on the remote sensing and GIS techniques," *Applied Water Science*, vol. 11, no. 6, p. 96, Jun. 2021, doi: 10.1007/s13201-021-01425-1.

[3] P. S. Thenkabail, "Global Croplands and their Importance for Water and Food Security in the Twenty-first Century: Towards an Ever Green Revolution that Combines a Second Green Revolution with a Blue Revolution," *Remote Sensing*, vol. 2, no. 9, pp. 2305–2312, Sep. 2010, doi: 10.3390/rs2092305.

[4] L. Zhang, K. Jia, X. Li, Q. Yuan, and X. Zhao, "Multi-scale segmentation approach for object-based land-cover classification using high-resolution imagery," *Remote Sensing Letters*, vol. 5, no. 1, pp. 73–82, Jan. 2014, doi: 10.1080/2150704X.2013.875235.

[5] K. Jia *et al.*, "Land Cover Classification of Landsat Data with Phenological Features Extracted from Time Series MODIS NDVI Data," *Remote Sensing*, vol. 6, no. 11, pp. 11518–11532, Nov. 2014, doi: 10.3390/rs61111518.

[6] I. N. Sinarta and I. W. A. Basoka, "Safety factor analysis of landslides hazard as a result of rain condition infiltration on Buyan-Beratan Ancient Mountain," *Journal of Physics: Conference Series*, vol. 1402, no. 2, p. 022002, Dec. 2019, doi: 10.1088/1742-6596/1402/2/022002.

[7] M. Sarti, F. P. Vaccari, C. Calfapietra, E. Brugnoli, and A. Scartazza, "A Statistical Approach to Detect Land Cover Changes in Mediterranean Ecosystems Using Multi-Temporal Landsat Data: The Case Study of Pianosa Island, Italy," *Forests*, vol. 11, no. 3, p. 334, Mar. 2020, doi: 10.3390/f11030334.

[8] P. S. Latha and K. N. Rao, "Assessment of land use and land cover changes (1988-2020) through NDVI analysis and geospatial techniques," *International Journal of Research and Review*, vol. 7, no. 12, pp. 549–559, 2020.

[9] P. S. Roy and A. Giriraj, "Land Use and Land Cover Analysis in Indian Context," *Journal of Applied Sciences*, vol. 8, no. 8, pp. 1346–1353, Apr. 2008, doi: 10.3923/jas.2008.1346.1353.

[10] C. E. Woodcock *et al.*, "Free Access to Landsat Imagery," *Science*, vol. 320, no. 5879, pp. 1011–1011, May 2008, doi: 10.1126/science.320.5879.1011a.

[11] D. P. Roy *et al.*, "Conterminous United States demonstration and characterization of MODIS-based Landsat ETM+

atmospheric correction," *Remote Sensing of Environment*, vol. 140, pp. 433–449, Jan. 2014, doi: 10.1016/j.rse.2013.09.012.

[12] M. Li, S. Zang, B. Zhang, S. Li, and C. Wu, "A Review of Remote Sensing Image Classification Techniques: the Role of Spatio-contextual Information," *European Journal of Remote Sensing*, vol. 47, no. 1, pp. 389–411, Jan. 2014, doi: 10.5721/EuJRS20144723.

[13] M. G. Ghebrezgabher, T. Yang, X. Yang, X. Wang, and M. Khan, "Extracting and analyzing forest and woodland cover change in Eritrea based on landsat data using supervised classification," *The Egyptian Journal of Remote Sensing and Space Science*, vol. 19, no. 1, pp. 37–47, Jun. 2016, doi: 10.1016/j.ejrs.2015.09.002.

[14] A. Canetti, M. C. Garrastazu, P. P. de Mattos, E. M. Braz, and S. Pellico Netto, "Understanding multi-temporal urban forest cover using high resolution images," *Urban Forestry & Urban Greening*, vol. 29, pp. 106–112, Jan. 2018, doi: 10.1016/j.ufug.2017.10.020.

[15] V. S. da Silva, G. Salami, M. I. O. da Silva, E. A. Silva, J. J. Monteiro Junior, and E. Alba, "Methodological evaluation of vegetation indexes in land use and land cover (LULC) classification," *Geology, Ecology, and Landscapes*, vol. 4, no. 2, pp. 159–169, Apr. 2020, doi: 10.1080/24749508.2019.1608409.

[16] J. Xue and B. Su, "Significant Remote Sensing Vegetation Indices: A Review of Developments and Applications," *Journal of Sensors*, vol. 2017, pp. 1–17, 2017, doi: 10.1155/2017/1353691.

[17] H. Etemadi, J. M. Smoak, and J. Karami, "Land use change assessment in coastal mangrove forests of Iran utilizing satellite imagery and CA–Markov algorithms to monitor and predict future change," *Environmental Earth Sciences*, vol. 77, no. 5, p. 208, Mar. 2018, doi: 10.1007/s12665-018-7392-8.

[18] Y. Ke, J. Im, J. Lee, H. Gong, and Y. Ryu, "Characteristics of Landsat 8 OLI-derived NDVI by comparison with multiple satellite sensors and in-situ observations," *Remote Sensing of Environment*, vol. 164, pp. 298–313, Jul. 2015, doi: 10.1016/j.rse.2015.04.004.

[19] D. Jeevalakshmi, S. N. Reddy, and B. Manikiam, "Land cover classification based on NDVI using LANDSAT8 time series: A case study Tirupati region," in *2016 International Conference on Communication and Signal Processing (ICCSP)*, Apr. 2016, pp. 1332–1335, doi: 10.1109/ICCSP.2016.7754369.

[20] Indrayani, E. Buchari, D. D. A. Putranto, and E. Saleh, "Analysis of land use in the Banyuasin district using the image Landsat 8 by NDVI method," 2017, p. 030007, doi: 10.1063/1.5011514.

[21] M. Mohajane *et al.*, "Land Use/Land Cover (LULC) Using Landsat Data Series (MSS, TM, ETM+ and OLI) in Azrou Forest, in the Central Middle Atlas of Morocco," *Environments*, vol. 5, no. 12, p. 131, Dec. 2018, doi: 10.3390/environments5120131.

[22] P. Singh and O. Javeed, "NDVI Based Assessment of Land Cover Changes Using Remote Sensing and GIS (A case study of Srinagar district, Kashmir)," *Sustainability, Agri, Food and Environmental Research*, vol. 9, no. 4, Mar. 2021, doi: 10.7770/safer-V0N0-art2174.

[23] I. Putrajaya and I. P. Mas Martayana, "Analysis of Vegetation Density Using Landsat 8 Imagery for Mapping Characteristics of Green Open Space in Denpasar City," 2021, doi: 10.4108/eai.10-11-2020.2303425.

[24] M. S. Sumarniasih and M. Antara, "Land suitability for food crops and plantations in Bangli regency Province Bali-Indonesia," *Plant Archives*, vol. 20, no. 1, pp. 1693–1701, 2020.

[25] C.-Y. Liu, P. Aryastana, G.-R. Liu, and W.-R. Huang, "Assessment of satellite precipitation product estimates over Bali Island," *Atmospheric Research*, vol. 244, p. 105032, Nov. 2020, doi: 10.1016/j.atmosres.2020.105032.

[26] J. R. Thomlinson, P. V Bolstad, and W. B. Cohen, "Coordinating Methodologies for Scaling Landcover Classifications from Site-Specific to Global," *Remote Sensing of Environment*, vol. 70, no. 1, pp. 16–28, Oct. 1999, doi: 10.1016/S0034-4257(99)00055-3.

[27] G. M. Foody, "Status of land cover classification accuracy assessment," *Remote Sensing of Environment*, vol. 80, no. 1, pp. 185–201, Apr. 2002, doi: 10.1016/S0034-4257(01)00295-4.

[28] N. Patel and B. Kaushal, "Improvement of user's accuracy through classification of principal component images and stacked temporal images," *Geo-spatial Information Science*, vol. 13, no. 4, pp. 243–248, Jan. 2010, doi: 10.1007/s11806-010-0380-0.