http://journal.uir.ac.id/index.php/JGEET

E-ISSN : 2541-5794
P-ISSN : 2503-216X

Journal of Geoscience,
Engineering, Environment, and Technology
Vol 8 No 3 2023

RESEARCH ARTICLE

Impact of Land Use Change on Land Capability in Katingan Regency, Central Kalimantan, Indonesia

Beni Iskandar [1]*, Fathul Zannah[2], Rifqi Anshari[3]

[1] *Department Forestry, Faculty of Agriculture and Forestry, University Muhammadiyah of Palangkaraya, Palangka Raya City, Indonesia.*
[2] *Department Basic Education, Faculty of Teacher and Education, University Muhammadiyah of Palangkaraya, Palangka Raya City, Indonesia.*
[3] *Department Forestry, Facultry of Forestry, University of Lambung Mangkurat, Banjarbaru City, Indonesia.*

* Corresponding author : beniiskandar@umpr.ac.id
Tel.: +6281254674873
Received: Mar 9, 2023; Accepted: Jul 24, 2023.
DOI: 10.25299/jgeet.2023.8.3.12423

Abstract

The imbalance between land use and land capability can cause environmental problems in Katingan Regency. This study aims to analyze changes in land use change for the 2015-2021 period, land capability, land cover suitability with land capability in Katingan Regency. This research uses the method of overlaying the 2015 and 2021 land cover maps, analyzing land capability with variables of erosion maps, flood maps, and aridity maps, and analyzing land suitability by overlapping land use maps and land capability maps. The results show that land use change is 67.864 ha with map accuracy KA = 90.6% and OA 81.1%, while the concentration of land use change in Malan Island District with an LQ value of 2.5. Land capability is divided into three with the limiting factors of erosion, flooding, and slope class, namely: class II, III, IV, VI, and VII which are designated as productive paddy fields, dry land agriculture, and agriculture mixed with shrubs. Land use change has an impact on land capability, namely the increase of unsuitable land by 23.050 ha. This research can provide important information for taking policies and strategies for optimizing land use at the site level in Katingan Regency in the future.

Keywords: Land use change, Land capability, Katingan Regency

1. Introduction

Land use change or land cover (LULC) a general term resulting from human conversion of land on the Earth's surface (Gaveau *et al.*, 2014). Previous research has shown that the drivers of LULC are biophysical and socio-economic. (Lambin *et al.*, 2001; Margono *et al.*, 2014; Purwanto, Rusolono and Prasetyo, 2015). Humans have brought about varied land uses according to the purposes of food production, provision of shelter, recreation, and industry (Roy and Roy, 2010; Gaveau *et al.*, 2014). Analysis of quantitative estimation of LULC in the end population growth exceeds land production capacity (Roy and Roy, 2010).

Katingan Regency is a regency located in the province of Central Kalimantan, The population growth rate in this district showed a positive upward trend of 1.65% in 2015 (BPS, 2016) and the population growth rate has increased by 0.54% in 2021 (BPS, 2022). Several studies have shown that the regency is vulnerable to flooding and there was a decrease in forest area of 243,255 ha from 1990 to 2006 (Niin, 2010; Rusdiyatmoko, 2012). The regency has experienced flooding in recent years due to overflows from the Samba and Katingan rivers in 2021 and 2022. (BNPB, 2021, 2022). One major contributing factor to flooding is land use change, with villages living close to mines, rivers and oil palm plantations more likely to be affected by flooding (Wells *et al.*, 2016).

Some studies mention that there is a relationship between the influence of LUCL on the carrying capacity of land capability. Land use change can decrease the land capability in Lake Victoria (Maitima *et al.*, 2010), (Wijitkosum, 2016) Land use change causes a decrease in land capability in Thailand (Wijitkosum, 2016), (Fitriah, 2011) concluded that land use change resulted in a decrease in the carrying capacity of land in Bima City, (Pugara, Pradana and Puspasari, 2021) showed the impact of land use change on water carrying capacity in Kajen and study of watershed carrying capacity and land use change in flood-prone areas in Semarang City (Setyowati *et al.*, 2021). Regulation of the Minister of Environment of the Republic of Indonesia nomor 17 of the year 2009, the scope of environmental carrying capacity in spatial planning includes considering the determination of land capability for the allocation of spatial utilisation.

The unbalance between land use and the carrying capacity of land capability can lead to environmental problems such as damage and natural disasters, this phenomenon is proven that Katingan Regency experienced floods in 2021 and 2022 respectively. This condition is an indicator that there are changes in land use that have an impact on the carrying capacity of the environment. This study aims to analyze changes in land use change for the 2015-2021 period, land capability, land cover suitability with land capability in Katingan Regency

2. Data and Methods

The data used in this research are: 2015 Land Use (LU) map and 2021 Land Use (LU) map, slope map, erosion hazard map, and flood vulnerability map. This research is located in Katingan Regency, Central Kalimantan Province (Fig. 1).

2.1 Validation

Validation procedures by comparing land use maps with field survey results and supporting SPOT high spatial resolution imagery in 2022. (Dorais and Cardille, 2011) high-resolution imagery can be used to support the validation of land use maps. Validation points on the ground and on the image were randomly determined, considering the representativeness of the land use class. The technique of calculating validation by testing the results of land use interpretation is overall accuracy (OA) and kappa accuracy (Kappa) (Foody, 2002), the formulation is as follows:

$$OA = \frac{\sum_{i=1}^{r} X_{ii}}{N} 100 \qquad (1)$$

$$Kappa = \frac{N\sum_{i=1}^{r} X_{ii} - \sum_{i=1}^{r} X_{i+}X_{+i}}{N^2 - \sum X_{i+}X_{+i}} 100 \qquad (2)$$

where X_{ii} = diagonal value of contingency matrix row-*i* and column-*i*; *N* number of observation points; and *r* = number of land use classes.

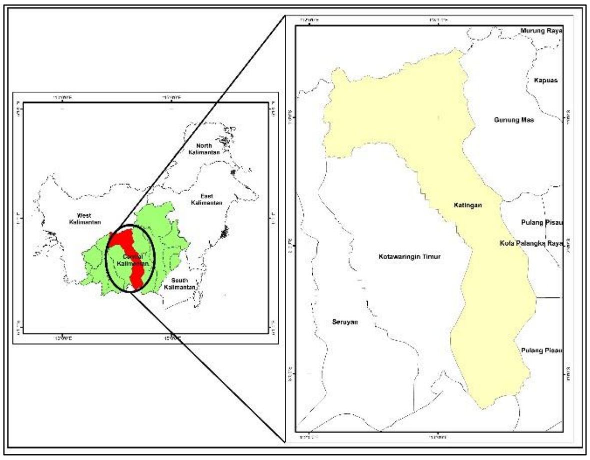

Fig. 1. Map of research location

Overview of the method procedure used in the study (Fig. 2)

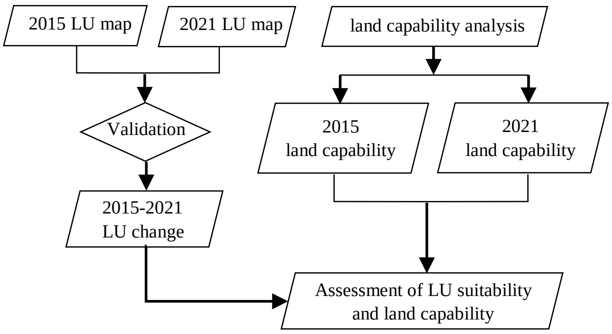

Fig. 2. Research procedure

2.2 Land use change analysis

Analysis of land use change by overlaying the 2015 land use map with the 2021 land use map, which then describes the phenomenon of land use change patterns, then analyses the concentration of land use change (Wheeler, 2005), the formula as follows:

$$LQ = \frac{X_{IJ}/X_L}{X_J/X_{...}} \qquad (3)$$

where X_{ij} = area of land use change in the district to-*i; XL* = total area of land use change in the regency*;* X_j = district are to-*i;* and *X...* = total area of the Regency.

2.3 Land capabilitya analysis

Land capability is identifying potential land capability with the aim of good land management practices (Brown *et al.*, 2009). The variable used to assess land capability are soil texture map, surface slope map, drainage map, effective depth map, erosion hazard map, and flood vulnerability map. According to (Arsyad, 2005) the determination of land capability class considers land characteristics with land capability class criteria presented in. Land capability is classified into 8 classes, the threat of damage or resistance increases linearly from class I to class VIII, land classes I to IV can be used as agricultural land with low to high level cultivation, land classes V, VI and VII are intended for grassland, forestry crops or natural plants, and land class VIII is intended as a conservation area (Hardjowigeno and Widiatmaka, 2007)

2.4 Assessment of land use suitability and land capability

Evaluation of the suitability of land use and land capability is done by overlapping the land use and land capability maps (Fitriah, 2011), each land unit can be described in terms of its characteristics related to inhibiting factors as well as its potential to develop its spatial use and determine its suitability for use, illustrated as follows:

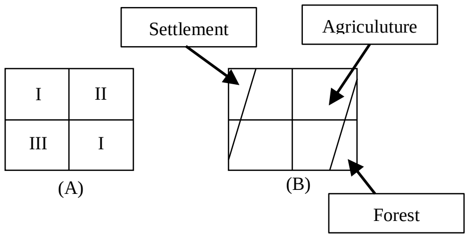

Fig 1. (A) land capability and (B) land use

3. Result and Discussion

3.1 Validation

This study showed map validation results with an accuracy of KA 90.6% and OA 81.1% with 138 sample points collected in the field and SPOT-6/7 image interpretation (Table 1). A total of 65 validated points are true land use change and a total of 60 validated points are true no land use change, while the points that do not match the reality in the field are 6 points and 7 points (Table 1). According to (Purwanto, Rusolono and Prasetyo, 2015) land use data sourced from the Ministry of Environment and Forestry resulted in accuracy KA above 90% on the island of Kalimantan. According to (Foody, 2002) OA 81% accuracy is categorised as good accuracy.

Table 1. Validation map

Description	Land use change	No land use change	Amount
Land used change	65	7	72
No land used change	6	60	66
Amount	71	67	138
			KA = 90.6%
			OA = 81.1%

3.1 Land use change analysis

The pattern of land use change from 2015-2021 (Table 2), there are three highest changes in land use change, namely forest changing into shrubs 28,580 ha (42.1%), forest changing into agriculture around 24,776 ha (36.5%), forest changing into plantations 7,590 ha (11.2%). This fact shows that after exploiting the timber forest products, it is then abandoned to become unproductive scrub land, besides that, with the increase in population, the pressure to fulfil the needs of life causes changes to agriculture and plantations. Spatial distribution of land use change (Fig. 1). The land use change trend in this study is in line with the study of (Purwanto, Rusolono and Prasetyo, 2015) stated that the majority of forest cover changes to the scrub class on Kalimantan Island for the 2000-2013, (Ekadinata *et al.*, 2011) stated that the majority of forest cover changes turned into shrubs around 52% in the 1990-2000 period, and 23% in the 2000-2005, plantations contributed to forest cover change of 3.7-3.9 million ha on the island of Borneo in the 1990-2015 (Gaveau *et al.*, 2016) and according to (Scriven *et al.*, 2015) there is a high demand for land for agriculture or plantations on the island of Borneo.

Table 2. Land use change track

Track	Year		Area	Percent
	2015	2021	(Ha)	(%)
1	Forest	Bare land	6.384	9.4
2	Forest	Agriculture	24.776	36.5
3	Forest	Scrub	28.580	42.1
4	Forest	Water body	57	0.1
5	Forest	Plantation	7.590	11.2
6	Forest	Settlement	87	0.1
7	Forest	Ricefield	389	0.6
Amount			67.864	100

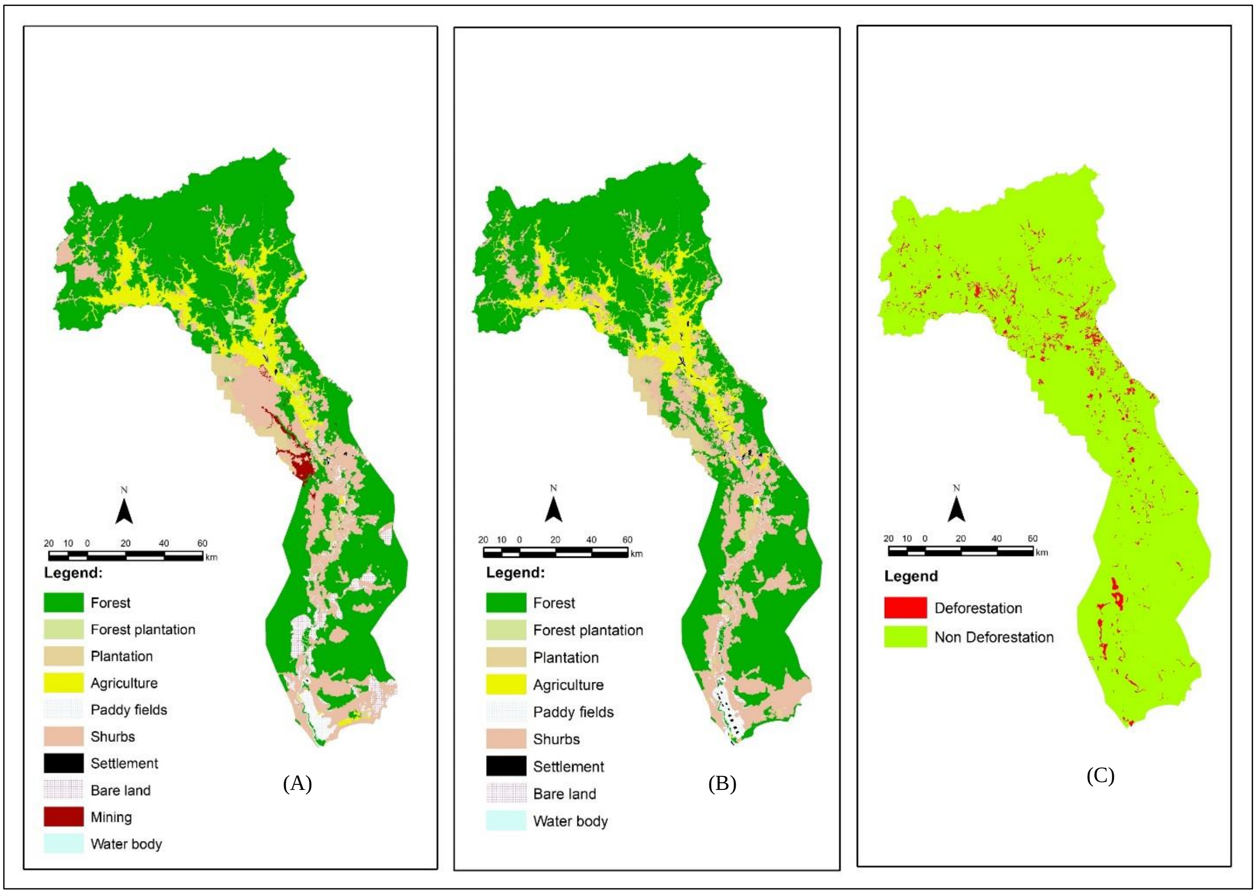

Fig 1. Land use 2015 (A), Land use 2021 (B), and deforestation 2015-2021 (C)

The concentration of land use change activities based on administration in sub-districts in Katingan Regency shows that six districts have LQ values < 1, five districts have LQ values ≈ 1, and one district has LQ values > 1. Malan Island district has the highest LQ value (2.5), and Petak Mali district has the lowest LQ value (0.4) (Table 3) and spatial distribution of LQ values (Fig. 2). LQ value > 1 means that there is a high concentration of land use change activity in the district, compared to other districts, and vice versa for an LQ value < 1, while an LQ value ≈ 1 means that the concentration of land use change activity in the district is equal to the total regional average. (Wheeler, 2005). The results of the study (Niin, 2010) showed that Pulan Malan district had an average LQ value of 2.5, while Marikit District had an LQ value of 0.3 in the 1990-2000, when compared to the results of this study, the highest

LQ value was the same in Malan Island District, while the lowest LQ value was in a different sub-district, thus Marikit District experienced a decrease in land use change activity in the 2015-2021. Data from the Central Statistics Agency states that there is an increasing trend in the area of Palm Oil plantations in Pulan Malan District for the period 2020-2021 (BPS, 2022)

Table 3. Land use change concentration value

Districk	Nilai LQ
Bukit Raya	1.0
Kamipang	0.6
Katingan Hilir	0.9
Katingan Hulu	0.9
Katingan Kuala	0.6
Katingan Tengah	1.3
Marikit	1.4
Mendawai	1.1
Petak Malai	0.4
Pulau Malan	2.5
Sanaman Mantikei	1.4
Tasik Payawan	0.6
Tewang Sanggalang Garing	1.0

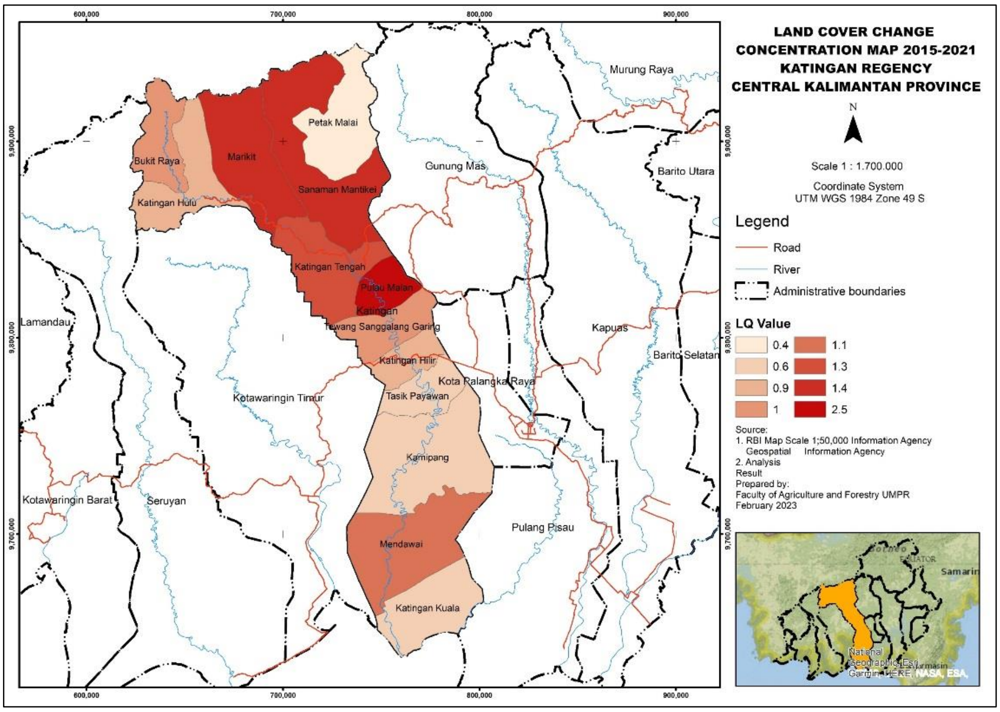

Fig. 3.Value LQ Katingan Regency

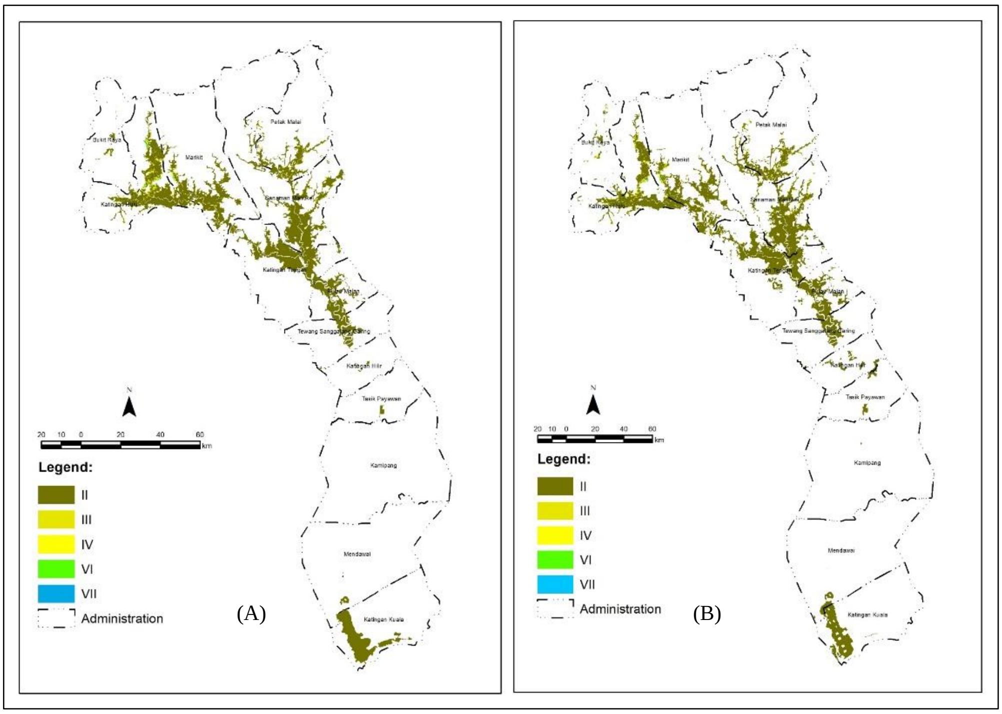

Fig. 4. Land capability map (A) 2015 and (B) 2021

3.3 Land capability analysis

The results showed land capability from class II to VII, meaning that the land capability class can be developed into rice field use, dry land farming, and dry land farming mixed with shrubs, but there are limiting factors such as erosion, flooding and slopes, on land with limiting factors the need for soil and water conservation treatment so that this land can be productive. The largest land capability is class II with erosion limiting factors covering 139.603 ha (78.1%), then class III limiting factors of flooding and erosion covering 26.608 ha (14.9%), class III limiting factors of erosion covering 6.865 ha (3.8%) (Table 4) and spatial distribution of land capability (Fig. 4). According to (Nikkami, Elektorowicz and Mehuys, 2002) erosion management strategies by means of vegetative approaches such as cover crops, and optimal land use. (Fang, 2021) land management with terraces on contoured land has an impact on reducing soil and nutrient loss, reducing water runoff. (Maetens, Poesen and Vanmaercke, 2012) Soil and water conservation management can use three approaches: first, plant and vegetation management (cover crops, mulching, strip cropping, and exclusion), second, soil management (tillage according to contours, drainage and soil improvement), third, mechanical methods (terracing, contour borders, geotextiles).

Table 4. Land capability

Land capability	Area (Ha)	(%)
II (E)	139.603	78.1
II (F, E)	1.501	0.8
II	2.059	1.2
II (F, E)	26.608	14.9
III (E)	6.865	3.8
III (E)	70	0.0
III (F,)	14	0.0
III (F,)	0.3	0.0
III	0.8	0.0
IV (E)	1.492	0.8
IV (E)	47	0.0
VI (S, E)	494	0.3
VI (L, E)	21	0.0
VII (L,E)	16	0.0
VII (L)	44	0.0
Amount	**178.839**	**100**

3.4 Assessment of land use suitability and land capability

Overlapping analysis between the suitability of productive land use (dry land farming, mixed land farming with shrubs, and rice fields) with land capability, obtained three categories, namely suitable means that productive land use with land capability meets the criteria, conditionally suitable means that there is one inhibiting factor, namely erosion, flooding and slope, while not suitable means that productive land use with land capability is not in accordance with its designation. The results of this study showed that there was no change in the suitable class, conditionally suitable decreased by an area of (-23.050 ha), while there was an increase in the unsuitable class of (+23.050 ha) (Table 5) and spatial distribution of land suitability, thus changes in land use can have an impact on the ability of the unsuitable class of land to increase, but also have no impact if the suitable class does not change (Table 5). (Mujiyo, Sutarno and Rafirman, 2018) land change has an impact on land capability sub-classes, but not so much on the general class of land use in Wonogiri Regency. (Vijith, Hurmain and Dodge-Wan, 2018) revealed that land change can reduce land capability, changes in forest cover reduce protection against erosive rainfall and sediment delivery is relatively high due to changes in forest cover.

Table 5. Change in suitability of productive land use and land capability 2015-2021

Desctiption	2015 area (ha)	2021 area (ha)	Change area (ha)
Suitable	2.061	2.061	0
Conditionally suitable	171.012	147.962	-23.050
No suitable	5.767	28.817	+23.050
Amount	178.839	178.839	

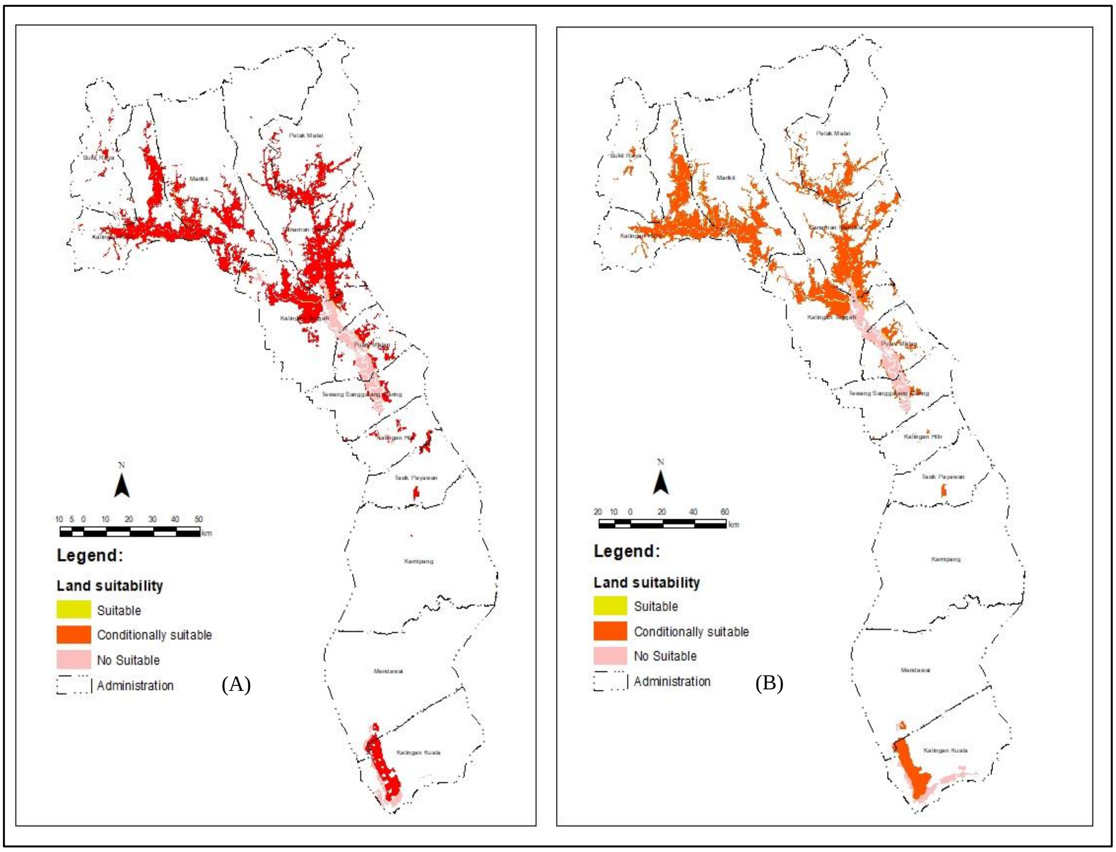

Fig. 4. Land suitabiliy (A) 2015 dan (B) 2021

4. Conclusion

The results of the study concluded that there was a change in land use change is 67.864 ha with map accuracy KA = 90.6% and OA 81.1%, while the concentration of land use change in Malan Island District with an LQ value of 2.5. Land capability is divided into three with the limiting factors of erosion, flooding, and slope class, namely: class II, III, IV, VI, and VII which are designated as productive paddy fields, dry land agriculture, and agriculture mixed with shrubs. Land use change has an impact on land capability, namely the increase of unsuitable land by 23.050 ha. This research can provide important information for taking policies and strategies for optimizing land use at the site level in Katingan Regency in the future.

Acknowledgements

We would like to acknowledge the Assembly for Higher Education Research and Development of the Muhammadiyah Central Leadership for funding this research. We would like to acknowledge the Organization for Research and Community Service University Muhmmadiyah of Palangkaraya for assisting us in the administration of the research grant for Research Muhammadiyha Batch VI.

References

Arsyad, S. (2005) *Soil and Water Conservation*. 2nd edn. Bogor, Indonesia: Pustaka IPB Press.

BNPB (2021) *Data dan Informasi Kebencanaan Bulanan Teraktual*. Jakarta. Available at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi32M7--NH5AhUN6HMBHaHwDiAQFnoECA4QAQ&url=https%3A%2F%2Fperpustakaan.bnpb.go.id%2Fbulian%2Findex.php%3Fp%3Dfstream-pdf%26fid%3D424%26bid%3D2026&usg=AOvVaw0EQFG397OXyJVVjVfni9Sr.

BNPB (2022) 'Banjir Ganggu Aktivitas Warga Kabupaten Katingan', *bnpb.go.id*. Available at: https://bnpb.go.id/berita/banjir-ganggu-aktivitas-warga-kabupaten-katingan.

BPS (2016) *Kabupaten Katingan dalam Angka 2016*. Katingan: Banda Pusat Statistik.

BPS (2022) *Kabupaten Katingan dalam Angka 2022*. Katingan: Badan Pusat Statistik.

Brown, I. *et al.* (2009) 'Land capability: A strategic planning tool for integrated climate change responses', *Iop Conference Series: Earth and Environmental Science*, 6. Available at: https://doi.org/10.1088/1755-1307/6/34/342015.

Dorais, A. and Cardille, J. (2011) 'Strategies for Incorporating High-Resolution Google Earth Databases to Guide and Validate Classifications: Understanding Deforestation in Borneo', *Remote Sensing*, 3, pp. 1157–1176. Available at: https://doi.org/10.3390/rs3061157.

Ekadinata, A. *et al.* (2011) *Indonesia's land-use and land-cover changes and their trajectories (1990, 2000 and 2005)(ALLREDDI Brief 01), Bogor: World Agroforestry Centre–ICRAF, SEA Regional Office*.

Fang, H. (2021) 'Effect of soil conservation measures and slope on runoff, soil, TN, and TP losses from cultivated lands in northern China', *Ecological Indicators*, 126, p. 107677. Available at: https://doi.org/https://doi.org/10.1016/j.ecolind.2021.107677.

Fitriah, D. (2011) 'Perubahan penggunaan lahan dan pengaruhnya terhadap daya dukung lahan untuk mendukung perencanaan penataan ruang (Studi kasus di kota Bima provinsi Nusa Tenggara Barat)', in.

Foody, G.M. (2002) 'Status of land cover classification accuracy assessment', *Remote Sensing of Environment*, 80(1), pp. 185–201. Available at: https://doi.org/https://doi.org/10.1016/S0034-4257(01)00295-4.

Gaveau, D.L.A. *et al.* (2014) 'Four decades of forest persistence, clearance and logging on Borneo', *PloS one*, 9(7), p. e101654.

Gaveau, D.L.A. *et al.* (2016) 'Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo', *Scientific reports*, 6(1), pp. 1–13.

Hardjowigeno, S. and Widiatmaka (2007) 'Suitability Evalution and Land Use Planning'. Yogyakarta, Indonesia: Gajah Mada University Press.

Lambin, E.F. *et al.* (2001) 'The causes of land-use and land-cover change: moving beyond the myths', *Global Environmental Change*, 11(4), pp. 261–269. Available at: https://doi.org/https://doi.org/10.1016/S0959-3780(01)00007-3.

Maetens, W., Poesen, J. and Vanmaercke, M. (2012) 'How effective are soil conservation techniques in reducing plot runoff and soil loss in Europe and the Mediterranean?', *Earth-Science Reviews*, 115(1), pp. 21–36. Available at: https://doi.org/https://doi.org/10.1016/j.earscirev.2012.08.003.

Maitima, J. *et al.* (2010) 'Land use changes, impacts and options for sustaining productivity and livelihoods in the basin of lake Victoria'.

Margono, B.A. *et al.* (2014) 'Primary forest cover loss in Indonesia over 2000–2012', *Nature climate change*, 4(8), pp. 730–735.

Mujiyo, M., Sutarno, S. and Rafirman, R. (2018) 'The impact of land use change on land capability in Tirtomoyo-Wonogiri', *Journal of Degraded and Mining Lands Management*, 6(1), p. 1449.

Niin (2010) 'Dinamika Spasial Penggunaan Lahan di Kabupaten Katingan dan Kota Palangaka Raya Provinsi Kalimatan Tengah'.

Nikkami, D., Elektorowicz, M. and Mehuys, G.R. (2002) 'Optimizing the management of soil erosion', *Water Quality Research Journal*, 37(3), pp. 577–586.

Pugara, A., Pradana, B. and Puspasari, D.A. (2021) 'The Impact of The Land-Use Changes on The Water Carrying Capacity in Kajen, Indonesia: A Spatial Analysis', *{IOP} Conference Series: Earth and Environmental Science*, 887(1), p. 12018. Available at: https://doi.org/10.1088/1755-1315/887/1/012018.

Purwanto, J., Rusolono, T. and Prasetyo, L. (2015) 'Spatial Model of Deforestation in Kalimantan from 2000 to 2013', *JMHT*, 21, pp. 110–118. Available at: https://doi.org/10.7226/jtfm.21.3.110.

Roy, P. and Roy, A. (2010) 'Land Use and Land Cover Change: A Remote Sensing & GIS Perspective', *Journal of the Indian Institute of Science*, 90, pp. 489–502.

Rusdiyatmoko, A. (2012) 'Analysis of Flood Susceptibility Based on Raster Operation Method by Using Geographic Information System'.

Scriven, S.A. *et al.* (2015) 'Protected areas in Borneo may fail to conserve tropical forest biodiversity under climate change', *Biological Conservation*, 184, pp. 414–423.

Setyowati, D.L. *et al.* (2021) 'Assessment of Watershed Carrying Capacity and Land Use Change on Flood Vulnerability Areas in Semarang City', in *Forum Geografi*.

Vijith, H., Hurmain, A. and Dodge-Wan, D. (2018) 'Impacts of land use changes and land cover alteration on soil erosion rates and vulnerability of tropical mountain ranges in Borneo', *Remote Sensing Applications: Society and Environment*, 12, pp. 57–69. Available at: https://doi.org/https://doi.org/10.1016/j.rsase.2018.09.003.

Wells, J.A. *et al.* (2016) 'Rising floodwaters: mapping impacts and perceptions of flooding in Indonesian Borneo', *Environmental Research Letters*, 11(6), p. 64016. Available at: https://doi.org/10.1088/1748-9326/11/6/064016.

Wheeler, J.O. (2005) 'Geography', in K.B.T.-E. of S.M. Kempf-Leonard (ed.). New York: Elsevier, pp. 115–

123. Available at: https://doi.org/https://doi.org/10.1016/B0-12-369398-5/00277-2.

Wijitkosum, S. (2016) 'The impact of land use and spatial changes on desertification risk in degraded areas in Thailand', *Sustainable Environment Research*, 26(2), pp. 84–92. Available at: https://doi.org/https://doi.org/10.1016/j.serj.2015.11.004.