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Land use change on mangrove forest conservation of Kelumpang Bay nature reserve, South Kalimantan

Mufidah Asyari[1*], Udiansyah[2], BagyoYanuwiadi[3], M. Luthfi Rayes[4]

[1]*Doctoral Program of Agriculture, University of Brawijaya, Malang, 65145, Indonesia*

[2]*Faculty of Forestry, University of Lambung Mangkurat, Banjarmasin, 70123, Indonesia*

[3]*Faculty of Mathematics and Natural Science, University of Brawijaya, Malang, 65145, Indonesia*

[4]*Faculty of Agriculture, University of Brawijaya, Malang, 65145, Indonesia*

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Abstract

Rapid population triggered the function conversion of land for agriculture, farming and settlement. It also occurred in the area of nature reserve that should not experienced function-change of the land. The research was conducted to assess the land use change in Kelumpang Bay Nature Reserve, South Kalimantan in 2000, 2003, 2006, 2001, and 2012 using Landsat 7 Enhancement Thematic Mapper Plus (ETM+) imageries. Total covering area of the research is 29.925.738 hectare. Land use identify by Land sat 7 ETM+ on screen image interpretation. Spatial analysis used Two Dimensional Matrix Overlay Method (Pivot Table). Application of GIS (9.3 Arc View program) was used for covered land analysis. We compared the two land use maps on different years. The results showed that there was a change of land use in 12 years (from 2000 to 2012) in the Kelumpang Bay Nature Reserve (KBNR). Primary mangrove forest area decrease in the area of 952.91 ha (3.18%), while the secondary mangrove forest decreases for 28.07 ha (0.09%). The mangrove area reduction was caused by the deforestation for the use of timber. There were increasing of the land use conversion for shrub-lands swamp for 571.16 ha (1.91%), 157.98 ha of ponds (0.53%), the open land for 116.67 ha (0.39%), the mines for 76.98 ha (0.25%), shrubs for 63.20 ha (0.21%), the plantation for 62.42 ha (0.21%), and settlement for 34.58 ha (0.12%). The increased land conversion should not occur because it will destroy the function of the area as a nature reserve.

***Corresponding Author:** Mufidah Asyari ✉ mufie_ikhsan@yahoo.com

Introduction

The rate of mangrove forests degradation was increased in the period between 2000 and 2006 covered an area of 45,887 ha, with average about 7,647.83 ha per year; then from 2006 to 2009, covered an area of 7,995 ha, with average about 2,665 ha per year (BPDAS Barito, 2006; Sirang *et al.*, 2010). These rising rate of degradation due to the utilization of mangrove forests to meet the daily needs of the community.

The existence of mangrove forests is essential for life, as it functional, directly and indirectly benefit for living beings (Sathirathai and Barbier, 2001), and support their social and economic development (Anwar and Gunawan, 2007; Ndenecho, 2007). Examples of mangrove forests utilization by society are as a raw material for charcoal (Tepu, 2004; Saunders *et al.*, 2007), organic materials, sources of food ingredients, cosmetic ingredients, tanners (made of mangroves wood: *Langadai* and *Mirih*), the ingredients of medicines (Alongi, 2002; Rönnbäck *et al.*, 2007; Hussain and Badola, 2010), agricultural land, plantations and fishponds (Sremongkontip *et al.*, 2000; Alongi, 2002 Sirang *et al.*, 2010;), and settlement (Alongi, 2002; Sirang *et al.*, 2010; Klemas, 2011; Elsebaie and Aguib, 2013). Mangrove forests also contribute to organic detritus, a crucial source of energy (Dahuri, 2003), and feed (Jayatissa *et al.*, 2006; Sandin, 2009) for the water organism. In addition, the mangrove forests block the strong wind, prevent abrasion and restrain sea waves (Bengen, 2002; Bengen, 2004; Onrizal, 2006; Tarigan, 2008).

The changing in coastal area is not only caused by natural factors, but it is also affected by activities of human who inhabits the surrounding area (Klemas, 2011; Omo-Irabor *et al.*, 2011). Coastal region is the gate of various activities of community and it suffered the impact of their activities (Saunders *et al.*, 2007; Biswas *et al.*, 2009). There were many commercial activities in the coastal area that negatively change the environment (Mohanty *et al.*, 2008; Biswas *et al.*, 2009).

Distribution of mangrove forests in South Kalimantan covered an area of 135,181.5 ha; includes a conservation area of 77,944.3 ha (57.66%), production forest area of 4,792.3 ha (3.55%) while intensive use forest area of 52,444.9 ha (38.79%) (BKSDA, 2008; Sirang *et al.*, 2010). Mangrove forests covered area of 98,494 ha located in Kotabaru Regency, while based on the status of forest, there are an area that served as nature reserve with total area cover of 66,487.5 ha (67.50%), as the production forest area of 3,510.4 ha (3.57%), and other uses covering an area of 28,496.7 ha (28.93%) (Ministry of Forestry, 2009).

The indication of mangrove forests degradation has taken place on parts of the coastal area. The level of mangrove forests destruction in Kotabaru, are heavily destructed area of 45,887 ha (69.02%) contained on Conservation Area (BPDAS Barito, 2006). Based on canopy density, the mangrove forest consists of open land area of 25,609.7 ha (26%), moderate canopy density area of 45,160.5 ha (45.85%), and dense canopy density area of 27,724.4 ha (28.15%) (Sirang *et al.*, 2010).

Kelumpang Bay Nature Research (KBNR) – including mangrove forest conservation area – has a total area of 29,925.74 ha or 30.38% of total area of mangrove forests in Kotabaru District. It means that this natural reserve reaches 45.01% of all mangrove forests area. It showed that there had been destruction to mangrove forests in conservation areas. It is due to excessive exploitation and land conversion into residential, agricultural, forestry or fishpond. Based on those, the landuse changed in KBNR should be taken into account due to the fact that this conservation area is one of the remaining mangrove forest ecosystems in South Kalimantan. Thus the objectives of this study are: to identify and delineate land cover of mangrove forest conservation area in The KBNR, to assess the land use change of mangrove forest conservation area in different periods ,to delineate all changes that occurred in mangrove

forests area and determines the level of degradation of the mangrove forests in KBNR.

Materials and methods

Study Area

This research was carried out in the conservation area of Mangrove Forests in the KBNR, which covers ± 29,925.74 ha (Ministry of Forestry, 2009). The areas are located between 9,690,560 mU and 9,656,294 mU of the equator, and 391,775 mT and 420,369 mT of the Greenwich meridian (Fig. 2). The topography in the study area consists of flat plain with 0-8% slopes; with soil type consist of alluvial, red yellow podsolic, latosol and lateritic soils. There is a slight muddy at the beach area (BKSDA, 2008; BKSDA, 2010).

Conservation area of Kelumpang is located along the Gulf of Coast Central Kelumpang, 350 km from Banjarmasin city. The nearest distance from the capital of Kotabaru District is 15 miles across the Selat Laut nature reserve. Administratively, this nature reserve is located in four sub district in Kotabaru District. These sub districts are Central Kelumpang, West Kelumpang, Kelumpang Hulu, and South Kelumpang (BPS, 2010; BPS, 2013).

Data Collection

This study used primary and secondary data. Primary data was obtained by identification study of Landsat 7 ETM+ (Path/row: 117/063) of 2012. Land cover digital map of KBNR for the year of 2000, 2003, 2006 and 2009 were obtained from the interpretation of Land sat imageries (BPKH Region V Banjarbaru). Secondary data include: digital topographical map of Indonesia published in 2007, at the scale of 1:25,000 and South Kalimantan Forest Area map of 2009.

The equipment used in this study include: a computer, digitizer, plotter and printer. The following software was used in this study namely Arc View 3.3 and ArcGis 9.3 (for data analysis and mapping) and Microsoft Office 2007 (for database processing). Those equipments and softwares were available in the laboratory of Geographic Information Systems (GIS), and Remote Sensing Laboratory of BPKH Region V Banjarbaru.

Processing and Data Analysis

The methods used in this study were identification and delineation of the land use/land cover (LULC) on mangrove forest conservation area in KBNR. The interpretation on digital map of 2000 to 2009 and LULC areas of mangrove forests in KBNR of the year of 2000, 2003, 2006 and 2009 were obtained from BPKH Region V Banjarbaru. The LULC map of 2012 was obtained from interpretation of Land sat 7 ETM+ of 2012, by means of on-screen/visual interpretation (using the elements of interpretation, namely: hue/color, textures, shapes, sizes, patterns, shadows, the site and the association). Finally, it will eventually retrieve the land cover/use in 2012 on mangrove of Kelumpang Bay's.

Annual land cover was analyzed using two dimensional matrix method (a pivot table) of Arc View 3.3. We compared two maps in different years and theme to determine the condition of each land cover. Each Land cover was delineated from 2000, 2003, 2006, 2009 and 2012 to get the land cover area. Land cover/use classifications are presented in table form. The stages of processing and data analysis are described in Fig. 1.

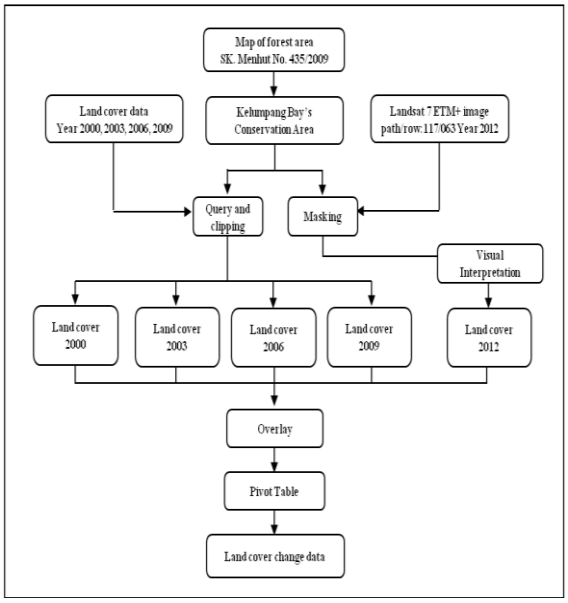

Fig. 1. Data processing.

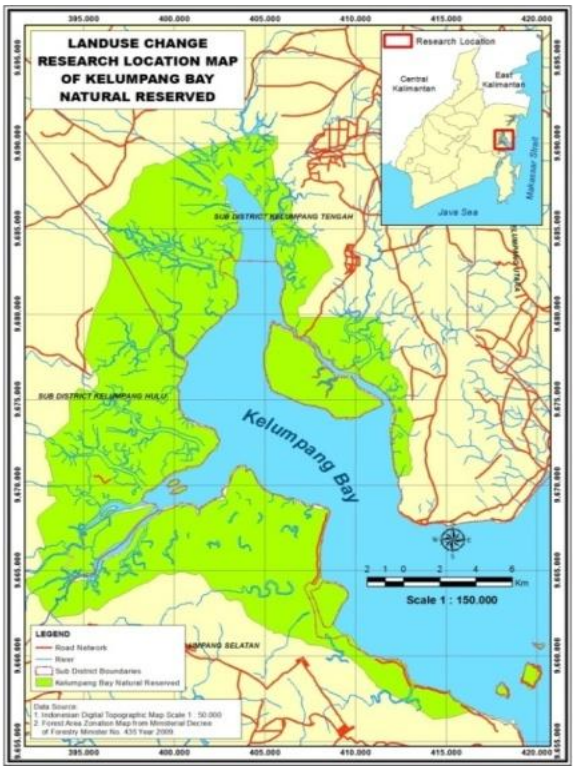

Fig. 2. Study area of Kelumpang Bay Nature Reserve.

The effort to determine land cover/use change was carried out by comparing 2 (two) map of different year. At this stage, data and land use change map were resulted for period of 2000-2003, 2003-2006, 2006-2009, and the 2009-2012, in order to monitored the changes in that area from time to time (Kario *et al.*, 2002). Sukojo and Susilawati (2003) as well as Kumar *et al.* (2012), stated that remote sensing and geographic information systems (GIS) as a tool in determining ecosystem classification of mangrove forest, and become an accurate method in land use change analysis.

The rate of degradation forest in Kelumpang Bay's was determined by using the technical direction of land critical spatial data (BPDASPS, 2013). Forestry Minister Regulation No.P.32/Menhut-II/2009 procedure was used to determine land critical criteria, thus the level of land degradation was acquired. The assessed parameters include the land cover, slope, level of danger erosion and management. Data were tabulated by scoring methods. The scoring results become the consideration to preserved the forest area. The influence of land cover change was known by nonparametric test (Mann Whitney). If the value is significance > 0.05, thus land cover/use-change would not affect Kelumpang Bay's area.

Results and discussion

Classification of Land Cover and Land Use (LULC)

The result of identification and delineation of KBNR were classified based on land cover, i.e. primary mangrove forest; secondary mangrove forest; plantation; dry land farming; mixed dry land – bush farming; bush; shrub swamp; settlement; pond; open land; mines and water bodies.

According to BPDAS Barito (2006) and Sirang *et al.* (2010), land cover in the area of mangrove forests in Kotabaru, consist of woodland, shrubs, swamps, plantations, open land and fishponds. Suwargana (2008) stated that the results of the classification of mangrove forest change consist of mangrove, pond, fields, open land, trees, and mixed settlements. Results of the analysis of the Landsat image from 2000-2012, acquired area-extents with each land cover (Table 1). Land cover was dominated by secondary mangrove forest and primary mangrove forest during 2000-2012.

The Change of Land Use

Land sat analysis result of 2000-2012 shows that there has been change in each land use (Fig. 3). Land use changes from 2000 to 2003 (Table 2) indicates that land cover decrease from the secondary mangrove forest 78.59 ha (0.63%). It was transformed into ponds for fish and shrimp, covers 78.59 ha (25.67%). Based on the map, the conversion only occurred in one location, i.e. Upstream of Kelumpang Sub district, around the estuary. Some location of the pond was very close to the shoreline (≤ 200 m); there was even a 10 meter site from the river's edge. Because it convertion into intensive shrimp farming systems, it led to the deforestation and environmental pollution (Sremongkontip *et al.*, 2000; Singkran and Sudara, 2005; BPDAS Barito, 2006; Tran, 2009).

Table 1. Classification of land covers in KBNR.

Land Cover	Area Width (ha)				
	2000	2003	2006	2009	2012
Primary Mangrove Forest	9,292.34	9,292.34	9,292.34	8,568.33	8,339.43
Secondary Mangrove Forest	12,384.87	12,306.28	11,946.81	12,370.78	12,356.80
Shrubs Bogs	2,778.20	2,846.57	2,927.97	2,927.97	2,840.62
Plantation	1,082.46	1,082.46	1,022.66	1,008.87	1,051.27
Settlement	1,451.32	1,451.32	1,451.32	1,451.32	1,514.52
Dry land mixed bush farming	306.21	384.80	384.80	407.76	464.16
Dry land farming	190.32	190.32	190.32	190.32	224.89
Shrub lands Swamp	217.69	141.61	141.61	147.81	147.81
Fishpond	66.76	-	-	7.60	183.43
Mine	94.72	170.80	170.80	170.80	170.80
Water Body	1,736.16	1,736.16	1,736.16	1,736.16	1,736.16
Open Land	324.69	323.09	660.96	938.02	895.85
Total	**29,925.74**	**29,925.74**	**29,925.74**	**29,925.74**	**29,925.74**

Table 2. Land use change in terms of area in 2000 and 2003.

Classification of Land Use	Width (ha)		Change	
	2000	2003	ha	%
Primary Mangrove Forest	9,292.34	9,292.34	0	0
Secondary Mangrove Forest	12,384.87	12,306.28	-78.59	0.63
Shrubs Bogs	1,451.32	1,451.32	0	0
Plantation	2,778.20	2,778.20	0	0
Settlement	190.32	190.32	0	0
Dry land mixed bush farming	1,082.46	1,082.46	0	0
Dry land farming	217.69	141.61	- 76.08	34.95
Shrub lands Swamp	324.69	323.09	- 1.60	0.49
Fishpond	306.21	384.80	78.59	25.67
Mine	94.72	170.80	76.08	80.32
Water Body	1,736.16	1,736.16	0	0
Open Land	66.76	0	- 66.76	1.00
Total	**29,925.74**	**29,925.74**		

Note: + = Increase; – = Decrease

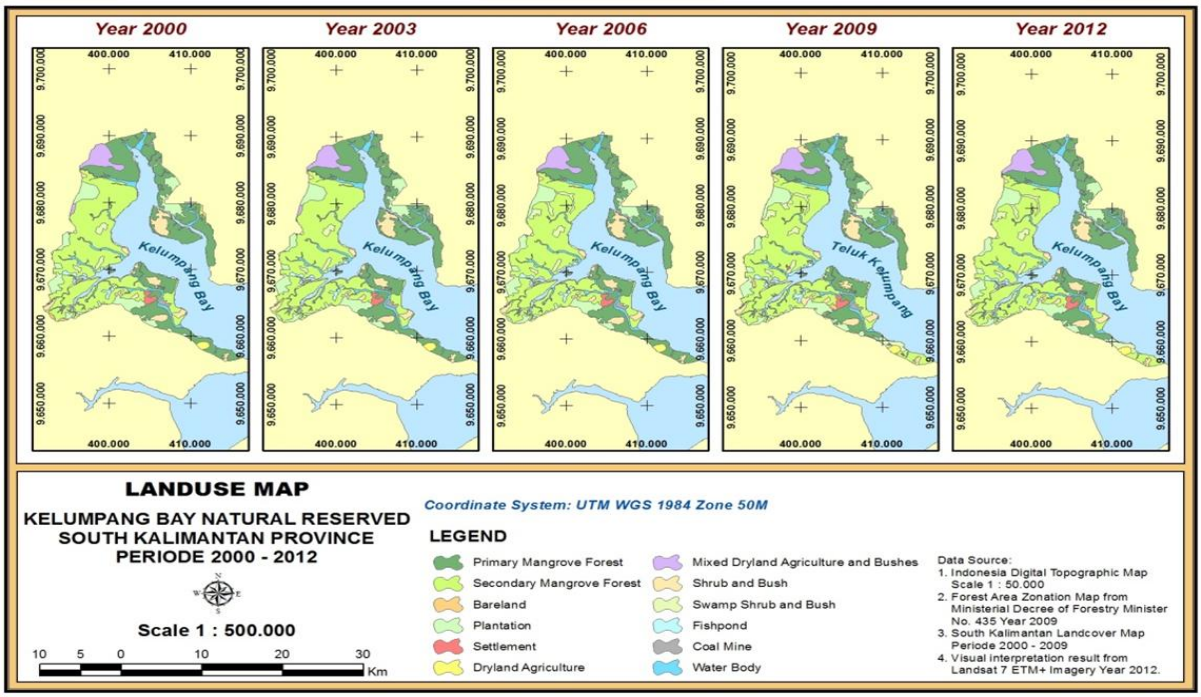

Fig. 3. Land cover of mangrove forest area in KBNR.

The dry land for agriculture was declining from 217.69 ha to 76.08 ha (34.95%), which change into mines. The mine area was utilized for piling the coal before loading and port (BPDAS Barito, 2006; Sirang *et al.*, 2010). The reduced area of mangrove forests as a result of mining activities caused ecological disturbances that lead to the degradation of mangrove forests (Sremongkontip *et al.*, 2000).

The results showed that the largest change of land use occurs from secondary mangrove forests decrease for 359.47 ha (2.92%). This condition indicates that during three years (2003-2006) there has been extensive encroachment of mangrove forests. It was not intentionally caused by the community that wants to convert with specific purposes, such as ponds, rice fields or settlements, but they only take the woods and the land turned into Shrub lands Swamp.

The mangrove trees species which is usually used by community are Bakau (*Rhizophora* sp.), and Mirih (*Xylocarpus granatum* Koen) for building materials, and Tingi (*Ceriops tagal* C.B. Rob) is used for firewood or charcoal (Saunders *et al.*, 2007; Hussain and Badola, 2010; Bengen, 2004; Tarigan, 2008). The existence of illegal logging activities are logging wood with diameter of 10-20 cm, with a length of about 5 meters for firewood, and the mangrove wood for building materials. The mixed dry land – bush fallow decreased about 59.80 ha (5.52%). It transformed into plantation increase about 149.77 ha (5.39%). In addition, some of plantation increases, because venturing from the secondary mangrove forest. Detail land use change in 2003-2006 is presented in Table 3.

The biggest land use change was occurred on mangrove forests conservation (Table 4); the decrease was about 724.01 ha (7.78%). Logging activity causes the increasing of swamp bush land of 277.06 ha (41.92%). Secondary mangrove forest increased to 423.97 ha (3.55%). Some of opening mangrove forests utilized by the community with converting into embankment is 22.96 ha (5.97%) (Alongi, 2002; Sirang *et al.*, 2010). Otherwise, dry land farming mixed bush fallow decrease about 13.79 ha (1.35%) occasionally became dry land farming increased 6.20 ha (4.38 %), while the dry open land about 7.60 ha. Due to excessive illegal logging of mangrove areas, it cannot naturally regenerate and consequently became an open land.

Table 3. Land Use Change Based on Polygons in 2003 – 2006.

Classification of Land Use	Width (ha)		Change	
	2003	2006	ha	%
Primary Mangrove Forest	9,292.34	9,292.34	0	0
Secondary Mangrove Forest	12,306.28	11,946.81	- 359.47	2.92
Shrubs Bogs	1,451.32	1,451.32	0	0
Plantation	2,778.20	2,927.97	149.77	5.39
Settlement	190.32	190.32	0	0
Dry land mixed bush farming	1,082.46	1,022.66	- 59.80	5.52
Dry land farming	141.61	141.61	0	0
Shrub lands Swamp	323.09	660.96	337.87	104.57
Fishpond	384.80	384.80	0	0
Mine	170.80	170.80	0	0
Water Body	1,736.16	1,736.16	0	0
Open Land	0	0	0	0
Total	**29,925.74**	**29,925.74**		

Note: + = Increase; – = Decrease

Table 4. Land use change based on polygons in 2006 – 2009.

Classification of Land Use	Width (ha)		Change	
	2006	2009	ha	%
Primary Mangrove Forest	9,292.34	8,568.33	-724.01	7.78
Secondary Mangrove Forest	11,946.81	12,370.78	423.97	3.55
Shrubs Bogs	1,451.32	1,451.32	0	0
Plantation	2,927.97	2,927.97	0	0
Settlement	190.32	190.32	0	0
Dry land mixed bush farming	1,022.66	1,008.87	- 13.79	1.35
Dry land farming	141.61	147.81	6.20	4.38
Shrub lands Swamp	660.96	938 02	277.06	41.92
Fishpond	384.80	407.76	22.96	5.97
Mine	170.80	170.80	0	0
Water Body	1,736.16	1,736.16	0	0
Open Land	0	7.60	7.60	100
Total	**29,925.74**	**29,925.74**		

Note: + = Increase; – = Decrease

Land use change occurred in the period of 2009-2012 is presented in Table 5. The results indicated that land use from 2009 to 2012 was changing; the primary mangrove forests decrease about 228.90 ha (2.67%), and secondary mangrove forests decrease about 13.98 ha (0.11%). Based on these data, the current primary and secondary forest area decreased in the same period even the width addition of open land by 23.14%, shrubs bogs by 4.35%, fishponds by 13.83% (Fig. 4-a), and settlement by 18.16%. This condition indicates that there have been changes in land cover of Kelumpang Bay. Swamp shrub lands area reduced, covering an area of 42.17 ha (4.50%) caused by the growth of dry land mixed bush farming (Fig. 4-b) covering 42.40 ha (4.20%). The increasing of short term and long term urbanization will increase the demand for land, and affect to land use change (Kucukmehmetoglu and Geymen, 2008; Klemas, 2011).

Table 5. Land use change based on polygons in 2009 – 2012.

Classification of Land Use	Width (ha)		Change	
	2009	2012	ha	%
Primary Mangrove Forest	8,568.33	8,339.43	- 228.90	2.67
Secondary Mangrove Forest	12,370.78	12,356.80	-13.98	0.11
Shrubs Bogs	1,451.32	1,514.52	63.20	4.35
Plantation	2,927.97	2,840.62	-87.35	2.98
Settlement	190.32	224.89	34.57	18.16
Dry land mixed bush farming	1,008.87	1,051.27	42.40	4.20
Dry land farming	147.81	147.81	0	0
Shrub lands Swamp	938.02	895.85	-42.17	4.50
Fishpond	407.76	464.16	56.4	13.83
Mine	170.80	170.80	0	0
Water Body	1,736.16	1,736.16	0	0
Open Land	7.60	183.43	175.83	23.14
Total	**29,925.74**	**29,925.74**		

Note: + = Increase; – = Decrease

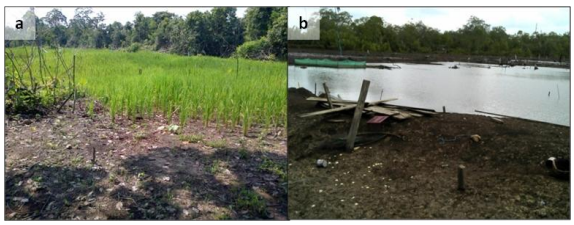

Fig. 4. Existing condition of land use changing into fishpond (a) and dry land mixed bush farming (b).

The Level of Mangrove Forest Degradation in KBNR

Based on classification of land use from 2000-2012, mangrove forest area of nature reserves in Kelumpang Bay's undergoes a change in land use. Land use change for 12 years showed a reduction in land area and population (Table 6). The map of land use change from 2000-2012 is presented in Fig. 5.

Table 6. The area of land use and change in mangrove forest of KBNR.

Classification of Land Use	Width (ha)		Change	
	2000	2012	ha	%
Primary Mangrove Forest	9,292.34	8,339.43	-952.91	10.25
Secondary Mangrove Forest	12,384.87	12,356.80	- 28.07	0.23
Shrubs Bogs	2,778.20	2,840.62	62.42	2.25
Plantation	1,082.46	1,051.27	- 31.19	2.88
Settlement	1,451.32	1,514.52	63.20	4.35
Dry land mixed bush farming	306.21	464.16	157.98	51.59
Dry land farming	190.32	224.89	34.58	18.17
Shrub lands Swamp	217.69	147.81	- 69.88	32.10
Fishpond	66.76	183.43	116.67	174.76
Mine	94.72	170.80	76.08	80.32
Water Body	1,736.16	1,736.16	0	0
Open Land	324.69	895.85	571.16	175.91
Total	**29,925.74**	**29,925.74**		

Note: + = Increase; – = Decrease

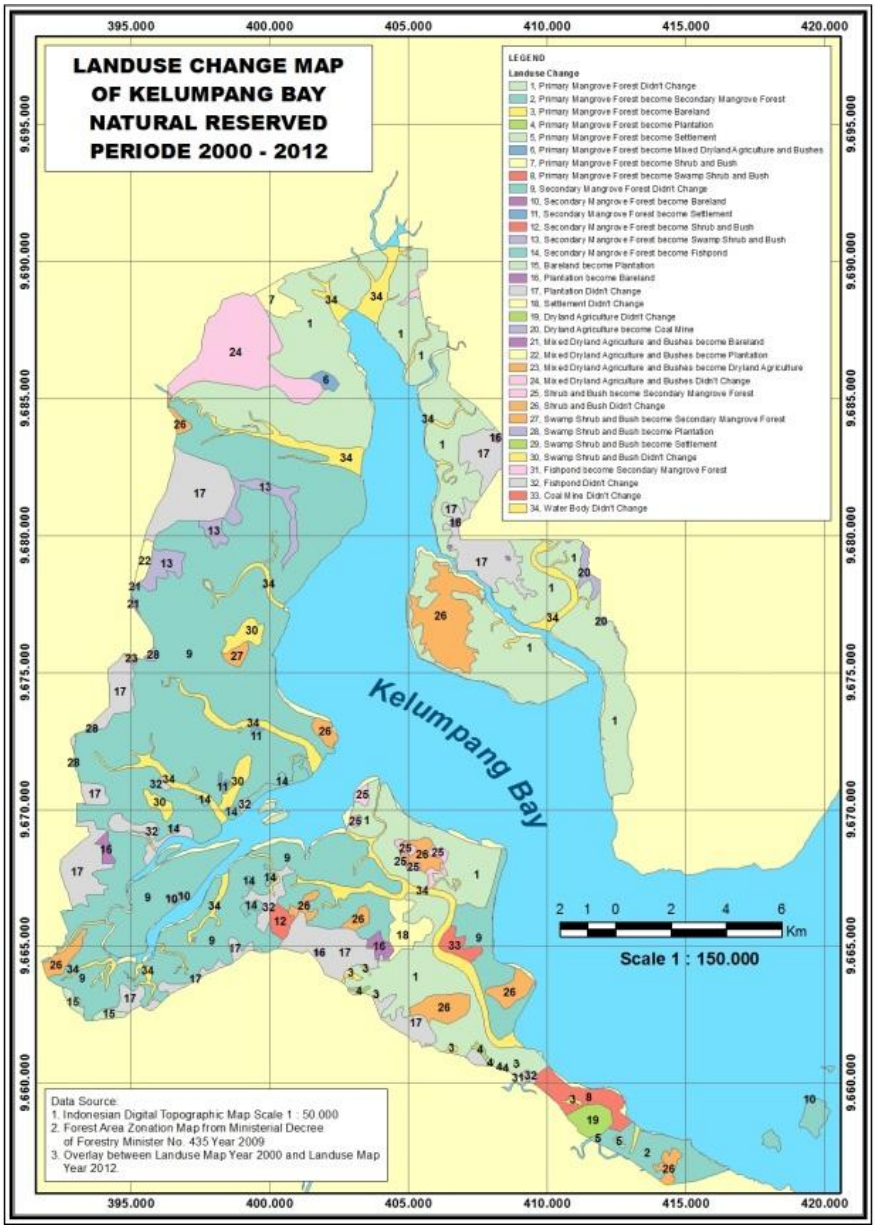

Fig. 5. Map of mangrove land use changing in KBNR 2000-2012.

The primary mangrove forests in the period of 2000-2012 (12 years) were decreased in the total area of 952.91 ha (10.25%) or 3.18% of KBNR total area. It showed that the primary mangrove forest was exploited for wood-work, for example the use of Bakau (*Rhizophora* sp.) and Mirih (*X. granatum*) for building materials, then Tingi (*C. tagal*) for firewood (Tepu, 2004; Saunders *et al.*, 2007; Hussain and Badola, 2010; Tarigan, 2008). Because the land was abandoned, it become open land increased to 116.67 ha; and finally changes into a swamp shrub lands area about 571.15 ha (1.91% from the nature reserve area).

The reduction of primary and secondary mangrove forest was caused by the community who opens land into an embankment of 157.98 ha (51.59%) and into settlements by 34.58 ha (18.17%). This condition associated with demographic data surround the nature reserve area, it showing the occurrence of population growth (in 2005-2010), with an average 2.21% per year (BPS, 2010; BPS, 2013). Elsebaie and Aguib (2013) stated that some of the mangrove forest disturbed, due to the development of population.

The reduction of the mangrove forest was much influenced by the role of PT. Smart Tbk that moves in the fields of oil palm plantations, which controls an area as large as ± 2.117 ha (BKSDA, 2010).The factory venturing the area for 723.62 ha (43.18%); average of 60.30 ha per year.

Besides the increase on the mining area of 76.08 ha (averaged 6.34 ha per year), the decline of mangrove forests was aggravating circumstances (Fig. 6). PT Arutmin Indonesia and CV. Laju Sejahtera used it as a place for stock pile and the special port of coal (BPDAS Barito, 2006; Sirang *et al.*, 2010; BKSDA, 2010). The coastal land use change occurred as a result of the development of aquaculture/pond, port and urban settlements (BPDAS Barito, 2006; Mohanty *et al.*, 2008; Sirang *et al.*, 2010). It consequences decrease the quality of the environment, the increase of critical land, soil erosion, and reduced the biodiversity (Sandin, 2009; Sihite, 2009; Qazi *et al.*, 2012).

Fig. 6. Existing condition of mangrove forest change into coal mining.

Based on Table 6, change in land use was created into a graph (Fig. 7) to find out the relationship of land use change and the degradation degree of the mangrove forests in the nature reserve of Kelumpang Bays. Land use changing in KBNR began to occur in the period of 2006-2009 and 2009-2012. It shown that the decreasing of primary mangrove forest were 7.78% in 2006-2009, and 2.67% in 2009-2012. Increasing of the secondary mangrove forest were 3.55% in 2006-2009, and 1.42% in 2009-2012. Shrub lands and swamp also increased by 41.92% in 2006-2009, and 0.93% in 2009-2012, which the fishpond increased by 5.97% in 2006-2009 and 13.84% in 2009-2012. It was caused by logging and encroachment to take advantage of the timber. The description by Chief of Karang Payau village that most change of mangrove forests by the community is 116 ha of ponds for fish and shrimp.

The analysis of overlay spatial data scoring resulted the scoring of mangrove forest degradation level in KBNR is 430, it means that this area is on potential critical criteria (361-450). Criteria for the classification of protected forest area equivalent to the conservation forest (BPDASPS, 2013). Forest land of the mangrove was still 69.16% of broad nature reserve in Kelumpang Bay's. Based on raw criteria mangrove destruction, forest degradation was still in low

category because the % range of land covers ≥50% - < 75% (Ministry of Environment, 2004).

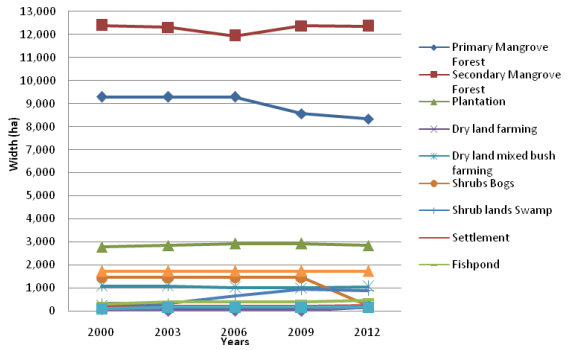

Fig. 7. The area distribution of the land use and changing in the mangrove forest of KBNR.

The influence of land use change revealed through a nonparametric analyses (Mann Whitney). Results of the analysis revealed significance value (0.840) > 0.05. It means that land cover changes from 2000-2012, has no effect on the nature reserve in Kelumpang Bay's area, although each area of land cover in each period unchanged.

Land use change analysis by spatial data were useful for knowing the land use location (Kumar *et al.*, 2007; Baharuddin, 2009; Miettinen and Liew, 2009), the decline of potential mangrove forest (Omo-Irabor *et al.*, 2011), and for monitoring the width of mangrove forest area (Kario *et al.*, 2002; Heumann, 2011). Utilization of geographic information system (GIS) integrate spatial data to produce the map of mangrove forest (Heumann, 2011), restoration measurement and conservation (Kumar *et al.*, 2012), and data attributes as reference for statistic analyses to predict land use area and issues in the future.

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