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Patterns of landscape change on small islands: A case of Gili Matra Islands, Marine Tourism Park, Indonesia

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Abstract

The aim of this study is to investigate patterns of landscape changes in small islands as exemplified by Gili Matra Islands, Lombok, Indonesia. Satellite imagery, hard infrastructures data and tourism spot were used to observe patterns of land use/land cover (LU/LC) by using overlay method in order to find suitable indicators for assessing landscape changes in the case study. The results showed that the changes tend to grow based on the closeness to the paths, port, coast line, public service, rural center, commercial areas, settlement areas, tourism accommodation, tourism center areas, and tourism spots and keep away landfill area.

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Keywords: Small islands; landscape changes; tourism; Gili Matra Islands; Indonesia.

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1. Introduction

Integrated Coastal Management (ICM) has remained a great challenge in Indonesia, especially for small island management. ICM has been activated under the Indonesian Cooperation Law, Act No. 1 in 2014 Jo. Act No. 27 in 2007 about coastal and small islands management. A well-planned management for small islands is undeniable because they have a high vulnerability, from global processes (such as climate change that implicated sea level rise), regional processes (developing cities pollution influence that located near the small islands), and local processes (environmental and resources degradation as impact of population growth) (Adrianto & Matsuda, 2004; Barrientos, 2010; Farhan & Lim, 2011; Farhan & Lim, 2012; Pelling & Uitto, 2001).

Development of small islands provides a promising future in Indonesia. As archipelagic state, Indonesia government leads to small islands development for tourism. Small islands-based tourism is one of the favourite tourist destinations due to its beauty, exotic, aesthetic, diversity of natural habitat (coral reef, sandy beach and sand dune), the warm, clear and attractive water (Daby, 2003). Tourism of small island in Indonesia has grown rapidly and become a world tourist destination, such as Trawangan Island (Lombok), Nusa Lembongan Island (Bali), Seribu

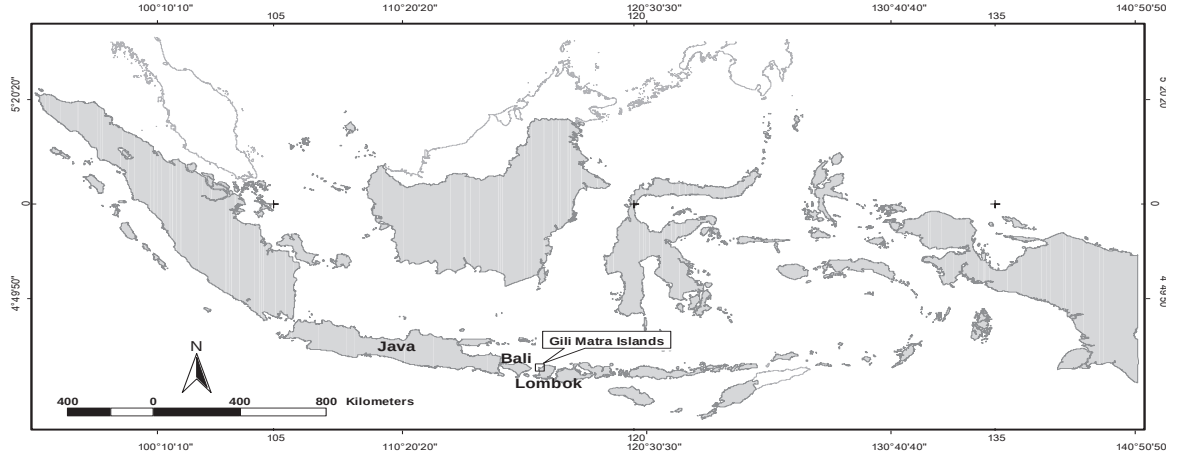

Fig. 1. Gili Matra Islands.

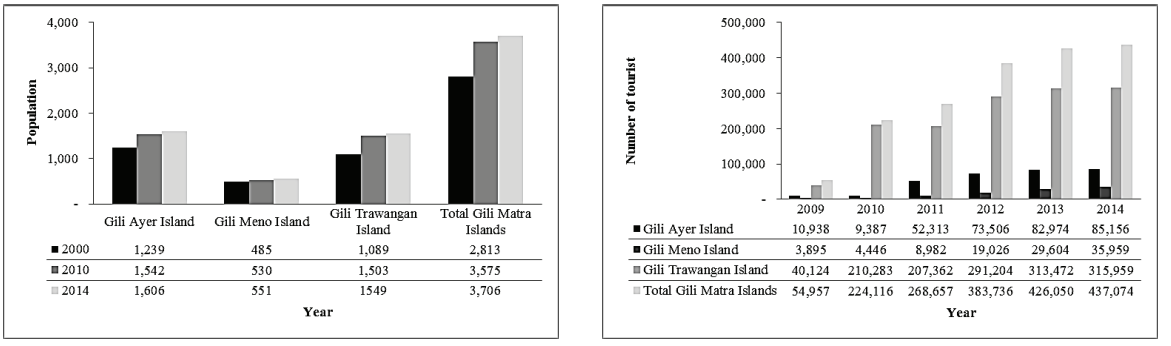

Fig. 2. (a) Population growth in Gili Matra Islands on 2000, 2010 and 2014; (b) Tourist arrival growth in Gili Matra Islands on 2009-2014.

Islands (Jakarta), Karimunjawa (Central Java), Bunaken Island (Manado), Waigeo Island (Raja Ampat), Banda Island (Maluku), etc.. Additionally it provides significant economic benefits as a source of income, employment and livelihood (Bottema & Bush, 2012; Hampton & Jeyacheya, 2014; Long & Wall, 1996; Yulianto, Fahrudin, & Kusmaningsih, 2007). However, tourism is also one of the actors that responsible for environmental degradation, due

Tabel 1. Land use/land cover classification in Gili Matra Islands.

LU/LC classifications	Descriptions
Shoal beach	The outer part of the land/sand towards the sea and inundated at high tide
Sand beach	Open land associated with marine activities with sand as the constituent material
Salt lake	Waters area that are naturally, with water flooding the deep and permanent and shallow flooding, including its functions
Mangrove area	Forests that grow in wetland habitats, which has not undergone human intervention with a dominant vegetation of mangroves
Mixed forest	Forests that grow on dry land habitat that has not undergone human intervention with mixed vegetation
Plantation	Land used for agricultural activities without a change of the plant for two years
Bare areas	Land without land cover both natural, semi-natural or artificial. According to the characteristics of the surface, bare area can be divided into a consolidated and unconsolidated surface
Settlements area	Areas or land used as a living environment or residential environment and the activities that support life, including houses, facilities, port and other hard infrastructures
Non built-up areas	Land that has suffered human intervention, so that the natural land cover (semi-natural) can not be found anymore. Nevertheless, the land is not experienced as a development which occurred on built-up areas
Tourism accommodation	Something that is provided to meet the needs of tourism, including hotels, guest houses, resorts, dive shop, restaurant, bungalow, etc..

to building constructions and tourism activities (Fabinyi, 2008; Hannak, Kompatscher, Stachowitsch, & Herler, 2011; Pickering & Hill, 2007).

Tourism requires good infrastructures such as hotel, guest house, restaurant, port, road, etc., so its presence greatly affects landscape composition and spatial configuration and increases island vulnerability. Therefore, spatial planning is a remarkable tool in development management and land utilisation to achieve small island sustainability and social as well as economic demands should be balanced with ecological function (Douvere & Ehler, 2009). This study aims to investigate patterns of landscape changes in small islands as exemplified by Gili Matra Islands, located in Lombok, Indonesia, as small islands that are developed for marine tourism park in conservation area.

2. Gili Matra Islands

Gili Matra is abbreviation from three islands (Gili), that is Gili Meno, Gili Ayer and Gili Trawangan. Administratively, Gili Matra region is part of Pemenang Sub-district, North Lombok Regency, West Nusa Tenggara Province (Fig. 1). Based on Ministry of Marine Affairs and Fisheries Decree No. 67 in 2009 about Decree of National Marine Conservation Area of Gili Ayer, Gili Meno, dan Gili Trawangan in West Nusa Tenggara, this area has been appointed as conservation area and marine tourism park with 2.954 Ha.

Gili Matra's tourism has been developed since 1990s, as increasing tourism in Lombok. It gained popularity with tourist backpackers from Europe and Australia. Some major attractions in Gili Matra region are scuba diving, snorkelling, sun bathing, canoeing, sport fishing and water skiing (Dodds, Graci, & Holmes, 2010; Yulianto, Fahrudin, & Kusmaningsih, 2007). The first accommodation businesses were established in 1985 by local islanders. Currently, Tourism in Gili Matra particularly in Gili Trawangan Island possesses modern facilities such as star hotels, dive shop, ATMs, air conditioning, wi-fi..

3. Methods

To understand landscape change pattern, Satellite images QuickBird in 2010 and GeoEye in 2014 were used. Both of them are very reliable to get LU/LC patterns in different years on small island because they have high resolution. Based on the spatial resolution of the satellite images used, LU/LC in Gili Matra Islands was classified in accordance with the classification system put forward by *Badan Standarisasi Nasional, Indonesia* (BSN) about *Standar Nasional Indonesia* / National Standard of Indonesia (Appendix C SNI 7645:2010) for scale 1:25.000 (BSN, 2010) and Food and Agriculture Organization of the United Nations about Land Cover Classification System (FAO, 1998) (Table 1). The building of data of satellite images ware used digitization on screen.

Tabel 2. Landscape patterns in Gili Matra Islands 2010 and 2014.

LU/LC classifications	Islands in 2010						Islands in 2014					
	Gili Ayer (Ha)	Percent (%)	Gili Meno (Ha)	Percent (%)	Gili Trawangan (Ha)	Percent (%)	Gili Ayer (Ha)	Percent (%)	Gili Meno (Ha)	Percent (%)	Gili Trawangan (Ha)	Percent (%)
Shoal beach	6.66	3.75	7.94	4.32	8.59	2.47	6.43	3.62	7.82	4.25	8.16	2.34
Sand beach	3.58	2.02	6.03	3.28	10.98	3.15	2.81	1.58	5.43	2.95	8.49	2.44
Salty lake	0.00	0.00	6.70	3.65	0.00	0.00	0.00	0.00	6.70	3.65	0.00	0.00
Mangrove area	0.00	0.00	2.76	1.50	0.00	0.00	0.00	0.00	2.74	1.49	0.00	0.00
Mixed forest	0.48	0.27	37.21	20.24	14.11	4.05	0.48	0.27	36.76	20.00	12.84	3.69
Plantation	63.78	35.90	44.19	24.04	109.15	31.33	54.75	30.82	43.40	23.61	102.62	29.46
Bare areas	76.05	42.81	56.81	30.91	131.92	37.87	62.56	35.21	46.29	25.18	116.92	33.56
Non built-up areas	9.44	5.31	7.47	4.06	27.61	7.93	15.28	8.60	12.23	6.65	19.19	5.51
Settlements area	7.54	4.24	2.61	1.42	13.77	3.95	12.59	7.09	3.92	2.13	21.58	6.91
Tourism accommodation areas	10.13	5.70	12.08	6.57	32.25	9.26	22.77	12.82	18.52	10.08	58.58	16.81
Total	177.66	100	183.80	100	348.38	100	177.66	100	183.81	100	348.38	100

Tabel 3. Landscape changes in GIli Matra Islands from year 2010 to 2014.

LU/LC classifications	Landscape changes from year 2010 to 2014					
	Gili Ayer (Ha)	Percent (%)	Gili Meno (Ha)	Percent (%)	Gili Trawangan (Ha)	Percent (%)
Shoal beach	-0.23	-0.13	-0.12	-0.07	-0.43	-0.12
Sand beach	-0.77	-0.43	-0.60	-0.33	-2.49	-0.71
Salty lake	0.00	0.00	0.00	0.00	0.00	0.00
Mangrove area	0.00	0.00	-0.02	-0.01	0.00	0.00
Mixed forest	0.00	0.00	-0.45	-0.24	-1.27	-0.36
Plantation	-9.03	-5.08	-0.79	-0.43	-6.53	-1.87
Bare areas	-13.49	-7.60	-10.52	-5.72	-15.00	-4.31
Non built-up areas	5.84	3.29	4.76	2.59	-8.42	-2.42
Settlements area	5.05	2.84	1.31	0.71	7.81	2.24
Tourism accommodation areas	12.64	7.11	6.44	3.50	26.33	7.56

In addition to spatial data, field observations in driven factors of the selected area including the types of LU/LC, hard infrastructures, and other types of existing utilisations were conducted. Field data was collected by tracking and marking method using Geographic Position System (GPS). Furthermore, satellite imagery interpretation data, hard infrastructures data and type utilization (tourism spot) was employed to observe patterns of land-cover by using overlay method in order to find suitable indicators for assessing landscape changes in the case study using Geographic Information System (GIS) with the support of ArcGIS 10.2.2.

4. Result and Discussions

The study results indicated that the LU/LC pattern in Gili Matra Islands has changed significantly from 2010 to 2014 (Table 2). Positively, land use alteration in tourism accommodation, settlement area and non built-up areas remarkably changed approximately 27.43% or 61.76 Ha, and the biggest change was on the category of tourism accommodation (18.18% or 46.41 Ha). Otherwise, the negative changes occurred in the categories of shoal beach,

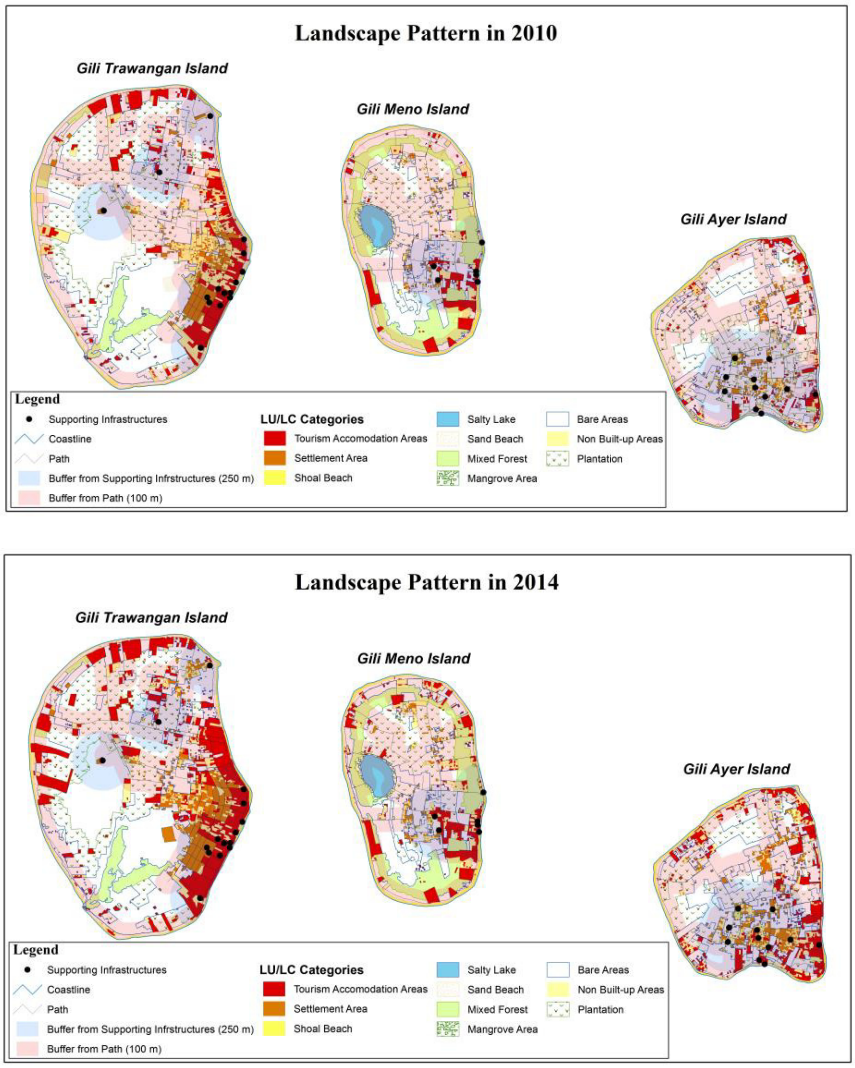

Fig. 3. Landscape pattern in Gili Matra Islands year 2010 and 2014.

sand beach, mangrove area, mixed forest, plantation and bare areas. The greatest changes occurred in the categories of bare areas (-17.62% or -39.01 Ha), plantation (-7.39% or -16.35 Ha) and sand beach (-1.47% or -3.86 Ha), respectively, whereas no change was observed for the category of the salty lake. The changes indicated the increasing necessary for space to support tourism activities and the island's inhabitants that are constantly expanding others LU/LC.

The LU/LC changes also showed that tourism industry led to population explosion that increases drastically for about 31.75% (2,813 person in year 2000 to 3,706 person by 2014) as seen in Fig. 2a (primary data of Desa Gili Indah, 2015). Furthermore, from 2009 to 2014 number of tourist also increased significantly 695.30% (from 54,957 to 437,050 tourist) as seen in Fig. 2b (primary data of Dinas Pariwisata Kabupaten Lombok Utara, 2015). Until 2010, BPS–NTB (2011) recorded that there was 299 accommodations with 2,365 beds in Gili Matra region and the highest number was 204 units in Gili Trawangan Island, followed by 61 units in Gili Ayer Island and 34 units in Gili Meno Island.

Based on comparison results from maps of the years 2010 and 2014 (Fig. 3), indicating that patterns of landscape changes in GIli Matra Islands tend to grow based on the closeness to the paths, port, coast line, public service, rural center, commercial areas, settlement areas, tourism accommodation, tourism center areas, and tourism spots, both coral reef and sand beach that support tourism activities, that is 3S (sand, sun, and sport), and keep away landfill area. These components can be used for suitable indicators for assessing landscape changes in small 'tourism' islands. They are very different compared to urban areas, where the landscape changes were greatly influenced by elevation, slope, roads, city centers, sub-centers, airport and harbor (Han, Hayashi, Cao, & Imura, 2009).

The trend of LU/LC changes illustrated an alarming condition. A rapid and uncontrolled conversion of land into built-up areas would contribute to the higher vulnerability of small islands, especially to the environmental conditions. Houses, resorts, hotels, and other hard infrastructures accounted for water pollution and deteriorated fresh water catchment that induces seawater intrusion (Falkland, 1993; Gössling, 2001; SOPAC–UNEP, 2005). The aforementioned condition has occurred, which ground water level at Gili Meno and Gili Trawangan Island was relative shallow from 1-3 m with brackish to salty quality (Bakti, Lubis, Delinom, & Naily, 2012). Therefore, Bengen, Retraubun, & Saad (2012) stated that land use for development area in small island should be limited to maximum of 50% development for very small island and 30% development for small island. Thus, the arrangements for restriction of spatial use and environmental-supporting development were needed for the sustainable development of Gili Matra Islands.

5. Conclusions

Tourism industry led to LU/LC changes. According to comparative study of 2010 and 2014 maps, there was tendency that patterns of landscape changes in Gili Matra Islands was increased based on the closeness to the paths, port, coast line, public services, rural center, commercial areas, settlement areas, tourism accommodations, tourism center areas, and tourism spots, both coral reef and sand beach that support tourism activities, that is 3S (sand, sun, and sport), and keep away landfill area. These mentioned factors are acceptable indicators for landscape change assessment in small 'tourism' islands. Afterwards, these indicators are dissimilar in comparison with urban areas, where the landscape changes are highly influenced by elevation, slope, roads, city centers, sub-centers, airport and harbor (Han, Hayashi, Cao, & Imura, 2009). Land use for development area in small island should be limited. A rapid and uncontrolled conversion of land into built-up areas would contribute to the higher vulnerability of small islands. The arrangements for restriction of spatial use and environmental-supporting development were needed for the sustainable development of Gili Matra Islands.

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