Impact of human interventions on mangrove ecosystem in spatial perspective

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Abstract : Climate change components that affect mangroves include changes in sea level, high water events, storms, precipitation, temperature, and oceanic circulation. Cumulative impacts of these factors have a distinct synergy with respect to an accelerated rate of mangrove degradation. development of coastal agricultural land and shrimp farming ponds in intertidal areas are considered as the major factors behind mangrove delineation. There is no agreement for the extensive of mangrove forest in Indonesia, but invarious forums it is usually used the number of 4.25 million ha for that. At approximately 9 years ago, the extensive vast of mangrove forest in Indonesia was about 4.13 million ha but now it is only 2.49 million ha (60%). The methodology of this study consisted of two main steps: (1) image analysis, and (2) post classification. The aim of this study is to analysis the human intervention base on spatial dynamic of mangrove. The study site was selected Sagara island in Spermonde Archipelago. The results of analyze shows that decreasing of mangrove is caused human intervention.

Keywords: mangrove, fishpond, landsat, Spermonde, spatial

1. Introduction

1.1 Background

Mangroves are considered to behave like a natural barrier against ocean dynamics along the shoreline. Their ability to protect shoreline and inland areas from natural hazards (hurricanes, cyclones, tsunamis) was recently discussed [2]. They can break the force of waves and help to prevent coastal-erosion processes [5]. Mangrove ecosystems support aquatic food chains and form habitats for marine fauna, such as juvenile crabs, prawns, offshore fish, reef fish, and larvae [7].

South Sulawesi is facing massive mangrove forest destruction, for over the past 30 years deforestation and pollution have taken their toll and damaged almost 90 percent of the total original areas. Before 1980s, the mangrove forest in South Sulawesi was over 214,000 hectares. The conversion of the mangrove forest into fishpond reduced the area into 23,000 hectares in the early 1991, or a decrease of 61 percent. The conversion of mangrove forests into fish farms was a result of a government policy in the early 1980s that instructed the offices of local fisheries and maritime affairs to carry out intensification of shrimp cultivation, which was then a major export commodity and earned the state a huge amount of money.

IOP Conf. Series: Earth and Environmental Science **47** (2016) 012041 doi:10.1088/1755-1315/47/1/012041

Deforestation led by increasing demand for land and climate change events such as the rise of sea level and reduction in freshwater flow are considered as major players behind the continuous annihilation of mangrove; however, climate change events may have an impact of only 10-15% reduction of mangrove habitats in the distant future whereas the immediate threat comes from uncontrolled exploitation and deforestation [1]. This has resulted in serious concerns among conservationists and has exposed the coastal communities to a further increasing threat of climate change and hydro meteorological disasters.

Remote sensing is an indispensable tool for assessing and monitoring mangrove forests primarily because many mangrove swamps are inaccessible or difficult to reach for a field survey. Remote sensing data providing synoptic coverage and those of historical satellites dating back to the 1960s are available. Global mapping initiatives have failed to map the extent and rate of deforestation with sufficient details. For example, only extensive mangrove areas were mapped as part of the Global Land Cover of 2000 survey [10]. The quantitative information achieved from interpretation image might be useful for forest managers to devise better plans for long-term management of mangrove ecosystems in Sagara island.

1.2 Objectives

The aim of this study is to analysis the human intervention base on spatial dynamic of mangrove.

2. Methodology

2.1 Study area

The study area is located in Sagara island, Pangkajene District, South Sulawesi, Indonesia. The geographical boundary of the study area between 119^{0}127’18”East and 04^{0}42’9” South (Figure 1).

Figure 1. Sagara island is one of the small islands in Spermonde Archipelago, Indonesia as study area

2.2 Data collection

We used Landsat GeoCover and recently acquired a Landsat Thematic Mapper (TM) in 1990 and Operational Land Imager (OLI) data in 2015, made available through the US Geological Survey (USGS) Center for Earth Resources Observation and Science (EROS). Landsat TM data have seven spectral bands, with a spatial resolution of 30 m for bands 1–5 and 7. The Landsat 8 OLI-TIRS data have nine spectral bands with a spatial resolution of 30 m for bands 1-7 and 9.

2.3 Image Processing

Landsat satellite imagery t=1990 and t=2015 were being corrected in radiometric aspect and geometric aspect by rectify/resampling pixel position in image, and geo-referencing the image into the selected projection system. Optical band of imageries had 30 m of resolution. There were several characteristics in interpretation such as tone, pattern, texture, shape, size, shadow and association. In this study, the process was done by visual classification method to obtain land use for two time series. The combination bands of 453 is commonly used in the interpretation of satellite image. This band combination is used because in the visual interpretation, the appearance of natural vegetation and planted areas can be seen clearly. Accuracy assessment was being conducted by Kappa coefficient (κ) for accuracy assessment which relies on image training area. Image validation was counted based on the above table such as *Overall Accuracy* (OA), *Producer's Accuracy* (PA), and *User's Accuracy* (UA). OA is a percentage of sample units that were classified accurately. A classification scheme was developed to obtain a broad level of classification, to derive various land use classes, i.e., mangrove, fishfond, bare land and settlement. A post-classification change matrix function was applied between 1990 to 2015.

3. Result And Discussion

3.1 Spatial Distribution of Mangrove

Textural and spectral characteristics of the canopy and leaves are the main features used to distinguish among mangrove communities [8]. Their structural appearance, partially more homogeneous or heterogeneous, depends on several factors, such as species composition, distribution pattern, growth form, density growth, and stand height. The spectral variations of the canopy reflectance as a function of several optical properties, such as leaf area index (LAI), background reflectance, and leaf inclination [6]. Identification of mangrove in Sagara island using Landsat image selected Landsat TM and Landsat 8 to the years 1990 and 2015. The classification result for the 1990 and 2015 can be seen in Figure 2.

Table 1. Areal and percentages of land use/cover changes

Classes	Mangrove area (ha)		Mangrove change (ha) 1990 to 2015	
	1990	2015	Ha	%
Fishpond	26,71	39,88	(+)13,17	33,03
Mangrove	21,02	10,94	(-)10,08	47,97
Setlement	4,03	6,54	(+)2,51	38,39
BareLand	6,96	2,17	(-)4,79	68,77

Monitoring deforestation at a regional scale using moderate resolution satellite images over a long period of time requires the processing of large volumes of data. By classification of image in 1990 and 2015, the resulst of mangrove for two time periods are presented in Table 1. Time-series analysis of

TM and OLI-TIRS data has revealed a net loss of 10,08 ha (47.97%) of mangrove in the region from 1990 to 2015 and the area of fish fond and setlement had increased by 13.17 ha and 2.51 ha.

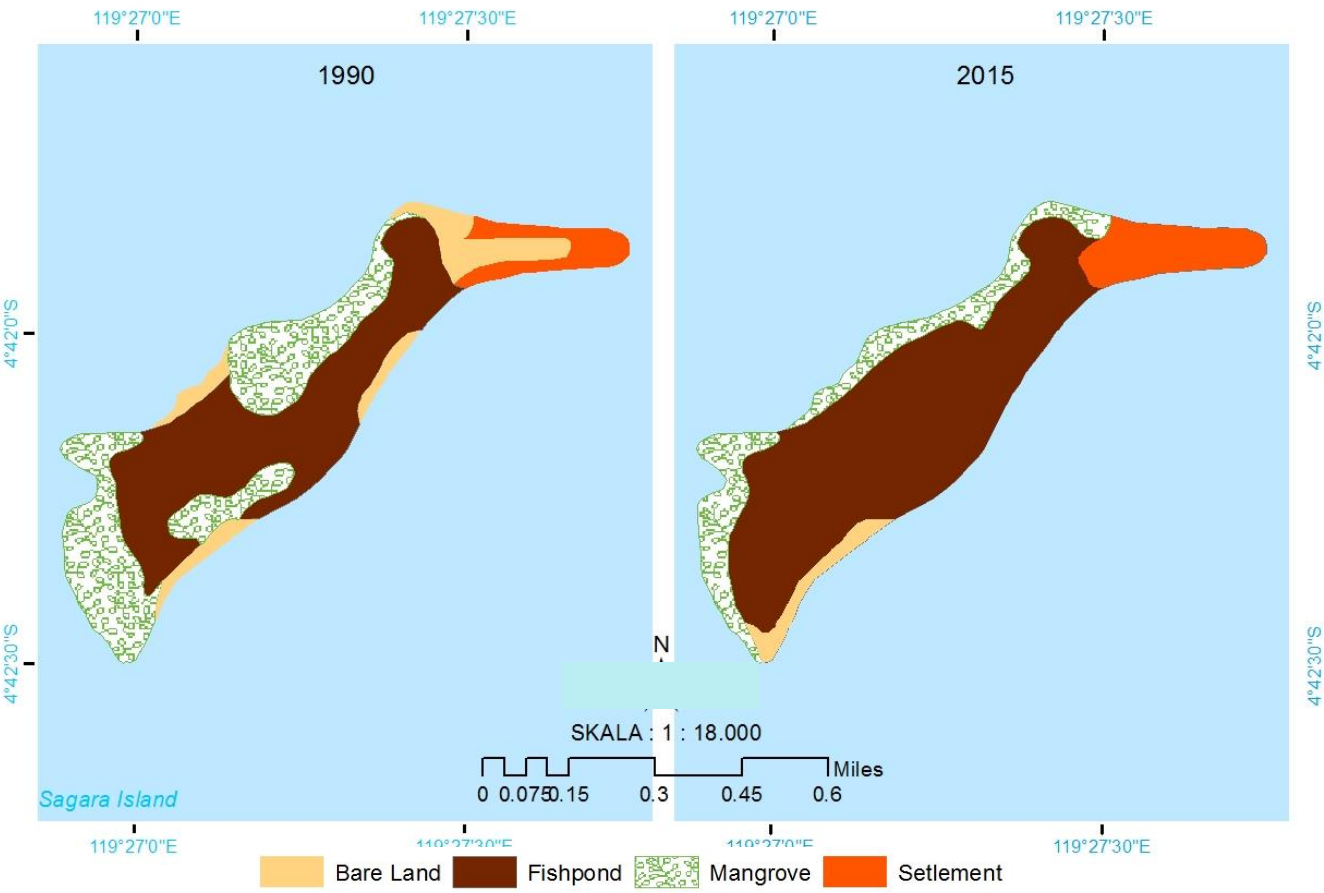


Figure 2. Mangrove classification maps in 1990 and 2015

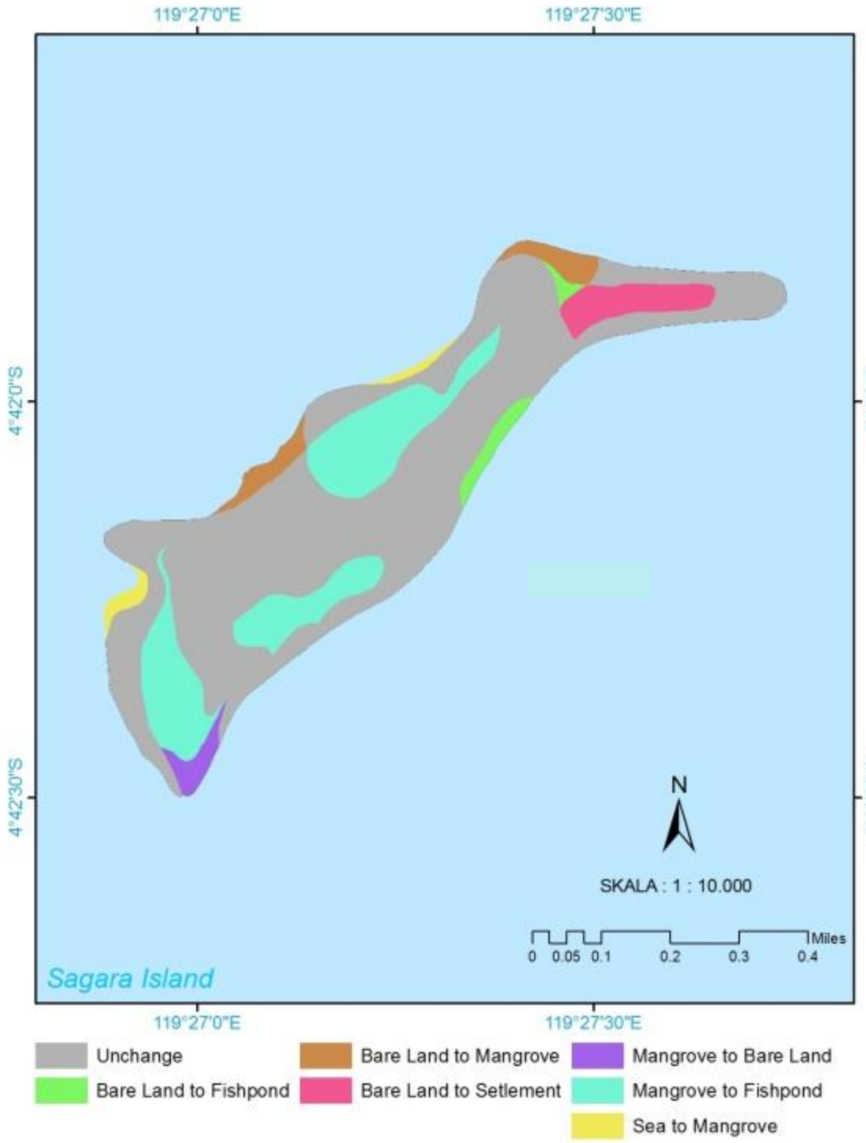
While the measured net loss of mangrove forest is not that high, the change matrix (Table 2) shows that turnover was much greater than net change. mangrove changed to fishpond and bare land by 2016. The largest category of mangrove change was loss to fishfond by 8,05 ha.

Table 2. Areal change of mangrove during 25 years

Years in 1990 to 2015	Areal change of mangrove (ha)				
	Fishpond	Mangrove	Setlement	Bare land	Sea
Fishpond	26.71	0	0	0	0
Mangrove	12.07	8.05	0	0.9	0
Setlement	0	0	4.03	0	0
Bare land	1.11	2.07	2.51	1.27	0
Sea	0	0.81	0	0	0

3.2 Human Intervention of Mangrove

Monitoring deforestation at a regional scale using moderate resolution satellite images over a long period of time requires the processing of large volumes of data. We used simple but such estimates on the sustainability of mangrove resources may contribute to the evaluation of impacts of mangrove degradation on socio-economic systems [3]. According to hierarchy theory [4], processes at a particular organization level can be explained by constraints at higher levels along with mechanisms at lower levels of organization. Thus, it is essential to evaluate the climatic and landform characteristics of coastal regions which result in local and often gradual environmental gradients that represent top-down constraints of mangrove forest development. At the same time, tree performance, growth response, and interactions among trees affect bottom-up patterns of forest development [9]. Clearing forests for farms on a large scale by investors from the main land of Pangkajene district in cooperation with the local community in Sagara island resulted in loss of mangrove. Factors influencing loss of mangrove in Sagara island from the human intervention are conversion of mangrove for fishpond on a large scale and utilization of mangrove trees for domestic use. Other abandoned fishpond areas are very difficult to rehabilitate or regenerate, mainly because these sites are highly degraded by pollution and pesticides. Delineations of degraded mangrove forests are needed to promote regrowth and enrichment planting.



Fifure 3. Post classification of mangrove in Sagara island of 1990 to 2015

4. Conclusion

Our measure of extent for the Sundarbans mangrove forest shows large change in net area (approximately 33.03% loss) in the last 25 years. Factors influencing loss of mangrove in Sagara island from the human intervention are conversion of mangrove for fishpond, clearing of mangrove trees for charcoal production on a large scale, and utilization of mangrove trees for domestic use.

Acknowledgement

We would like to thank to Ministry of Research Technology and Higher Education, Indonesia, for funding sponsor. We gratefully acknowledge Regional Development and Spatial Information, Hasanuddin University for the field survey team support.

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