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Land Degradation Analysis by Landscape Balance in *Lebak* Swamp Jakabaring South Sumatra

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ABSTRACT

This research aimed to analyze land degradation by using landscape balances in *lebak* swamp Jakabaring South Sumatra. Field survey method was applied, the field observations and respondents were taken by randomly purposive sampling. The interviews with farmers were conducted by using open questionnaire. The results showed that erosion and abrasion raised above 1,000 % which includes the acreage of 1.16 % in 1988 to 12.34 % in 2015. The landscape was more dynamic from year to year (namely 88.75 % of normal landscape in 1988 and becoming 68.14 % in 2015). The drought in the *lebak* swamp was increasingly unpredictable, making it difficult for farmers to manage their farming activities. Deposited landscape was found about 272.43 ha (10.09 %) in 1988 and increased to approximately 527.04 ha (19.52 %) in 2015. *Lebak* swamp served a lot of coming water from the upstream catchment area of approximately 3 million ha. This service is more and more complicated, irregular and burden *lebak* swamps. The *lebak* swamp ecosystem has not only enormous potential, but also has a very high resilience.

Key words: Land degradation, landscape balance, *lebak* swamp, Jakabaring, South Sumatra

INTRODUCTION

Land degradation by water belongs to a global problem because it is able decrease soil productivity, especially in agriculture sector (Armanto, 2014). Actually land degradation is considered as an unwanted disruption of land resources and it is defined as a process in which a declined value of the biophysical environment caused by some combination of human actions on land resources (Sjarkowi *et al*., 2007). An increase in the population, increasing needs of food, energy, water, all kinds of goods and services, all of which lead to an increased need for land resources, while the presence of land resources are limited and cannot be renewed. Such conditions could potentially cause land degradation (Sjarkowi and Noerdin, 2015).

It is estimated that approximately 30-40 % of *lebak* swamp in South Sumatra is seriously degraded. At least there are four main ways of *lebak* swamp degradation and its effects on human supporting system (Wildayana, 2014, 2015, Imanudin and Armanto, 2012), among others (1) a decline in land productivity (assessed through the biomass loss, alteration of vegetative cover and soil nutrients), (2) capacity decrease of land to provide natural resources for life humans (assessed by comparing the capacity of the land in the past), (3) biodiversity loss (loss of species or complexity of the ecosystems which cause *lebak* swamp degradation), and (4) improvement of ecological risk (increased environment vulnerability, namely erosion, abrasion, sedimentation, drought and others).

Lebak swamp degradation is assessed by a group of people as the benefits or opportunities, for example *lebak* landfills for construction and industry, but another group of people concerns for the man-made disaster, such as the risk of erosion, drought, floods and sedimentation. The main causes of *lebak* swamp degradation are i.e. landfills, erosion, abrasion, sedimentation, over drainage, drought, deforestation, logging, construction of commercial and industrial centers, land clearing, soil contamination, soil acidity, soil-C loss, off-road vehicles, mining of sand and mineral as well as dumping non-

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biodegradable garbage, such as plastic and any others (Imanudin *et al*., 2010a, 2010b, 2011).

Lebak swamp degradation can be analyzed by some approaches of landscape balances. The landscape diversity indicates the occurrence of various high diversity of processes that occur in landscape (Armanto *et al*., 2010, 2013). Therefore, the landscape balance is able to provide information on how *lebak* swamp degradation has taken place. One of the dominant landscape in South Sumatra which plays an important role in economic development is *lebak* swamp in Jakabaring. This research aimed to analyze land degradation by using landscape balances in this *lebak* swamp.

METHODS

This study was carried out in Jakabaring, South of Palembang. Field survey method was applied in this study. Landsat images (1987 to 2014) and some supported thematic maps were applied, namely topographic map and administrate map of Palembang (1:50,000 scale), swamp map (1:500,000 scale) as well as the planimetric calculation of the research area. The field observation and respondents were taken by randomly purposive sampling. The interviews with farmers were carried out by using open questionnaire

RESULTS AND DISCUSSION

Analysis of land degradation by using landscape balance in *lebak* swamp Jakabaring South Sumatra can be illustrated by discussion of the following components, among others erosion and abrasion of rivers and canals, drought in agricultural arable lands, sedimentations, and landscape balances.

Erosion and Abrasion of Rivers and Canals

Based on the field survey by using Landsat imagery analysis, Jakabaring area can be classified into three categories, namely the eroded landscape, normal landscape, and deposited landscape. In 1988 about 31.32 ha (1.16 %) of Jakabaring area was classified as an eroded area. In 2015 the eroded landscape has increased over 1,000 % becoming around 333.18 ha or 12.34 %. The normal landscape in 1988 occupied an area of approximately 2,396.25 ha (88.75 %). However, this composition in 2015 turned into a more dynamic, in which the normal landscape was decreased by 23 % becoming 1,839.78 ha or 68.14 % (Table 1).

Table 1. Acreages of erosion and sedimentation in 1988 and 2015

No.	Landscape Status	Before landfills (1988) */		Existing conditions (2015)	
		ha	%	ha	%
1	Eroded	31.32	1.16	333.18	12.34
2	Deposited	272.43	10.09	527.04	19.52
3	Normal	2,396.25	88.75	1,839.78	68.14
	Total	2,700	100.00	2,700	100.00

Source : */ Calculated and interpreted on the basis of Palembang land use map (1: 250,000 scale) and Landsat 2014 as well as Google map 2014 as well as field survey (2015).

River and canal abrasion occurs due to the influence of tides and waves and is generally found in the riverside area and sloping area. On the riverbanks in the East of Jakabaring, a process of accelerated erosion happened which is located near to the Sriguna River. Abrasion on the Babatan Saudagar River in South Jakabaring was predicted due to the construction of drainage canals around this river. This happened in West season, where a big wave is coming in through the Ogan River and directly create abrasion of the Babatan Saudagar River.

The erosion and abrasion occurrence in the Babatan Saudagar River and the Perupitan River were found along the 1.5 km with a

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width of 2-3 m. Interview with farmers and field observation concluded that apparently accelerated erosion and abrasion was increased in the last 10-15 years. This situation is quite worrying because the rivers are potential tidal areas. Abrasion in the Babatan Saudagar River has eroded along the canals, so that the canals cannot function normally. Erosion and abrasion can create critical lands. This critical land conditions continue to deteriorate if counter measures against the damage is not properly anticipated.

Open land will be more easily eroded especially in the sloping areas and a lots of soil particles and soil nutrients are transported by runoff. On the flat places, leaching of nutrients into the deeper layers will be more significant. Other main problem in Jakabaring is indicated by high sedimentation in the rivers and canals, then the choice of conservation techniques can be done by improving the filtering functions of the *lebak* swamp. Improved filtering function can be done by planting grass, shrubs, and trees or by constructing sediment traps. If we use vegetative methods, the placement of plants becomes crucial and important. According to Sjarkowi *et al*. (2007), planting of permanent crops on around 20 % of *lebak* swamp has been very effective in reducing sedimentation in the river and canals as long as the plants are planted in the right places, such as the riverbank zone (buffering zones on left and right sides of the rivers and canals).

Drought in Agricultural Arable Lands

Drought is often complained by farmers since drought brings production failure in *lebak* swamp. Drought occurs as the water in the root layer is not available during a certain period. The largest portion of water stored in the root layer comes from the rain that penetrates the soil through infiltration. The water availability for agricultural crops is mostly determined by two main factors, namely the soil water holding capacity (porosity and layer thickness of rooting) and the rainfall distribution (continuity of water supply). Although the annual rainfall of the area is high, but not all falling rainwater accumulated in rooting layers because its capability is a very limited for water holding capacity. Most of the water is leaving the soil layers through runoff and percolation process. Based on the interview with farmers, some of the water availability problems (drought) are expressed by the farmers as follows:

1) The beginning of the rainy season is always changing every year, making it difficult for the farmers to start the growing season.
2) The period length of rainy season is not always stable every year (ranging from 3 to 10 months), as well as the length of the dry period. It is difficult for the farmers to choose the crop type and to determine the cropping period.
3) It often happens that dry period was found in the middle of the rainy season, causing interference to the plant growth of *lebak* swamp or even death.
4) Occurrence opportunity of wet years or dry years is almost similar that make it complicated for farmers to do anticipation ahead.

These facts and information are lessons-learned for us that the water availability problem is not as simple as it is often predicted (Sjarkowi *et al*., 2007). It is connected with other aspect, such as the time dimension. Thus the frequency of uncertainty factor (the frequency of droughts) and duration (the length of the period of drought) have to be intensively studied.

Sedimentation

In 1988 (before landfills), deposited landscape was analyzed in an area of around 272.43 ha (10.09 %) and increased to approximately 200 % becoming 527.04 ha (19.52 %) in 2015. This occurs in the field because the eroded material is distributed by water on a much wider area, while the number of eroded materials mass is equal to that deposited materials that can be observed in flooded riverbanks.

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Sedimentation is almost found sporadically throughout the Jakabaring area. Contributing factors to sedimentation are among others, high rainfall, the dynamics of the river water, the slope of the land surface, the physical properties of soil (easily decomposed and dispersed) and the use and management of land tends to ignore the soil erosion.

These factors should be broken through conservative land management. But in reality, most of the land use is less effective in breaking the flowing water (run off) to erode the surface soils.

Sedimentation is mainly caused by the transport of sediment by the Perupitan River and the Babatan Saudagar River. Opening of canals contributed to the soil erosion. Eroded materials are being transported to the main canals which cause sedimentation in the main canals. The sedimentation process has occurred in all canals and all rivers. Landsat interpretation showed that around 50-70 % of rivers and canals are already deposited.

Governments need to anticipate this sedimentation before it becomes triggered process of man-made disasters, such as flooding and drought. If all rivers and canals will be dredged with a dredging capacity of 20,000 tons month^{-1} (240,000 tons year^{-1}), then it is needed two months to remove sediment dredging as much as 316,224 tons of sediment. If the dredging costs are around Rp 5 billion month^{-1}, it will require a total annual cost of Rp 10 billion. With this simple calculation, then the Jakabaring area is relatively safe from the threat of man-made disaster, namely floods during the rainy season and drought in the dry season.

Landscape Balance

The sedimentary material consisted of small stones, sand, silt, garbage, and mud. If the predicted average rate of erosion and sedimentation ranged about 5 cm year^{-1} and the soil bulk density was around 1.20 kg dm^{-3}, then the total amount of sediment was collected around 163.458 tons in 1988 and increased by 116 % in 2015 (becoming 316.224 tons). On the other hand, the total amount of soil erosion and abrasion in 1988 was around 18.792 tons and increased to 199.908 tons in 2015 (an increase of approximately 1,064 %). This rate of erosion and abrasion as well as sedimentation was increased in the last 10-15 years (Table 2).

Table 2. Sedimentation rate before and after landfills

No	Parameter	Year of 1988 */	Year of 2015
1	Total erosion/abrasion (tons)	18,792	199,908
2	Total sedimentation (tons)	163,458	316,224

Source : */ Condition before landfills and it was interpreted on the basis of Palembang land use map (1:250,000 scale), Landsat 2014, Google map 2014 as well as field survey (2015)

Potential erosion and sedimentation occurred in the Jakabaring area because there are a lot of available erosion causing factors, namely a high rainfall, slope, and physical properties of surface soils (easily decomposed and dispersed). Another driving factor of soil erosion is land use management that tends to minimize the danger of erosion. The main three main causes have to be broken down through land management, the majority of land use in Jakabaring is not effective in breaking the runoff that transport the surface soils.

Jakabaring is located in the downstream of the Musi water catchment area, which has to be ready to collect water in a very large number (about 5,800 tons of water). It is equivalent to a 1.8-m high increase in the water level of the *lebak* swamp. These data were obtained from the precipitation that falls during the rainy season multiplied with the Musi catchment area approximately three million ha by assuming some of the water evaporates. Beside that as a flat area on the downstream, Jakabaring should serve a lot of water coming from the upstream catchment area.

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The large volume of water is obtained from the shipment of water from upstream catchment area due to damaged ecosystem in the upper Musi catchments area. Soil loss in the upper Musi catchments area calculated by USLE method was around 415 tons ha^{-1} per year on sloping area of 35-65 %, planted with young coffee plant without any soil conservation measures. This soil loss reduce soil capability to absorb rain water, thus a lot of sediment materials flow to the downstream (*lebak* swamp) as well as rain water runoff.

This situation is more and more complicated, irregular, and burden *lebak* swamps. Field observing showed that the *lebak* swamp ecosystem has not only enormous potential, but also has a very high resilience. This means that each regional development (reclamation) will have a direct impact on the balance of the *lebak* swamp ecosystem.

The mitigation program of sedimentation in the upstream catchment areas has not been applied. As a result, the rivers and canals will be filled with small stones, sand, silt, garbage and mud. Therefore, the water holding capacity of the areas has been decreased, and the problem of flooding and drought was not solved again. To sum up, the intensity, frequency, area and duration of land use conversion continues to increase. The next question is: how to anticipate the impact of land use changes occurrences can be minimized? Early detection system of land conversion is the answer.

Therefore, *lebak* swamp needs to be understood thoroughly from aspects of genesis, dynamics, processes, classification, character, and function for agriculture and non-agriculture in the broad sense. Characters of *lebak* swamp ecosystems are heterogeneous. These characters are not only visible on the soil physical properties, but also the soil chemical properties as well as differences in the water system.

In the area which is adjacent to one another (< 50 m), it is often found different water problems. Without an understanding of the character, typology, classification, and behaviors of specifically typical *lebak* swamp, the development of agriculture in the *lebak* swamp will face many constraints. Drastic changes of *lebak* swamp resulted in the damaged environmental condition which are difficult to be recovered. Appropriate utilization, balanced development, and management in harmony with the character, typology, classification, and behavior can turn this *lebak* swamp into a high-productivity agricultural land and the environment.

CONCLUSIONS

Based on the results of research and discussion, it can be drawn some conclusions as follows:

1) Erosion and abrasion was above 1,000 % which includes the acreage of 1.16 % in 1988 to 12.34 % in 2015. The landscape becomes more dynamic from year to year (namely 88.75 % of normal landscape in 1988 and becoming 68.14 % in 2015).
2) The drought in the *lebak* swamp is increasingly unpredictable, making it difficult for farmers to manage their farming activities. Deposited landscape was found about 272.43 ha (10.09 %) in 1988 and increased to approximately 527.04 ha (19.52 %) in 2015.
3) *Lebak* swamp serves a lot of coming water from the upstream catchment area of approximately three million ha. This service is more and more complicated, irregular and burden *lebak* swamps. The *lebak* swamp ecosystem has not only enormous potential, but also has a very high resilience.

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