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Functions of *Lebak* Swamp Before and After Landfills in Jakabaring South Sumatra

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Abstract: The research aimed to analyze the functions of *lebak* swamp before and after landfills and to seek some alternative management approaches in Jakabaring South Sumatra. The research used quantitative and qualitative approaches. The research area description was assisted with interpretation of landsat images. The research was using survey method and interviews with local people. Two major functions of *lebak* swamp are ecological functions and non-ecological functions. Before landfills (1988), ecological function of *lebak* swamp was very dominant (91.64%) and non-ecological functions was about 8.36% meaning that the human intervention was only 8.36%, so *lebak* swamp has very high resilience capability to recover its ecosystem. After landfills (2016), that ecological functions are reduced becoming 53.88% and non-ecological functions increased to 46.12%. The region is still save enough for office and housing because the ecological functions (greening areas) occupy an area of more > 30%. In 2030, ecological functions will decrease about 15.53%, while the non-ecological functions will increase around 84.47%. Although in 2016 Jakabaring is still environmentally safe, if we analyze more deeply and intensively, Jakabaring will be vulnerable to man-made disasters such as potential of floods and droughts, sedimentation, migration and dependency on other local staple food.

Keywords: Functions, lebak swamp, landfills, Jakabaring, South Sumatray

Abstrak (Indonesian): Penelitian ini bertujuan untuk menganalisis fungsi rawa lebak sebelum dan sesudah landfill dan mencari beberapa alternatif pendekatan pengelolaan di Jakabaring Sumatera Selatan. Penelitian ini menggunakan metode campuran pendekatan kuantitatif dan kualitatif. Deskripsi daerah penelitian dibantu dengan interpretasi citra landsat tahun 1987 dan 2015 dan metode survei di ladang. Pengamatan lapangan dan wawancara dilakukan dengan kuesioner. Dua fungsi utama rawa lebak, fungsi yaitu ekologi dan fungsi non-ekologis. Sebelum landfill (1988), fungsi ekologis rawa lebak sangat dominan (91,64%) dan fungsi non-ekologis hanya sekitar 8,36% yang berarti bahwa intervensi manusia hanya 8,36%, sehingga lebak memiliki kemampuan sangat tinggi untuk memulihkan ekosistemnya. Setelah landfill (2016), bahwa fungsi ekologis berkurang menjadi 53,88% dan fungsi non-ekologis meningkat menjadi 46,12%. Daerah ini masih menyimpan cukup untuk pusat kantor dan perumahan karena fungsi ekologis sebagai daerah penghijauan menempati area seluas lebih dari > 30%. Pada 2030, fungsi ekologis akan menurun sekitar 15,53%, sedangkan fungsi non-ekologis akan meningkat sekitar 84,47%. Meskipun pada tahun 2016 statusnya Jakabaring masih tergolong aman lingkungan, jika kita menganalisis lebih dalam dan intensif, Jakabaring akan sangat rentan terhadap bencana buatan manusia seperti banjir dan kekeringan, sedimentasi, migrasi dan ketergantungan pada makanan pokok dari luar kawasan lebak.

Katakunci: Fungsi, rawa lebak, penimbuna, Jakabaring, Sumatera Selatan

1. Introduction

The widest swamp in Sumatra Island is found in South Sumatra Province covering an area of around 3.2 million ha. Approximately 2.1 million ha or 18% of the total area of the South Sumatra Province is tidal swamp. The remaining about 1.1 million ha are classified as *lebak* swamp [1-2]. The estimated swamp area is still needed to be considered that swamp ecosystem also covers some other ecosystem, namely the river area, lakes, general waters, man-made swamps (e.g. retention ponds, fish ponds and ricefields) and the sea area adjacent to the beach with an elevation of approximately 1-2 m below the low marine tide and others [3-5].

In the theory *lebak* swamp is capable of supplying a wide range of ecosystem services to achieve the welfare of human life [6-8], for example that the *lebak* swamp is more capable of supplying rice, fiber, fish, water, and environmental aspects (regulation of climate,

water purification, climate, flooding, coastal lines, tourism and recreation area).

Lebak swamp belongs to an absolutely limited resource, which cannot be renewed and enlarged. Limited resources, high population increase, the need for food increases, energy, water, all kinds of goods and land resources caused partly *lebak* swamp, vegetation, soil and water threatened by the impact of land resource management that is less focused and unplanned [9].

The main issue often discussed and debated in the *lebak* swamp function is the sustainability issue [10]. Holistically, *lebak* swamp can be defined as the simultaneous use of temporary or spatially from all these functions, although they are not always complementary in certain areas. The main problem of *lebak* swamp management is not just a technical, but the crucial problem is how to establish comprehensive land use planning that can meet the interests of beneficiaries and stakeholders. In addition, the question that always arises in our mind is how the huge functions provided by *lebak* swamp can be conserved. Until now, the government is less creative and less innovative in landuse planning for *lebak* swamp, especially on aspects of changes, dynamics and trends. Therefore, we need an operational concept of landuse planning in order to continue the needs of preservation of human life.

Three components of the macro importance need to be managed in planning of *lebak* swamp, namely: the space aspect, which includes *lebak* swamp for agricultural and non-agricultural purposes; the object aspect, which includes agricultural commodities (goods and services) will be managed; and the time or moment aspect, that the incidence of agricultural or non-agricultural activities whether planned or unplanned. Therefore this study aimed to analyze the functions of *lebak* swamp before and after landfills and to seek some alternative management approaches of *lebak* swamp functions in Jakabaring South Sumatra. This paper is expected to be useful to provide guidance to beneficiaries and stakeholders in planning the use of *lebak* swamp.

2. Experimental Sections

The research location is sited in Jakabaring South of Palembang, South Sumatra (Figure 1). The research was an intensive field survey with quantitative and qualitative approaches. The primary data collection was assisted with interpretation of Landsat imagery in 1987 and 2014 and several thematic maps (scales 1:50.000) as well as planimetric calculated. Respondents were randomly determined in the fields by using purposive sampling. Interviews with local people were recorded by using open and closed questionnaires. All primary and secondary data were collected and analyzed either narrative forms or presented in forms of tables.

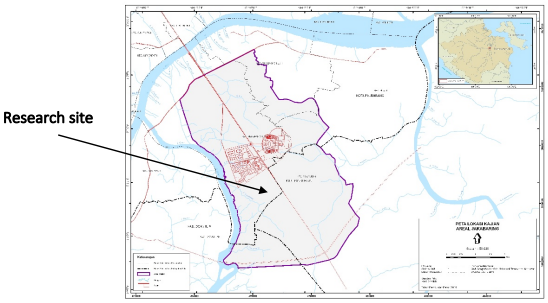

Figure 1. Research site in Jakabaring Palembang

3. Results

Jakabaring landfills in 1989-1998 have been done by the Governor of South Sumatra through the Regional Swamp Control Program Project. Landfills materials consisting mud, sand, silt and small stones were taken from the Musi River and directly pumped to Jakabaring swamp. It was gained in 1997 around a territorial area of almost 2,700 ha (48.25%) and the remaining area is still not yet reclaimed (around 2,825 ha or 51.13%).

Generally *lebak* swamp functions play very important roles in food securities, water, and climate, and energy, protection of biodiversity and delivery of ecosystem services. Almost all these functions are similar in characteristics and phenomena; among other they behave global, inter-related, complex and relatively difficult to resolve the problem of each function. Major functions of land swamp are namely ecological functions and non-ecological functions (Table 1).

Ecological Functions of *Lebak* Swamp

The ecological functions are divided into production functions of biomass, storing, filtering, buffering and transforming (SFBT), and providers of biodiversity.

Biomass Productions

Biomass productions are the basis of all living beings because these functions are able to ensure the food safety, animal feed, renewable energy and raw materials. Through biomass production function, it is obtained food, clothing, and housing. Increased need for food, clothing, population growth and exploitation of biological resources without regard to sustainability aspects lead to this function more endangered than other functions, such as abrasion, erosion, sedimentation, soil and water pollution.

Some biomass productions were found in Jakabaring before landfills, namely rice production, fish supply, livestock and any others. Rice production is obtained only < 20% of the lebak swamp that cultivated as rice fields because of the inability of farmers to manage water. The cultivated lebak swamp was randomly distributed along the Musi River and the Ogan River. Fish supply of various types is determined as the

most important function of the *lebak* swamp, especially for the main source of animal protein for local communities, for example Palembangnese earning around 56-75% of the total animal protein from *lebak* fishery. *Lebak* swamp produced various types of fishes, not only for consumption fishes, but also for ornamental fishes. The ecosystem functions of *lebak* swamp can be summarized in Table 1.

Table 1. Ecosystem functions of lebak swamp

Functions	Descriptions
A. Biomass production	
1) Food agriculture	Production of grains, fruits, vegetables and others
2) Fishery	Consumption fish, Decorative fish
3) Livestock	Buffalos, cows, goats, chickens, ducks and so on
4) Forestry	Wood logs, firewood, fodder and others
5) Plantation	Jelutung (indigenous rubber) and others
6) Biochemical	Producing basic materials for medicines and raw materials for industry
B. Storing, Filtering, Buffering and Transforming (SFBT)	
1) Storing	Groundwater recharge/discharge, the media to reduce greenhouse gases Regulating air temperature, rainfall and weather processes Flood attenuation, control and protection, Disposal of wastes, organic matter and others
2) Filtering	Recovery, retention and neutralize pollutants
3) Buffering	Regulating of major nutrient cycles (C, N, P etc.), Retention of soils and sediments
4) Transforming	Retention, renewal, transformation of soil nutrients, production function, fertilization
C. Biodiversity	
1) Habitat	Habitat for pollinators
2) Species	Reserves of natural species
3) Genetic	Pools of gene for resistance to pathogens, new species, cultivars, sources of new genes
D. Physical media	
1) Roads/buildings	Roads, buildings, bridges, industrial, factory, infrastructures
2) Soil formation	Retention of sediment, organic matter accumulation
3) Nutrient cycling	Processing, recycling, storing and nutrient acquisitions
E. Raw materials	
1) Fresh water	Storing and retention of freshwater
2) Raw materials	Water, sand, clay, rocks, peat, charcoal, woods, plan residues
F. Education, culture and heritage	
1) Educational	Opportunities for education, training, tourisms and research
2) Inspirational	Inspiration sources (values to swamp aspects Tourism places (recreational activity areas)
3) Aesthetic	Values of beauty or aesthetics in swamp aspects
4) Heritage sites	Archeological preserver of artifacts

Source : Survey results (2016)

Types of the consumption fishes are among others: fishes of head-snake, toman, seluang, baung, sepat, betok, catfish, patin, tembakang, and others, whereas the ornamental fish types are as follows: fishes of botia (*Botia sp*.), arowana or tangkeleso (*Scleropages formasus*), belida (*Notopterus sp*.), serandang (*Ophiocephalus pleurophthalmus*), sumpit (*Taxotes sp*.), and any others. Livestock widely distributed especially in Jakabaring are as follows: swamp buffalos, cows, goats, chickens, and swamp ducks and so on. Farmers of buffalo have been utilizing these animals to produce meat and milk.

Storing, Filtering, Buffering & Transforming (SFBT)

SFBT will involve the atmosphere, groundwater and crops, and all these things will protect overall environment, namely the protections of water, soil and the food chain from the threat of pollution, pollutant elements both physical and chemical, soil flora and fauna as well as other organic and inorganic substances. Storing provides some place for all substances and other elements in the environment. Filtering functions to filter solutes or pollutants in order not to pollute the ground water. Buffering is played by the process of physical-chemical soil reaction (adsorption) of the dissolved substance, while the transformation is formed by the process of decomposition and mineralization of organic matter by microbes to get a simple element or compound. If SPTF functions are reduced, then the changes of *lebak* swamp can be instantly expanded in ecosystem, creating the emergence of less useful vegetation (eceng gondok) and leading to form oxygen layers, as well as able to kill all bio life. SBFT function will be greatly influenced by the hydrological cycle. The hydrological cycle will serve as a water supply for the general public, irrigation water, energy and transport. Changes of SPTF will affect the overall dynamics of *lebak* swamp.

1) Fresh water from the *lebak* swamp helps to reduce flooding, improve groundwater recharge, and regulate the flow of the river, but the nature and value of these functions varies on the type of *lebak* swamp. Fresh water plays a major role in neutralizing a wide range of waste products, such as lowland swamp water can lower the concentration of nitrate by more than 75%.
2) *Lebak* regulation plays an important role in regulating global climate change through the execution and releasing most of the carbon fixed into the biosphere.
3) Flood is mentioned as a natural process which belonging to very important process to maintain the ecological functions. It is to ensure and to provide some environmental services to the human life, especially for farmers and fishermen, who living in *lebak* swamp because they can harvest a lot of moving fishes from the Musi River and Ogan River.
4) *Lebak* swamp able to reduce the destructive nature of flooding, and loss of swampy marsh will increase the risk of flooding. *Lebak* swamp is the main provider of flood attenuation potential in inland water systems. The increase in sea levels cause abrasion, erosional process and habitat, increased salinity of fresh water aquifers, changes in sediment and nutrient transport, and increase coastal flooding and. This may increase the vulnerability of some coastal populations. *Lebak* swamp can play an important role in the physical buffer the impact of climate change.

Biodiversity Providers

Biodiversity includes diversity and reservation of habitats, species and genes. All forms of biodiversity reserves genes for a variety of plant and animal species that must be protected from extinction. This function plays a very important role in human life. Without this function, human survival will be threatened both economically and environmentally. Generally it is concluded that the function of biodiversity as poverty alleviation, food security, increased production of crops, livestock and fish, the security of forest resources, wildlife and human health and tourism.

Loss of species and gene diversity will reduce food security by decreasing the ability of the ecosystem to sustain a certain ecosystem services for production. The existence of certain species is highly dependent on the presence of *lebak* swamp. If *lebak* swamp degenerate, there is also the decline of species and even lead to extinction on earth. Naturally life depends on biodiversity because we will never realize what we would need new genes to protect human life in the future. In addition, gene biodiversity is getting very means when many of the technologies needed to support human life, especially the process of biotechnology and bioengineering.

Non Ecological Functions of *Lebak* Swamp

There are three non-ecological functions, which are related with our life support system outside the agricultural activities serving as physical media, sources of raw materials and energy, and education, culture and heritage. These functions could be kept balanced and harmony with the nature condition in order to stabilize our life support system.

Physical Media

Lebak swamp is able to provide space for the activities of engineering, industrial, residential, transportation, sports, recreation, waste disposal, industrial activities and socio-economic, such as residential, industrial, transportation, traffic, sports, recreation, and other activities. Increasing this function is exponential, especially in urban areas, such as road infrastructure, public facilities, land conversion, water drainage, eutrophication and pollution, harvesting and exploitation. The introduction of alien invasive species causing lowland bog lose the ability to recover itself.

This function acts as a potential conflict for the agricultural sector due to land conversion of biomass production function for physical media function is approximately 5-10% per year. There is a tendency that the conversion of agricultural land into non-agricultural land intensive increase from year to year. This is due to the population growth of about 1-3% per year. Without the preservation of this function, one day we cannot learn more from the experience of past lives (our own history) valuable for human life on this earth.

Sources of Raw Materials and Energy

Lebak swamp can provide a variety of raw materials, such as wood, crop residues, fresh water, sand, peat, charcoal, clay, rocks, minerals and any other minerals. The raw material is the basis for the development of technical, industrial and socio-economic. The presence of raw materials are to support the welfare of human life. Due to raw material resources are non-renewable energy, planning needs to be done effectively, efficiently and sustainably. Due to the lack of a comprehensive development plan may cause serious damage to land resources. For example, at least 25% of the raw water source for drinking water in the city of Palembang is not fit for use as polluted by mud and organic contamination. *Lebak* swamp plays a very important role in the provision of water as a source of drinking water. Ogan River Musi River and have been substantially modified to improve the availability of drinking water for urban public consumption.

Water quality will increase the prevalence of disease, especially for people who are vulnerable to water-related diseases (such as malaria, diarrhea and others). This disease is one of the most common causes of death that affect the lives of the poor. Some chemicals that are transmitted through water and microbiological pollutants also endanger human health, in terms of chemical pollution, through bio-magnification through the food

Services of Cultures, Heritage and Education

Lebak swamps can provide aesthetic benefits, education, culture, and the significant spiritual and opportunities for recreation and tourism, fishing and others. Concrete examples of the economic value exceeds the *lebak* swamp rather than converted, for example, the conservation of Kenyir Lake in Malaysia where most of the life of freshwater fish species will be endangered. In such conditions, the conversion of *lebak* swamp is never justified economically, but it illustrates the fact that many economic and social benefits of *lebak* swamp has not been taken into account by decision makers. Nowadays Kenyir Lake is fully conserved for environmental purposes and determined as the world heritage of the endangered freshwater fishes species

Changing Functions of *Lebak* Swamp over Time

Functions of *lebak* swamp before landfills (1988) were dominated respectively by the functions of biodiversity provider, physical media, biomass production, SFBT, raw materials and culture/recreation with an area of around 2,362.03 ha (87.48%); 212.67 ha (7.88%); 62.81 ha (2.34%); 49.19 ha (1.82%); 7.09 ha (0.26%) and 6.21 ha (0.23%) respectively. It shows that before landfills, ecological function of lebak swamp was very dominant amounting to 2,474.03 ha (91.64%) and non-ecological functions was only about 225.97 ha (8.36%). In other words it can be mentioned that that the human intervention in the lebak swamp before landfills amounted to only 225.97 ha (8.36%) only, so lebak swamp has very high resilience capability to recover itself if the ecosystems are disturbed, for example, contamination of organic waste, erosion and others. Some organic waste decompose naturally becoming simple forms (Table 2).

After landfills (2016), *lebak* swamp functions have been changing where the non-functioning ecological function was more dominant than ecological

function. Sequence functions of *lebak* swamp are dominated by physical media around 1,013.32 ha (37.53%), biomass production amounted to 583.19 ha (21.60%), SFBT worth 454.57 ha (16.84%), biodiversity provider of around 416.98 ha (15.44%), culture/recreation covering an area of about 151.71 ha (5.62%) and raw materials amounting to 80.23 ha (2.97%) respectively.

This land use change occurs because *lebak* swamp areas were landfilled to develop the Palembang city and its surrounding, so that ecological functions are reduced becoming 1.453.74 ha (53.88%) and non-ecological functions increased to 1,245.26 ha (46.12%). The region of Jakabaring is still qualified as a good place for office and residential center because ecological functions as greening area is still more > 30%.

Table 2. Changes of *lebak* swamp functions in Jakabaring 1988 to 2030

Lebak functions	1988[a]/		2016[b]/		2030[c]/	
	ha	%	ha	%	ha	%
Biomass production	62.81	2.34	583.19	21.60	129.47	4.80
SFBT[d]	49.19	1.82	454.57	16.84	199.70	7.40
Biodiversity provider	2,362.03	87.48	416.98	15.44	90.23	3.34
Physical media	212.67	7.88	1,013.32	37.53	1,926.68	71.36
Raw materials	7.09	0.26	80.23	2.97	81.52	3.01
Culture/recreation	6.21	0.23	151.71	5.62	272.40	10.09
Total	2,700	100	2,700	100	2,700	100

Note : [a]/ before landfills, [b]/ existing condition, [c]/ predicted data, [d]/ Storing, filtering, buffering & transforming

Source: */ It was calculated and interpreted on the basis of Palembang land use map (1: 250,000 scale) and Landsat 2015 as well as Google map 2016 as well as field survey (2016)

In 2030, the functions of lebak swamp will be predictably changed. Sequence functions of *lebak* swamp are dominated by physical media, culture/recreation, SFBT, biomass production, biodiversity provider and raw materials with a value of around 71.36%; 10.09%; 7.40%; 4.80%; 3.34% and 3.01% respectively. Ecological functions will be about 419.40 ha (15.53%), while the non-ecological functions will be around 2,280.60 ha (84.47%). This means that by the year 2030 if there is no arrangements and resource management of lebak swamp wisely, effectively, efficiently and sustainably, there will be an imbalance in the allocation of land use based on its allocation. It should be developed on the basis of carrying capacity and land capability. The ecological functions have to be maintained at least 30%. In 2030 Jakabaring will only provide ecological functions of around 15.53%, thus it is necessary to increase the ecological functions of at least more than 15%, for example by the expansion of city forest, planting along the main roads with shading trees, planting all of the open area and an artificial lake with shading trees, so that more water can infiltrate into the soils. In addition, arrangements granting building permits should be more selective and environmentally friendly.

Threats of Man-made Disasters

Although in 2016 Jakabaring status is still classified as environmentally safe, if we analyze more deeply and intensively, Jakabaring will be extremely vulnerable to man-made disasters such as potential of floods and droughts, sedimentation, migration and dependency on other local staple food. In detail the overall threat is analyzed as follows:

1) **The First Threat**, SFBT and biodiversity can be used as a major indicator of *lebak* swamp capability to hold water temporarily and are able to release the water slowly. SFBT area and biodiversity continues to decline at very high speed amounting around 2,411.22 ha (89.30%) in 1988, dropped to 871.55 ha (32.28%) and 289.93 ha (10.74%) in 2016 and 2030 respectively. By 2030, *lebak* swamp will lose their capability to hold water and release water slowly. This capability is only left for around 289.93 ha (10.74%). It means that warning of red light sign for Jakabaring will be performed.
2) **The Second Threat**, approximately 90% of Jakabaring is located in *lebak* swamp. After landfills it was obtained territorial land with average elevation of just 0.5-1.5 m above sea level, while the difference in water level at maximum high tide and maximum low tide range 1.5-2.5 m. This resulted that the tide water can smoothly flow into Jakabaring area. The water source is largely derived from the overflow of the Musi River and Ogan River and rain (an average rainfall of about 2,750 mm/year). Both of these great rivers border Jakabaring area, so naturally the depth of the ground water is almost 100% determined by the water level in the both rivers.
3) **The Third Threat**, the extent of biomass production continues to decline as well with high speed, meaning Jakabaring region cannot afford to feed themselves to all the people who live in the Jakabaring. This is evidenced through that function biomass production by 62.81 ha (2.34%) in 1988, rising to 583.19 ha (21.60%) in 2016 and declined very sharply to 129.47 ha (4.80%). Assuming all function biomass is able to grow rice with production of around 2.0 tons Milled Dry Grains (MDG)/ha/year, then potency of rice production was gained by 126.62 tons MDG/ha in 1988, approximately 1,166.38 MDG/ha in 2016 and sank very sharply into 258.94 MDG/ha in 2030. With this total rice production, Jakabaring is obviously not able to perform self-sufficiency for food, especially rice.
4) **The Fourth Threats**, this threat is originated from the area of culture/recreation. Wide area of culture/recreation continues to increase physical and extents, especially the formation of a layer of water impermeability. The emergence of public facilities such as the International Sport Centers, parks and recreation complex, modern residential, restaurants and cafes and others. Everything is like a magnet that will attract many people to do the migration and settling or just recreation or conduction training in Jakabaring. This is consistent with the population of

Jakabaring increased sharply by 232.369 people in 2000, increased to 262.390 people in 2016 and will be predicted to increase to 280.692 people in 2030. The addition of this population will automatically be putting serious pressure on the region of increased volume of garbage and domestic waste (organic and inorganic). In addition, increasing the number of population will lead to flooding and drought also.

5) **The Fifth Threat**, extensive physical media means an increase in the number of buildings and public facilities. All of these will form a common facilities which make water impermeable layers, so that most of the rain water cannot be infiltrated into the soils, but water will flow on the soil surface as runoff. Runoff will stimulate flood in the rainy seasons and water crisis in the dry seasons and the soils will lose their ability to hold water and release water slowly.

Management Approaches of *Lebak* Swamp

The goal of management approach is to manage all functions of *lebak* swamps to obtain optimal benefit and at the same time it is capable to conserve *lebak* swamp, which are integrated, effective, efficient and sustainable. This management approach is started from legislation and policies of government to focus that all functions provided by *lebak* swamp are considered as absolute necessity. The management approach should be a long-term policy and is beneficial to all stakeholders and beneficiaries as well as able to generate economic growth in relevant with the conservation measures.

Decisions and policies of *lebak* swamp utilization is often made through not a sympathetic process to local needs, less transparency and less accountability. This is caused at least by the following points:

1) The direct benefits of *lebak* swamp conversion exceed often indirect benefits and other benefits, such as happening in border of urban areas. *Lebak* swamp will be fully landfilled and environmental functions are becoming disappeared.
2) Degradation of *lebak* swamp as "public goods" occurs regardless of public interest. Individuals who are concerned with these issues often do not get enough incentives from the government and private sector, so that *lebak* swamp functions get less attention in the market (market failure). If some people reclaim and degrade swamp functions that harm others, then there is not available market mechanisms to ensure that these people to provide compensation to those who suffered from damages of *lebak* swamp functions.
3) Some public decision makers are less aware of the relationship between the conditions, the existence and functions of *lebak* swamp. This linkage is very useful for everyone both directly and indirectly. In some cases, decisions are often made without considering the total economic valuation of *lebak* swamp.
4) Many ecological functions of *lebak* swamp (like SBFT, climate regulation, groundwater recharge, flood mitigation, erosion control and any others) do not have a market value (market failure) and their impact is not only locally, but also globally to the public.
5) The personal benefits of *lebak* swamp conversion is often exaggerated and the common benefits as public goods are reduced as low as possible. Thus the developers encouraged to perform large-scale drainage and build intensive infrastructure, industrial development and tourism and others.

Lebak swamp management requires careful planning, utilization and application of appropriate technology, balanced development as well as optimal water and land management.

4. Conclusion

On the basis of results and discussions of this research, some conclusions can be desirably made as follows:

1) There are two kinds of major functions of *lebak* swamp, namely ecological functions and non-ecological functions
2) It shows that before landfills (1988), ecological function of *lebak* swamp was very dominant amounting to 2,474.03 ha (91.64%) and non-ecological functions was only about 225.97 ha (8.36%). It means that the human intervention was only 225.97 ha (8.36%), so *lebak* swamp has very high resilience capability to recover its ecosystem.
3) After landfills (2016), that ecological functions are reduced becoming 1.453.74 ha (53.88%) and non-ecological functions increased to 1,245.26 ha (46.12%). The region is still save enough for centers of office and housing because the ecological functions as greening areas occupy an area of more than > 30%. In 2030, ecological functions will decrease about 419.40 ha (15.53%), while the non-ecological functions will increase around 2,280.60 ha (84.47%).
4) Although in 2016 Jakabaring status is still classified as environmentally safe, if we analyze more deeply and intensively, Jakabaring will be extremely vulnerable to man-made disasters such as potential of floods and droughts, sedimentation, migration and dependency on other local staple food.

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