The External-Internal Factor and Ecosystem Services to Support Mangrove Rehabilitation Planning on the North Coast of Jakarta

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Abstract. The mangrove ecosystem on the North Coast of Jakarta has many services and function both of ecology, social, and economic functions, and services, including tidal flooding reduction, land subsidence reduction, pollution reduction, ecotourism, and others. However, the mangrove ecosystem on the North Coast of Jakarta Mangroves are being badly damaged, so requires effort and activity to rehabilitate. This research aimed to develop a rehabilitation for strategy of mangrove ecosystem on the North Coast of Jakarta to reduce coastal disasters and support ecosystem services. The methods of this research used IFAS, EFAS analysis, and Buchard analysis. The results showed that the ecosystem services of the mangrove ecosystem were ecotourism, conservation, wildlife reserves, reduction of tidal flooding, abrasion and accretion, reduction of intrusion, reduction of land subsidence, economic income, fishing and fishpond activities, pond activities, and social benefits. The strategy of mangrove rehabilitation was a weakness-opportunity strategy (minimalizing weakness, taking advantage of opportunities, and avoiding threats. The strategies of mangrove rehabilitation planning were mangrove rehabilitation, mangrove revitalization, supporting the creative economy, developing greenbelt, increasing human resources, and developing blue carbon

Keywords: mangrove ecosystem, North Coast of Jakarta, rehabilitation planning, ecosystem services, coastal disaster

Introduction

The coastal area on the North Coast of Jakarta has a mangrove ecosystem covering area the estuary of the Angke river (East side) and terrestrial between Jakarta and Banten (west side) [1]–[3]. The mangrove ecosystem is found in Jakarta Bay which has an area of 490 km2, with a beach length of 40 km and an average depth of 15 m [4]. The mangrove area on the North Coast of Jakarta also is found in Kepulauan Seribu, DKI Jakarta Province [5], [6]. The mangrove ecosystem area on the North Coast of Jakarta consists of the Angke Kapuk Protection Forest (HLAK), the North Jakarta Mangrove Ecotourism Area, the Mangrove Arboretum Area, and the Muara Angke Mangrove [3], [6]–[10] with an area of more than 1000 ha.

The mangrove ecosystem on the North Coast of Jakarta is a unique and dynamic ecosystem which have economic, ecological, and social functions [2], [11]–[13]. The ecological function are

organism habitat, feeding ground, nursery ground and spawning ground, and microclimate regulator [3], [14]–[16]. In addition, mangroves also have economic functions including the main factor supporting the community and industry activity and ecotourism. Other functions are coastal protection from various disasters including abrasion and flooding, preventing seawater intrusion [4], [17]–[20](Hilmi, 2018), and blue carbon [12], [21].

The mangrove ecosystem on the north coast of Jakarta also takes environmental pressure, due to the development and growth of the area to support economic sectors such as trade centers, settlements, government centers, recreation, and education [3], [4], [13], [16], [22]–[24]. However, to support the sustainability of mangrove ecosystems on the North Coast of Jakarta, must be able to have a positive correlation with the sustainability and availability of ecosystem services to support the benefit and welfare of the community [25]. The assessment of ecosystem services is very important to support conservation and management planning [7], [26]–[28], and requires the data and information including the geomorphological description of the coastal area [25], [29], level of damage and degradation, extent and density of mangrove ecosystems [4], [17], [30].

The degradation of mangrove ecosystem on the North Coast of Jakarta must be reduced through sustainable management activities. This sustainable mangrove management activity must be able to minimize and anticipate losses, reduce threats to coastal development, and improve the welfare of coastal communities [31]–[33]. The mangrove rehabilitation activities are one of the activities which aim to restore damaged ecosystem conditions, restore ecosystem functions both ecological, physical, social, and economic functions. Management activities including mangrove rehabilitation need various aspects both external and internal aspects of management, the existence, and sustainability of the function of the ecosystem. This research aims to develop a rehabilitation strategy for mangrove ecosystems on the North Coast of Jakarta to reduce coastal disasters and to support ecosystem services.

Materials and Methods
Site research

This research was carried out in January 2022 – April 2022 on the North Coast of Jakarta, namely the mangrove ecosystem area which includes Muara Angke protected forest, Muara Angke, Elang rehabilitation area, Galatama Muara Angke, Muara Angke Ecotourism, Sediyatmo Toll mangrove area and Muara Angke Arboretum, and The administrative areas are Cilincing, Kelapa Gading, Koja, Pademangan, Penjaringan and Tanjung Priok sub-districts [3], [4], [9]. The research location can be seen in Figure 1 and Table 1.

The mangrove ecosystem area in Table 1 is the area for data collection in the mangrove area to obtain information about mangrove ecosystem services and management strategies.

Table 1. The research stations

| Stations	Coordinate's	
	Latitude (S)	Longitude (E)
1. Mangrove ecotourism area	06˚07'18.880"	106˚45'18.370"
2. Forest preservation Angke Kapuk 1	06˚06'15.500"	106˚45' 05.410"
3. Forest preservation Angke Kapuk 2	06˚06'16.556"	106˚45'49.608"
4. Forest preservation Angke Kapuk 3	06˚06'16.614"	106˚45'49.619"
5. Mangrove - Arboretum	06˚06'41.386"	106˚43'57.374"
6. Mangrove greenbelt Galatama 1	06˚07'24.733"	106˚45'16.124"
7. Mangrove greenbelt Galatama 2	06˚07'22.820"	106˚45' 56.03''
8. Mangrove greenbelt - Taman Elang	06˚07'24.240"	106˚44' 55.19''
9. Muara Angke Suaka Margasatwa (SM)	06°06'56.940"	106° 46' 09.21''
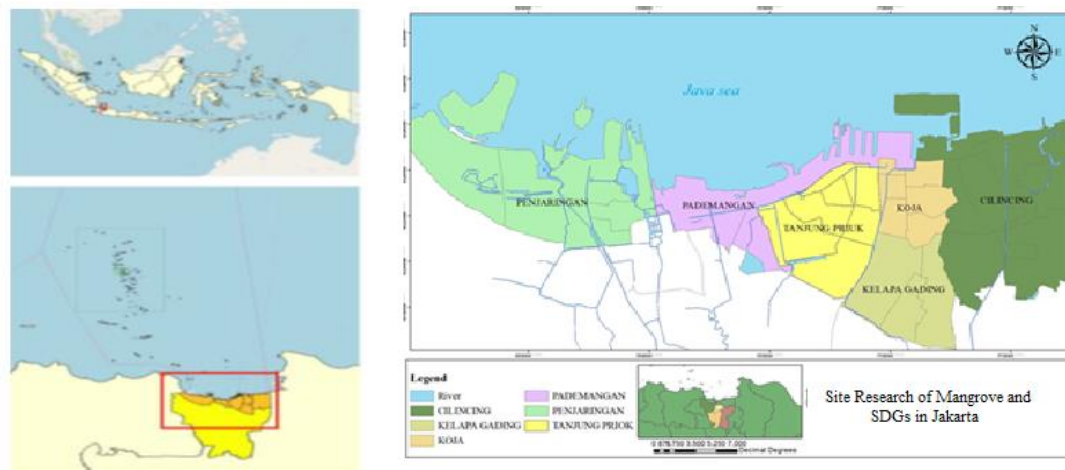
Figure 1. Site research

Research variables and sampling technique

The research variables and sampling techniques can be seen in Table 2. Table 2 explains the variables and how to obtain data from the research variables being measured.

Table 2. Research variables and sampling technique

No	Data type	Sampling technique	Data resources
1.	Jakarta North Coast Mangrove baseline data	Analysis of mangrove area, changes in mangrove area, Literature study, interviews and field observations	Landsat Satellite Imagery, Mangrove Ecotourism Manager and stakeholders
2.	Ecosystem services	Analysis of environmental services, protection functions, ecotourism functions, socio-economic functions	In-depth interview of the determination of environmental services analysis with the Buchard index
3.	Building Strategy with IFAS and EFAS methods	• Knowledge of the local community and visitors regarding the existence of the mangrove forest on the North Coast of Jakarta • The interest of the local community and visitors to the mangrove forest of the North Coast of Jakarta • Public and visitor perceptions of the conservation and rehabilitation of mangroves on the North Coast of Jakarta • Perceptions of local communities and visitors to mangrove rehabilitation activities on the North Coast of Jakarta	• Local Communities and Visitors to Mangrove Ecotourism on the North Coast of Jakarta • Managers and local government in supporting Mangrove Forest management activities on the North Coast of Jakarta • Developers and other stakeholders.

Data analysis
Ecosystem services analysis support mangrove management

Ecosystem services analysis support mangrove management and rehabilitation could be shown on Table 3.

Table 3 Ecosystem services analysis support mangrove management and rehabilitation

Ecosystem services	Supply					Demand					Budget/capacity			
	LM	SM	EK	ARB	HK	LM	SM	EK	ARB	GB	LM	SM	EK	ARB
• Ecotourism services • mangrove and coastal sustainability • preservation protection • Animal preservation • Tidal flooding reduction • Abrasion reduction • Seawater Intrusion reduction • Land subsidence reduction • Social Income • Fishing activity • Fishpond activity • Social benefits	• Score demand: 3 (high), 2 (moderate), 1(low), 0 (no supply)					• Score suplay: 3 (high), 2 (moderate), 1(low), 0 no demand)					• budget = demand-supply • Score ranges -3 (very low capacity) until 3 (high capacityi			

Note:
LM = mangrove preservation;   SM = Animal preservation Muara Angke; EK = mangrove ecotourism, ARB = Mangrove Arboretum

The analysis of mangrove management strategy using I-FAS (Internal Factor Analysis Summary) and E-FAS (External Factor Analysis Summary)

SWOT analysis was conducted on 50 respondents by dividing the analysis of environmental factors into internal factor that were a number of strengths and weaknesses, and external factor dealing with various opportunities and threats (threats). SWOT pays attention to the weights, ranks and scores of each external and internal factor [34], [35]. Analysis of the internal and external factors of mangrove rehabilitation is shown in Table 4.

Table 4. The analysis I-FAS and E-FAS of mangrove management

IFAS (*Internal Factor Analysis Summary*)				
No.	*Strength* factor	Weight	Rank	Score
1	…			
	Total			
No.	*Weakness* factor	Weight	Rank	Score
1	….			
	Total..			
	Score S-W			
EFAS (*External Factor Analysis Summary*)				
No.	*Opportunity* factor	Weight	Rank	Score
1	……			
	Total			
No.	*Threats* factor	Weight	Rank	Score
1	…			
	Total			
	Skor O-T			

Results and Discussion
Ecosystem services of the mangrove ecosystem in the North Coast of Jakarta

Mangrove ecosystem services were built using a study of the existence of mangrove ecosystems and the existence of mangrove vegetation around Pantai Indah Kapuk (PIK) starting from Muara Angke; along the Angke River which leads to Jakarta Bay, TWA Angke Kapuk and along the Sedyatmo toll

road (the south side). The Wildlife Reserve, Angke Kapuk Protection Forest, and Angke Kapuk Nature Park (Northside) [4]. In addition, there is a non-vegetation cover of mangroves such as residential buildings and bodies of water around Jakarta's North Beach. For this reason, the study of mangrove ecosystem services was carried out in the zoning of mangrove ecosystems in the North Jakarta area consisting of (1) Mangrove Protected Forest; (2) Wildlife Reserve; (3) Mangrove Ecotourism; and (4) the Arboretum which is adjacent to the Angke Kapuk Mangrove Nature Park which extends towards the Sedyatmo Toll Road [4], [6], [7]. The Ecosystem Services Matrix for the mangrove area on the North coast of Jakarta can be seen in Table 5.

The first is Ecosystem services for ecotourism at the five locations observed, namely Protected Forest (HL), Wildlife Reserve (SM), Ecotourism (EK), Arboretum (ARB) and Green Belt (GB) still had positive capacity to be developed with a positive value (score between 1 -2); Especially for the arboretum which had a score of 2 because it is still not optimal utilization. The second Ecosystem services was the conservation services at the five observed locations, namely in HL and ARB, have a negative score (-1), because the capacity provided is smaller than the required demand, while for ecotourism zones and wildlife reserves had a capacity of 0 which had meaning that the supply is the same as the demand (balance). The third was wildlife preservation services at the five observed locations, namely in HL, SM, EK ARB and Green Belt still had a positive capacity to be developed with a value scale that is still positive (score 1-2); Especially for ecotourism which has a value of scale 2, this is because it is still not optimal for its services to be developed [23].

The fourth of Ecosystem services was tidal flooding reduction for Mangrove Protected Forests, Wildlife Sanctuaries and Arboretum Areas which still had capacity with a negative scale of (-1-2),. This condition showed that the demand exceeds the existing supply, therefore the rehabilitation activities aims to increase the value of supply [4], [36]. The fifth was seawater abrasion reduction services. The Protected Forest area had a value of -2, which means the supply capacity is still smaller than the demand. The area of Wildlife preservation, EK, ARB and GB have a scale with a value of 0 (zero) which means that supply is equal to demand, so this can still be developed again for the enrichment of mangrove vegetation [17], [19], [31].

Table 5. The matrix of Ecosystem services of mangrove ecosystem in North Coast of Jakarta

No	Ecosystem services	Supply					Demand					Budget/Capacity				
		LM	SM	EK	ARB	GB	LM	SM	EK	ARB	GB	LM	SM	EK	ARB	GB
1	Ecotourism	3	3	3	3	3	1	1	2	1	2	2	2	1	2	1
2	mangrove and coastal sustainability	2	2	1	2	2	3	2	1	3	2	-1	0	0	-1	0
3	Animal preservation	3	3	2	1	1	1	2	0	0	0	2	1	2	1	1
4	Tidal flooding reduction	1	2	2	2	2	3	3	1	3	1	-2	-1	1	-1	1
5	Abrasion reduction	1	2	1	1	1	3	2	1	1	1	-2	0	0	0	0
6	Seawater Intrusion reduction	2	2	3	2	2	3	2	1	2	1	-1	0	2	0	1
7	Land subsidence reduction	2	2	2	2	2	3	3	3	3	3	-1	-1	-1	-1	-1
8	Social income	1	3	3	2	3	1	1	2	1	2	0	2	1	1	1
9	Fishing activity	2	1	3	3	3	1	0	2	1	2	1	1	1	2	1
10	Fishpond activity	1	1	2	1	2	0	0	1	1	1	1	1	1	0	1
11	Social benefit	1	1	3	1	2	1	0	2	1	2	0	1	1	0	0

Note:
LM = mangrove preservation;   SM = Animal preservation Muara Angke; EK = mangrove ecotourism, ARB= Mangrove Arboretum

The sixth ecosystem service was Sea water intrusion reduction services for the HL zone have a value of -1 meaning that demand exceeds the existing supply, meanwhile, for the SM and Arboretum zones, it has a score of 0 (zero). The high utilization of the mangrove ecosystem cause the decreasing function of the mangrove ecosystem to reduce seawater intrusion [11], [37], [38]; The Ecotourism Zone has a capacity of 2, because the location was not directly adjacent to the coast (tide) and is protected by settlements and the Pantai Indah Kapuk trading area (PIK).

The seventh ecosystem service was reducing land displacement in the value of Protected Forest, Wildlife Reserve, Ecotourism Arboretum and Green Belt has a value of -1, which gave indicates that the requires effort to rehabilitate and repair comprehensive mangroves to reduce land subsidence [4], [39]

The eighth of ecosystem services was a supply of economic services. The ecotourism zoning area had the largest value (Score 3), because give many activity for local community in North Coast Jakarta. The Wildlife Reserve had score 2, and the Arboretum and Green Belt had score 1 [40], [41]. This showed that mangrove utilization must support economic services. Meanwhile, the nineth of ecosystem services was fishing services from the five locations gave a positive value, specifically the arboretum (score 2), while the other 4 locations had score 1.

Based on observations of the five zoning or mangrove area showed that the zoning area of Protected Areas, Wildlife Sanctuaries, Ecotourism, Arboretum Zoning and Green Belts, especially services which high relation with the ability of tidal flooding reduction, abrasion and seawater intrusion. The mangrove degradation can be gave impact for the decreasing function and ecosystem services. But, the ecosystem services must have high notice to community welfare, disaster risk reduction and habitat for biota or organisms (Indriani, Marisa, & Zakaria, 2009; Yuliana et al., 2019).

The strategy of mangrove management in North Coast of Jakarta

Mangrove management in North of Jakarta is the activities/efforts of restoration, rehabilitation and developing of habitats, economic area and protection area. The SWOT analysis using the identification of internal and external factors were developed to create strategy of mangrove ecosystem management on the North Coast of Jakarta which aimed to support the stability of the mangrove ecosystem. The SWOT analysis can be seen in Table 6 and Figure 2.

Tabel 6 The strategy of mangrove management using I-FAS and E-FAS system

Internal Factor	Level	Weight	Rating	Score
STRENGTH				
The existence of mangrove functions for regional stability	3	0.19	4	0.75
The existence of a spatial policy in area management planning as an instrument for preparing a mangrove	2	0.13	2	0.25
The existence of potential non-timber forest products and mangrove ecosystem services with the presence of processed mangrove products	2	0.13	4	0.50
The existence of mangroves functions for ecotourism activities and other social activities	3	0.19	3	0.56
Mangroves as the habitat for long-tailed monkeys and several other protected species of birds	3	0.19	3	0.56
The presence of mangroves is a buffer zone against various abrasion disasters, seawater intrusion, land subsidence, tidal flooding,	3	0.19	3	0.56
TOTAL S	16	1.00		3.19
WEAKNESS				
There has not been a precise collaboration mechanism from the manager with related agencies and the private sector in mangrove rehabilitation and development activities	3	0.19	4	0.75

	Level	Weight	Rating	Score
Inadequate infrastructure in mangrove forest management activities to support its services and functions, including Protected Forests, Wildlife Sanctuaries, Ecotourism, Arboretums and Green Belts	3	0.19	4	0.75
Limited budget or funding allocations for mangrove development and rehabilitation activities in the North Coast of Jakarta	3	0.19	3	0.56
Lack of awareness and understanding of stakeholders in carrying out mangrove conservation activities	3	0.19	4	0.75
Not yet optimal implementation of local regulations or regulations related to mangrove management	2	0.13	2	0.25
Limited resources or internal human resources and mangrove management officers	2	0.13	3	0.38
TOTAL W	16	1.00		3.44
S-W				-0.25
Factor External	Level	Weight	Rating	Score
OPPORTUNITY				
There is an increase in public interest in ecotourism activities	3	0.20	4	0.80
The integration of natural tourism, cultural tourism and culinary tourism	3	0.20	4	0.80
Open access to the mangrove ecosystem due to the development of the reclamation island	4	0.27	4	1.07
the existence of investment and interest in managing mangrove tourism by the private sector	3	0.20	3	0.60
There is political will from the DKI government to make forest ecosystems in jkt in support of SDGs activities	2	0.13	3	0.40
TOTAL O	15	1.00		3.67
THREAT				
There is a decrease in the carrying capacity and capacity of the mangrove ecosystem due to the pressure of rapid development in urban areas	3	0.20	3	0.60
High level of sea water pollution in the North Coast Coastal Area of Jakarta	3	0.20	3	0.60
The occurrence of land conversion in the North Coast Coastal Area of Jakarta	3	0.20	2	0.40
Relatively high level of mangrove damage	3	0.20	3	0.60
The North Coast of Jakarta is the estuary of 13 rivers and the Ciliwung watershed, which will have an impact on waste problems in the waters and mangrove areas	3	0.20	3	0.60
TOTAL T	15	1.00		2.80
O-T				0.87

Figure 2. The Strategy using SWOT analysis based on I-FAS and E-FAS.

The results of the SWOT matrix analysis carried out based on a combination of internal factor environmental conditions consisting of strengths and weaknesses along with external factor environmental conditions consisting of opportunities and threats indicate a value that is located in quadrant III (negative-positive) namely the position supports the W-O strategy that minimizes weaknesses to take advantage of opportunities by avoiding threats. This position indicates a weak development effort but has good opportunities [34]. The strategy recommendation in this position is a change in strategy, mangrove managers must change their strategy to take advantage of existing opportunities because it is feared that the old strategy will not be able to take advantage of these opportunities. The North Coast Mangrove Ecosystem Rehabilitation Matrix for Jakarta in supporting Ecosystem stability in Mangrove Forest Areas is presented in Table 7.

Table 7 Matrix of W-O strategy directions in mangrove rehabilitation in supporting the stability of the Mangrove ecosystem on the North Coast of Jakarta

IFAS EFAS	Weaknesses (W) 1. There is no precise cooperation mechanism integrated from the manager with related agencies and the private sector in mangrove rehabilitation and development activities (W1) 2. Not yet optimal infrastructure in mangrove forest management activities to support its services and functions, including Protected Forests, Wildlife Sanctuaries, Ecotourism, Arboretums and Green Belts (W2) 3. Limited budget or funding allocations for mangrove development and rehabilitation activities in the North Coast of Jakarta (W3) 4. Lack of awareness and understanding of stakeholders in carrying out mangrove conservation activities (W4) 5. Not yet optimal implementation of local regulations or regulations related to mangrove management (W5) 6. Limited internal resources or human resources and mangrove management officers (W6)
Opportunities (O) 1. There is an increase in public interest in ecotourism activities (O1) 2. The integration of natural tourism, cultural tourism and culinary tourism (O2) 3. Open accessibility to the mangrove ecosystem due to the development of reclamation islands (O3) 4. There is investment and interest in managing mangrove tourism by the private sector (O4)	W-O Strategy 1. Landscape-based Mangrove Rehabilitation that balances the interests of land use so that mangrove protection for the protection function and biodiversity conservation and the use of mangroves for production, tourism and other infrastructure functions can take place in harmony in the North Coastal Area of Jakarta (W1-O5)(W4; O2) 2. Revitalization of the Mangrove Ecosystem Area on the North Coast of Jakarta, which is integrated with the development of reclamation islands (W2-O2; W1-O1; W2-O3)

5. There is political will from the DKI government to make forest ecosystems in Jakarta to support SDGs activities (O5)	3. Development of a creative economy based on mangrove ecosystems (W1-O2; W1-O4; W3-O4). 4. Development of a Green Belt (Green Belt) to reduce disaster risk (W4-O4) 5. Increasing the competence of HR and related stakeholders in Mangrove management ((W6-O1; W6-O5; W5-O5) 6. Development of Blue Carbon potential in supporting the achievement of the Nationally Determined Contribution (NDC) target (W6-O5; W1-O4; W3-O4)

The strategy of mangrove management and rehabilitation on the North Coast of Jakarta was weakness and opportunity strategies that were (1) Landscape-based Mangrove Rehabilitation that balances the interests of land use so that mangrove protection for the protection function and biodiversity conservation and the use of mangroves for production, tourism, and other infrastructure functions can take place in harmony in the North Coastal Area of Jakarta (support the combine Weakness1 - Opportunity5 and Weakness4 – Opportunity2); (2) Revitalization of the Mangrove Ecosystem Area on the North Coast of Jakarta, which is integrated with the development of reclamation islands (Weakness2 – Opportunity2; Weakness1 – Opportunity1; Weakness 2 – Opportunity3); (3) Development of a creative economy based on mangrove ecosystems (Weakness1 – Opportunity2; Weakness1 – Opportunity4; and Weakness3 – Opportunity4). (4). Development of a Green Belt (Green Belt) to reduce disaster risk (Weakness41 – Opportunity4); (5) Increasing the competence of HR and related stakeholders in Mangrove management (Weakness6 – Opportunity1; Weakness 6-Opportunity5; Weakness5 – Opportunity5) and (6) Development of Blue Carbon potential in supporting the achievement of the Nationally Determined Contribution (NDC) target (Weakness6 – Opportunity5; Weakness1 – Opportunity4; Weakness3 – Opportunity4)

Conclusion

The management and rehabilitation of mangrove ecosystem can be developed by the ecosystem services analysis and I-FAS and E-FAS analysis. The activities of mangrove ecotourism, fishing activity and fishpond activity are the best opportunity for social activity on the North Jakarta. The others ecosystem services are reducing coastal disaster, reducing land subsidence and preservation of organisms. The strategy of mangrove management is developed by weakness-opportunity strategy that are Landscape-based Mangrove Rehabilitation, Development of a creative economy, Development of the Green Belt (Green Belt), Increasing the competency of human resources and related stakeholders and Developing the potential of Blue Carbon

Acknowledgement

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