PLANNING MALAYSIA:
Journal of the Malaysian Institute of Planners
VOLUME 22 ISSUE 4 (2024), Page 474 – 484

ESTABLISHING MANGROVE FOREST PRODUCTS FOR ECO-TOURISM ACTIVITY AT KOTA KINABALU WETLAND RAMSAR SITE, SABAH. MALAYSIA

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Abstract

Mangrove forests are found ubiquitously across the global landscape and are known to assume a pivotal role in supporting the surrounding ecosystem. The study purposely estimates the ability of absorption in CO2 towards the subject area to understand the precautions of visitors in future demand. By leveraging the advanced technology of Geographic Information Systems (GIS) and employing carbon footprint analysis, the study estimated the daily footfall to the area and the resultant carbon footprint. The analysis conclusively revealed a surplus of minus 7,957.65 tons/year, indicating that the area can assimilate more CO2. This underscores the wealth of natural resources and the potential to accommodate a larger number of visitors in the future.

Keywords: Ramsar Site, KK Wetland, Mangroves Forest, Urban Forest

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INTRODUCTION

Mangroves are among the most carbon-rich tropical forests (Donato et al., 2011) and are considered natural barriers to carrying capacity for maintaining coastal urban environmental health (Analuddin et al., 2023). Furthermore, Diaz et al. (2016) and Hsu (2019) indicate that the forest contributes to economic activity directly and indirectly, especially in wetland tourism. The activity required stakeholders' initiative in handling the limited mangrove area's resources at the micro and macro levels. Latip et al. (2013) and Pimid et al. (2020) initiate the importance of forest management, especially in wetland areas. Meticulous frameworks are crucial in ensuring all forest matters are covered. Globally, the Convention on Wetlands is an intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources (Ramsar, 2014). Worldwide currently registered Ramsar sites up to 2,471 sites, covering 256,192,602 ha, including Malaysia, with a total area of 134,182 ha.

RESEARCH BACKGROUND

Visual mapping from NASA (2010) indicates the location and relative density of mangrove forests covering 137,760 square kilometres of the earth's surface involving 118 countries. UNESCO (1987) indicates that the world's largest mangrove forest is the Sundarbans Reserve Forest (SRF) in Bangladesh. Mangrove forests are an ecosystem located between the land and sea. The forest contributes an economic gain to locals by providing a source of fisheries and tourist activity and coastal protection from erosion and weather changes (Anuar & Latip, 2020). According to NOAA (2023), mangrove forests stabilise the coastline, reducing erosion from storm surges, currents, waves, and tides, and the intricate root system of mangroves makes these forests attractive to marine species seeking shelter from predators. Moreover, its potential services related to the ecosystem and human health primarily cover the supply of water, food, nutrition, and medicine, purification of waste products, and buffering against adverse flooding and climate effects (Skov, 2019). Mangroves store up to five times as much organic carbon as tropical upland forests (Donato et al., 2011). Brander et al. (2012) indicated that mangrove forests contribute to ecosystem services and human well-being by providing nursery habitat for many species of plants, birds, insects, crabs, fish, and cultural services.

Table 1 presents a comprehensive catalogue of wetland services and functions that are indispensable in preserving the ecosystem. All the stakeholders and relevant authorities must give due and diligent attention to these services and functions. As per an empirical study conducted by The Conservation Fund, it has been observed that the capacity of wetlands to store carbon ranges from 81 to 216 metric tons per acre, depending on the specific type and location of the wetland.

Table 1: List of Wetland Services

No	Services	Statement
1	Habitat and Biodiversity	Nature Tourism Commercial and Recreational Fisheries
2	Recreation	Hunting and Fishing Revenues
3	Nutrient Regulation	Reduced Water Purification Costs
4	Soil and Sediment Regulation	Reduced Water Purification Costs Reduced Soil Erosion
5	Disturbance & Natural Hazard Regulation	Storm Surge Mitigation Runoff and High-Water Event Mitigation
6	Cultural Values and Aesthetics	Sabah
7	Water Supply	Increased Water Quantity Increased Downstream Productivity (fisheries, etc.)
8	Food Production	Food (both plant and animal) and fibre harvest

Source: Authors (2024), Woodward & Wui (2001) and Cooley (2015)

Malaysia is known for its diverse and flourishing mangrove forests. However, it is essential to note that out of the numerous mangrove forests in the country, only seven have been officially gazetted and granted the esteemed Ramsar Site status. As indicated in Table 2, these sites have been judiciously selected based on their geographical location, size, and year of recognition.

Table 2: Ramsar Sites in Malaysia.

Year	Site No	State	Location	Area (ha)	Total (%)
1994	712	Pahang	Tasek Bera	38,446	28.65
2003	1287	Johor	Pulau Kukup	647	0.48
2003	1288	Johor	Sungai Pulai	9,126	6.80
2003	1289	Johor	Tanjung Piai	526	0.39
2005	1568	Sarawak	Kuching Wetlands National Par	6,610	4.93
2008	1849	Sabah	Lower Kinabatangan-Segama Wetland	78,803	58.73
2016	2290	Sabah	Kota Kinabalu Wetland	24	0.02
Total Area				134,182	100
Worldwide Ramsar Area				256,192,602	0.05

Source: Authors (2024) & Ramsar (2014)

Jonas & Yapp (2016), a researcher from The International Union for Conservation of Nature (IUCN) has conducted research on the mangrove forest and wetland in Sabah, identifying several critical issues such as pollution, human-wildlife conflict, and lack of awareness regarding renewable resources. To address these challenges, the IUCN recommends implementing good governance by introducing a Ramsar Site and Management Plan (RSMP). The proposed RSMP will provide the framework to mitigate the identified issues and promote sustainable management practices.

Study area: Kota Kinabalu Wetland Ramsar Site

Kota Kinabalu Wetland Ramsar Site (KKWRS) is in Kota Kinabalu city, 2 km from the city centre, with an area of 24.2 hectares. It is considered the city's hidden gem and green belt. Consists of 32 types of mangrove species, including rare and (Ono et al., 2016) critically endangered ones listed in the IUCN Red List of Threatened Species, namely Bruguiera hainesii (Rhizophoraceae). It coexists with Limulus polyphemus, well known by locals as 'Belangkas', which exist in the area as part of the marine life contribution. It was gazetted as a bird sanctuary in 2000, with more than 90 species in the area. As well as migrating birds from Siberia, namely Leptoptilos javanicus and Egretta eulophotes. The area is also a nursery ground for 21 fish and aquatic species, including crustaceans, molluscs,

horseshoe crabs and jellyfish (RAMSAR, 2017). Kota Kinabalu Wetlands is the 2nd Ramsar site in Sabah, after Hilir Kinabatangan-Segama and the 7th in Malaysia, with the registration Ramsar Site at 2,290 worldwide by the Ramsar Convention. The recognition entitles the KK Wetland as the 1st Ramsar Site in the city, nationally and the 2nd globally after the wetland in Yatsu-Higata, Chiba in Japan.

Table 3: Chronology to Ramsar Status.

Year	Statement
1980-an	Proposed as a protected area by the funding from World Wildlife Federation (WWF)
1996	Gazette as a protected area by Section 28 of the Sabah Land Ordinance (Cap 68) and managed by the 'Jawatankuasa Pengurusan Santuari Likas' (LWSMC)
1999	Gazette as a Cultural Heritage Site under the Cultural Heritage (Conservation) Enactment 1997
2000	Gazette as a bird sanctuary and known as the Kota Kinabalu Bird Sanctuary (KKCBS) in December
2005	The Sabah Wetlands Conservation Society (SWCS) was established and took over management from LWSMC in August
2006	Officially named KK Wetlands to expand its importance as a mangrove swamp ecosystem conservation area
2009	Proposed as a Ramsar site by the Sabah Ministry of Tourism, Culture and Environment
2011	Information relating to Ramsar sites is submitted to Ramsar headquarters
2013	Approved by the Sabah Cabinet as the second Ramsar site in Sabah in March, while by the Federal Cabinet in November
2016	Listed as the Seventh Ramsar Site in Malaysia on 22 December.
2017	Officially announced as a Ramsar Site by the Ministry of Natural Resources and Environment on 17 July, with the official launch on 21 September.

Source: Abdullah, (2017) and Lahasing et al., (2016)

Table 3 outlines the events that led to KK Wetland receiving a Ramsar site status. The wetland provides a range of visitor facilities to meet the needs of individuals and organisations. These facilities include an information centre, AV and meeting room (available for rental), a trail with a boardwalk (1.3km in length), informative signboards, a gravel path (200m in length), a nursery, an

outdoor classroom, a bird hide and an observation tower. In addition, there is an exhibition hall and an interactive library. The provision of these facilities demonstrates good governance of scarce resources in the study area.

The Sabah Wetland Conservation Society (SWCS) has taken a commendable initiative to synchronise human and natural attributes in conserving and enhancing the attractiveness of KK Wetland as a globally recognised Ramsar site. To maintain the sustainability of the forest involved, detailed studies on ecosystem balance must be conducted in the study area, both in the central area and the buffer zone. This will help ensure the perpetuation of the ecosystem's equilibrium and promote the attractiveness of the wetland.

METHODOLOGY

The Geospatial and Visual Impact Assessment (VIA) methods were utilised to determine the overall CO_2 levels present in the area. The GIS mapping technique was employed to estimate the size of the green space in the mangrove forest, which comprises three main types of plants that absorb CO2, namely trees, bushes, and meadows. Although the VIA method is typically used for building assessments, it was modified in this case to confirm the actual situation on the ground after the GIS analysis. Additionally, secondary data on daily visitor estimates was collected from the information centre. It is interesting to note that the site mainly attracts international visitors. The estimated number of daily visitors ranges from 20 to 50 people, averaging 35 people per day. Most visitors are bird enthusiasts, environmental groups, researchers, scholars, and school groups on excursions. Visitors' presence is crucial to the study, whereby each visitor will contribute as the subject in calculating CO_2 emissions (Latip & Umar, 2022). Furthermore, Grey & Deneke (1978) and Idris et al. (2017) argue that the CO_2 produced by visitors to the area is the same at 0.3456 tons of CO_2/human/year. To complete the assessment, the formula modification by Latip & Umar (2022) imposes the attribute below:

$$P = J_p \times C_{visitor}$$

Where,
P = Total CO_2 emissions from the population (tons/year)
J_p = Total population (visitor)
$C_{visitor}$ = Total CO_2 produced by humans, which is 0.3456 (ton/human/year)

The CO_2 absorption capacity is based on Table 2 with the type of plant, namely tree, bushy and meadow.

Table 4: CO_2 Absorption Ability According to the Type of Plant

No	Type of Plant	CO_2 Absorption Capacity (Kg/Ha/Day)	CO_2 Absorption Capacity (Ton/Ha/Year)
1	Tree	1559.1	569.07
2	Bushy	150.68	55.00
3	Meadow	32.88	12.00

Source: Latip & Umar, (2022), Idris et al. (2017) and Prasetyo et al. (2002)

ANALYSIS AND FINDINGS

Table 5 portrays the recorded and estimated number of visitors to the study area. The average number of visitors per day is 35, and the estimated annual visitation number is 12,775. Consequently, the CO_2 emission is 4415.04, the Pt value.

Table 5: Average Visitor Daily (08.00-18.00)

Estimate Daily	The visitor (J_p)	$C0_{2/Visitor}$	Total CO_2 (P)
Min	20	0.3456	6.912
Maximum	50	0.3456	17.28
Average Daily	35	0.3456	12.10
Annually (P_t)	12775	0.3456	4415.04

Source: Authors, (2024)

According to Figure 1, GIS estimated a point to measure consequences and calculate the study area, approximately 24.2 hectares.

Figure 1: Estimate Profile Area (24.2 ha)
Kota Kinabalu Wetland Ramsar Site
Source: Authors, (2023)

As per the data presented in Table 6, the CO_2 absorption ability of different plant types in the study area is evaluated. The analysis was performed by computing the percentage of each plant type's occurrence in the area. The evaluation results indicate that trees had the highest presence in the area, covering 89% of the total area and exhibiting a CO_2 absorption ability of 12,257.77. On the other hand, small trees covered 8% of the area, with a CO_2 absorption ability of 106.15. Lastly, the remaining plant types covered 3% of the area and had a CO2 absorption ability of 8.76.

Table 6: Estimate CO_2 Absorption Ability According to the Type of Plant

No	Type of Plant	Area (%)	Area (Ha)	Ability Absorb CO_2 (Ton/Ha/Year)	Amount
1	Tree	89	21.54	569.07	12,257.77
2	Bushy (small tree)	8	1.93	55.00	106.15
3	Meadow (grass area)	3	0.73	12.00	8.76
	The total amount of CO_2 absorption ability for the area (T_t)				12,372.69

Source: Authors, (2024)

Carbon footprint Analysis (S_{value})

During the assessment of an area's functionality, it has been observed that negative S values signify the thriving status of the area, implying its capability to sustain an increase in visitors. Conversely, positive S values suggest that the area is not performing well and must be cautiously approached.

Table 5: Estimate Carbon footprint analysis (S value)

Variable	Description	Total
P_t	Total CO_2 emissions from the population (tons/year)	4,415.04
T_t	Total CO_2 absorption ability according to the type of plant (tons/year)	12,372.69
S_{Value}	$P_t - T_t$	-7,957.65

Source: Authors, (2023)

According to the estimations provided in Table 5, the existing trees in the area have a CO_2 absorption capacity with S values of -7957.65. This data indicates that the area can accommodate more visitors while maintaining its current carbon footprint. Therefore, KK Wetland, an area managed by Sabah Wetlands Conservation Society in partnership with the City Council of Kota

Kinabalu, has ample mangrove trees that meet visitors' needs and contribute to the environment's wellness.

CONCLUDING REMARK

Conclusively, the results of the conducted studies unequivocally demonstrate the potential of the subject sites to accommodate an increased number of visitors in the future. However, the realisation of this potential is contingent upon implementing a rigorous monitoring regime, providing expert guidance from relevant parties, and undertaking measures with utmost diligence to safeguard the existing area, particularly the site's buffer zone. This will necessitate meticulous planning and physical action, in strict parallel with the planning of local authorities and the state.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Sabah Wetland Conservation Society (SWCS), the Borneo Institute of Indigenous Studies (BorIIS), and the Universiti Malaysia Sabah (UMS) for providing the platform and financial support to conduct this research.

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Received: 5th Mar 2024. Accepted: 17th July 2024

