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DETERMINING TOURIST'S CARRYING CAPACITY BASED ON ECOLOGICAL APPROACH IN TUNKU ABDUL RAHMAN PARK, MALAYSIA

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ABSTRACT

Tunku Abdul Rahman Park (TARP) is a Marine Protected Area (MPA) and a famous tourist destination in Sabah. The possible long-term negative impacts on the ecology and sustainability of the Park due to the very high number of tourists is of much concern to the Park management authority. This study was conducted to determine the ecological and tourism carrying capacity in three islands in TARP, Manukan, Mamutik and Sapi islands. The Effective Carrying Capacity (ECC) concept is applied in this study, in which the results are expected to provide the Park Authority with data and effective management actions. Calculation of carrying capacity in this study was based on three distinct visiting patterns or seasons: i) Regular season; ii) High season, and iii) Festive season in order to ensure optimal tourists' satisfaction and revenue, while still maintaining ecological sustainability. ECC was calculated after considering the various limitations imposed by physical, climate, ecological, and management capabilities. Land and ocean areas were considered and calculated separately as they occupied different variables. Our findings showed that Manukan island recorded the *highest ECC, while Mamutik and Sapi island shared almost similar ECC value. Optimization of Carrying Capacity (CC) in different seasons was also achieved with a few Correction Factor (CF) adjustments. It shows that Festive season recorded the highest ECC, followed by High Season and Regular Season. The ECC obtained was suggested to be implemented to TARP management as to preserve and sustain the ecological value of the Park.*

Keywords: *Carrying capacity, Sustainability, Tourism, Marine Protected Area, Sabah*

INTRODUCTION

Malaysian tourism is a fast-growing industry in which it has expanded tremendously and brings huge revenues to the country (Aitchison, 2001). In Sabah, Tunku Abdul Rahman Park (TARP) has been flooded with tourists from all over the world with over 400,000 visitors from 2013 to 2019 (prior to Movement Control Order) (Sabah Parks, 2020) and a question of carrying capacity has been a concern for the Park authority. Areas with natural resources such as TARP are a valuable commodity itself, and are important for a country's economy, as they are valued for the goods and services that they provide society (Musa, 2017; Santoso et al., 2014). However, with minimal management and regulation, tourism expansion in these areas will only raise concerns about practices and ethics of how to gainfully benefit from the commercialisation of such places. Overly commercialized destinations, particularly in the marine areas, can negatively impact resources, due to the fragility of the ecosystem. For example, the granting of permits by the management authority to tour operators to commence profitable activities in public areas, have brought about issues like a rapid upsurge in visitation. When a place is overcrowded, it will not only cause harm to the ecosystem but also towards other visitors and importantly, the local residents. As a researcher, we need to look into effective long-term environmental policies to solve environmental problems (Rasiah et al., 2017; Keshminder, J. (2018).

The concept of carrying capacity in tourism is strongly related to the operation of mass tourism where it typically involves large tour groups, with very structured programmes, low cost to the consumer (the tourist) and heavily regulated by the tour operators. In this regard, a very static concept of package tourism will be seized on mass tourism (Spilanis & Vayanni, 2004). Impacts on the environment will increase with the rise of anthropogenic factor in TARP especially to the marine area that comprises a sensitive and fragile ecology. The carrying capacity based on ecology will help determine the optimal number of visitors of an area at a time, so the impact still can be minimized and still manageable without any permanent damage (Chapman, 2018). The evolution of various definitions of tourism carrying capacity begins with the transition of the maximum number of users to the desired condition and identified as the limits of appropriate (Massiani & Santoro, 2012) and it is achieved when the average tourists' experiences remained satisfactory, when exerting an "acceptable" or minimum impact to the protected area (Cupul-Magana & Rodríguez-Troncoso, 2017).

The purpose and objectives of this study are to determine the exact value of carrying capacity of tourist in TARP through ecological approaches by considering various variables. Three seasons were considered in this study which are the Regular Season, High Season and Festive Season. Since TARP offers two different types of experiences, the carrying capacity for Land-based and Ocean-based tourists were separated to obtain different carrying capacity value for its respective area.

METHODOLOGY

Study Sites

The study sites for data collection are in three TARP islands, namely Manukan, Mamutik and Sapi islands. According to tourists' arrival reports by the Park Authority, these islands were selected as the sampling localities (stations) because of its popularity and high arrival of tourists yearly, contributing to 97.9% of tourists' total arrival to TARP in 2019 according to the tourists' arrival reports of Sabah Parks (2020).

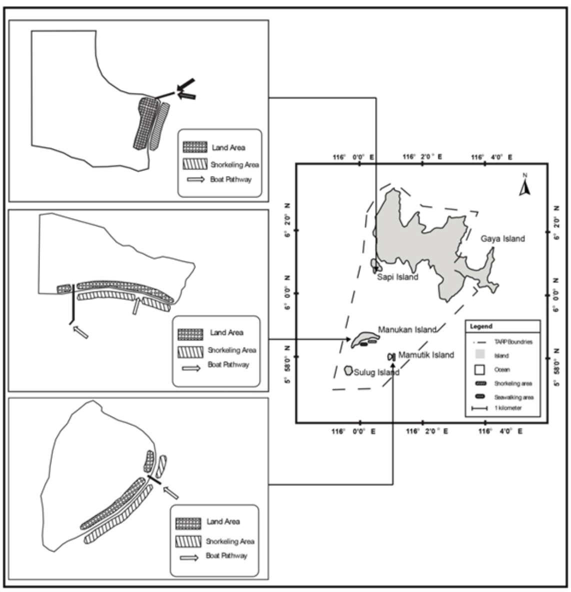
Data were collected from both Land-based area; comprising terrestrial areas, where the tourist can sit down, relax, sunbathe, play and do any activities on the dry part of the island. While for Ocean-based; it comprises water areas where tourist can do water-based activities such as swimming, snorkelling, sea walking and any recreational activities in the ocean that is safe and within the supervision of lifeguards (Table 1, Map 1).

Table 1. Study Site in the Three Islands of TARP

The size of each Land-based and Ocean-based area in three different islands.

No.	Island	Study sites	Size (m²)
a.	Manukan island	i. Land-based ii. Ocean-based	5,378.70 3,413.53
b.	Mamutik island	i. Land-based ii. Ocean-based	3,667.30 3,051.08
c.	Sapi island	i. Land-based ii. Ocean-based	3,881.50 3,133.46

(Source: Author, 2021)



Map 1. Land-based and Ocean-based area in Three Islands of TARP (Sabah Parks, 2020).

Only Manukan, Mamutik and Sapi island were included in this study as they received the most tourists over the past years. The circled region is an area that is suitable for tourism, and the lined area is the suitable snorkelling area that is within lifeguards' supervision.

Calculations of Carrying Capacity

Carrying capacity was calculated following Cifuentes et al. (1999), and the various adaptations of the approach (Cupul-Magana & Rodríguez-Troncoso 2017; Rı´os-Jara et al., 2013; Gallo et al., 2001; Souza-Melo et al., 2006). Based on the method, three parameters were estimated: (a) Physical Carrying Capacity (PCC): an estimate of the relationship between the time and duration of the visit with the available space; (b) Real Carrying Capacity (RCC): calculated as the PCC normalized to the group size, characteristics and fragility of the substrate, interactions with the substrate, climatic factors, and visitor accessibility and skill and; (c) Effective Carrying Capacity (ECC): calculated as the RCC corrected by the Management Capacity (MC) of TARP.

This study collected data from three different seasonal situations from two separate areas for optimal result. These criteria were considered based on the tourists' arrival data from the Park Authority, which showed that tourists visiting TARP were irregular and seasonal. Thus, we considered the following seasons;
i)Regular season
ii)Peak Season (High season and Festive season)

The calculation for RCC and ECC of both areas; (i) Land-based and (ii) Ocean-based were affected by different variables and limiting factors, resulting in additional carrying capacity.

Physical Carrying Capacity (PCC)

This parameter is the first carrying capacity value which only considered the area's physical factor. In brief, PCC is the maximum number of visits that can physically accept a defined site at a particular time (opening hour).

(i) Land-based Tourists
PCC of Land-based tourists on the island was calculated using the following formula;

$$PCC = A \times V/a \times Rf$$

Where;
A = Available area for tourist use (m2)

V/a = Area required per tourist (m2)
Rf = Rotation factor; hours of visits per day (hour)

(ii) Ocean-based Tourists
PCC of Ocean-based tourists or snorkelers in the island was calculated using the following formula;

$$PCC = (S/SP) \times V$$

Where;
S = snorkeling surface available (m2),
SP = surface used per person during the activity (m2)
V = total potential snorkeling time; time spent on the island (hour)/actual snorkeling time.

Real Carrying Capacity (RCC)

The RCC, defined as the maximum number of visitors admissible at each site, results were obtained once the PCC was corrected based on physical, biological, and climate factor.

$$RCC = PCC \times (CF1 \times CF2 \times CF3 \times \ldots \times CFn)$$

Where:
CF = correction factor that limits tourists arrival/activity.

Few factors were considered in calculating the RCC of TARP. We have decided and include seven limiting factors that could affect the tourists' arrival or activity in TARP. The characteristics are shown in Table 2.

Table 2. The Seven Limiting Factors that Hugely affect TARP Tourists' Arrival and Activity for the Past Years

Climate factors are important for tourist safety purposes, while ecological factors involve the interaction between the reefs and tourists. Factors that were considered and included in the calculation for water activity (snorkelers) and land activity are as follow:

No.	Limiting Factors	Snorkelers	Tourists on Land
1.	CF social	√	X
2.	CF fragility	√	X
3.	CF damage	√	X
4.	CF low tide	√	X

5.	CF rain	√	√
6.	CF wind	√	√
7.	CF limited sunshine	√	√

(Source: Author, 2021)
√: included in the calculation
X: not included in the calculation

(1)According to Cupul-Magana and Rodríguez-Troncoso (2017), the "social" factor for diving activity pertains to the human element consider group sizes, number of visitors per guide, activity time, and the distances between groups. Optimization of these parameters ideally will achieve high safety standards and client satisfaction. We adopt this concept to snorkelling area and calculate CF social using the following equation;

$$\text{CF social} = 1 - (\text{mlx}/\text{mtx})$$

Where:
mlx = area covered by snorkelling activity (m2)
mtx = total snorkeling area (m2)

(2)The fragility factor (CF fragility) is the percentage of absolute cover fragile coral type that snorkelers can damage. The data were obtained using a 50m transect survey in the snorkelling area of each island. The quadrate was taken for every 2 meters of transect, which makes 25 quadrat/site. Based on the previous study, we determined the fragile coral based on morphology. Therefore, it is decided that foliaceous corals (Hughes 1987) and all Acropora coral types (Edinger & Risk, 2000) will be the limiting factor as they are the most fragile. Fragile coral coverage was identified using PhotoQuad software. CF fragility then calculated using the following formula;

$$\text{CF fragility} = 1 - \%\ \text{fragile coral}$$

(3)The correction factor by damage (CF damage) is associated with the frequency of interactions or contact with the coral reef. This factor was calculated based on the probability of both voluntary and involuntary contact with the reef. Observations were done loosely following any anonymous and random snorkeler within the reef area and recording the frequency of contact to coral. Ten minutes of observations were done for each sample. However, the sample must not notice our intention to ensure a reliable and unbiased result. CF damage was calculated using the following formula;

$$CF\ damage = 1 - (Frequency\ of contact/snorkeler/min)/(Snorkeling\ time) \times 100\%$$

(4)Low tide correction factor (CF low tide) refers to the period of non-optimal conditions for tourist activities to do any water activities as it exposes coral reef to a higher chance of breakage and damage. This parameter was obtained from the seasonal reports by Sabah Marine Department and CF low tide calculated using the following formula;

$$CF\ low\ tide = 1-(hl / ht)$$

Where;
hl = number of hours that the Park experience low tide
ht = number of hours that the Park is normally open

(5)A heavy rain correction factor (CF rain) is one factor that affects both Ocean-based and Land-based activity in TARP. No boat was allowed during heavy raining. As a result, this prevented any tourists from arriving on the island. Data of annual rain were retrieved from the Meteorology Department of Malaysia (MetMalaysia) and count the number of days with heavy raining (>8 mm of raining according to MetMalaysia), before calculating the CF rain using the following formula;

$$CF\ rain = 1-(dl / dt)$$

Where;
dl = number of days that the Park experience heavy rain (>8 mm)
dt = number of days that the Park is normally open

(6)A wind correction factor (CF wind) is a factor that affects the wave actions of the ocean. It affects both Land-based and Ocean-based activities. According to North-Eastern Regional Association Coastal Ocean Observing System (NERACOOS) on their sites, a wind speed of 8.5 m/s is the speed that can sway a whole small tree and break waves on inland waters. Annual data of wind surface was obtained from

MetMalaysia. Days with >8.5 m/s of wind speed will be counted as a limiting factor, and CF wind will be calculated using the following equation;

$$CF\ wind = 1-(dl / dt)$$

Where;
dl = number of days that the Park experience strong wind (>8.5 m/s)
dt = number of days that the Park is normally open

(7)A limited sunshine correction factor (CF limited sunshine) refers to cloudy weather that influence the tourists' decisions to visit TARP as it will risk their visits with upcoming bad weather. Annual data of solar radiation was obtained from Jabatan Meteorologi Malaysia Cawangan Sabah. Referencing Matuszko in 2011, the limiting factor of limited sunshine access will be cut off at <14.34 MJ/m2. CF of limited sunshine will be calculated as follows;

$$CF\ limited\ sunshine = 1-(dl / dt)$$

Where;
dl = number of days that the Park experience limited sunshine (>8.5 m/s)
dt = number of days that the park is normally open

Effective Carrying Capacity (ECC)

The ECC is the final carrying capacity number that incorporates factors that are related to Management Capacity; the quality and quantity of certain aspect in infrastructure (I), personnel (P) and services (S) available to measure the Management Capacity (MC). Data were obtained based on tourist satisfaction and rating questionnaire form and quality score by some Park staff. I, S and P were averaged to get the MC as follows;

$$\%MC = ((S \times I \times E)/ 3) \times 100$$

Finally, the ECC represents the maximum numbers of tourists that can be allowed per site in the park and calculated using the following formula;

$$ECC = RCC \times MC = \text{number of tourist visits per day}$$

RESULTS

A total of 4,740 respondents participated in answering the questionnaire and 400 snorkelers were recorded and used to find the value of certain variables to achieve ECC. Coral cover was also monitored, and climate data were obtained from MetMalaysia and were factored into the calculation to obtain CF's value. A few adaptations were made to achieve different levels of seasonal CC.

Regular Season

Physical Carrying Capacity (PCC)

To acquire the PCC in the study area based on the applied approach (refer to Table 3), there is a need to calculate and assess required data including a suitable site for tourism, applicability duration of the location and visit duration, as shown in Table 2. The same formula was applied and adapted to Ocean-based tourists (Cupul-Magana and Rodríguez-Troncoso, 2017; Rı´os-Jara et al., 2013). However, instead of land area, we measured water area suitable and safe for tourists to do any water activity.

Table 3. Land-based and Ocean-based PCC of three of the islands in TARP
The value of 4.03 of V/a and 4.21 of visit duration were acquired from the questionnaire (n=4,740). For safety purposes, the space occupied per snorkeler was assumed to be SP=3.0 m2, and the duration of the activity was 1.5 hour for the entire island visit.

Regular season (Land-based; PCC)			
Island	Manukan	Mamutik	Sapi
A	5,378.7	3,667.3	3,881.5
V/a	1/4.03	1/4.03	1/4.03
Rf	8/4.21	8/4.21	8/4.21
PCC	2,536.18	1,729.22	1,830.22
Regular season (Ocean-based; PCC)			
S	3,413.53	3,051.08	3,133.46
SP	3.0	3.0	3.0
V	4.21/1.5	4.21/1.5	4.21/1.5
PCC	3,193.55	2,854.45	2,931.53

(Source: Author, 2021)

A =Area of tourism (m2)
V/a= 1/ Average tourist comfortable area (m2)
Rf= TARP opening hours/ Average duration of tourist in TARP
S= snorkelling surface available (m2)
SP= surface used per person during the activity (m2)
V = total potential snorkelling time; time spent on the island (hour)/actual snorkelling time.

Real Carrying Capacity (RCC)

RCC calculation includes respective CF that affects Land-based and Ocean-based tourists.

A total of three CF of climate affects tourists' arrival or activity on land in TARP as shown in Table 4, along with the value of RCC of Manukan, Mamutik and Sapi Islands. The snorkeling area considered in the calculation of PPC comprises coral reefs that act as a magnet for tourists worldwide. However, the coral reef is a marine life facing great degradation due to various reasons, including tourism (Su & Lin, 2014). Thus, four CF of ecological factors were considered that could cause harm to the coral reef in generating an RCC that could sustain a healthy reef community.

Table 4. Land-based RCC Calculated after Including Three Climate Correction factors that can Affect Tourists' Arrival and Activity

Ocean-based RCC calculated after including three ecological factors and four climate factors that can affect or disrupt coral reef community in the snorkelling area and affect tourists' activity (snorkelling).

Regular season (Land-based; RCC)			
Island	Manukan	Mamutik	Sapi
PCC	2,536.18	1,729.22	1,830.22
- CF rain	0.8077	0.8077	0.8077
- CF wind	0.7284	0.7284	0.7284
- CF limited sunshine	0.8805	0.8805	0.8805
RCC	1,313.80	895.78	948.10
Regular season (Ocean-based; RCC)			
PCC	3,193.55	2,854.45	2,931.53
- CF social	0.8028	0.7038	0.7097
- CF fragility	0.9020	0.8001	0.6139
- CF damage	0.8260	0.7710	0.7730
- CF low tide	0.9111	0.9111	0.9111
- CF rain	0.8077	0.8077	0.8077

- CF wind	0.7284	0.7284	0.7284
- CF limited sunshine	0.8805	0.8805	0.8805
RCC	901.54	584.91	465.97

(Source: Author, 2021)

Effective Carrying Capacity (ECC)

Management Capacity (MC) was calculated and analyzed from interviews and questionnaire forms regarding tourists' satisfaction and perception of the infrastructures, personnel, and TARP services. A few of Sabah Parks' higher authorities were also involved in judging and grading these components to be considered and included in MC's calculation.

Based on Table 5, ECC of Land-based was achieved after the determination of MC. Components of Infrastructure (I), Personnel (P) and Services (S) were considered in the calculation of MC. Fewer factors were considered in calculating Ocean-based MC as they do not interact or involve with certain categories listed, as shown in Table 2 earlier.

Table 5. ECC of Land-based Tourists after Considering the Averaged Value of Infrastructure (I), Personnel (P) and Services (S); the Management Capacity (MC), which was obtained from both Tourists and Sabah Parks Authority.

ECC of Ocean-based tourists indicate the number of tourists (snorkelers) per day that is suitable to keep the sustainability of coral reef in the designated area.

Regular season (Land-based; ECC)			
Island	Manukan	Mamutik	Sapi
RCC	1,313.80	895.78	948.10
Infrastructure (I)	0.6489	0.6185	0.5831
Personnel (P)	0.5299	0.5602	0.5420
Services (S)	0.6465	0.6321	0.5974
MC (I+P+S)/3	0.6084	0.6036	0.5741
ECC	799.32	540.69	544.30
Regular season (Ocean-based; ECC)			
RCC	901.54	584.91	465.97
Infrastructure (I)	0.8054	0.8205	0.7998
Personnel (P)	0.3105	0.3231	0.3395
Services (S)	0.5875	0.6171	0.6429

MC (I+P+S)/3	0.5678	0.5869	0.5941
ECC	511.89	343.28	276.83

(Source: Author, 2021)

High Season

Few adjustments were made and adapted to calculate the carrying capacity during high season. Based on the TARP's previous reports, this season usually occurs mid-year, end of the year and new year.

Adjustments were made on PCC, where the comfortable distance of tourists (V/a) was only considered from 67.2% of the 4740 respondents that answered 1 meter and 3 meters as their comfortable distance and ignoring choices of 6 and 9 meters. This consideration was made as the island will be more crowded during the high season and have limited space. The average comfortable distance from the 67.2% of respondents was recorded to be V/a=2.84 m. Table 6 shows the ECC of Land-based tourists after the adjustment in PCC.

According to the Park Authority, more lifeguards will be put on duty to guard and cover bigger snorkeling area in response to higher tourist arrival during this season. Some restricted areas will be opened and patrolled by lifeguards during this season to ensure tourists' satisfaction. Therefore, changes were made in calculating PCC and CF social, affecting Ocean-based ECC's end value (Table 6).

Table 6. Land-based ECC during High Season

No changes were made on CF and MC.

High season (Land-based; ECC)			
High Season	Manukan	Mamutik	Sapi
PCC	3,598.88	2,587.60	2,597.10
- CF rain	0.8077	0.8077	0.8077
- CF wind	0.7284	0.7284	0.7284
- CF limited sunshine	0.8805	0.8805	0.8805
RCC	1,864.30	1,340.44	1,345.36
MC	0.6084	0.6036	0.5741
ECC	1,134.24	809.09	772.37

High season (Ocean-based; ECC)			
PCC	4,435.03	3,753.82	3,757.25
- CF social	0.8580	0.8323	0.8324
- CF fragility	0.9020	0.8001	0.6139
- CF damage	0.8260	0.7710	0.7730
- CF low tide	0.9111	0.9111	0.9111
- CF rain	0.8077	0.8077	0.8077
- CF wind	0.7284	0.7284	0.7284
- CF limited sunshine	0.8805	0.8805	0.8805
RCC	1,338.09	909.64	700.48
- MC	0.5678	0.5869	0.5941
ECC	759.77	533.87	416.16

(Source: Author, 2021)

Festive Season

According to Borg (2016), it was found that tourism percentage increased during the festive season. This category must be included to provide optimal tourist's satisfaction and keep the TARP ecosystem's sustainability intact. Therefore, we calculated the highest possible number of tourists to enjoy tourism in TARP in a day within the capability to carry TARP capacity.

The same concept was adopted for high season; however, for celebration or festive season, tourists will expect a denser and more crowded island due to even a higher number of tourists. Therefore, we determine the comfortable distance for tourists to be 2.2m, which was observed to be the highest distance in previous studies' dyadic interactions (Ozdemir, 2008). The observation was also based on a previous study on the ECC of Land-based tourists during the festive season after applying the lowest comfortable distance.

The same changes were made as a high season where PCC was higher due to more lifeguards will be on duty during the high and festive season. Therefore, PCC during the high and festive season shares the same value. However, as shown in Table 7, ECC of Ocean-based tourists was recorded to be higher during the festive season as changes were made in calculating

RCC; CF social, where the assumption was made that tourists or snorkelers will cover up to 50% less area (mlx) of usual snorkeling activity.

Table 7. Land-based and Ocean-based ECC during the Festive Season
No changes were made on CF and MC for Land-based, while for CF social of Ocean-based was adjusted to meet the optimal CC in the festive season.

Festive season (Land-based; ECC)			
Festive Season	Manukan	Mamutik	Sapi
PCC	4,645.82	3,167.61	3,352.62
- CF rain	0.8077	0.8077	0.8077
- CF wind	0.7284	0.7284	0.7284
- CF limited sunshine	0.8805	0.8805	0.8805
RCC	2,406.64	1,640.90	1,736.74
- MC	0.6084	0.6036	0.5741
ECC	1,464.10	990.45	997.06
Festive season (Ocean-based; ECC)			
PCC	4,435.03	3,753.82	3,757.25
- CF social	0.9290	0.9161	0.9162
- CF fragility	0.9020	0.8001	0.6139
- CF damage	0.8260	0.7710	0.7730
- CF low tide	0.9111	0.9111	0.9111
- CF rain	0.8077	0.8077	0.8077
- CF wind	0.7284	0.7284	0.7284
- CF limited sunshine	0.8805	0.8805	0.8805
RCC	1,448.82	1,001.22	771.0
- MC	0.5678	0.5869	0.5941
ECC	822.64	587.62	458.05

(Source: Author, 2021)

Overall ECC of TARP

Effective Carrying Capacity (ECC) or Tourism Carrying Capacity, was finally achieved, as shown in Table 8. The regular season was recorded to be the lowest in both areas, in all three islands. Manukan recorded ECC of 799 tourists day-1 for Land-based and 511 tourists day-1 for Ocean-based. Change in the comfortable distance by tourists for high and festive season allowed a bigger number of tourists to visit TARP within the sustainable carrying capacity of Manukan Island with 1,134 tourists day-1 and 1,464 tourists day-1 respectively. For Ocean-based tourists, with extra lifeguards and staff's deployment during the high and festive season, the carrying capacity recorded were 759 tourists day-1 and 822 tourists day-1

Mamutik and Sapi Island share almost the same suitable area for tourism, resulting in nearly the same ECC for Land-based tourists since Land-based was affected with the same limiting climate factor value. Throughout all different seasonal ECC in increasing order, Mamutik Island recorded ECC of 540 tourists day-1, 809 tourists day-1 and 990 tourists day-1. In contrast, Sapi Island recorded ECC of 544 tourists day-1, 772 tourists day-1 and 998 tourists day-1.

The bigger difference was observed in ECC of Ocean-based tourists as Sapi Island recorded a bigger limiting factor throughout the calculation process, especially in CF fragility. During the regular season, ECC of Ocean-based in Mamutik and Sapi Island recorded 343 tourists day-1 and 276 tourists day-1. With the adjustment of bigger snorkeling area during high season, and smaller limiting factor of CF social during the festive season, ECC of Ocean-based in Mamutik was 533 tourists day-1 during high season and 587 tourists day-1 during the festive season. Lastly, Sapi Island recorded ECC of 416 tourists day-1 and 458 tourists day-1 for Ocean-based tourists during the high and festive season.

Table 8 ECC of Land and Ocean-based Tourists, at Three different Seasonal Situations in TARP

Effective Carrying Capacity	Land-based Tourists			Ocean-based Tourists		
	Manukan	Mamutik	Sapi	Manukan	Mamutik	Sapi
Regular season	799.32	540.69	544.3	511.89	343.28	276.83
High season	1,134.24	809.09	772.37	759.77	533.87	416.16
Festive season	1,464.10	990.45	997.06	822.64	587.62	458.05

(Source: Author, 2021)

DISCUSSION

The questionnaire results showed that Manukan Island has the biggest number as a suitable area for tourism. Compared to Manukan and Mamutik, it results in a bigger PCC of Land-based tourists, to begin with. The same case was observed in Ocean-based tourists where ECC was the highest throughout all seasonal carrying capacity. The snorkeling area in Manukan Island is the largest and manned by the most number of lifeguards than the other two islands.

Based on the coral cover survey, Manukan Island recorded the lowest fragile coral structure resulting in a lower limiting factor in CF fragility. The limiting factor for CF damage in Manukan was also recorded to be the lowest as coral contact rate (CCR) was also the lowest in Manukan. Manukan Island comprised of patchy coral dominated by a massive and submassive type of corals.

Mamutik and Sapi Island share almost the same size, resulting in nearly the ECC's exact value for Land-based tourists ranging from 4 to 47 tourists difference only (Refer to Table 13). However, Ocean-based tourists observed bigger differences for Mamutik and Sapi due to the difference in the limiting factor, particularly the fragile coral cover's ecological aspect recorded to be higher in Sapi Island. According to Hawkins et al., (1999), MPA associated with coral reef ecosystems such as TARP, the coral cover itself is one of the most affected resources, mostly in Ocean-based activities. Any decrease in coral cover is direct evidence of damage to the ecosystem and a loss of the biodiversity (Schleyer & Tomalin, 2000). In case of Ocean-based tourists in Sapi Island, it recorded the smallest ECC throughout all season. This was caused by the biggest cut off by CF fragility as Sapi Island comprises the largest percentage of living coral cover with 73%. As much as 38.61% were determined as a fragile coral consisting of coral from genus Acropora and thin foliaceous plate corals. Reef structure in snorkeling area of Sapi is also very shallow with almost less than 0.5 during low tide. We observed that lifeguards in charge would control and prevent any tourists' activities during low tide. A border build-out of rope and buoy marks Sapi Island reef structure that cannot be passed during low tide.

Coral contact rate in TARP was recorded to be higher compared to a previous study in Pattaya, Thailand (Phillips, 2018) with almost double in number. If compared with the tour operator ratings, which was very low in determining MC, we could say that CCR was higher because of the tour operator and tour guides lack of effort to establish responsible tourist. It was proven before that a high-quality briefing would lower the chances of coral breaking. Furthermore, since the carrying capacity is also influenced by the visitors' behaviour (Leujak & Ormond, 2007), the damage to the environment may be simply because they might not care or be aware of the impact they are causing. Hence, this explained the low rating of tour guides. Simply briefing visitors about the vulnerability of organisms such as corals may mitigate effects (Marion & Rogers 1994; Medio et al., 1997), whereas in other places more direct intervention may be necessary (Barker & Roberts, 2004). Tackling this problem by promoting better or "greener" practices among tourists will be maintained or even increase resources in TARP.

Carrying Capacity is specifically calculated for each area/site as it considers the site's ecological characteristics in question and the specific use and benefits that society obtains from its resources. The estimation of the maximum use of a natural resource may cause conflicts between authorities and the touristic sector as it restricts the excessive use of the area. However, for MPA, the carrying capacity estimation is an essential tool for the stakeholders as it is considered a mandatory policy indicator to maintain sustainable use of the area/resources with a status of special protection (Cupul-Magana & Rodríguez-Troncoso, 2017).

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With the achieved value of CC from this study, a few steps can be done to control the tourists' number. One way is to limit the types of activities that can be carried out to promote green practices among tourists. In that regard, there is still a lack of related studies on the behaviour of tourists especially in an MPA such as TARP. Thus, it is recommended that future research could be carried out to fill a gap in the literature about tourists' behaviour in MPA to find the best way to promote green practices and raise awareness among tourists (Chiu et al., 2020).

CONCLUSIONS

This study provides the value of carrying capacity for three of the islands in TARP that had been recorded to be the most visited tourist islands in Sabah (Praveena et al., 2010). As Lane (2010) stated, the carrying capacity imperative is an environmental and ethical initiative of vital future importance. From investigating the current status of tourism activities in TARP region, it was found that the current status of tourism activities based was still within the carrying capacity of TARP based on tourists' arrival. This is a good sign as TARP is optimizing revenue from the tourists' arrival and still managing tourists sustainably. However, the tourism industry will keep growing, especially when there is a high demand for islands and coral reefs (Spalding, 2017) and the implementation of tourist limitation that is based on the results from this research that needs to be considered for the well-being of the island.

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