GTC | Geo-intelligence, Building Multi-dimensional Foundation

The Estimations of Recreation Carrying Capacity of Bukit Saga, Selangor, Malaysia

Rabiatul Adawiyah Nasir, PhD, Gs, Ts.
Center of Studies Park and Amenity Management,
Faculty of Architecture, Planning and Surveying,
Universiti Teknologi MARA, Malaysia.

5th GIS Software Technology Conference (GTC 2022)

Introduction

- Carrying capacity is defined as the maximum number of people that use a site without causing adverse effects on environmental resources while meeting the demands of the user [1].
- The number of visitors to the protected area is increasing due to the needs of leisure.
- The main problems are caused by the excessive number of visitor, overcrowding during peak periods, particularly at sites that are close to urban centres [7].

[1] Wall, G. and Mathieson, A., 2006. *Tourism: change, impacts, and opportunities*. Pearson Education.

[2] Tietenberg, T.H. and Lewis, L., 2016. *Environmental and natural resource economics*. Routledge.

Case Study: A simple trail measurement

- The study area is located at Bukit Saga, Selangor
- This study divided the trails used by the hikers into two, namely Trail A and C. The trailhead GPS coordinate is 3.112660 N 101.773242 E. The trail route coordinate has been logged by GPS and mapped using CAD.
- Trail A is shorter and steeper than Trail C. Trail A is approximately 500-600 m of hilly trail. Trail C is longer with an estimated 1 km hiking distance and approximately 300-400 m to the summit on mainly flat ground.

The site

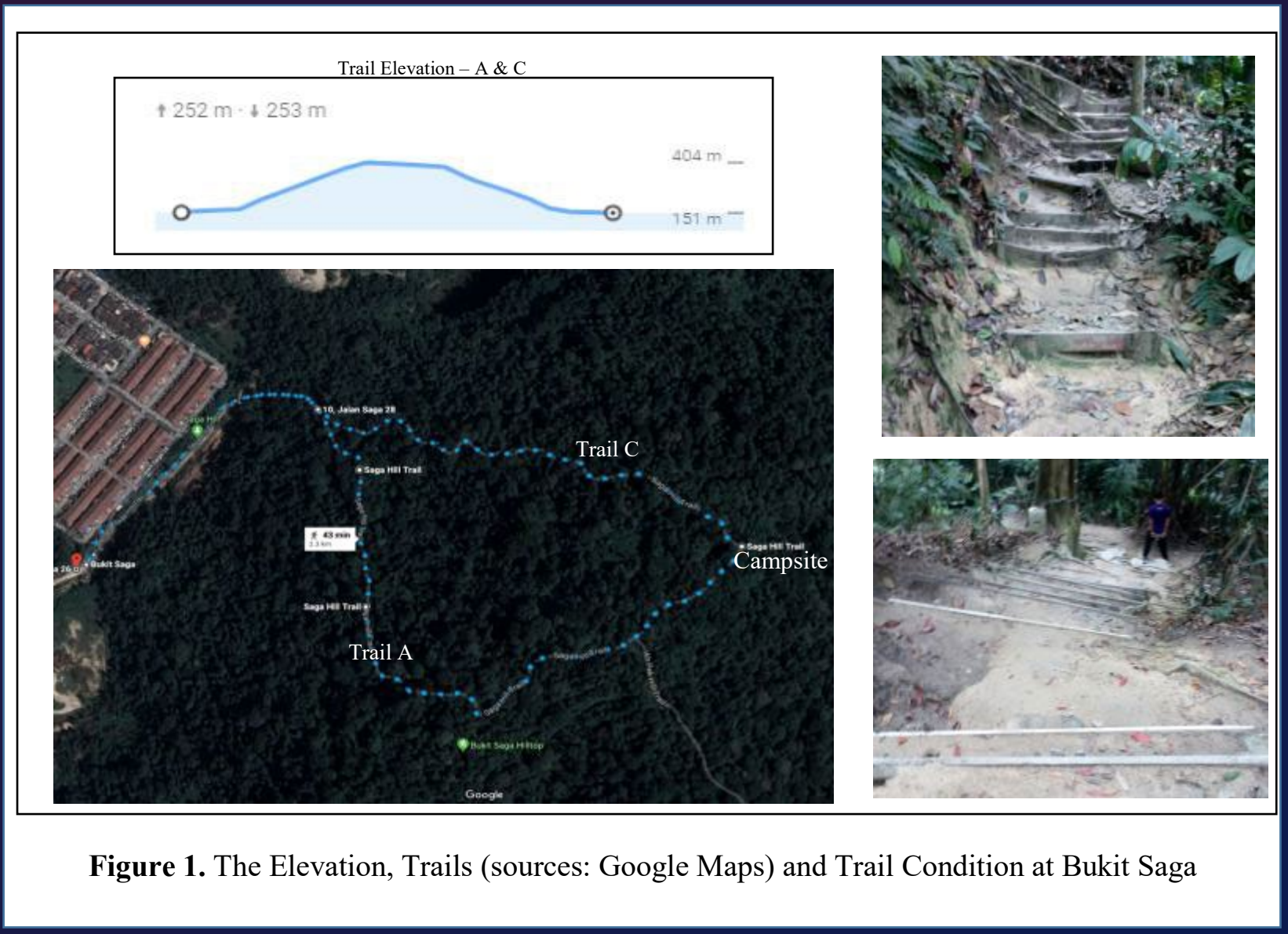


Figure 1. The Elevation, Trails (sources: Google Maps) and Trail Condition at Bukit Saga

The Carrying Capacity Methods

- The estimations of the Carrying Capacity (CC) were mainly referred to previous studies [3] & [4]-[5].
- The calculation of the Visitor Carrying Capacity considers three levels which are the Physical Carrying Capacity (PCC), the Real Carrying Capacity (RCC), and the Effective Carrying Capacity (ECC) [7].
- Each level constitutes a corrected estimation of the previous one based on the specific factors involved in each case studied. The relationship can be represented as follows: PCC > RCC ≥ ECC.
- The process on estimating the Carrying Capacity should attempt holistically consider the maximum number of tourists that an area can tolerate, based on its physical, biological and management conditions of the area [3].

[3] Kourandeh, H.H. and Fataei, E., 2013. Estimation of tourism carrying capacity of Fandoqloo Forest in Ardebil Province, Iran. *Bull. Env. Pharmacol. Life Sci*, *2*(12), pp.64-70.

[4] Zacarias, D.A., Williams, A.T. and Newton, A., 2011. Recreation carrying capacity estimations to support beach management at Praia de Faro, Portugal. *Applied Geography*, *31*(3), pp.1075-1081.

[5] Queiroz, R.E., Anunciação Ventura, M., Guerreiro, J.A. and Tristão da Cunha, R., 2014. Carrying capacity of hiking trails in Natura 2000 sites: a case study from North Atlantic Islands (Azores, Portugal). *Revista de Gestão Costeira Integrada-Journal of Integrated Coastal Zone Management*, *14*(2).

Physical Carrying Capacity

The PCC can be expressed according to following formula [9]:

$$PCC = A \times V/a \times Rf \quad (1)$$

A = available area for public use
V/a = area required per user
Rf = Open period / Average time of one visit

A subsection of the RCC is determined by the following equation [9]:

$$RCC = PCC \times 100 - Cf_1 / 100 \times 100 - Cf_2 /100 \times \ldots 100 - Cf_n /100 \quad (2)$$

$Cf = (M_1 / M_t) \times 100$
$Cf_1 - Cf_n$ are the Corrective Factors (%)
M_1 = limiting magnitude of variable
M_t = total magnitude of variable

The Effective or Permissible Carrying Capacity equation [9]:

$$ECC = RCC \times MC \quad (3)$$

MC = management capacity

Management Capacity (MC) measurements are demanding as it involves many variables, including policy measures, legislation, infrastructure, facilities, amenities and equipment, staff (both number and competency), funding, available budget [9].

The Estimations of Carrying Capacity of Bukit Saga

Table 1 shows the estimations of Physical Carrying Capacity of Trail A, Trail C and the Campsite. Trail C which is longer between two trails shows the higher PCC that can accommodate 2,975 persons in twelve hours of operation a day. Followed by Trail A that is the area of 884.46 which PCC is 1,769 persons. The lowest is in the Campsite that has with area 163.38 which is PCC is 327 persons. Trail A, Trail C and Campsite then been added together for calculation of Real Carrying Capacity. The total of Bukit Saga Physical Carrying Capacity is 5071 persons in twelve hours of operation a day (0600 – 1800 hours).

Table 1. The Estimations of Physical Carrying Capacity

	A	v/a	Rf	PCC	Person/m^2
Trail A	884.46	1	2	1768.92	1769
Trail C	1487.57	1	2	2975.14	2975
Campsite	163.45	1	2	326.9	327
TOTAL	2535.48	1	2	5070.96	5071

The Results of Real Carrying Capacity

Based on weather in Ampang, Malaysia, this data is used for the calculation of the Real Carrying Capacity. The calculation of this data was provided to estimate the corrective factor. Two Corrective Factors were using the Corrective Factors which is excessive sunshine hours and rainy days. The data were assumed that Bukit Saga' s operating hours are 12 hours (0600 – 1800 hours). Table 2 shows the corrective factor of excessive sunshine by monthly after estimation — the highest Corrective Factors of excessive sunshine which is 57% in February. For the second highest is 56% in March and May. Then, for the lowest Corrective Factors of excessive sunshine which is 42% in November.

The Results of Real Carrying Capacity (cont’)

Table 2. The Estimations of Excessive Sunshine Hour by Month (Hours)

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
M_1	185	192	208	199	207	194	200	189	164	169	152	163
M_t	372	336	372	360	372	360	372	372	360	372	360	372

Table 3. The Corrective Factor of Excessive Sunshine

	M1*100	Mt	Cf_s	%	/100
JAN	185	372	49.7312	50	0.5
FEB	192	336	57.1429	57	0.57
MARCH	208	372	55.914	56	0.56
APRIL	199	360	55.2778	55	0.55
MAY	207	372	55.6452	56	0.56
JUNE	194	360	53.8889	54	0.54
JULY	200	372	53.7634	54	0.54
AUG	189	372	50.8065	51	0.51
SEPT	164	360	45.5556	46	0.46
OCT	169	372	45.4301	45	0.45
NOV	152	360	42.2222	42	0.42
DEC	163	372	43.8172	44	0.44
TOTAL	2222	4380	50.7306	51	0.51

The Results of Real Carrying Capacity (Rainy Hours)

Table 4. The Rainy Hours of Monthly

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
M_1	168	168	204	240	192	156	144	168	204	240	240	216
M_t	372	336	372	360	372	360	372	372	360	372	360	372

Table 5. The Corrective Factor of Rainy Hours

	M1*100	Mt	Cf_r	%	/100
JAN	168	372	45.1613	45	0.45
FEB	168	336	50	50	0.5
MARCH	204	372	54.8387	55	0.55
APRIL	240	360	66.6667	67	0.67
MAY	192	372	51.6129	52	0.52
JUNE	156	360	43.3333	43	0.43
JULY	144	372	38.7097	39	0.39
AUG	168	372	45.1613	45	0.45
SEPT	204	360	56.6667	57	0.57
OCT	240	372	64.5161	65	0.65
NOV	240	360	66.6667	67	0.67
DEC	216	372	58.0645	58	0.58
TOTAL	2340	4380	53.4247	53	0.53

The Real Carrying Capacity of Bukit Saga Trail

Table 6. The Estimation of Real Carrying Capacity

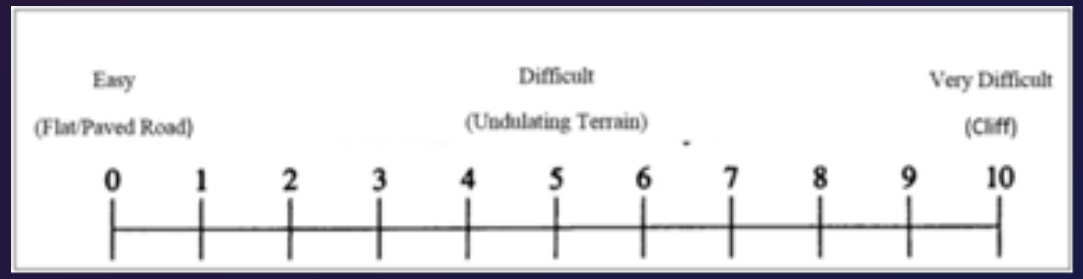
	PCC	100-Cfr	/100	100-Cfs	/100	RCC	Person/m^2
JAN	5071	50	0.5	55	0.55	1394.53	1395
FEB	5071	43	0.43	50	0.5	1090.27	1090
MARCH	5071	44	0.44	45	0.45	1004.06	1004
APRIL	5071	45	0.45	33	0.33	753.044	753
MAY	5071	44	0.44	48	0.48	1071	1071
JUNE	5071	46	0.46	57	0.57	1329.62	1330
JULY	5071	46	0.46	61	0.61	1422.92	1423
AUG	5071	49	0.49	55	0.55	1366.63	1367
SEPT	5071	54	0.54	43	0.43	1177.49	1177
OCT	5071	55	0.55	35	0.35	976.168	976
NOV	5071	58	0.58	33	0.33	970.589	971
DEC	5071	56	0.56	42	0.42	1192.7	1193
TOTAL	5071	49	0.49	47	0.47	13749	13750

Table 6 shows the Real Carrying Capacity of Bukit Saga trail. It was divided by monthly — the higher month of RCC on Bukit Saga trail which is 1,423 persons in July. For the second highest is 1,395 persons in January. Then, for the lowest of Real Carrying Capacity on Bukit Saga trail which is 753 persons in April. Therefore, the Real Carrying Capacity for total all the month which is for the year is 13,750 persons.

The Results of Effective Carrying Capacity

Since there was no accurate estimation of management abilities in Bukit Saga, the calculation of effective carrying capacity was done considering that, these abilities can be created in the future and interfered in actual carrying capacity about the available facilities including fundamental accessories and facilities.

The Difficulty Level Parameters



- The ‘Easy’ level trail is such as the trail is a flat or paved road. The hikers can walk along the ‘Easy’ level of trail. The slope along the ‘Easy’ trail is 30 degrees or less. The ‘Difficult’ level trail is accessible through walk for the hikers but needs more stamina than the ‘Easy’ level of the trail. Mostly the slope along the ‘Difficult’ trail is between 30 degrees to 60 degrees. Lastly, the trail level of ‘Very Difficult’. Along with this trail, the hikers are not hiking but climbing.

The Difficulty Level Map

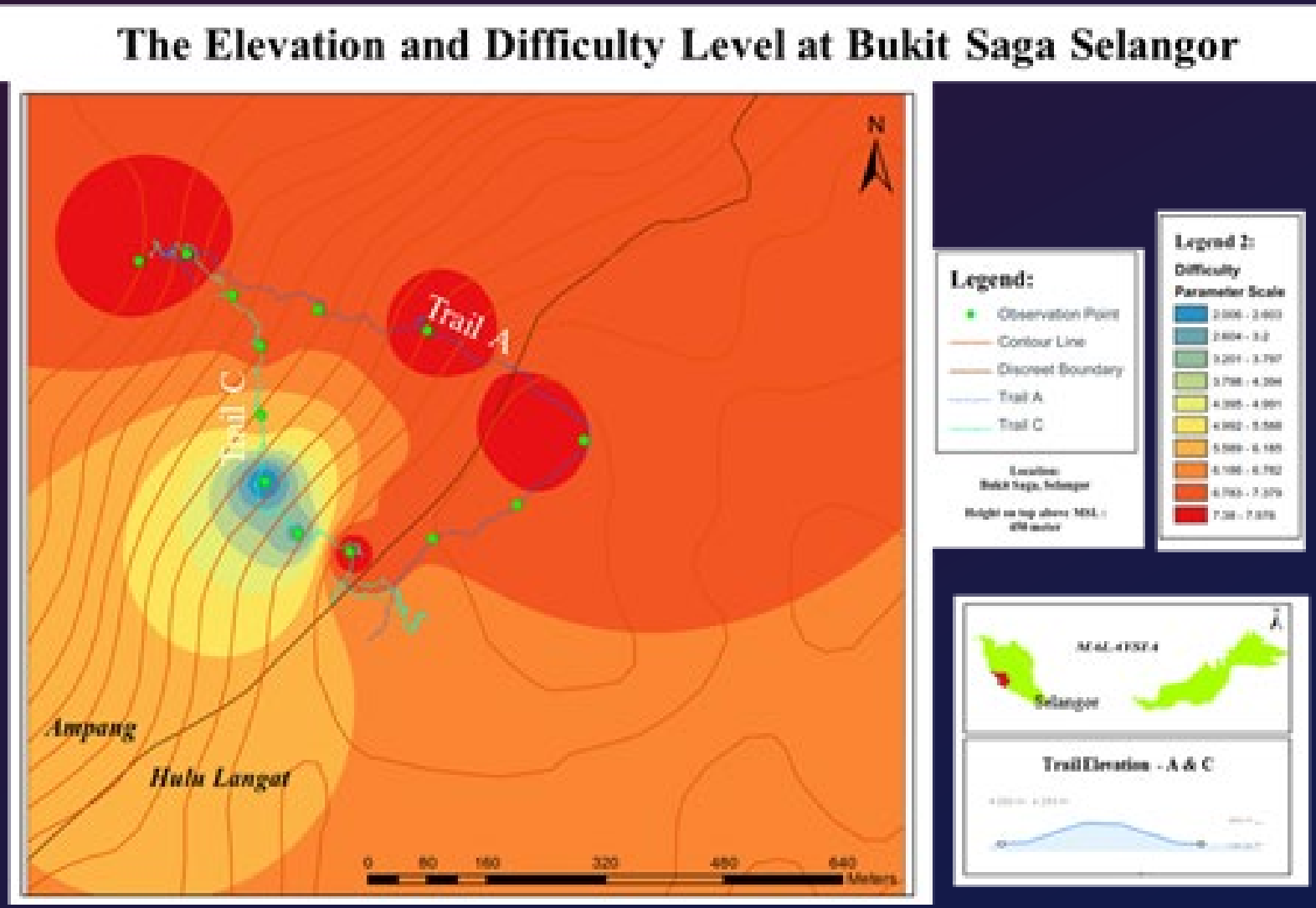


Figure 3 shows the Bukit Saga difficulty level of trails. The difficulty level of trails was classified into two parts due to Bukit Saga trails does not meet the level of the 'Very Difficult'. The trails on the map were determined by two types of value that is blue and cyan. The blue determined as 'Easy' trail while cyan as 'Difficult' level.

The Conclusions

- This research has revealed some perspectives of Physical Carrying Capacity (PCC) and Real Carrying Capacity (RCC) in Bukit Saga, Selangor, Malaysia.
- Due to the scope of the issue and the limitations of the study, the results are not able to represent the Effective Carrying Capacity (ECC) of Bukit Saga.
- However, further studies should focus more on the statistical analysis of the issue, perhaps using a combination of quantitative and qualitative research approaches.
- This study also recommends more studies in detail on soil compaction and PCC for future research.


GTC
Geo-intelligence,
Building Multi-dimensional Foundation
Thank You !
5th GIS Software Technology Conference (GTC 2022)