Siegrist, D., Clivaz, C., Hunziker, M. & Iten, S. (eds.) (2006). Exploring the Nature of Management.
Proceedings of the Third International Conference on Monitoring and Management of Visitor Flows in Recreational and Protected Areas.
University of Applied Sciences Rapperswil, Switzerland, 13-17 September 2006. Rapperswil.

Recreation Carrying Capacity Analysis at Khao Leam Ya – Mu Ko Samed National Park, Thailand

Dachanee Emphandhu[1], Thamasak Yemin[2], Sura Pattanakiat[3], Chatchai Tantasirin[1], Ranuka Ruschano[1], Surachet Chettamart[1] & Mayuree Nasa[1]

[1]Kasetsart University, Thailand
dach_1960@yahoo.com
fforcct@ku.ac.th
r_ruschano@hotmail.com
fforscc@ku.ac.th
Pixx65@hotmail.com

[2]Ramkhamhaeng University, Thailand
thamasakyeemin@yahoo.com

[3]Mahidol University, Thailand
enspt@mahidol.ac.th

Keywords: Recreation carrying capacity (RCC), impact, national park, Thailand.

Abstract: The objective of this research was to determine recreation capacity at Khao Leam Ya - Mu Ko Samed National Park (LY-KS NP). The study investigated the existing capacity of recreation resources by analyzing four capacity types: ecological (ECC), physical (PCC), facility (FCC), and social (SCC). This paper presented the findings on 3 main islands: Ko Samed, Ko Kudee, Ko Talu, and some snorkeling sites. The results found the ECC, PCC, and FCC exceeded at Ko Samed. At Ko Kudee, found the exceeded PCC while at Ko Talu found the exceeded PCC and FCC. One snorkeling site found FCC exceeded. The maximum carrying capacity at Ko Samed and Ko Kodee was 4,100 and 168 people per night respectively. Most ecological carrying capacities, however, have not yet determined since long term monitoring is needed.

Introduction

Khao Leam Ya - Mu Ko Samed National Park (LY-KS NP) experiences high recreational use as a popular marine park near Bangkok. Visitors come to enjoy park scenery, snorkeling and beach activities. Annual visitor numbers have almost doubled from 265,248 to 437,017 from 2003 to 2005. The focus of this research was to establish a long term monitoring programme of recreational impacts and assess recreation capacity at LY-KS NP.

Methods

The study followed Shelby and Herberlein's (1986) definition of recreation carrying capacity as "the level of use beyond which impacts exceed standards". The study investigated the existing capacity of recreation resources in the study area by analyzing four capacity types: ecological, physical, facility, and social. The results presented here were from 2004-2005 with data collection carried out during high tourist season, October through May.

For the ecological carrying capacity (ECC), the researchers identified the national park conservation targets (CTs) to set up indicators for long term monitoring of recreation capacity analysis. They were water quality, percentage of root exposure and vegetation regeneration on trails, amount of garbage and visual quality related to garbage management and percentage of changes in live coral coverage at diving sites. Information on visitor use such as number of visitors and their behavior at each recreation site was related to the existing ecological impacts upon the CTs indicators. Two

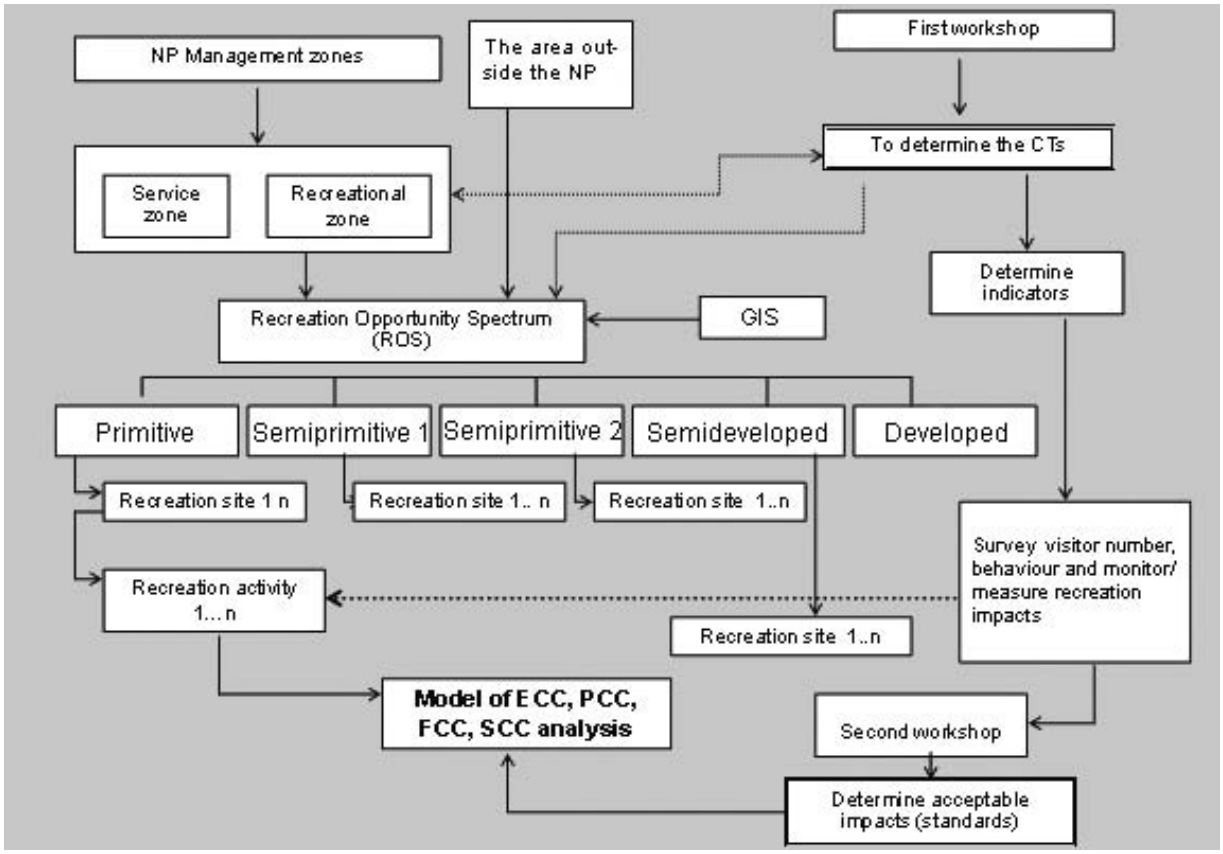

Figure 1: The overall research process of recreational capacity analysis at LY-KS NP.

workshops with park managers, ecologists, marine scientists, and the research team were held to set the acceptable impact levels for these indicators. Finally, the RCC analysis model was developed with 3 levels of impacts: exceeding capacity/ extreme impacts, approaching or at capacity/ moderate impacts, and below capacity/low impacts.

Physical carrying capacity (PCC) was determined by assessing the impact of available space on recreation. The researchers analyzed the Recreation Opportunity Spectrum (ROS) using GIS. Recreation space was measured together with the space required by a visitor for each recreation activity in different ROS zones. The visitor number at each recreation site was recorded to determine the impact of available space. The levels of impacts related to carrying capacity were classified into 3 levels: exceeding capacity/extreme impacts, approaching or at capacity/moderate impacts, and below capacity/low impacts with the acceptable impact of each level set at more than 80%, 50 to 80%, and less than 50% of maximum number of people at one time (PAOT) the space can accommodate, respectively.

Facility carrying capacity (FCC) examined whether facilities were able to accommodate existing visitor use and classified impacts into 3 levels: exceeding capacity/extreme impacts, approaching or at capacity/moderate impacts, and below capacity/low impacts with the acceptable impact of each level set at more than 80%, 50 to 80%, and less than 50% of maximum number of people at one time (PAOT) the facility can accommodate, respectively.

Finally, the social carrying capacity (SCC) was studied at selected recreation sites by a questionnaire survey of 342 respondents by opportunistic sampling. The crowding scale was set from 0 to 9 where 0 means not at all crowded and 9 means extremely crowded. The standard of visitor crowding impact was also set to determine the existing level of social impact. ROS was also employed here to identify the desired visitor experiences against their actual experiences. The levels of impacts related to social carrying capacity were classified into 3 levels: exceeding capacity/extreme impacts, approaching or at capacity/moderate impacts, and below capacity/low impacts which

Table 1: RCC indicators and acceptable impact levels for LY-KS NP.

Recreation capacity indicators	Recreational capacity Levels		
	Below capacity	At or Approaching capacity	Exceeding capacity
Impacts	Low or No concern	High to Moderate concern	Extreme concern
Ecological Capacity			
- Amount of soil loss from gully erosion on dirt road (ton/ha)	<25% of road area found soil erosion more than 31.25 ton/ha	25-50% of road area found soil erosion more than 31.25 ton/ha	>50% of road area found soil erosion more than > 31.25 ton/ha
- Root exposure (area in sq. m)	<25 % of the entire area of trail	25-50 % of the entire area of trail	> 50 % of the entire area of trail
- Sea water quality ▪ Temperature ▪ Turbidity ▪ pH ▪ Salinity ▪ DO ▪ Total Fecal coliform ▪ Oil film	Reference from the water quality standard for coastal water (Office of Natural Resources and Environmental Policy and Planning,2004)		
- Fresh water quality ▪ Temperature ▪ Turbidity ▪ pH ▪ Salinity ▪ BOD ▪ DO ▪ Total Fecal coliform ▪ Oil film	Reference from the water quality standard for inland fresh water for recreation uses (Office of Natural Resources and Environmental Policy and Planning.2004)		
- Garbage ▪ Smell/ odor	No smell within 20 meters	Slight to moderate smell within 20 meters	Severe or bad smell/odor within 20 meters
▪ Visual impact	No garbage/litter found outside garbage can	Found some garbage/litter outside garbage can causing moderate visual impact	Found a lot of garbage/ litters that cause high visual impact
▪ Garbage amount (kg/person/day)	<0.8	0.8-1.5	>1.5
- Plant regeneration (Difference in number of seedlings from 1x1 sq m permanent plots between disturbed area next to trail and undisturbed area) ▪ Important Species (CTs): *Mallotus floribundus* *Memecylon geddesianum* *Memecylon cyaneum* *Hydnocarpus ilicifolius*	<25% of Difference in No. of seedlings	25-50% of Difference in No. of seedlings	>50% of Difference in No. of seedlings
Physical Capacity			
- Number of People at One Time (PAOT) the space can accommodate	Less than 50% of the max. PAOT	50 to 80% of the max. PAOT	>80% of the max. PAOT
Facility Capacity			
- Number of People at One Time (PAOT) the facility can accommodate	Less than 50% of the max. PAOT	50 to 80% of the max. PAOT	>80% of the max. PAOT
Social Capacity			
- Perception of Crowding, scale from 0-9	0-3	>3-5	>5
- Decreased % of live coral reef coverage (before and after high season)	<25%	25-50%	>50%

Table 2: RCC analysis of root exposure at KBT and KKD trails.

Capacity Levels	Standard value (% root exposure density)	% of trail area where root exposure density found	
		KBT trail	KKD trail
Below CC (No/ Low impact)	<25	96.15	92.63
At and Approaching CC (Medium impact)	25-50	2.25	6.32
Exceeding CC (High impact)	>50	1.60	1.05
Total		100	100

Table 3: Water quality and recreational capacity analysis at LY-KS NP.

Data collection sites	Water quality indicators and capacity level 1/								
	Temperature 1/ °C	Turbidity 3/	pH 1/	Salinity 1/ (PP_t)	DO 1/	BOD 3/	Total Fecal Coliform 2/ (MPN/100ml)	Oil film	Total CC Level
1. Reservoir Koh Samed	29.9	7.97	8.05	0.1	6.3	1.8	<2	No trace	Exceed
	Below	Exceed	Below	-	Below	Exceed	Below	Below	
2. Sai Keaw	29.5	1.50	8.13	28.5	6.1		<2	Seen some	Approach
	Below	Below	Below	Below	Below	-	Below	Approach	
3. Wong Deun	29.8	1.03	8.17	28.7	6.5		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
4. Lung Dam	28.9	1.79	8.16	28.7	5.9		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
5. Aao Kew Na Noak	29.1	1.98	8.21	28.7	6.2		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
6. Aao Kew Na Nai	28.8	1.60	8.12	28.8	6.3		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
7. Aao Praw	29.7	2.11	8.05	28.6	6.2		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
8. Koh Kudee diving site	29.2	1.70	8.15	28.7	6.5		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
9. Koh Talu diving site	28.9	1.62	7.70	28.7	5.8		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
10. Koh Jan diving site	28.7	1.81	8.13	28.7	5.9		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
11. Leam Rue Taek diving site	29.3	1.27	8.04	28.6	6.1		<2	No trace	Below
	Below	Below	Below	Below	Below	-	Below	Below	
12. Nuantip pier	29.9	8.7	7.93	28.7	5.1		350	Seen some	Exceed
	Below	Exceed	Below	Below	Below	-	Below	Approach	
13. Na Dan pier	29.2	2.92	8.26	28.7	5.2		27	Seen some	Approach
	Below	Below	Below	Below	Below	-	Below	Approach	

Table 4: RCC analysis on garbage and litter management at LY-KS NP.

Data collection sites	Impacts related to garbage management			
	Odor/smell	Visual impact	Garbage amount (kilogram/visitor/day)	Overall Capacity level
Ko Samed				
1. Garbage rest area / dumping field	Exceeding CC	Exceeding CC	2.54 kg/person/day Exceeding CC	Exceed
2. Garbage cans position (6 sites)	Below CC	Below CC		
3. Bo Thong Nature Trail	Exceeding CC	Exceeding CC		
Ko Kudee and Ko Talu				
4. Ko Kudee Nature Trail	Below CC	Below CC	No data	Below
5. Ko Talu	Below CC	Approaching CC	No data	Approach

Table 5: The recreation impacts on vegetation regeneration at KBT and KKD Nature Trails.

Levels of Impact and Capacity Levels	Standard value (%)	Decreased number of seedlings between disturbed and undisturbed areas (%)				
		KBT Trail (number of plots =20)		KKD (number of plots =10)		
		Mallotus floribundus	*Memecylon geddesia num*	*Mallotus floribundus*	*Memecylon cyaneum*	*Hydno Carpus-ilicifolius*
No/ Low impact (Below CC)	Less than 25%		- 24.4	+22.2	+73.3	
Medium impact (At and Approaching CC)	25-50%	- 33.7				
High impact (Exceeding CC)	> 50%					- 87.5

the acceptable impact of each level was set by the crowding scale of more that 5, 3 to 5, and 0-3, respectively. The social carrying capacity did not cover the study of perception of local people living nearby the national park.

After the four carrying capacities were investigated, the overall capacity of each recreational site was determined. The researchers identified what carrying capacity type limited the recreation use of each site by locating the highest impact found among the four carrying capacities. Figure 1 shows the overall research process and table 1 shows the recreational capacity analysis indicators and their acceptable impact levels. This paper presents the findings on 3 main islands: Ko Samed, Ko Kudee and Ko Talu.

Results and Discussion

Soil loss and root exposure

Only 5.92 % of the total dirt road area had soil loss >31.25 T/ha. The soil loss impact was still low and below capacity level. Impacts on root exposure at Khao Bo Thong (KBT) and Ko Kudee (KKD) nature trails were found to be minimal. Only 1.59 and 1.05 % of KBT and KKD trail areas had root exposure coverage more than 50 %, which is the highest root exposure density (table 2). The present recreation use levels at both trails did not exceed the recreation capacity regarding root exposure impact.

Water quality

Water quality parameters with severe and moderate impacts were turbidity, BOD and oil film (table 3). Turbidity values were exceeded at Ko Samed reser-

voir and Nuantip pier. BOD capacity was also exceeded at Ko Samed reservoir. Several sites such as the popular Sai Keaw beach and Na Dan pier had excessively high oil films.

Garbage and litter

Impact on garbage and litter was over capacity at Ko Samed (table 4). The garbage disposal system can not handle the large amount of garbage thus causing the garbage accumulation at the disposal site.

Table 6: Changes in percentage of live coral reef coverage before and after high season at snorkling sites in LY-KS NP.

Components of live corals	Live reef coverage (%)								
	Aao Kew Na Noak			Leam Reua Taek			Ko Talu		
	Dec. 2004	May 2005	Change	Dec. 2004	May 2005	Change	Dec. 2004	May 2005	Change
Massive Coral	16.8	19.9	+ 3.1	27.8	44.1	+ 16.3	23.4	26.0	+ 2.6
Submassive Coral	0.7	2.6	+ 1.9	19.1	15.7	- 3.4	2.9	2.8	- 0.1
Foliose Coral	7.0	3.5	- 3.5	0.2	1.1	+ 0.9	2.5	1.1	- 1.4
Encrusting Coral	0.4	0.2	- 0.2	0	0.2	+ 0.2	0.5	0.2	- 0.3
Table Coral	-	-	-	-	-	-	-	-	-
Branching Coral	0.1	3.4	+ 3.3	0	0.2	+ 0.3	1.2	1.0	- 0.2
Free – living	1.1	0.9	- 0.2	0	0.3	+ 0.3	0.1	0.6	+ 0.5

Table 7: Physical carrying capacity (PCC) of tourism sites in LY-KS NP.

Tourism sites	ROS	Max. PCC (PAOT)	Present use (PAOT)	Carrying capacity level
1. Sai Kaew beaches	SD	5,810	2,096	Below
2. Wongdeun beaches	SD	720	697	Exceed
3. Lung Dam, Aao Wai, Aao Kew, and Aao Pakarang beaches	SP-2 SP-1	338	236	Approach
4. Snorkeling sites		1,397	250	Below
4.1 Aao Kew Na Noak	SP-2	150	39	Below
4.2 Leam Reua Taek	SD	144	81	Approach
4.3 Koh Talu	SD	715	70	Below
5. Aao Praw beach	SD	509	253	Below
6. Ko Kudee	SP-2	282	111	Below
6.1 beach		120	97	Exceed
6.2 campground		138	14	Below
6.3 nature trail		23	15	Approach
7. Ko Talu beach	SP-1	116	412	Exceed

Note:

P = Primitive area
SP-1 = Semi-primitive 1 area (non-motorized area)
SP-2 = Semi-primitive 2 area (Motorized area)
SD = Semi-developed area

Vegetation seedlings

Results from the 1st year data showed only high impact on decreased number of seedlings between disturbed and undisturbed areas at KKD trail for Hydnocarpus ilicifolius which is considered an important species for Dry Dipterocarp forest at LY-KS NP (table 5). These figures however were only from the first year measurement. Long term monitoring of this indicator is definitely needed for an accurate recreation capacity analysis.

Table 8: Summary of the ecological, social, physical, and facility carrying capacities of recreation sites in LY-KS NP.

Recreation sites/ data collection sites	Recreation carrying capacity					Recreation uses (persons)
	ECC	SCC	PCC	FCC	Total	
Ko Samed Islands						
1. Main dirt road	Below	-	-	-	Below	No Data
2. KBT nature trail	Exceed (garbage)	-	Below		Exceed	<10 persons/day 2/
3. Reservoir and nearby dumping field	Exceed (garbage, water quality)	-	-	Exceed (Garbage)	Exceed	15,667 persons/month 1/
4. Sai Keaw beaches	Approach (water quality)	Approach	Below	Approach	Approach	2,096 (PAOT) 2/
5. Wong Deun beaches	Below	Approach	Exceed	Approach	Exceed	697 (PAOT) 2/
6. Lung Dam beaches	Below	Below	Approach	Approach	Approach	236 (PAOT) 2/
7. Aao Praw beach	Below	Approach	Below	Approach	Approach	236 (PAOT) 2/
Ko Kudee Islands						
8. KKD nature trail	Inconclusive (vegetation)	-	Approach	-	Approach	15 (PAOT)
9. Ko Kudee beach	Below	Approach	Exceed	Approach	Exceed	97 (PAOT) 2/
10. Campground	-	-	Below	-	Below	14 (PAOT) 2/
Ko Talu Islands						
11. Ko Talu beach	-	Approach	Exceed	Exceed	Exceed	412 (PAOT) 2/
Snorkeling sites						
12. Aao Kew Na Noak	Inconclusive (coral reef)	-	Below	Approach	Approach	39 (PAOT) 2/
13. Leam Reua Taek	Inconclusive (coral reef)	-	Approach	Exceed	Exceed	81 (PAOT) 2/
15. Ko Talu	Inconclusive (coral reef)		Below	Approach	Approach	70 (PAOT) 2/
Piers					Exceed	
16. Nuantip	Exceed (Water quality)	-	-	Approach	Exceed	No Data
17. Na Dan	Approach (Water quality)	-	-	Approach	Approach	No Data

1/ Secondary data from high tourism season in 2001-2004

2/ PAOT = People at One Time during visitor survey on weekends and holidays at high tourism season

Live coral reef coverage

Data on the percentage of live coral reef coverage before and after high season is presented in table 6. Most sites experienced decreased coverage. However, at this early stage of our long term research, these figures were inconclusive for RCC analysis.

Physical carrying capacity (PCC) and Social capacity (SCC)

With respect to PCC for beach activities, Wongdeun was over capacity. Many private bungalows located in this area together with easy access brought quite a few people here. Ko Talu beach was also considered over capacity. It was designated as a SP-1 recreation opportunity for a quiet and remote experience and had limited beach area and therefore cannot accommodate very large numbers of visitors. However this island is now popular for most tour programs for lunch stops and afternoon relaxation. Ko Kudee is another site that exceeded physical capacity, especially for the beach area. For most snorkeling sites, the spaces are acceptable except at Leam Reua Taek where current numbers approach space capacity. Table 7 presents the analysis of PCC for several sites in the national park.

The over capacity of space for beach activities was consistent with the findings of the social carrying capacity measured at 4.2 from 9 for Ko Talu and Ko Kudee and 4.0 for Wong Deun beaches. Use levels at Ko Talu, Ko Kudee and Wongdeun beaches are over physical carrying capacity and approaching/at social capacity. The crowding scale at other tourism sites was 3.8 at Sai Keaw and 3.7 at Aao Praw beach, respectively.

Facility Carrying Capacity (FCC)

Most facilities for tourist services in LY-KS NP could accommodate current use levels. Only at the restroom at Ko Talu was over capacity. Since accommodation development at Ko Samed has been very demanding, park management has launched strict regulations for any new development in Ko Samed to cap the growth. It is expected that the number of overnight stays should not be more than the current figures of 4,100 people per night (inclusive of campgrounds) while Ko Kudee should not exceed 168 people per night.

Overall Carrying Capacity

After the four carrying capacity assessments were completed, the overall capacity was determined as shown in Table 8. At Ko Samed, the maximum carrying capacity for overnight use is now set at 4,100 people per night, with accommodation as the constraint. High impact on garbage management was also found at this level. However, national park management is trying to reduce garbage impact by launching a strategy on visitor management focusing on garbage reduction through interpretation and educational programs. Several aspects of the ecological impacts analysis for RCC cannot be completed at this time since long term monitoring is needed to obtain enough data for meaningful analysis on ecological carrying capacity especially at snorkeling sites.

References

Shelby, B. & Hererlein, T. A. (1986). Carrying Capacity in Recreation Settings. Corvallis.

Office of Natural Resources and Environmental Policy and Planning (2004). Water Quality Standards. Bangkok.