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Fiscal Gaps and Financing of Southeast Asia's Protected Areas: A Cross-Country Analysis

Gem B. Castillo, Chan Somaly, Li Wenjun, Li Yanbo, Luthfi Fatah, Sivannakone Malivarn, Kian Foh Lee, Alexander D. Anda, Jr., Prinyarat Laengcharoen, Pham Duc Chien, and Benoit Laplante

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Front cover photo: Bacuit archipelago, with limestone formations all around in El Nido, Palawan, Philippines. Photo by Mr. Gary Larson under the creative commons license at
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The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics. Its goal is to strengthen local capacity in the economic analysis of environmental issues so that researchers can provide sound advice to policymakers.

To do this, EEPSEA builds environmental economics (EE) research capacity, encourages regional collaboration, and promotes EE relevance in its member countries (i.e., Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines, Thailand, and Vietnam). It provides: a) research grants; b) increased access to useful knowledge and information through regionally-known resource persons and up-to-date literature; c) opportunities to attend relevant learning and knowledge events; and d) opportunities for publication.

EEPSEA was founded by the International Development Research Centre (IDRC) with co-funding from the Swedish International Development Cooperation Agency (Sida) and the Canadian International Development Agency (CIDA). In November 2012, EEPSEA moved to WorldFish, a member of the Consultative Group on International Agricultural Research (CGIAR) Consortium.

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EXECUTIVE SUMMARY

In 2010, the Convention on Biological Diversity reported that there were approximately 130,000 protected areas (PA) covering nearly 13% of the world's terrestrial surface and over 6% of territorial marine areas. However, quite a number of these PAs, particularly in Southeast Asia, are not sufficiently well-planned or sufficiently managed to maximize their contribution to biodiversity conservation. A large proportion of Southeast Asia's population continues to depend on timber, fuel wood, and other forest products for their livelihood. They also convert forests to agricultural and industrial uses. Between 1980 and 2007, the region lost a total of 555,587 square kilometers (km^2) of forests (ACB 2010).

In 2011, the Economy and Environment Program for Southeast Asia funded a cross-country study to examine how park managers and decision makers in Southeast Asia responded in the face of pressures on PAs, and to assess the level of resource gaps based on a number of indicators. A sample of 402 PAs from Cambodia, China, Indonesia, Lao PDR, Malaysia, Philippines, Thailand, and Vietnam were surveyed in the study. Of the 16 pressure and 15 response variables identified for the pressure-response analysis, the indicators of pressure were (1) number of inhabitants per 1,000 hectares (ha) (or per square kilometer) of PA; (2) population adjacent to the PA per 1,000 ha of the PA; (3) number of visitors per 1,000 ha; (4) length of trails per 1,000 ha; and (5) length of roads per 1,000 ha. The response indicators were (1) full-time staff per 1,000 ha; (2) number of enforcement staff per 1,000 ha; (3) expenditure for operations per hectare; and (4) patrol stations per 1,000 ha.

In analyzing the pressure-response relationships, pairwise graph plots and correlation analysis were used for the country analysis. Canonical correlation analysis was used for the pooled regional data on the PAs. The results of the canonical correlation analysis showed that response variables (e.g., number of full-time staff and number of patrol stations) had a positive relationship with pressure variables such as length of roads and trails, number of visitors, and population adjacent to the PA. A slight exception was the Operating expenditure per hectare, which showed an inverse relationship with length of roads and trails. This indicates that changes in operating expenditure are not responsive to changes in length of roads and trails. Other pairwise graph plots and simple correlation analysis showed weak correlation for untransformed pressure and response variables.

For the fiscal gap analysis, the number of full-time staff and the annual budget for operations were compared with the average and highest levels in the country and in the region. In the country-level analysis, full-time staff gaps ranged from 50%–160% of the average and highest benchmarks established. The ratios between the individual PAs and the benchmarks ranged from 1.5:1 to 2.6:1. This means that the established benchmarks are higher than the individual PAs, with gaps ranging between 0.5 and 1.6 staff. The analysis at the regional level showed that the full-time staff gaps ranged from 200% to more than 700%. The ratios of full-time staff between the benchmarks and individual PAs ranged between 3:1 and 8:1. Fiscal gaps in terms of operating expenditure per hectare ranged between 25% and 300% for the country-level analysis, and between 200% and 900% at the regional level. These results indicate that the responses of PA managers and decision makers do not commensurate with the pressure faced by the PAs in the region.

1.0 INTRODUCTION

1.1 Rationale of the Study

The Convention on Biological Diversity reported that there are about 130,000 protected areas (PA), covering nearly 13% of the world's terrestrial surface and over 6% of territorial marine areas (CBD 2010). In Southeast Asia, however, a large percentage of the population continues to depend on timber, fuel wood, and other forest products; they also convert forests for agricultural and industrial uses. Between 1980 and 2007, the region lost a total of 555,587 square kilometers (km^2) of forests (ACB 2010). This reflects the ineffectiveness of the PA system in protecting biodiversity. According to the study of Bruner et al. (2001), the effectiveness of PAs is correlated with enforcement, boundary demarcation, and direct compensation to local communities.

This study sought to gain insights into the pressures faced by PAs and how PA managers are responding to these pressures in terms of resources and manpower investment. In particular, the research assessed how park managers in different countries in Southeast Asia respond to various pressures in their respective parks. The key pressure indicators used were similar to those used by Laplante and Lee (2009), namely, visitors, the population living within 5 kilometers (km) of the PA, and length of roads and hiking trails.

1.2 Research Objectives

In general, this research assessed the extent to which park managers and decision makers have been investing adequate resources in managing the PAs in response to external and internal pressures. We analyzed for the first time the results of the survey of 402[1] PAs in Southeast Asia and China, and drew conclusions on the resource gaps. As far as we know, there has never been an analysis of this kind for such number of PAs in Southeast Asia. We created sets of indicators to assess the pressure on the PAs and PA management responses. Our survey thus sought to acquire the following information on the various indicators:

1. Internal and external pressure brought upon PAs, using a common set of internal pressure and external pressure indicators;
2. Management responses (resource allocation) across the various PAs in Southeast Asia;
3. Extent of the resource gaps experienced by PAs;
4. Existing fiscal structures, including an assessment of the characteristics of the existing user fee structures; and
5. Various options aimed at addressing the identified resource gaps.

1.3 Research Framework

The conceptual framework summarized in Figure 1 presupposes that the resource and fiscal responses of PA managers and decision makers are largely influenced by both internal and external pressures on their PAs. The hypothesis set forth is that there is a direct correlation between internal/external pressure and response mechanisms. As the pressure increases, *ceteris paribus*, the response mechanism would also increase, according to Laplante and Lee (2009).

[1] Actually, 411 PAs were surveyed but only 402 were included in the analysis because of insufficient information on certain variables. In some analyses, only 400 could be used because of insufficient data on a particular variable.

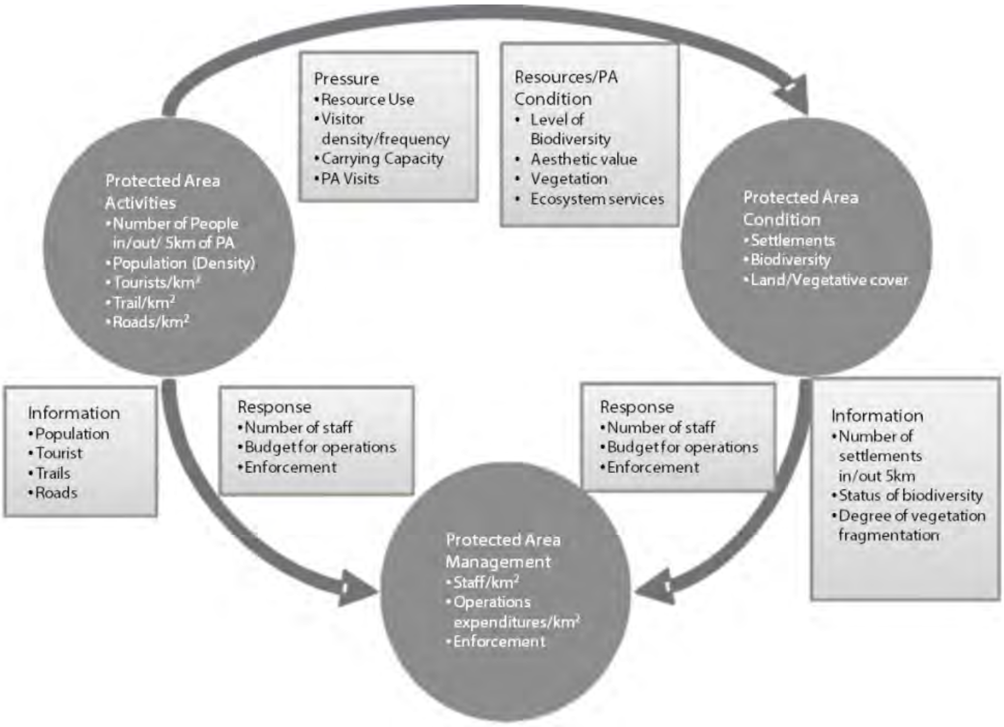


Figure 1. Pressure-response framework of the study

Based on Figure 1, the key indicators of external pressure are primarily related to the population around or adjacent to the PA, including types of illegal and legal activities related to the use of resources by this population. The key indicators of internal pressures are (1) population within the PA, (2) number of visitors (frequency and quantity), and (3) number and length of roads within as the means of access to and within. The key responses are to increase personnel and budget, the indicators of which include the (1) number of permanent and part-time staff, (2) number of park rangers, (3) annual operations budget, and (4) increase in patrol stations.

2.0 LITERATURE REVIEW

In 1993, the World Conservation Monitoring Centre (WCMC) initiated a project to collect financial data on government budgets for PAs. The project sent survey questionnaires to more than 600 PA agencies in its database, and a follow-up questionnaire two years later to 193 agencies. The survey obtained data on each agency's budget for PA conservation, including an assessment of unmet financial requirements for adequate conservation. The study defined the financial indicator as government investment in core PAs (IUCN Category I-V). Foreign assistance for biodiversity conservation was removed and treated separately (James, Green, and Paine 1996).

The survey found that the global mean investment in parks and PAs was USD 776/km^2 in 1993, but that PA budgets varied widely by region with a mean investment of USD 57/ km^2 in South America and USD 11,551/km^2 in East Asia (excluding China). High-biodiversity regions in the tropics tended to have lower levels of investment, such as South and Southeast Asia at USD 390 and Sub-Saharan Africa at USD 143/km^2. On average, the developed countries outspent the less developed countries by a factor of USD 1,687–161 per square kilometer.

The study also defined a financial target to be a measure of the financial capacity required for the achievement of a stated conservation objective. The investment required for adequate PA conservation in a country is a financial target for biodiversity. It is expressed in terms of total financial requirements or per area of investment requirements. This target investment level provides a benchmark against which the adequacy of actual investment can be measured.

The WCMC project established target budgets based on country self-assessments of financial requirements for adequate PA conservation. In the survey, each PA agency was asked to estimate the amount of additional funds required to meet their stated conservation objectives. In this way, the survey asked the agencies to judge for themselves the cost of adequate conservation. In the study, a per-square-kilometer target budget was calculated for each country by summing its actual investment in PAs with their reported shortfall amount. Then, an assessment of budgetary adequacy was made by dividing actual budgets by the self-assessed target budgets.

The WCMC study by James, Green, and Paine (1996, p. v) concluded that *"PA budgets and staffing levels are positively correlated with economic development (per capita income) and population density. Budgets (per km²) and staffing (per 1,000 km²) are negatively correlated to mean PA size and a country's biological richness."*

The first review on PA budget and staff was undertaken by James, Green, and Paine (1999). They reported that the global average staff per 1,000 km² was quite low compared to developing countries (Table 1). Developed countries spent 80–100 times more than the developing countries if expenditure per hectare of PA was considered. A 1997 study of 123 conservation agencies in 108 developed and developing countries (comprising 28% of PAs) recorded USD 3.2 billion in annual budgets or USD 893/km² overall, but only USD 10/km² in 13 of the developing countries studied and less than USD 100/km² in 32 of the developing countries studied (Green and Paine 1997). The 60% of the sample parks in developing countries received only 10% of the capital expenditure (James, Green, and Paine 1999; Green and Paine 1997).

Table 1. Average budget per km² and staff per 1,000 ha in 1996

Budget/km²	USD/km² (1996)*	USD/ha (1996)*	2009-Adjusted USD/ha**	Staff per 1,000 km² (1996)	Staff per 1,000 ha (1996)
Global Average	893	8.9	12.2	27.0	0.270
Developed countries	2,058	20.6	28.1	26.9	0.269
Developing countries	157	1.6	2.1	27.6	0.276
East Asia	12,308	123.1	168.3	432.0	4.320
Africa (West/Central)	24	0.2	0.3		

Notes: (1) * Data were sourced from James, Green, and Paine (1999). (2) ** Inflation rate = 36.7% as estimated by the authors using officially published inflation rates

The review of James, Green, and Paine (1999) was based on the data from the WCMC survey of over 600 PAs in 1993 and 1995 throughout the world. Budget data was provided by 108 countries with 3.7 million km² under protection (28% of global PAs). Staffing data was provided by 78 countries (China, Japan, India, Indonesia, and the former Soviet Union were not included) with 3.0 million km² under protection (23% of global PAs). Marine PAs were not included in the study. The budgets included both operating and capital expenditure; the capital expenditure was identified separately. The PA staff data was presented on the basis of number of staff per 1,000 km² protected. Field staff, administrative staff, and other staff were identified separately where possible. In many cases, however, the data allowed the presentation of only an aggregate staffing level. In countries where more than one agency administered PAs, a mean was presented.

A study by Mansourian and Dudley (2008) showed that government investments in PAs in Southeast Asia had not increased significantly; thus, the fiscal gap remained large. The same study reported that the fiscal gap for Peninsular Malaysia alone was calculated to be MYR 8,867,919, which translates to a 90.7% shortfall in funding. In China, PAs are mostly paper parks, and oftentimes considered a nonproductive drain on local resources. Due to lack of development funds, offices are generally located in the county rather than inside or adjacent to the PA (nature park) itself (Li, Cui, and Li 2001).

In Cambodia, where 23 PAs occupy 18% of its total land area, PA management planning has been done, but implementation remains weak (ICEM 2003a). The Lao People's Democratic Republic has achieved more than the Convention on Biological Diversity's (CBD) recommended 10% of land area devoted to PAs (for biodiversity conservation), but these areas are beset with management problems ranging from degradation of forests due to excessive exploitation, ineffective management, and difficulties in mobilizing resources or even matching donor-assisted projects (ICEM 2003b). In Indonesia, most PAs do not receive regular budget allocations and relies on supplementary donor financing (contributing 11%–18% of funds to PAs), which covers only short implementation periods (Sumardja 2003).

In Malaysia, the management of PAs is unusually complex with many management authorities and different types of PAs, most of which have yet to realize their potential in terms of tourism revenue. Thus, they are dependent on funding from the state or federal government and from international, private, or government aid agencies (Mansourian and Dudley 2008). In the same survey of 50 countries by Mansourian and Dudley (2008), the Philippines spent only USD 0.59/ha (ranking 36^{th}) of public funds for PAs; the country ranked 46^{th} when measured in terms of public funds for PAs as a percentage of GDP.

Thailand's PAs have grown rapidly in the last 15 years; it now comprises 15% of its total land area (Mansourian and Dudley 2008). However, the challenges have also increased. The increase in PAs means that additional staff, incentives, training programs, and equipment to increase management effectiveness and frequency and coverage of patrolling are needed. The PAs are still not free from the human threat of exploitation (Emphandhu and Chettamart 2003). Not surprisingly, Thailand is the highest among the Southeast Asian countries in terms of public funds spent on PAs per hectare; it ranked 18^{th} among the 50 countries (Mansourian and Dudley 2008). In terms of public funds for PAs as a percentage of GDP, it ranked 20^{th}.

In Vietnam, around 50% of the Special Use Forests (SUF)—the category for PAs in the country—have investment plans and investment budgets (those without management boards do not receive funds). However, on average, only 25%–40% of the costs requested in the investment plans are actually provided to SUF management boards. The domestic funding mechanisms for PA management are complex because various PAs range from central- to provincial-managed.

Hockings et al. (2006) introduced the framework of the International Union for Conservation of Nature (IUCN) for assessing the management effectiveness of PAs. The framework includes assessing the context (which includes threats), legislation and planning, resources available to park agencies, appropriateness of the processes, results, and impacts. This framework requires establishing standards and estimating the costs for the required human resources, infrastructure, equipment, and operational budgets to meet the standards.

Balmford et al. (2003) used modeling to estimate an average of USD per 1,000 km^2 for effective management. They pointed out the gross mismatch between the costs of effective nature conservation and current global spending. A large portion of the resources for conservation came from intergovernmental organizations and major private foundations. However, data on how conservation costs vary globally was scarce. To address this issue, the authors collated information on the costs of 139 field-based projects from around the world, and compared the cost variations to a set of measures of development. They built a simple model capable of predicting costs and likely conservation benefits, and then compared their findings with the current global distribution of conservation investment.

Vreugdenhil (1992, 2002) and Vreugdenhil et al. (2003) developed a computer program named MICOSYS to calculate the worldwide costs of the PAs of developing and transition countries with areas greater than 30,000 km^2. The program generated cost totals for every individual PA based on more than 50 cost factors as well as system-wide costs. Factors included in the model are (1) a labor force of 20% professional and administrative staff and 80% field staff (primarily park rangers); (2) park infrastructure (with furniture) such as visitor centers, exhibitions, park entry ticketing booths, ranger stations for the field staff; (3) social security arrangements; (4) trails and trail signs; (5) field transportation and communication equipment; (6) uniforms and trails; (7) monitoring; and (8) an endangered species fund.

The data of UNEP-WCMC was used in the program. As it turned out, the program produced investment requirements that were much lower than originally expected. Laplante and Lee (2009) conducted a fiscal gap analysis of the PAs in Malaysia, and found a direct correlation between PA pressure and the response of PA managers (Figure 2).

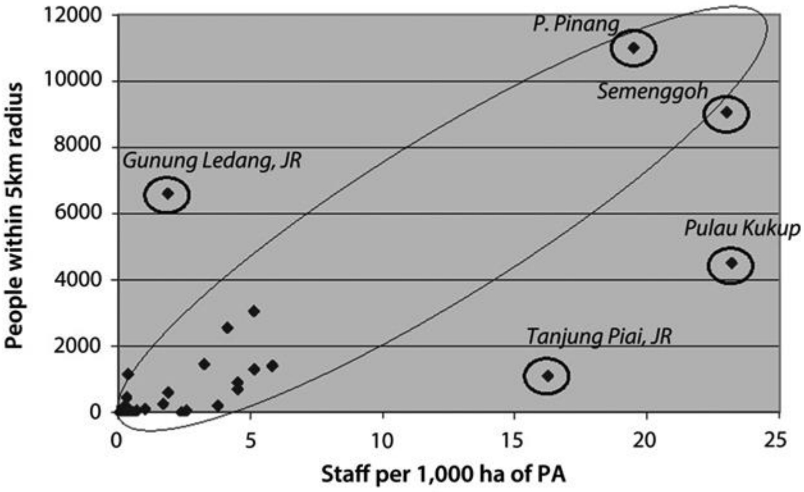


Figure 2. Example of assessment of a pressure-response relationship in PA management

Source: Laplante and Lee (2009)

3.0 METHODOLOGY

3.1 Survey

The survey method was the same for all countries; it followed the conceptual framework discussed at the exploratory workshop participated by the country researchers of this study in Manila, Philippines. A standardized questionnaire was either mailed to PA managers or used in face-to-face interviews. However, there were slight variations in the survey questionnaire used in each country, taking into account the different categorizations, representations, and mandates of the various authorities in charge of PAs. Some countries added questions. Survey protocols such as pretests prior to actual surveys, observance of ethical standards related to human subjects of interviews, and seeking approval for the survey questionnaire were observed. Questionnaires were translated into the respective local languages. Table 2 summarizes the targets and numbers of completed surveys in the eight research countries.

Table 2. Summary of surveys completed in the project countries

Country	Target PAs for Inclusion in Survey	Mailed Questionnaires	No. of PAs Included in Interview Survey	Surveys Completed	Data Encoded
Cambodia	23	–	23	23	23
China	319	115	58	58	58
Indonesia	265	37*	52	52	52
Lao PDR	20	–	20	20	20
Malaysia	80***	80	44	44	44**
Philippines	223	223	–	79	79
Thailand	181	50	21	82	81
Vietnam	95	50	53	53	53

Notes: (1) * With mailing addresses; (2) ** Only data on land area, number of staff and operating expenditure were available for analysis at the regional level (3) *** 57 terrestrial and 13 marine PAs

Cambodia surveyed all 23 PAs designated by the Royal Decree of Cambodia in 1993. China had planned to survey 319 national nature reserves (NR)—which accounted for 63% of the total area of China's NRs—but managed to receive only 58 completed questionnaires. Indonesia had planned to send a simplified survey to 265 PAs that were classified according to the IUCN classification, but managed to produce completed questionnaires from 52 PAs only. Lao PDR surveyed all the national PAs, which totaled 20. Malaysia had planned to cover the PAs in Peninsular Malaysia, Sabah, and Sarawak that were not classified as permanent reserve forests. This was supposed to include national and state parks, wildlife sanctuary/reserves, and bird sanctuary/reserves. Marine parks were excluded. In the Philippines, out of the 238 PAs, 79 questionnaires were completed, which represented the different categories of National Integrated PAs (NIPA) sites such as natural monuments, natural parks, resource reserves, wildlife sanctuaries, protected landscapes/seascapes, and natural biotic areas. Thailand completed questionnaires from 81 PAs. The selection of the PAs was done in consultation with the National Parks and Wildlife and Plant Conservation Department. Vietnam completed its survey of 53 SUFs from the original target of 95. A total of 33 national parks and 20 nature reserves were included in the survey. Table 3 summarizes the survey statistics by country. In the end, only 411 PAs (see footnote 1) were included in the survey.

Table 3. Summary of PAs successfully surveyed in the project countries

Country	Total No. of PAs	% of Total PA and Area to Total Land Area of the Country	No. of PAs Targeted for Survey	Number of PAs with Encoded Data	Encoded PAs as Percentage of Survey Target
Cambodia	23	18	23	23	100
China	2,541	15	319	58	18
Indonesia	457	12	265	52	20
Lao PDR	23	15	20	20	100
Malaysia		6	70	44*	63
Philippines	238	18	223	79	35
Thailand	418	20	181	82	45
Vietnam	164	14	50	53	106
Total			**1,151**	**411**	

Note: *Limited data on pressure variables

3.2 Data Collection

There were four categories of data collected:

1. The background information regarding the PAs included complete name, date of establishment, agency jurisdiction, IUCN category (where applicable), type (marine or terrestrial), land area, water area, and other information related to management such as management plan and existence of park office.
2. Physical characteristics included access to PA, inhabitants, modes of travel within the PA, and tourist facilities and other facilities including accommodation.
3. Visitor characteristics included number of visitors in 2009, visitor entrance fees, accommodation fees, and activity fees.
4. Staffing, revenue, and costs data included staffing in 2009, assessment of staff adequacy, operational expenditure in 2009, fees collected in 2009 and revenues from the PA in 2009.

The country researchers also collected and compiled data published in different media. Data collection for all countries was completed in September 2011. The data was encoded by the participating countries using a standardized encoding Microsoft Excel template.

3.3 Analysis of Indicators of Internal and External Pressures

The first step was to establish the relationship of the responses of PA managers to the pressures on the PA. Table 4 lists the pressure and response variables from an original list of 15 variables, which were finally used in both country and regional analyses. Other variables were set aside.

Table 4. Variables included in the pressure-response analysis

Pressure Variables*	Response Variables*
(1) Number of inhabitants per km^2 or per 1,000 ha inside PAs	(1) Number of full-time staff per km^2 or per 1,000 ha**
(2) Length of roads in the PA per km^2 or per 1,000 ha	(2) Number of patrol stations per km^2 or per 1,000 ha
(3) Length of trails inside the PA per km^2 or per 1,000 ha	(3) Number of enforcement staff per km^2 or per 1,000 ha
(4) Number of visitors per km^2 or per 1,000 ha	(4) OpEx per km^2 or per 1,000 ha
(5) Population adjacent to the PA per km^2 or per 1,000 ha	(5) Total expenditure per hectare, likewise normalized to per 1,000 ha

Notes: (1) * Normalization of variables was necessary considering the wide variations. (2) **Part-time staff was excluded because of the different methods of accounting by the project countries. (3) OpEx = operating expenditure

All analyses at the country level used pairwise plots for visual evaluation of the relationships. Simple pairwise scatter plots of data showed a pattern of positive or negative linear relationships. China used pairwise Pearson correlation analysis. On the other hand, the regional analysis took into account the possible simultaneous effects of pressure on the response variables. In the sets of variables listed in Table 4 above, the first set was treated as a combination of the independent variables (pressure), whereas the second set was treated as a combination of the dependent variables (response). This is a case of a canonical correlation analysis of composite (more than two) independent and dependent variables. Although pairwise scatter plots, bivariate correlation analysis, and multiple regression analysis produce several pairs of dependent and independent variables that must be explained individually, canonical correlation can simultaneously explain multiple relationships, and thus the correlation is maximized.

Canonical correlation analysis was used to identify and measure the associations of the above sets of multiple dependent and independent variables. The correlations of interest were between the linear combinations (variates) created for both sets of variables. In this approach, there are several possible ways to combine the variables in order to provide a useful interpretation of a relationship. Canonical correlation analysis determines a set of canonical variates, which are the independent linear combinations of the variables within each set that best explain the variability both within and between sets of variables. Each linear combination maximizes the correlation between the new variables (synthetic variables) under the assumption that they are uncorrelated with all other previous linear combinations. Then, the number of linear combinations needed to capture more information (where the linear combinations are all uncorrelated) is determined. The maximum number of variates is determined by the smallest of the variable sets.

Figure 3 illustrates the combinations (or variates) of pressure (independent variables [IVs]) and response (dependent variables [DV]) variables that were used in this analysis.

The canonical correlation analysis (CCA) had several layers of analysis:

1. Correlation between pairs of canonical variates
2. Loadings (structural coefficient) between pressure variables (IVs) and their canonical variates
3. Loadings (structural coefficient) between response (DVs) and their canonical variates
4. Adequacy, or how well a given canonical variable represents the variance in that set of original variables
5. Communalities, or how much of a given original variable's variance is reproducible from the canonical variates

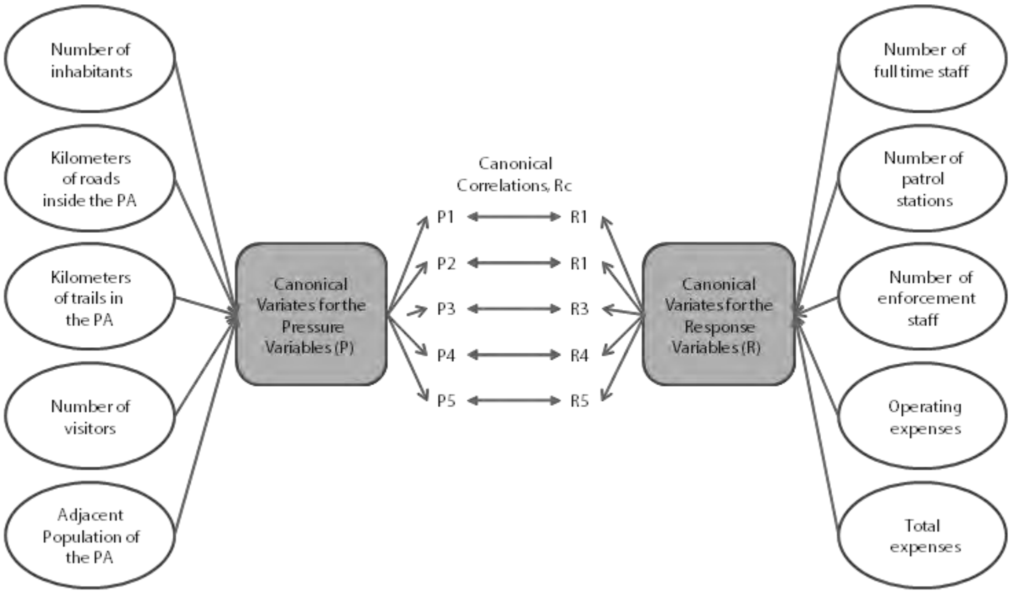


Figure 3. Layers of canonical correlations analysis for five pressure and response variables

Note: P = PA pressure variates, R = PA managers' response variates in a combination of variates,
R_c = correlation coefficient of the combination of variates

A number of terminologies are important in CCA. The *canonical correlation coefficient* (R_c), which is analogous to the multiple R in regression, is the Pearson relationship between the two synthetic variables of a canonical function. The *squared canonical correlation* (R_C^2) is the simple square of the canonical correlation, and is directly analogous to the R^2 effect in multiple regression. A *canonical function* (or variate) is a set of standardized canonical function coefficients (from two linear equations) for the observed predictor and criterion variable sets. A *structure coefficient* (r_s) is the bivariate correlation between an observed variable and a synthetic variable. They inform interpretation by helping to define the structure of the synthetic variable, that is, what observed variables can be useful in creating the synthetic variable and therefore may be useful in the model. These are discussed in the succeeding sections of this report.

Linearity, homoscedasticity, normality, and multicollinearity were tested prior to the canonical correlation analysis. Pressure and response variables were transformed into log form in view of the prior indications of nonlinearity of observed values. Canonical correlations coefficients were tested and only significant combinations were interpreted. Canonical correlation analysis was not possible for the country-level analysis due to inadequate number of observations.

3.4 Fiscal/Resource Gap Assessment

The second part of the analysis determined the fiscal gaps by comparing each PA to a benchmark that was endogenously determined for each fiscal gap indicator. The wide variations in the sizes of the PAs included in the survey required clustering them into hectare classes (Table 5) prior to determining a benchmark for each cluster of PAs. This clustering of PAs within country and across the region is one of the unique approaches of this research on PA financing assessment. The resulting benchmarks (average and highest fiscal gap indicators) in each cluster served as the bases for estimating the overall fiscal gaps. The total fiscal gap for all PAs in each country was estimated by summing up the gaps of all the PAs. Likewise, the fiscal gap in the region was estimated by summing up the gaps of all the PAs included in the region. The primary indicators of fiscal gaps used were staff per 1,000 ha and total operating expenses per hectare.

Table 5. Summary of PA clusters in the project countries

Country	Total Area of PAs in Size Class (ha)				Total
	0– 2,000	2000 – 30,000	30,000 – 300,000	300, 000 – 800,000	
Cambodia		5	14	4	23
		2,795.00	32,401.00	316,250.00	2,795.00
		27,700.00	255,036.00	402,500.00	402,500.00
China	2	22	24	6	54
	900.00	4,284.00	31,000.00	335,085.00	900.00
	2,000.00	29,906.00	242,510.00	800,000.00	800,000.00
Indonesia	20	12	16		48
	63.60	2,500.00	35,747.00		63.60
	2,000.00	25,000.00	239,000.00		239,000.00
Lao PDR			18	2	20
			70,000.00	353,200.00	70,000.00
			240,000.00	420,000.00	420,000.00
Malaysia	12	16	16		44
	24.20	2,727.00	31,255.10		24.20
	1,379.00	30,000.00	248,121.00		248,121.00
Philippines	39	27	12	1	79
	12.00	2,019.00	31,235.00	333,300.00	12.00
	1,983.00	26,010.00	278,914.00	333,300.00	333,300.00
Thailand		32	48	1	81
		4,457.00	30,326.50	471,438.00	4,457.00
		30,000.00	291,500.00	471,438.00	471,438.00
Vietnam	1	34	18		53
	1,549.00	2,805.00	31,422.00		1,549.00
	1,549.00	28,506.00	125,000.00		125,000.00
Total	**74**	**148**	**166**	**14**	**402**
	12.00	**2,019.00**	**30,326.50**	**316,250.00**	**12.00**
	2,000.00	**30,000.00**	**291,500.00**	**800,000.00**	**800,000.00**

Notes: (1) The first row shows the number of samples, the second row shows the lowest area (ha) in the cluster, and the third row shows the largest area (ha) in the cluster. (2) Cluster sizes: (a) 0 to ≤ 2,000; (b) > 2,000 to ≤ 30,000; (c) >30,000 to ≤ 300,000; (d) > 300,000 to ≤ 800,000.

3.5 Limitations of the Research

The PAs included in the survey in each country varied depending on the availability of resources, accessibility of information, time needed to conduct the survey, and importance of the PAs. Hence, researchers need to be careful in making any generalizations based on the results of this study. The analyses carried out were based solely on numerical data. There was no analysis or comparison in terms of how effectively the surveyed PAs were managed on-the-ground. The sole intention of this research was for benchmarking. It is not possible to compare the performances of PAs because no two PAs are the same. The canonical correlation analysis in this study used only five pressure variables and five response variables because of limited observations for the other indicator variables. Nonetheless, these fulfilled the requirements of the CCA.

4.0 ANALYSIS OF INTERNAL AND EXTERNAL PRESSURES

4.1 Collated Findings from Country Studies

Each of the eight countries analyzed the internal and external pressures of PAs following agreed upon procedures. In the Cambodia country study, the internal and external pressures evaluated were population, visitors, road lengths, and hiking trails. Population and full-time staff per 1,000 ha showed positive correlations. As regards to population pressure versus operational expenditure, the responses were generally positive except for three PAs, namely, Prea Viha Protected Landscape, Phnom Samkos Wildlife Sanctuary, and Kirorom National Park where the relationship was inverse. Visitors versus full-time staff showed a weak positive correlation, whereas visitors versus operational expenditure per hectare showed no clear correlation due to insufficiency of data to make a conclusion. Road length versus full-time staff per 1,000 ha and hiking trails versus full-time staff per 1,000 ha both showed no clear correlation. In summary, the dose response analysis found positive correlation only with respect to staff versus population and staff versus number of visitors, but there was no clear correlation with respect to operating expenditure.

The country study in China reported a statistical analysis of log-transformed indicators of pressure, namely, number of inhabitants per 1,000 ha; visitor bed nights per 1,000 ha; length of roads and trails (in kilometers) per 1,000 ha; and proportion of the PA to people. Except for inhabitants per 1,000 ha and proportion of people, all indicators had significant Pearson correlation at 0.05 level (two-tailed). Length of roads and trails per 1,000 ha was significant at the 0.01 level.

The Indonesia country study reported on dose response analyses of population, visitors, and staff. The graphical analysis using scatter plot techniques did not show any direct relationship. A quick review revealed the use of raw untransformed indicators resulting in weak relationships, and only few data points were included.

The Lao PDR country study contained discussions on internal and external pressures only, particularly density of inhabitants within PAs, population surrounding PAs, and number of tourists/visitors. There were neither graphical nor statistical analyses simply because there were only 20 samples to work on.

In the Malaysia study, the pressure-response analysis focused on populations within and adjacent to the PAs versus full-time staff, number of visitors versus full-time staff, number of visitors versus operating expenditure, and population versus operating expenditure. The researchers used scatter plots to determine the relationships of full-time staff and operating expenditure to populations within and outside the PAs. The response indicators were transformed by dividing these with the square root of the PA size. The analyses showed that there was a stronger positive relationship between responses in terms of staff and operating expenditure to pressure from visitors compared to pressure from population. However, there were other "pressures" and factors to be considered, such as distance from towns and cities and ex-situ conservation activities. Population (as used in the analyses) consisted of two variables, namely, (1) estimation of the population of villages and indigenous communities living within the PA boundary, and (2) estimation of the top five most populous settlements within 5 km from the PA boundary.

The pressure-response analysis in the Philippines first compared at length the external and internal pressures faced by PAs in the 13 political regions of the country, and then separately analyzed the response indicators. In the external-internal pressure analysis, PAs were tabulated by region and by IUCN category; then, the internal and external pressure indicators were described. The external pressure indicators described were (1) population within a 5-kilometer distance from the PAs, (2) hotels within a 500-meter radius outside the PAs, and (3) visitors that could be accommodated outside of PAs per 1,000 ha. The internal pressure indicators described were (1) number of inhabitants within the PAs, (2) number of visitors, (3) kilometers of driving roads, and (4) kilometers of hiking trails inside the PAs.

The next step in the pressure analysis was to analyze graphically the response indicators versus the internal and external indicators. The response indicators were (1) employed regular staff, which in the case of the Philippines, was the proportion of the time that the Department of Environment and Natural Resources (DENR) personnel devote to PA management; (2) enforcement staff, usually a combination of regular and contractual staff; and (3) operating expenses, which included personnel services and other operating expenditure incurred in the direct management of the PAs. The pressure-response analyses were done through scatter plots, that is, response indicators versus number of visitors per 1,000 ha, versus population within 5 km outside of the PA per 1,000 ha, versus inhabitants per 1,000 ha of the PA and versus kilometers of roads and trails per 1,000 ha of the PA. The staff versus population indicators showed a positive and direct relationship, whereas the staff versus number of visitors and roads and trails showed a positive relationship only to a certain degree. The analysis of the latter was not further explored. Operating expenditure had a positive relationship with population, inhabitants, visitors, and roads. However, the relationship was weaker for population and roads compared to inhabitants and visitors. This means that the PA managements tended to incur more expenses as inhabitants and visitors increased in the PAs compared to increases in population outside the PAs or along road networks.

In Thailand, the pressure variables were (1) population within a 5-kilometer radius surrounding the PAs; (2) number of tourists; and (3) length of roads as per collected data in 2009, all per 1,000 ha. The response variables analyzed were (1) number of full-time staff per 1,000 ha; (2) personnel expenditure per hectare; and (3) other operational expenditure recorded in 2009 per hectare. The study separated the analysis for personnel expenditure and other operating expenditure, but also treated total expenditure as a separate response variable. The relationships of staff per 1,000 ha to the number of tourists and to populations within a 5-kilometer radius were positive, respectively, although the scatter plots showed weak relationships. Likewise, the relationship between personnel expenditure and operating expenditure to number of tourists and population within a 5-kilometer radius surrounding the PA, respectively, were positive, although the scatter plots showed weak relationships. These pressure-response indicators were considered positive in terms of providing local livelihood and warranting more investment in staff and operations.

In Vietnam, two analytical approaches were used to assess the pressure-response relationships: scatter plot diagrams and pairwise correlation. The pressure variables were number of people per 1,000 ha within the PA; number of people per 1,000 ha adjacent to the PA; and number of visitors per 1,000 ha of PA. The response variables were number of full-time staff per 1,000 ha; number of enforcement staff per 1,000 ha; operating expenditure per 1,000 ha or per hectare; and number of patrol stations per 1,000 ha. The pair-wise correlation analysis indicated that the response variables did not have significant correlation with regard to population within the PA, but were significantly correlated with the population outside of or adjacent to the PA. Likewise, the response variables did not have a significant correlation with the density of roads and trails within the PA, but the number of patrol stations was directly correlated with length (kilometers) of roads. Meanwhile, full-time staff and operating expenditure were found to be directly correlated with the number of visitors per 1,000 ha.

The country-level analysis of internal and external pressures showed positive but weak relationships with the response indicators for all the countries in general. In Cambodia, a clear correlation existed with respect to staff only. In China, all the pressure factors had positive correlations except for the number of inhabitants within 1,000 ha. In Malaysia, there were generalized weak positive correlations between pressures and staff and operating expenditure, whereas the Philippine and Thai studies showed weak but positive relationships between visitors and staff and operating expenditure.

4.2 Analysis of Pooled Regional Data

For the regional analysis, the indicators of pressure considered were (1) number of inhabitants per 1,000 ha within the PA; (2) population adjacent to the PA; (3) number of visitors per 1,000 ha; (4) length of trails per km^2; and (5) length of roads per km^2. The response indicators considered were (1) full-time staff per 1,000 ha; (2) number of enforcement staff per 1,000 ha; (3) operating expenditure per hectare; (4) patrol stations per 1,000 ha; and (5) total expenditure per hectare.

Other variables initially considered in the canonical correlation analysis included facilities constructed, accommodation, communication, and transportation. Table 6 summarizes these pressure and response indicators. The data were clustered by PA size because of the large differences in area.
The observable trend was that, except for total values, the average values per 1,000 ha of pressure indicators decreased as the PA size increased.

4.3 Analysis of Pooled Regional Data using Pearson *r*

Tests for correlation were conducted for selected pressure and response indicators using the Pearson *r* test built into Microsoft Excel. Table 7 shows the summaries of the Pearson *r* correlations for selected pressure and response variables. At a value of 0.5 set as the threshold for strong correlation, all the paired tests did not show strong positive or negative correlation. The signs of the Pearson correlation were consistent. Note that the tests were done using raw data without any transformation. The results of the graphical analysis of transformed indicator values are presented in a later section.

4.4 Scatter Plot Analysis of Pooled Regional Data

A simple approach employed to establish the relationship between the pressure and response indicators at the regional level was to generate scatter plots and visually evaluate the patterns of the data points. This process involved several iterations and clustering of data to validate the relationship between the pressure and response indicators. In the first iteration, a scatter plot of visitors per 1,000 ha versus the number of staff per 1,000 ha for all data across countries was generated.

Figure 4 shows the results of this first iteration where all data across countries were included.
Note that these are actual observations or untransformed data.

In Figure 4a, the data on the number of visitors and number of full-time staff indicators are clustered at the bottom of the scatter plot. This pattern is influenced by a number of staff data points, which are relatively higher than the rest of the staff data. In Figure 4b, a procedure to remove the outliers was applied. Using the method of interquartile range, 27 observations were removed from 357 observations, retaining the 25^{th} to the 75^{th} percentiles of the data points. The resulting scatter plot and plotting of a trend line indicates some direct relationship between “visitors” and “staff.” The trend line is almost flat, which suggests a weak relationship.

Table 6. Summary of pressure and response indicators of PAs in the project countries

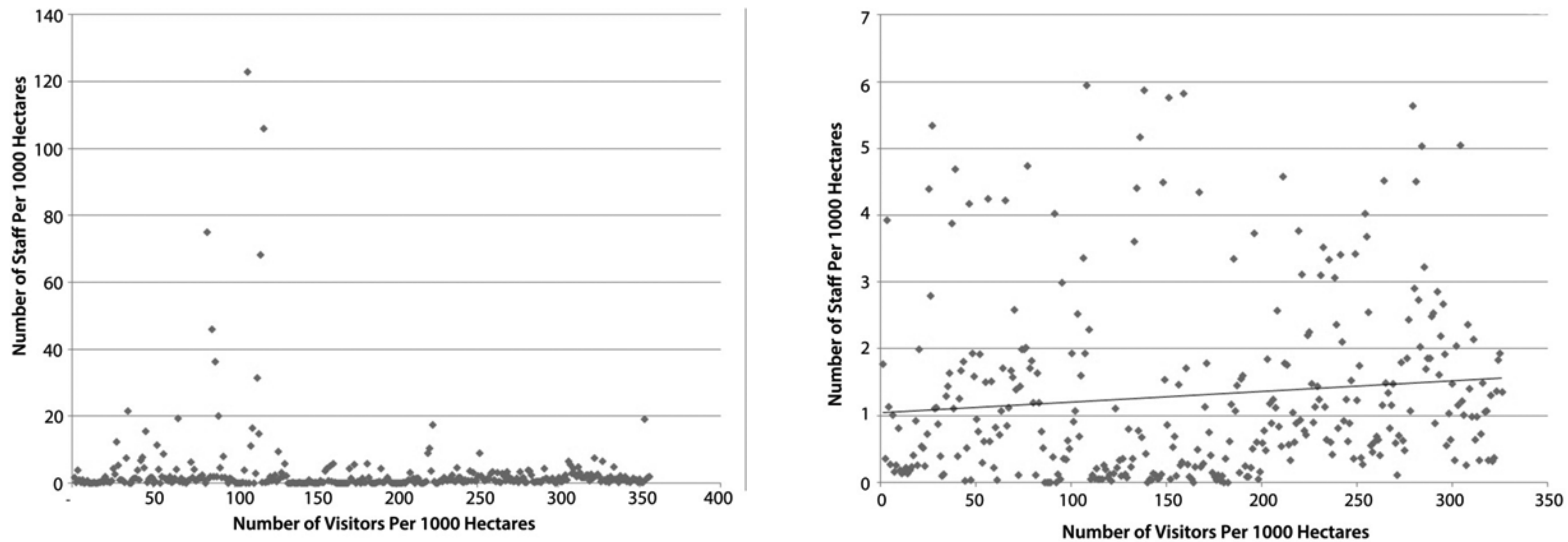
Indicators	PA Size Classes (ha)				Total
	0–2,000	2000–30,000	30,000–300,000	300, 000–800,000	
Pressure Indicators					
Total number of PA inhabitants *	16,725	333,073	808,586	248,907	1,407,291
Average number of inhabitants per 1,000 ha*	1,352	260	77	56	231
Population adjacent to the PA (within 5-kilometer distance)*	686,569	3,305,421	6,494,392	504,106	10,990,488
Average of population adjacent to the PA per 1,000 ha of the PA*	246,941	2,672	850	82	41,238
Total number of visitors (in 2009) in the PA*	704,315	4,304,282	8,568,537	735,240	14,312,374
Average number of visitors per 1,000 ha of the PA*	319,522	2,891	833	145	58,799
Total length of trails, km (inside PA)*	313	2,694	15,485	1,366	19,858
Average length of trails per km^2 (per 1,000 ha)*	27.74	2.19	1.17	0.46	6.04
Total length of roads, in km inside the PA*	249	3,537	16,972	1,279	22,037
Average length of roads in km per 1,000 ha of the PA*	14.73	2.49	1.5	0.27	3.89
Response Indicators					
Number of full-time staff in PA	569	4,678	10,375	1,234	16,857
Average number of full-time staff per 1,000 ha	35	3	<1 (0.83)	<1 (0.23)	7
Total number of enforcement staff in the PA*	204	2,048	4,095	431	6,778
Average number of enforcement staff per 1,000 ha*	50.57	1.25	0.43	0.07	8.25
Total OpEx in the PA	480,135	16,369,603	29,338,150	1,938,880	48,126,769
Average OpEx per ha, PHP	45.6	10.6	2.6	0.3	13
Number of patrol stations inside the PA*	22	317	736	144	1219
Average number of patrol stations per 1,000 ha*	4	<1 (0.28)	<1 (0.08)	<1 (0.03)	<1 (0.52)
Total (annual) expenditure *	3,274,116	46,007,879	75,553,822	6,777,005	131,612,823
Average total (annual) expenditure per 1,000 ha*	262.67	29.04	6.65	1.12	57.75

Notes: (1) The number of observations used in estimating the values of each indicator varied between 360 and 402 depending on whether the values were available. (2) *Does not include data from Malaysia.

Table 7. Pearson *r* correlation table for selected pressure and response indicators for PAs in the project countries except Malaysia

Pressure Indicators	Response Indicators			
	Facilities Constructed	Full-Time Staff per 1,000 Ha	Enforcement Staff	Operations Expenditure per Hectare
Entrance points to PA	0.081005	−0.02883	0.130811	0.00700
Settlements in the vicinity (w/in 5 km)	−0.123920	−0.06762	−0.159150	−0.08852
Settlements within PA	0.242941	−0.17914	−0.018170	−0.04706
Population of nearest settlements (w/in 5 km)	0.207606	−0.01413	0.201257	0.00418
Inhabitants within PA	−0.041020	−0.14035	−0.103470	−0.03432
Roads within PA	0.202691	−0.13106	0.118319	−0.04964
Trails within PA	0.196171	−0.10172	0.036705	−0.05661
Total Number of Visitors	0.022897	0.29614	−0.066120	0.28269

Note: The number of observations for each test varied with the availability of data.



(a) Uncensored data

(b) Outliers removed

Figure 4. Pressure-response relationship between number of visitors and number of staff per 1,000 ha

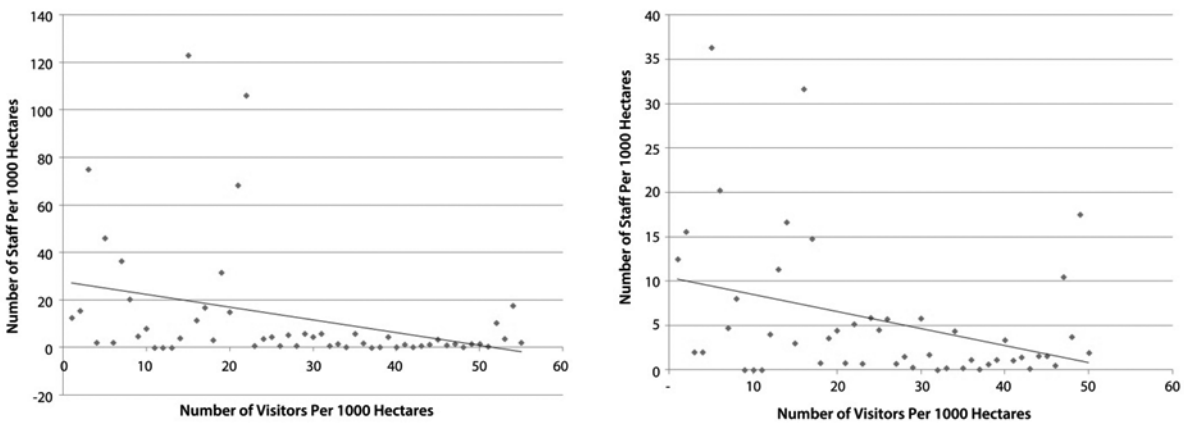
Notes: (1) Data is across countries. (2) Figure 4a covers 357 sample PAs. (3) Figure 4b includes 326 sample PAs. (3) Outliers were removed using the interquartile range approach.

4.5 Clustering of Pooled Regional Data

The scatter plot in Figure 4b shows clustering of data and scatter plots for clusters of PAs in the ranges of 0–2000; 2,000–30,000; 30,000–300,000; and greater than 300,000 in order to evaluate whether the same trend and relationship would occur. The general trend of all the scatter plots was a direct relationship between "visitors" and "staff" in the PAs. The pooled PA data (across countries) on staff per 1,000 ha and number of visitors per 1,000 ha indicate direct and positive relationships. At lower PA sizes and extremely higher PA sizes, the relationship was direct and negative. Note that most outliers in terms of number of PA staff per 1,000 ha occurred in the lower sizes of PAs with few outliers in the larger size range.

4.5.1 PAs smaller than 2,000 ha in size

In the second iteration, we excluded PAs less than 2,000 ha in size simply to isolate the effect of small-sized PAs. We, nonetheless, analyzed relationships for PAs less than 2,000 ha for exploratory purposes. Figure 5 shows the results for PAs below 2,000 ha. The results of plotting the raw data (Figure 5a) and where the outliers were removed (Figure 5b) appear to be similar. In this size range, the relationship is interestingly direct and negative, as indicated by the trend line. That means that as the number of visitors per 1,000 ha increases towards 2,000 ha, the number of staff employed declines. Possible reasons relate to lack of personnel capacity to undertake PA management activities, low operations budget available for PAs of that size range, and the type of PA being managed. Most PAs in this size category had fewer than 10 staff per 1,000 ha.



(a) Uncensored data (b) Outliers removed

Figure 5. Pressure-response relationship between number of visitors and number of staff per 1,000 ha for PAs smaller than 2,000 ha

Note: (a) N = 55 sample PAs, and (b) N = 50 sample PAs

4.5.2 PAs bigger than 2,000 ha in size

Figure 6 shows the results of the analysis for PAs bigger than 2,000 ha. In this scatter plot, the relationship is direct and positive. The trend lines in Figure 6a and Figure 6b are similar. The trend line in Figure 6b indicates a positive relationship between the number of visitors per 1,000 ha and the number of staff per 1,000 ha. Again, the number of staff was mostly fewer than 10 per 1,000 ha. The scatter plot method of analysis showed extreme values probably influencing the averages of the indicators. These extreme values were treated by determining if these were possible outliers. Literature recommends using various techniques such as box plots, extreme studentized tests, and omitted means. The first stage in determining what to use is to know if the distribution of the samples is normal or non-normal. If the normality assumption is not valid, then a determination that there is an outlier/s may in fact be due to the non-normality of the data rather than the presence of an outlier. Box plots and scatter plots are useful for determining outliers for non-normal data.

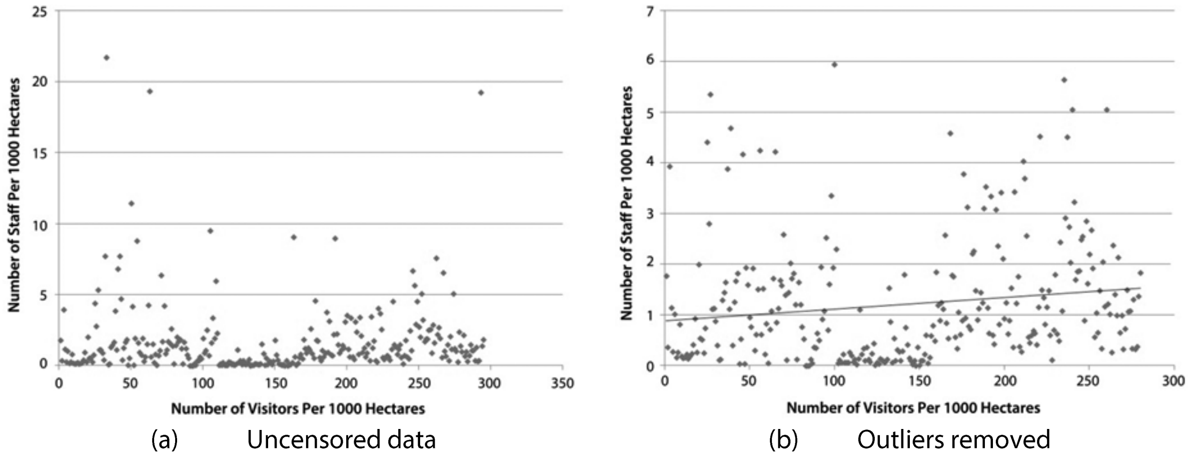


Figure 6. Pressure response relationship between number of visitors and number of staff per 1,000 ha for PAs bigger than 2,000 ha

Note: (a) N = 297 sample PAs, and (b) N = 281 sample PAs

4.6 Tests for Normality of Data Distribution of Pressure and Response Variables

The test for normality was used in order to determine if there were outliers in the observations (or data) on pressure and response variables. Outliers were presumed to affect the estimates of fiscal gaps by either bringing them down or raising the estimated values of the indicators. A pre-programmed Excel file that employed normal probability-quantile plots was used to test for the normality of the distribution for full-time staff, total number of visitors, and operating expenditure in 2009 (Figures 7, 8, and 9).

a. Normal probability-quantile plots to test for normality of the full-time staff values of pooled PA data

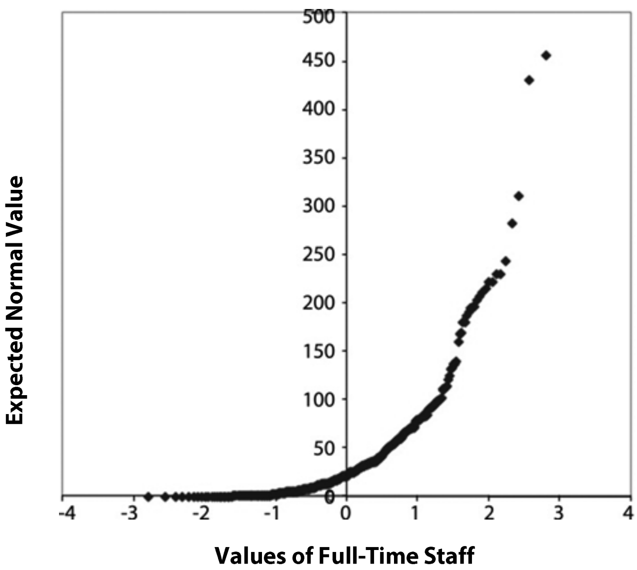


Figure 7. Test for normal distribution of full-time staff of pooled regional data for PAs in the project countries

Note: N = 390 observations, critical value (at α = .05) = 0.99821812

The result of the normal probability-quantile plots test indicated that the collected observations on full-time staff values were not normally distributed; thus, doing a correlation analysis of pressure and response variables, which assumed a normal distribution, should not be undertaken on the raw data. Thus, transforming the data was necessary.

b. Normal probability-quantile plots to test for normality of total visitor values of pooled PA data

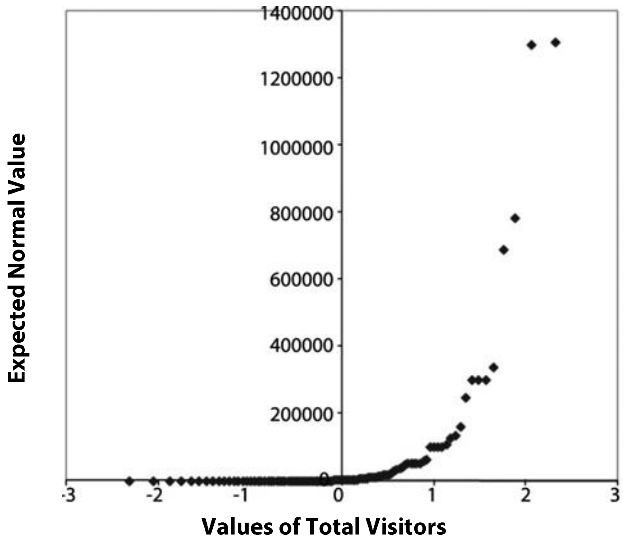


Figure 8. Test for normal distribution of total visitors of pooled regional data for PAs in the project countries

Note: N = 100 observations, critical value (at α = .05) = 0.98743705

This test indicated that the total visitor observations values did not support the claim that it was normally distributed. Thus, doing a correlation analysis of the pressure and response variables, which assumed a normal distribution, should not be undertaken on the raw data. Thus, transforming the data was necessary.

c. Normal probability-quantile plots to test for normality of the operating expenditure values of pooled PA data

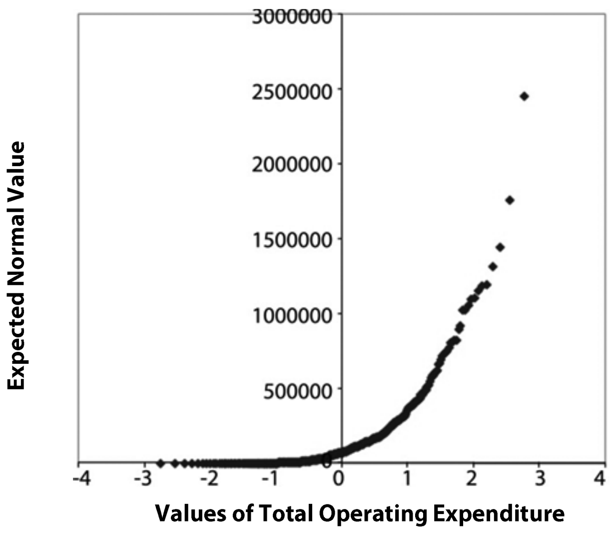


Figure 9. Test for normal distribution of OpEx of pooled regional data in the project countries

Note: N = 361 observations, critical value (at α = .05) = 0.997836679

This test result also indicated that the total operating expenditure values did not support the claim that the total operating expenditure values came from a normally distributed population. This indicated that doing a correlation analysis of pressure and response variables, which assumes a normal distribution, should not be undertaken on the raw data. Accordingly, transforming the data was necessary.

Thus, the tests for the three indicator variables showed non-normality. A normal distribution plot will show points along an upward diagonal line. The plots for the three indicators, however, showed negatively skewed distributions.

4.7 Transformation of Non-normal Data of Pressure and Response Variables

Figure 10 indicates that the relationship between visitors and full-time staff was not evident in the untransformed data. There were extremely low and high values of full-time staff and visitors per 1,000 ha, which were possible outliers. These outliers were not necessarily errors of data, but may have been simply truly existing extreme values. There are many cases in literature that deal with such. Transformation of data is one technique used to check relationships in the presence of outliers.

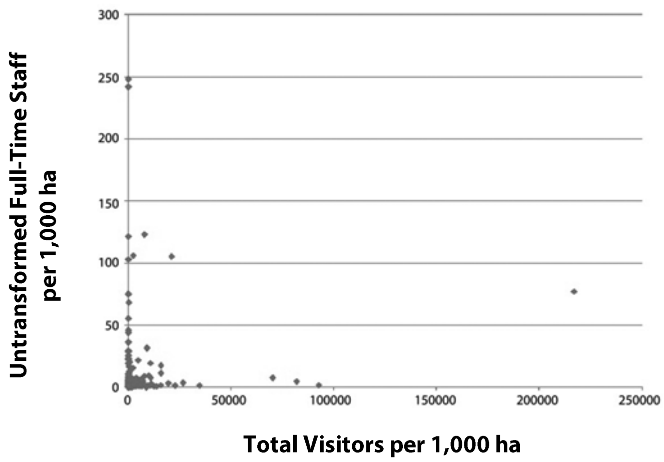


Figure 10. Scatter plot of untransformed total visitor data and full-time staff of pooled PA data

The raw data on the number of visitors, full-time staff, and total operating expenditure were transformed using square root, $\log_2$ and $\log_{10}$ transformation methods. The natural logs of total visitor data, full-time staff, and total operating expenditure were obtained and the corresponding pressure-response relationships were plotted.

Figure 11 shows the scatter plot of the $\log_2$ transformation. Note that when log transformation is used, any observation with values less than 0 becomes negative and so, a constant (i.e., value of 10) was added to the transformed data to maintain the relationship among the data. The values of the data are no longer in interval scale but become ordinal and the distance between the values is reduced, which is the intent of the transformation.

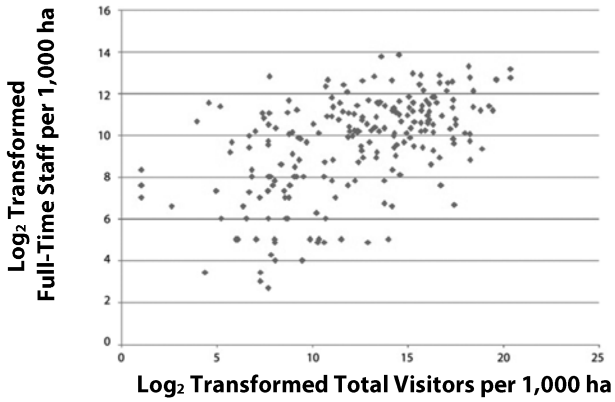


Figure 11. Scatter plot of $\log_2$ transformed data of total visitors per 1,000 ha and full-time staff per 1,000 ha of pooled PA data

The results indicated a positive direct relationship between number of visitors and the deployment of full-time staff. The implication is that PA managers indeed respond to increases in number of visitors by increasing the number of staff per 1,000 ha. However, the elasticity of the response is rather small, which indicates that other factors constrain the increase in the number of staff. In the next stage of the analysis, we determine the magnitude of the responses to the increases in PA pressures. The approach used was to assess the magnitude by comparing individual PAs to endogenously identified benchmarks in order to determine the extent of the gaps in responses.

4.8 Canonical Correlation Analysis of Pooled Regional Data

The previous analysis of external and internal pressures and responses focused on bivariate analysis. However, it is likely that the pressure-response relationship came from a combination of effects of several pressure variables on multiple response variables. We used CCA to address this. However, there were several layers of interpretation of the CCA results before the PA pressure-response relationships could be established.

Firstly, there were five different pressure variables that were supposed to predict five different response variables in the analysis of PA fiscal gaps. The research question of interest was whether there was a relationship between sets of pressure (predictor) and response (criterion) variables based on the observations obtained from the PAs. CCA creates a synthetic criterion (from dependent variables) and a synthetic predictor (from independent variables) variables that are weighted based on the relationships of the variables within the respective sets. These synthetic variables were created in the CCA by applying a linear equation to the observed predictor variables and another linear equation to the observed dependent variables (Sherry and Henson 2005). These combinations of equations yield correlation functions with the largest possible correlation between the two synthetic variables (or variates).

There are as many canonical functions as there are variables in the smaller pressure and response variable sets. The first function creates two synthetic variables (variates) that are as strongly correlated as possible given the observed values of the variables. However, the canonical correlation of the first function is rarely perfect; thus, there will be residual variance left over that are unexplained. The second function then creates two more synthetic variables that are as strongly correlated as possible given the residual variance left over after the first function, and satisfies the condition that the two new functions are not perfectly correlated with the first. Only those functions that are able to explain a reasonable amount of the relationship between the original variable sets are considered for interpretation. Table 8 shows the results of Step 1 of the CCA.

Table 8. Tests of significance of all canonical correlations (Step 1)

Parameter	Statistic	df1	df2	F	Prob > F
Wilks' lambda	0.165565	20	176.731	6.3610	0.0000 a
Pillai's trace	1.287100	20	224.000	5.3137	0.0000 a
Lawley-Ho telling trace	2.740590	20	206.000	7.0570	0.0000 a
Roy's largest root	1.838240	5	56.000	20.5883	0.0000 u

Note: e = exact, a = approximate, u = upper bound on F

The test based on Wilks' lambda of 0.165565, F(20,176.731) = 6.361, $p < 0.00$ indicate that, possibly, there existed a relationship between the pressure and response variables. The correlation coefficient, R_C^2, for the full model, which can be calculated from the Wilks' lambda (i.e., 1– λ = 1– 0.165565 = 0.834435), was the proportion of the variance shared between the variable sets across all functions. This indicated that the full model was both statistically significant and had what may be considered as a large effect size.

The second step in the CCA was examining the linear functions. Each function was evaluated because some may not explain enough of the relationship between the variable sets to warrant interpretation. A weak or poorly defined factor would be discarded.[2] Only those functions that explained a reasonable amount of variance between the variable sets were interpreted; otherwise, we risked interpreting an effect that was not noteworthy or replicable for future studies. Table 9 below shows how canonical roots 1–3 contributed significantly to explaining the pressure-response relationship.

Table 10 shows the test results proving that linear functions 1–3, with a *p*-value of < –0.001 contributed significantly to explaining 91% the variance in the canonical correlations. The first three sets of canonical variates were significantly correlated and dependent on one another.

Table 9. Contribution of canonical roots (linear combinations) in explaining the relationship of pressure to response in the project PAs (Step 2)

Root No.	Canonical Correlation	Squared Canonical Correlations	Percentage	Cumulative Percentage
1	0.8048	0.6477	38	38
2	0.5606	0.3143	27	65
3	0.5377	0.2891	26	91
4	0.1900	0.0361	9	100

Table 10. Tests of significance of canonical correlations of canonical dimensions

Canonical Root	Canonical Test	Statistic	df1	df2	F	Prob>F
1–4	Wilks' lambda	0.165565	20	176.731	6.3610	0.0000 a
2–4	Wilks' lambda	0.469912	12	143.162	3.9411	0.0000 a
3–4	Wilks' lambda	0.685254	6	110.000	3.8137	0.0017 e
4	Wilks' lambda	0.963906	2	56.000	1.0485	0.3572 e

Note: e = exact, a = approximate, u = upper bound on F

[2] For example, each function may not contribute much to the total solution, but the cumulative total solution may be statistically significant and noteworthy. In such cases, the interpretation of each function separately would be questionable.

The third step was to assess the importance of each variable in each variable set. Apart from the relationship, of major importance was whether or not each pressure variable was useful in predicting the responses of PA managers and the expected directions, that is, a positive or negative relationship. Table 11 shows the raw coefficients of the sets of pressure and response variables.

Table 11. Raw coefficients of sets of pressure and response variables based on canonical correlation analysis (Step 3)

Raw Coefficients for the First Variable Set				
	1	2	3	4
logInhabPA	–0.0739	–0.3715	0.3530	0.0140
logkmrodK	0.1166	0.2794	0.4715	0.2598
logkmtralK	0.0675	–0.0212	–0.0533	–0.5285
logVisitK	0.0847	0.1304	0.0831	0.1074
logOutPopK	0.3909	–0.0286	–0.4736	0.0601
Raw Coefficients for the Second Variable Set				
	1	2	3	4
logStafpkh	0.3442	–0.0888	0.1787	–1.4734
logPatrolS	0.3210	–0.6691	0.4710	0.6483
logEnfStaK	0.1626	0.3608	–1.0027	0.7666
logOpExPH	–0.0878	0.3645	0.6152	–0.0257
Canonical Correlations				
	0.8048	0.5606	0.5377	0.1900

Note: Number of observations = 62

In both cases, the magnitudes of the coefficients provided the contributions of the individual variables to the corresponding canonical variable. However, these magnitudes also depend on the variances of the corresponding variables. Thus, using the coefficient values in the first column, the first canonical variable set for Pressure (P) was determined using the following formula:

P_1: –0.0739*LogInhabPA* + 0.1166*LogkmrodK* + 0.0675*LogkmtralK* + 0.0847*LogVisitK* + 0.3909*LogOutPopK*
P_2: –0.3715*LogInhabPA* + 0.2794*LogkmrodK* – 0.0212*LogkmtralK* + 0.1304*LogVisitK*– 0.0286*LogOutPopK*
P_3: 0.353*LogInhabPA* + 0.4715*LogkmrodK* – 0.0533*LogkmtralK* + 0.0831*LogVisitK* – 0.4736*LogOutPopK*
P_4: 0.014*LogInhabPA* + 0.2598*LogkmrodK* – 0.5285*LogkmtralK* + 0.1074*LogVisitK* + 0.0601*LogOutPopK*

The second canonical variable set for Response (R) was determined using the following formula:

R_1: 0.3442*LogStafpkh* + 0.321*LogPatrolS* + 0.1626*LogEnfStaK* –0.0878*LogOpExPH*
R_2: –0.0888*LogStafpkh* + – 0.6691*LogPatrolS*+ 0.3608*LogEnfStaK* + 0.3645*LogOpExPH*
R_3: 0.1787*Log*Staf*pkh* + 0.471*LogPatrolS* – 1.0027*LogEnfStaK* + 0.6152*LogOpExPH*
R_4: –1.4734*Log*Staf*pkh* + 0.6483*LogPatrolS* + 0.7666*LogEnfStaK* – 0.0257*LogOpExPH*

The linear combinations were P1–R1, P2–R2, P3–R3, and P4–R4, and the canonical correlations were 0.8048, 0.5606, 0.5377, and 0.1900, respectively. Table 12 shows the coefficients and the corresponding tests of standard errors for each variable in all four linear functions. For the first linear function (u1–v1), t-statistics and *p*-values ≤ 0.05 (indicated by asterisks) indicated that for the pressure variables, the variables visitors per 1,000 ha and the population adjacent to PA were important in establishing the relationship. For the response variables, full-time staff and patrol stations were relevant in explaining the relationship of the linear function.

For the second set of linear functions (u2–v2), the number of inhabitants within the PA, patrol stations and operating expenditure were the relevant pressure and response variables, respectively. For the third set of linear functions (u3–v3), the number of inhabitants per 1,000 ha, kilometers of roads per 1,000 ha, and population adjacent to (outside) the PA per 1,000 ha of the PA were the significant pressure variables; the enforcement staff per 1,000 ha, patrol stations per 1,000 ha, and operating expenditure per hectare were the significant response variables. The contribution of the fourth function (u4–v4) can be considered less important since the first three already significantly explain the correlations. The coefficients of the log-log equation were easily interpreted as percentages of contribution of the variable to the relationship.

Table 12. Coefficients of variables in each linear combination[2] and corresponding tests for standard error

Variable	Coef.	Std. Err.1	t-stat	P > |t|	[95% Conf. Interval]	
u1						
logInhabPA	–0.073920	0.052246	–1.41	0.162	–0.17839	0.030554
logkmrodK	0.116639	0.080664	1.45	0.153	–0.04466	0.277936
logkmtralK	0.067547	0.063681	1.06	0.293	–0.05979	0.194885
logVisitK	0.084654	0.039692	2.13	0.037*	0.00529	0.164022
logOutPopK	0.390918	0.069642	5.61	0.000*	0.25166	0.530176
v1						
logStafpkh	0.344243	0.149094	2.31	0.024*	0.04611	0.642374
logPatrolS	0.321014	0.106698	3.01	0.004*	0.10766	0.534370
logEnfStaK	0.162631	0.129220	1.26	0.213	–0.09576	0.421022
logOpExPH	0.087841	0.070423	–1.25	0.217	–0.22866	0.052978
u2						
logInhabPA	–0.371490	0.104640	–3.55	0.001*	–0.58073	–0.162250
logkmrodK	0.279395	0.161557	1.73	0.089	–0.04366	0.602448
logkmtralK	0.021221	0.127543	–0.17	0.868	–0.27626	0.233816
logVisitK	0.130350	0.079496	1.64	0.106	–0.02861	0.289312
logOutPopK	0.028637	0.139482	–0.21	0.838	–0.30755	0.250274
v2						
logStafpkh	0.088772	0.298610	–0.30	0.767	–0.68588	0.508336
logPatrolS	0.669107	0.213699	–3.13	0.003*	–1.09642	–0.241790
logEnfStaK	0.360835	0.258806	1.39	0.168	–0.15668	0.878350
logOpExPH	0.364467	0.141046	2.58	0.012*	0.08243	0.646506
u3						
logInhabPA	0.353021	0.111083	3.18	0.002*	0.13090	0.575146
logkmrodK	0.471544	0.171505	2.75	0.008*	0.12860	0.814489
logkmtralK	0.053312	0.135396	–0.39	0.695	–0.32405	0.217428
logVisitK	0.083093	0.084391	0.98	0.329	–0.08566	0.251842
logOutPopK	0.473592	0.148070	–3.20	0.002*	–0.76968	–0.177510
v3						
logStafpkh	0.178700	0.316997	0.56	0.575	–0.45517	0.812574
logPatrolS	0.470982	0.226857	2.08	0.042*	0.01735	0.924610
logEnfStaK	1.002653	0.274742	–3.65	0.001*	–1.55203	–0.453270
logOpExPH	0.615170	0.149731	4.11	0.000*	0.31576	0.914576
u4						
logInhabPA	0.013969	0.366060	0.04	0.970	–0.71801	0.745951
logkmrodK	0.259822	0.565170	0.46	0.647	–0.87031	1.389949
logkmtralK	0.528540	0.446178	–1.18	0.241	–1.42073	0.363647
logVisitK	0.107438	0.278097	0.39	0.701	–0.44865	0.663527
logOutPopK	0.060116	0.487946	0.12	0.902	–0.91559	1.035823
v4						
logStafpkh	1.473369	1.044618	–1.41	0.163	–3.56221	0.615474
logPatrolS	0.648294	0.747576	0.87	0.389	–0.84658	2.143165
logEnfStaK	0.766563	0.905373	0.85	0.400	–1.04384	2.576969
logOpExPH	0.025709	0.493418	–0.05	0.959	–1.01236	0.960940

Note: (1) Standard errors were estimated conditionally. (2) The canonical correlations of the functions are 0.8048, 0.5606, 0.5377, and 0.1900, respectively. (3) * significant at 5% level (4) Number of observations = 62

The t-statistics and *p*-values of the relevant variables indicated multicollinearity; thus, diagnostics were undertaken by taking the correlation of the variance-covariance matrix in Stata, a general-purpose statistical software package created by StataCorp. For the pressure variables, the number of inhabitants and population adjacent to the PA in the first linear function (u1–v1) as well as kilometers of roads and kilometers of trails were highly correlated. The same held true for the succeeding sets of linear functions. For the response variables, the number of full-time staff and number of enforcement staff as well as number of enforcement staff and operating expenditure per hectare were highly correlated.

In view of possible multicollinearity between the variables, the number of inhabitants and number of enforcement staff were not included in the linear functions. The result of the canonical correlation analysis further maximized the correlation of the linear combinations. Table 13 below shows the coefficients of the pressure and response variables. These translate to three linear combinations of pressure (*P*) and response variables (*R*) similarly structured as the equations in the previous section.

For interpretation purposes, the standardized coefficients of the above variables were obtained (Table 14). The standardized coefficients indicate that total population adjacent to the PA, full-time staff per 1,000 ha, and patrol stations per 1,000 ha had the strongest influence in the canonical roots or the relationship between the pressure and response variables.

Table 13. Canonical correlation analysis results adjusted by excluding the number of full-time staff, number of enforcement staff and number of enforcement staff and OpEx per hectare

Raw Coefficients for the First Variable Set			
	1	2	3
logkmrodK	0.0570	0.5664	–0.1127
logkmtralK	0.0980	–0.1905	0.5375
logVisitK	0.0979	0.2296	–0.0257
logOutPopK	0.3112	–0.3586	–0.2365
Raw coefficients for the Second Variable Set			
	1	2	3
logStafpkh	0.3324	–0.1095	1.1290
logPatrolS	0.3444	–0.3909	–1.0177
logOpExPH	–0.0265	0.5892	–0.1888

Notes: (1) The canonical correlations are 0.8531, 0.4524, and 0.1580, respectively. (2) n = 97

Table 14. Standardized coefficient of the *P* and *R* variables excluding variables with multicollinearity

Standardized Coefficients for the First Variable Set			
	1	2	3
logkmrodK	0.0987	0.9805	–0.1951
logkmtralK	0.2107	–0.4099	1.1565
logVisitK	0.2804	0.6577	–0.0735
logOutPopK	0.6817	–0.7857	–0.5181
Standardized Coefficients for the Second Variable Set			
	1	2	3
logStafpkh	0.5446	–0.1794	1.8495
logPatrolS	0.5380	–0.6107	–1.5897
logOpExPH	–0.0563	1.2544	–0.4019

These standardized canonical coefficients were interpreted in a manner analogous to interpreting standardized regression coefficients. For instance, consider the variable logkmrodK (log of kilometers of roads per 1,000 ha). A one standard deviation increase in logkmrodK would lead to a 0.0987 or 9.87% increase in standard deviation in the canonical variate for Set 1 when the other variables in the model are held constant.

4.8.1 Canonical loadings

Also of interest were the correlations between the original variable lists and their canonical variates. Canonical loadings (or structural coefficients) were used to interpret the canonical variates. Table 15presents the standardized canonical function coefficients and structure coefficients (r_s) for all variables across the three functions. The squared structure coefficients r_s^2 are also given, which represent the percentage of shared variance between the observed (pressure or response) variable and the synthetic variable created from the observed variable's set. The last column lists the communality coefficients (h_2), which represent the amount of variance in the observed variable that was reproducible across the functions. It is simply the sum of the variable's r_s^2 . The communalities are analogous to communality coefficients in factor analysis and can be viewed as an indication of how useful the variable was for the solution.

Table 15. Standard and structural coefficients of linear function variables

Variable	Function 1			Function 2			Function 3			h_2(%)
	Coef	r_s	r_s^2(%)	Coef	r_s	r_s^2(%)	Coef	r_s	r_s^2(%)	
logkmrodK	0.099	0.537	28.8%	0.981	0.552	30.5%	–0.195	0.384	14.8%	74%
logkmtralK	0.211	0.555	30.8%	–0.410	0.007	0.0%	1.157	0.825	68.1%	99%
logVisitK	0.280	0.671	45.0%	0.658	0.405	16.4%	–0.074	–0.288	8.3%	70%
logOutPopK	0.682	0.942	88.7%	–0.786	–0.249	6.2%	–0.518	–0.192	3.7%	99%
R_c^2			72.8%			20.5%			2.5%	100%
logStafpkh	0.545	0.953	90.9%	–0.179	0.130	1.7%	1.850	0.273	7.4%	100%
logPatrolS	0.538	0.957	91.5%	–0.611	–0.049	0.2%	–1.590	–0.287	8.2%	100%
logOpExPH	–0.056	0.602	36.3%	1.254	0.792	62.7%	–0.402	–0.101	1.0%	100%

Note: The underlined r_s variables are those that are considered relevant to the corresponding function.

In Function 1, all pressure and response variables were considered relevant to the successive function (all $r_s \geq 0.5$, underlined in Table 15). This was supported by the squared structural coefficients (r_s^2), which showed large contributions (to the shared variance) of the pressure variables in the first linear function. Both kilometers of roads (*logkmrodk*) and kilometers of trails (*logkmtralK*) had modest contributions to the synthetic variate of PA pressure variables. All the structure coefficients had positive signs indicating positive relationships. In the same function, on the other side of the equation, all the variables had large contributions to the synthetic response variate. Note that operating expenditure had a negative sign in the canonical coefficient although the structure coefficient indicated a positive relationship with the pressure variables. This simply means that operating expenditure was not responsive to the size of the PA and the pressures on the PA.

In Function 2, operating expenditure had an inverse relationship with kilometers of trails and population adjacent to the PA, but was positively correlated with kilometers of roads. These inconsistent relationships indicated that operating expenditure was not responsive to pressures on the PA. Also, in Function 2, kilometers of roads and operating expenditure were the only relevant contributors to the pressure and response variates, respectively. The structure coefficients of population adjacent to the PA in the pressure variable set and patrol stations in the response variable set had the same signs indicating positive relationships, but did not make significant contributions to the canonical functions.

In Function 3, only kilometers of trails (underlined) contributed significantly to the linear function. The rest of the variables had no significant contribution to the canonical functions. The squared canonical correlations indicated that Function 3 modestly explained the variations of the function. The communality coefficient, h_2, indicated that all the response variables were relevant for the functions, and were thus relevant in the pressure-response analysis.

4.8.2 Summary interpretation of the results of the canonical correlation analysis

The canonical correlation analysis established the relationship between the pressure and response variables in the PAs. The number of visitors and population adjacent to the PA were useful predictors of the response variables, whereas length/kilometers of roads and trails had modest contributions as predictor variables in the relationship between the pressure and response variables. The variables full-time staff, number of patrol stations, and operating expenditure were useful in analyzing the pressure-response relationships. However, operating expenditure did not show a concrete correlation as a response variable to length of roads and trails. It also had an inverse relationship with most of the pressure variables, which can indicate that it was not responsive to the pressure variables in the functions.

5.0 FISCAL GAP ANALYSIS

In the analysis of fiscal gaps, this study focused primarily on full-time staff per 1,000 ha and total operating expenditure per hectare per year as response indicators. The ultimate goal was to arrive at fiscal gap estimates for all PAs in each project country in the region using Year 2009 information on staff and operating expenditure.

Table 16 presents a rough estimate of the total operating expenditure in Year 2009, which was calculated using simple averages based on a single value of operating expenditure per hectare. Columns *e* and *f* in the table were compared with the results using different methods of estimation introduced by this study to arrive at fiscal gaps. The estimates of the gaps were influenced by a number of factors such as extremely high and low values, and averaging. We were particularly vigilant in averaging the values of the above-identified response indicators because these were affected by extreme values, particularly size of PAs and the values of the response indicators such as staff per 1,000 ha.

Two approaches for minimizing the effect of extreme values were used in this study. The first was by considering the possibility that extreme values were potential outliers, and thus treatments were undertaken to remove these outliers. However, these "outliers" were not necessarily errors of data collection, but real values that may be treated as special cases. In such case, the other approach for treating extreme values used was to cluster the sample data so that those of similar characteristics were treated as one class from other groups of sample data.

5.1 Removing Outliers from Pooled Regional Data

The analyses of fiscal gaps at the country level had already considered outliers. At the regional level, the original total sample was 411 PAs. By removing marine PAs, this was further reduced to 402 PAs. In the analysis of fiscal gaps, some PAs did not have sufficient data; thus, the comparison was made for terrestrial PAs only. The scatter plots of pooled regional data indicated extreme values as shown, for example, by Figure 10.

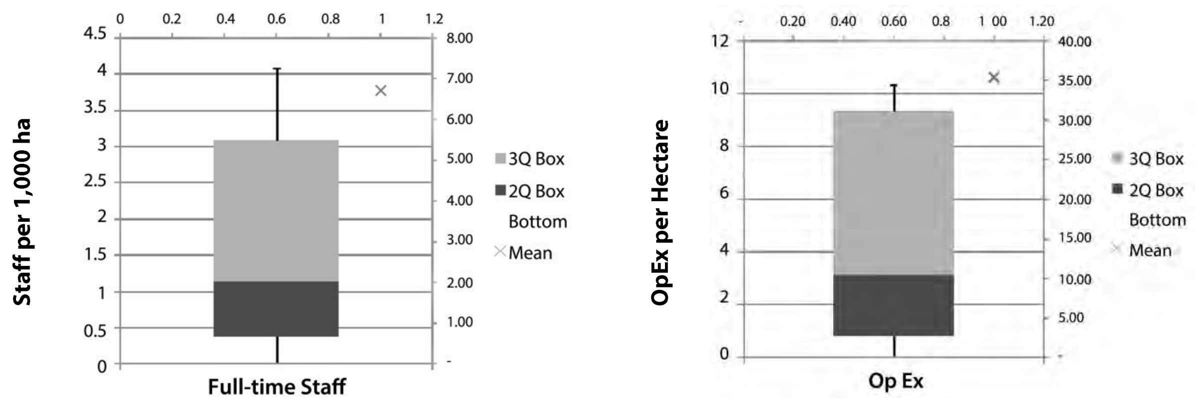
One approach to remove the outliers that does not rely on the assumption of normality is through using the box plot. Any value outside the inner and upper fences of the box plot is treated as an outlier. Figure 12 shows the box plots for the two response indicators, and Table 17 shows the parameters for determining outliers.

Thus, the values of full-time staff above 7 per 1,000 ha and operating expenditure values above USD 22.18/ha were considered outliers in this analysis. Hence, a total of 41 outliers were excluded from the analysis of full-time staff per 1,000 ha and 26 from the analysis of operating expenditure per hectare.

Table 16. PA OpEx in the project countries

Country	Total Area of Terrestrial PAs, National	Total No. of PAs[3]	Total Area of Sample	Existing OpEx of Sample (USD)[4]	OpEx per Hectare, (USD)[4]	Extrapolation of OpEx to Total Terrestrial PAs (USD)[4]
(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**
Cambodia	3,324,606	23	3,324,606	1,241,476	0.37	1,241,476
China[1]	92,671,100	319	5,860,119	26,256,491	4.48	415,216,480
Indonesia	22,498,374	457	1,689,587	7,890,722	4.67	105,072,064
Lao PDR	3,944,850	23	3,545,300	1,325,475	0.37	1,474,854
Malaysia	1,952,504		1,479,600	6,919,310	4.68	9,130,836
Philippines[2]	5,417,924	2,382	1,509,557	1,086,198	0.72	3,898,453
Thailand	10,263,600	181	4,811,091	13,359,433	2.78	28,499,953
Vietnam	2,198,744	164	1,614,258	8,010,997	4.96	10,911,596
Regional Total	**142,271,702**	**1,389**	**23,834,118**	**66,090,101**	**2.77**	**394,508,037**

Notes: (1) Covers only National Nature Reserves. (2) Only 222 PAs under the jurisdiction of the DENR were covered by the survey. (3) Malaysia's data was not available. (4) Not adjusted for purchasing power parity.



(a) Staff Box Plot

(b) OpEx Box Plot

Figure 12. Box plots for staff per 1,000 ha and OpEx per hectare (USD) for determining possible outliers

Table 17. Parameters that define the box plots for staff per 1,000 ha and OpEx per hectare

Statistics	Full-Time Staff	OpEx
Count	400	359
Mean	6.71	35.40
SD	23.70776	181.2632
Min	0.0003	0.0001
Q1	0.366353	0.794717
Median	1.14	3.11
Q3	3.080938	9.351175
Max	248.00	2,416.34
Bottom	0.366353	0.794717
2QBox	0.774702	2.310307
3QBox	1.939884	6.246152
Whisker–	0.366078	0.794659
Whisker+	244.9144	2406.991
Offset	0.5	0.5
Interquartile Range	2.714586	8.556458
Boundary of the box plot	4.071878	12.83469
Lower Inner Fence	–3.70553	–12.03997
Upper Inner Fence	7.152817	22.18586

5.2 Clustering of PAs by Size

The original intent of the analysis was to pool all PAs from all eight countries, and then estimate the average and highest value benchmarks of the indicators. However, as the data analysis progressed, it became apparent that simple averages of staff per 1,000 ha and average operating expenditure of pooled PAs produced relatively high values because of the wide variations in the PA sizes. Small-sized PAs (those below 1,000 ha) would produce higher values of indicator variables such as staff per 1,000 ha. After careful analysis, each country study team was asked to evaluate their fiscal gaps by clustering their PAs. Likewise for the regional analysis, clustering was applied to regional pooled PA data. The criteria and process of clustering is described briefly below.

Reviews of the different PA sizes from the eight countries indicated not only a wide range of areas (PA sizes), but an evident need for clustering of PAs by size. The bases for clustering into hectare classes were the two primary indicators for the gap analysis, namely, staff per 1,000 ha and operating expenditure per hectare, and the apparent clustering of the PAs by size as shown by scatter plots. The clustering went through several iterations until the cluster ranges and averages of indicators showed a consistent pattern, the pattern being that the averages of full-time staff per 1,000 ha and operating expenditure declined at higher hectare classes. The results of clustering for each country are briefly described below.

The numbers of clusters of the countries were not the same: Cambodia, China, Indonesia, Thailand, and Vietnam had three clusters; the Philippines had four; Malaysia had four clusters for the staff analysis and five clusters for the operating expenditure analysis; and the PAs of Lao PDR were not divided into any clusters because there was less variation and there were only 20 PAs.

The following tables show the clustering of the sample PAs from the eight project countries. The columns show the average values for staff and operating expenditure, and indicate declining averages at higher hectare classes of PAs. The average number of full-time staff and the average total operating expenditure per hectare are also shown in the tables. The presumption was that clustering of PAs by hectare classes for each country analysis would reduce the tendency toward higher gap estimates. Table 18 shows the clustering of PAs in Cambodia. All the PAs in Cambodia were included, except for two or three that were newly established and for which no treatment for outliers was undertaken. The data in Table 19 for China show different numbers of PAs in each cluster for the analyses of staff and operating expenditure. The number of PAs included in the analysis for the staff was 54, whereas that for operating expenditure was only 44 because 10 PAs did not have data on total operating expenditure (Table 20). Presumed outliers were removed from the sample.

Table 18. Clustering of all the 23 PAs in Cambodia

Cluster No.	Cluster Interval (ha)	No. of PAs in Cluster	Total Area in Cluster	Total No. of Staff in Cluster	Average No. of Full-time Staff per 1,000 ha in Cluster	Total OpEx in Cluster	Average Exchange Rate Adjusted OpEx per Hectare in Cluster
1	0 ≤ 5,000	2	7,795	21	2.97	15,139	2.10
2	>5,000 ≤ 50,000	6	168,026	181	1.03	105,455	0.60
3	>50,000 ≤ 402,500	15	3,148,785	689	0.25	1,120,882	0.30

Table 19. Clustering of PAs in China for the analysis of full-time staff

Cluster No.	Cluster Interval (ha)	Total Area in Cluster for Staff Analysis	No. of PAs in Cluster for Staff Analysis	No. of Full-Time Staff	Average Number of Full-Time Staff per 1,000 ha in Cluster (Without Outliers)
1	0 ≤ 2,000	2,900	2	39	14.03
2	>2,000 ≤ 70,000	880,961	33	2,577	3.27
3	> 70,000 ≤ 800,000	4,976,258	19	2,641	0.74

Table 20. Clustering of PAs in China for the analysis of OpEx

Cluster No.	Cluster Interval (Ha)	No. of PAs in Cluster for OpEx	Total Area in Cluster for OpEx (Without Outliers)	No. of PAs in Cluster (Without Outliers)	Average Exchange Rate Adjusted OpEx per Hectare in Cluster (Without Outliers)
1	0 ≤ 2,000	2	2,900	2	214.2
2	>2,000 ≤ 70,000	28	872,017	26	26.5
3	> 70,000 ≤ 800,000	14	4,887,758	13	2.5

Only 49 PAs were included in the analysis of staff and operating expenditure for Indonesia (Table 21). For reasons that need further review, after the largest value of expenditure per hectare was removed, the average operating expenditure per hectare was not consistent with the other countries where the value of the average operating expenditure per hectare decreased dramatically from the first cluster to the next. It was only in the case of the average operating expenditure for Indonesia where the trend was not consistent. In the last column of Table 21, the average operating expenditure per hectare goes from USD 7.49 to USD 9.24 to USD 4.10 from Cluster 1 to Cluster 3. Attempts to change the clustering range yielded the same inconsistent trend. Extremely large values were excluded from the sample for analysis of gaps.

The PAs of Lao PDR were not clustered for the analysis. Although the smallest and the largest PAs were quite far apart in terms of size in hectares, there were only 20 PAs to analyze; hence, the decision was not to cluster them. Table 22 shows the basic information on Lao PDR PAs that was used in the analysis.

Table 23 shows the clustering of PAs for Malaysia. The number of PA clusters for the analysis of staff was different from that of the operating expenditure. The analysis of operating expenditure needed an additional cluster because of the wide variations in total operating expenditure among the PAs. Out of the 44 PAs sampled, only 37 could be used for the staff analysis because of the absence of staff information from the rest of the sample. Presumed outliers were removed from the sample for the analysis of gaps. Only 23 PAs were included for the analysis of operating expenditure for Malaysia due to lack of data on the rest of the PAs that were included in the survey. The presumption was that increasing the clusters would reduce the estimated operating expenditure gap. Table 24 shows the basic data on clusters used for the operating expenditure gap analysis.

The PAs in the Philippines were divided into four clusters after several iterations of clustering to capture the wide variations in PA sizes. There was a significant number of smaller sized PAs (35 PAs with areas up to1,000 ha) as well as mid-sized PAs (26 PAs between 1,000 and 15,000 ha). When these smaller sized PAs were converted to per 1,000 ha, the resulting values became less than 1. The effect was that the number of full-time staff per 1,000 ha became large. For instance, the resulting 15 staff per 1,000 in reality rarely exists. What is common is that a DENR personnel assigned to a PA handles more than one function. Table 25 shows the clustering of the sample PAs in the Philippines.

Table 26 shows the clustering of sample PAs from Thailand. The 79 sample PAs were divided into three clusters. The PAs were generally large with 55 PAs between 10,000 and 75,000 ha. Table 26 shows quite a large number of full-time staff employed in PA management in Thailand.

Vietnam had 53 PAs sampled (Table 27) for this research project, most of which were from 5,000 to 35,000 ha in size. Despite this high number, the total operating expenditure in that size class was not far removed from Cluster 3, which had only 16 PAs. The total numbers of staff were also not much different.

Finally, all PA samples from the eight countries were pooled and divided into clusters as well. The bases for clustering were the same as for the eight countries individually. Table 28 shows the resulting clusters and average values of the indicators. Two versions of Average Number of Full-time Staff per 1,000 ha in Cluster and Average Exchange Rate Adjusted OpEx per Hectare in Cluster gave different results in the averaging. For full-time staff, the first version (Method 1) was essentially the average of the average, i.e., the average of full-time staff in the cluster divided by area in thousand hectares of the cluster to obtain the average of full-time staff per 1,000 ha for each cluster. The second (Method 2) was obtained by taking the sum of full-time staff in the cluster divided by the total area in the cluster further divided by 1,000. The same methods were applied for operating expenditure.

Table 21. Clustering of PAs in Indonesia

Cluster No.	Cluster Interval (ha)	Count of PAs in Cluster	Total Area in Cluster for Staff	Average No. of Full-Time Staff per 1,000 ha in Cluster	Total OpEx in Cluster	Average Exchange Rate Adjusted OpEx per Hectare in Cluster
1	0 ≤ 1,000	14	3,577	39.83	22,019	7.49
2	>1,000 ≤ 50,000	24	368,925	2.25	3,721,331	9.24
3	>50,000 ≤ 239,000	11	1,367,085	0.63	4,148,642	4.10

Table 22. Basic information on PAs in Laos

No. of PAs	Total Area (ha)	No. of Full-time Staff	No. of Full-Time Staff per 1,000 ha	Highest No. of Full-Time Staff per 1,000 ha
Total = 20	Highest = 420,000			
20	177,265	32.2	0.19	1.11

Table 23. Clustering of PAs in Malaysia for the analysis of staff indicators

Cluster No.	Cluster Interval (ha)	Count of PAs in Cluster for Staff	Total Area in Cluster (ha)	No. of Full-Time Staff	Average No. of Full-time Staff per 1,000 ha in Cluster	Highest No. of Full-time Staff per 1,000 ha in Cluster
1	0 ≤ 100	4	204	31	152.32	248.00
2	>100 ≤ 1,200	5	2,991	94	31.43	55.38
3	>1,200 ≤ 20,000	10	70,624	154	2.18	7.70
4	>20,000 ≤ 248,121	18	1,375,680	328	0.24	0.70

Table 24. Clustering of PAs in Malaysia for the analysis of OpEx indicators

Cluster No.	Cluster Interval (ha)	No. of PAs in Cluster for OpEx	Total Area in Cluster (ha)	Total Exchange Rate Adjusted OpEx in 2009 (USD)	Average Exchange Rate Adjusted OpEx per Hectare in Cluster (USD)	Highest Exchange Rate Adjusted OpEx per Hectare in Cluster (USD)
1	0 ≤ 100	3	166	208,306	1,252.41	2,416.34
2	>100 ≤ 1,200	4	2,338	838,449	358.69	454.09
3	>1,200 ≤ 20,000	3	32,503	850,349	26.16	34.74
4	>20,000 ≤ 80,000	7	255,777	2,503,957	9.79	13.40
5	>80,000 ≤248,121	6	809,393	2,518,247	3.11	5.85

Table 25. Clustering of PAs in the Philippines

Cluster No.	Cluster Interval (ha)	No. of PAs in Cluster	Total Area in Cluster for Staff Analysis	Average No. of Full-Time Staff per 1,000 ha in Cluster	Total OpEx in Cluster	Average Exchange Rate Adjusted OpEx per Hectare in Cluster
1	0 ≤ 1,000	35	8,281	15.76	165,381	102.52
2	>1,000 ≤ 15,000	26	118,438	1.37	259,511	3.25
3	>15,000 ≤ 70,000	12	410,240	0.18	292,148	0.87
4	>70,000 ≤ 333,300	6	972,599	0.06	369,158	0.42

Table 26. Clustering of PAs in Thailand

Cluster No.	Cluster Interval (ha)	No. of PAs in Cluster	Total Area in Cluster for Staff Analysis	Total No. of Staff in Cluster	Average No. of Full-time Staff per 1,000 ha in Cluster	Total OpEx in Cluster	Average Exchange Rate Adjusted OpEx per Hectare in Cluster
1	0 ≤ 10,000	5	39,280	131	3.50	426,245	12.24
2	>10,000 ≤ 75,000	55	1,825,855	2,364	1.52	7,858,261	5.53
3	>75,000 ≤ 471,438	19	3,443,727	1,986	0.66	5,036,171	1.80

Table 27. Clustering of PAs in Vietnam

Cluster No.	Class Interval (ha)	No. of PAs in Class	Total Area in Cluster for Staff	Total Staff in Cluster	Average No. of Full-time Staff per 1,000 ha in Cluster	Total OpEx in Cluster	Average Exchange Rate Adjusted OpEx per Hectare in Cluster
1	0 ≤ 5,000	2	4,354	57	10.59	124,686	23.00
2	>5,000 ≤ 35,000	35	585,751	1,387	2.43	4,345,237	7.97
3	>35,000 ≤ 125,000	16	1,024,153	1,466	1.31	3,541,075	3.18

Table 28. Clustering of pooled PAs in the region

Cluster No.	Cluster Interval (ha)	No. of PAs in Cluster	PAs in Cluster as Percentage of Total	Total Area in Cluster (ha)	Total No. of Staff in Cluster	Total OpEx in Cluster
1	0 ≤ 2,000	78	20%	43,318	411	1,793,117
2	>2,000 ≤ 30,000	144	36%	2,034,957	4,743	22,785,622
3	>30,000 ≤ 300,000	165	41%	16,258,363	10,700	37,686,430
4	>300,000 ≤ 800,000	13	3%	5,691,463	1,181	3,824,933

Note: Outliers were not removed

Table 29 also shows that 41% of the sample PAs were between 30,000 and 300,000 ha, while 36% were between 2,000 and 30,000 ha. The larger sized PAs between 300,000 and 800,000 ha comprised only 3% of the total sample. PAs in the lowest and highest ranges probably influenced the average values of the indicators. Table 29 shows the average numbers of full-time staff per 1,000 ha using Methods 1 and 2. The average number of full-time staff per 1,000 ha in the first cluster shows different results with 2.79 and 2.59 staff per 1,000 ha using Method 1 and Method 2, respectively. Previous estimates where outliers were not removed showed a higher value of 27.5 staff per 1,000 ha for PAs below 2,000 ha using Method 1 and 9 staff per 1,000 ha using Method 2.

Table 30 shows that the estimates of average exchange rate-adjusted operating expenditure per hectare in Cluster 1 showed widely different results. Method 1 produced USD 149.10 while Method 2 produced USD 48.44 per hectare. The method of calculation was similar to that for full-time staff, but this time using exchange rate-adjusted operating expenditure.

Table 29. Average number of full-time staff per 1,000 ha for all project countries

Cluster No.	Cluster Interval (ha)	Total Area in Cluster (ha)	No. of PAs Included in Analysis	Average No. of Full-time Staff per 1,000 ha in Cluster (Method 1)	Average No. of Full-time Staff per 1,000 ha in Cluster (Method 2)
1	0 ≤ 2,000	30,407	37	2.79	2.59
2	>2,000 ≤ 30,000	1,938,260	130	1.93	1.90
3	>30,000 ≤ 300,000	16,258,363	164	0.85	0.66
4	>300,000 ≤ 800,000	5,691,463	13	0.24	0.21

Notes: (1) Method 1: average of the average, i.e., average of full-time staff in the cluster divided by area in thousand hectares of the cluster to obtain the average of full-time staff per 1,000 ha for each cluster. (2) Method 2: the sum of full-time staff in the cluster divided by the total area of the cluster divided by 1,000. (3) Outliers were removed in this analysis, hence only 344 PAs were analyzed.

Table 30. Estimates of average exchange rate-adjusted OpEx per cluster of pooled regional data

Cluster No.	Cluster Interval (ha)	Total OpEx in Cluster	Ave Exchange Rate-Adjusted OpEx per Hectare in Cluster (Method 1)	Ave Exchange Rate-Adjusted OpEx per Hectare in Cluster (Method 2)
1	0 ≤ 2,000	1,793,117	149.10	48.44
2	>2,000 ≤ 30,000	22,785,622	15.84	12.41
3	>30,000 ≤ 300,000	37,686,430	3.56	2.55
4	>300,000 ≤ 800,000	3,824,933	0.69	0.67

Notes: (1) Method 1: average of the average, i.e., average of OpEx in the cluster divided by area in thousand hectares of the cluster to obtain the average OpEx per 1,000 ha for each cluster. (2) Method 2: the sum of OpEx in the cluster divided by the total area of the cluster, then divided by 1,000

5.3 Gap Analysis of Full-Time PA staff

The analysis of fiscal gaps focused on the response of PA managers to internal and external pressures in terms of full-time staff and operating expenditure. Table 31 shows information on PA land area in each project country. The average land area covered by the PAs of each country was estimated at 13%. This comprised about 11% of the total land area of the eight countries covered by the analysis. The total area of terrestrial PAs covered by this analysis was not the total for all PAs because in China, for instance, the 92,671,100 ha were National Nature Reserves while the 5,417,924 ha in the Philippines comprised the whole land area of PAs, but only the 222 PAs under DENR jurisdiction (including all officially proclaimed under the NIPAS law as of 2009) were covered by the survey. Cambodia and Thailand had the biggest percentage of PA land area.

Table 31. Country data on total areas and number of terrestrial PAs covered by the survey

Country	Total Land Area of the Country	Total Area of Terrestrial PAs (National)	Total No. of PAs	% of Land Area of Terrestrial PAs
Cambodia	17,652,000	3,324,606.00	23	19%
China	959,696,000	92,671,100.00*	319	10%
Indonesia	191,944,000	22,498,373.61	457	12%
Lao PDR	23,680,000	3,944,850.00	23	17%
Malaysia	32,975,000	1,952,504.00	–	6%
Philippines	30,000,000	5,417,924.00	238**	18%
Thailand	51,400,000	10,263,600.00	181	20%
Vietnam	32,956,000	2,198,744.00	164	7%
Regional Total	**1,340,303,000**	**142,271,701.61**	**1,389**	**11%**

Note: (1) * Covers only National Nature Reserves (2) ** Only 222 PAs under jurisdiction of the DENR were covered by the survey (3) 44 PAs in Malaysia were included in the survey.

5.3.1 Gap analysis of full-time staff at the country level

The first step in calculating staff gaps was to calculate the average staff gap per cluster. Two methods of calculating the average full-time staff per cluster were used by the different country study teams in order to estimate the staff gaps from the sample PAs. In Method 1, full-time staff per 1,000 ha in each cluster was obtained by dividing the number of full-time staff of each PA by the precomputed area in 1,000 ha, and then the resulting full-time staff values in each cluster were averaged. In Method 2, the total number of full-time staff in each cluster was divided by the total area of PAs in the cluster, and then the resulting value was divided by 1,000 to obtain the average number of full-time staff per 1,000 ha.

The second step in calculating the staff gaps was to internally calculate a benchmark. We established two types of benchmarks as bases for evaluation, so that each PA cluster in each country had a benchmark. The first benchmark was the highest value in the cluster, and the second benchmark was the average number of the cluster calculated in the first step. Figure 13 illustrates the benchmarking procedure used in calculating the full-time staff gaps. The vertical bars are the numbers of full-time staff of PAs (represented by numbers in the horizontal axis). The horizontal lines represent the highest and average numbers of full-time staff in each cluster.

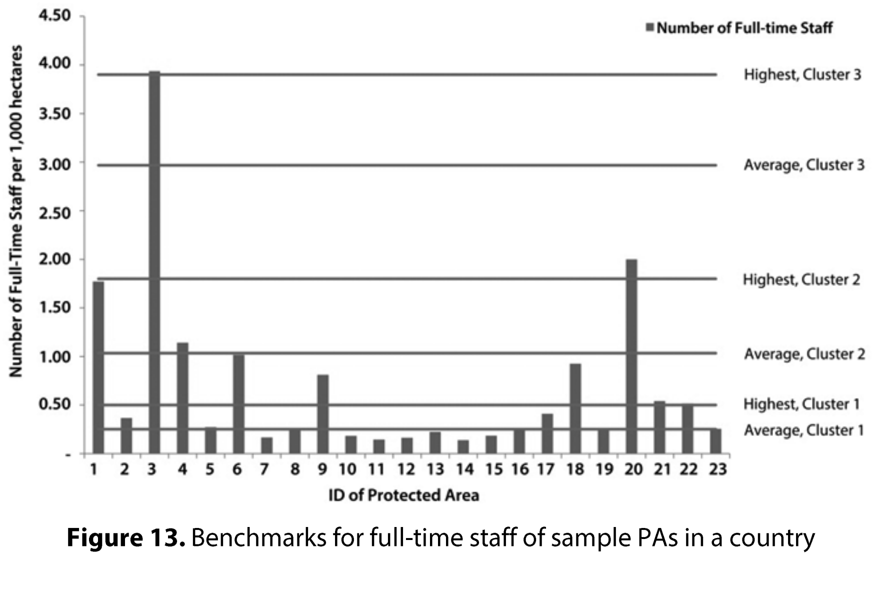


Figure 13. Benchmarks for full-time staff of sample PAs in a country

The third step in calculating the gaps was to take the difference between the number of full-time staff and the benchmark in the cluster. Those below the average were compared with the average while those above the average were compared with the highest in the cluster. The final step in calculating the full-time staff gaps was taking the total gaps calculated in Step 2 for all sample PAs in a country.

Individual countries used different estimation methods. In the interest of comparing results, the estimates done at the country level were also compared with those obtained by using a different method. The results of these estimations are shown in succeeding tables.

Results of Method 1 calculation at the country level. Table 32 shows the results of the calculations using the first method. The average level of understaffing at the country level was 102%. Cambodia had the lowest and Lao PDR had the highest with 50% and 166%, respectively. If all the gaps in these countries are summed up, then the percentage of understaffing would be 91% based on the total benchmark. This means that countries need to at least double or more than double the current number of staff based on the current average and highest benchmarks at the country level.

Lao PDR had the highest understaffing gap at 166% followed by the Philippines at 159%. These countries should roughly triple their existing number of staff as indicated by the ratios 2.7:1 and 2.6:1, respectively, of benchmark to existing staff.

Results of Method 2 calculation at the country level. Table 33 shows the results of the second method of calculation. The average understaffing was 100% of existing full-time staff. Cambodia still had the lowest gap at 53%, and this time the Philippines had the highest gap at 230%. Similar to the first calculation, each country needed to at least double the current number of staff based on the current benchmark at the country level. The Philippines had to increase its full-time PA staff by at least three times the current number.

Results of simple average calculation at the country level. The results of the two methods of calculation above were compared with the estimates of simple average figures at the country level. This simple averaging was done by dividing the total number of staff of the sample by the total area of the sample divided by 1,000 ha to obtain the average number of staff per 1,000 ha for the particular country. This single average was then used to estimate the staff benchmark and gap for the country. Table 34 shows the results of these calculations. It shows extremely high levels of understaffing. The average gap was 1,819% or more than 10 times the existing number of full-time staff.

Comparing the results of using simple averages (non-clustered PAs) versus clustered PAs (Methods 1 and 2). Table 35 shows the comparison of understaffing at the country level using the different methods of calculations. To use simple averaging would overestimate the understaffing of PAs in each country, except for Lao PDR because there was no clustering of the PAs done there. The estimates of understaffing percentages were reduced by clustering the PAs. The ratio of benchmark to existing full-time staff ranged from 1.5:1 to 3.3:1.

Cambodia and the Philippines had the lowest and highest ratios, respectively. Thus, the choice of averaging method was critical primarily for the Philippine case because of the difference of 71% between Methods 1 and 2. The differences between these two averaging methods were not uniform among the countries. Five countries, namely, Cambodia, Indonesia, Philippines, Thailand, and Vietnam increased percentage understaffing by 3%, 12%, 71%, 5% and 2%, respectively, under Method 2.

Table 32. Analysis of staff gaps based on clustered PAs of each country (Method1)[1]

Country	Total Area Included in Analysis for Staff	Number of PAs included in the Analysis	Existing Number of Staff of Sample	Benchmark Staff of Sample[2]	Staff Gap of Sample	National Gap[3]	% Understaffed[4]	Ratio of Benchmark to Existing Staff
Cambodia	3,324,606.00	23	891	1,340	449	449	50	1.5:1
China	5,860,118.85	58	4,650	10,311	5,661	89,529	122	2.2:1
Indonesia	1,739,587.08	49	1,588	3,483	1,895	24,511	119	2.2:1
Lao PDR	3,545,300.00	20	644	1,715	1,071	1,191	166	2.7:1
Malaysia	1,449,498.51	44	607	1,055	448	603	74	1.7:1
Philippines	1,509,557.30	79	259	670	412	1,478	159	2.6:1
Thailand	5,308,862.26	79	4,481	7,306	2,825	5,462	63	1.6:1
Vietnam	1,614,258.00	53	2,910	4,806	1,896	2,583	65	1.7:1
Regional Total	**24,351,788.00**	**405**	**16,030**	**30,687**	**14,657**	**125,806**	**91**	**1.9:1**

Notes: (1) The total number of full-time staff of each PA was divided by the area in 1,000 ha to get the number of full-time staff per 1,000 ha. Then the averages of these values were calculated per cluster to get the average value of full-time staff per cluster. (2) The "Benchmark Staff of Sample" is equal to the existing total number of full-time staff in the sample plus the estimated total gap in full-time staff in the sample.
(3) The national gap was extrapolated using the ratio of total area of PAs in the country to total area of PAs included in the sample. (4) The percentage of understaffing is the ratio of the staff gap of the sample to the existing number of staff of the sample.

Table 33. Analysis of staff gaps based on clustered PAs of each country (Method 2)[1,2]

Country	No. of PAs Included in the Analysis	Existing No. of Staff of Sample	Benchmark Staff of Sample	Staff Gap of Sample	National Gap	% of Understaffing	Ratio of Benchmark to Existing Staff
Cambodia	23	891	1,365	474	467	53	1.5:1
China	58	4,650	9,916	5,266	83,273	113	2.1:1
Indonesia	49	1,588	3,674	2,086	26,984	131	2.3:1
Lao PDR	20	644	1,071	427	475	66	2.7:1
Malaysia	44	607	1,012	405	546	67	1.7:1
Philippines	79	259	854	595	2,137	230	3.3:1
Thailand	79	4,481	7,539	3,058	5,913	68	1.7:1
Vietnam	53	2,910	4,867	1,957	2,665	67	1.7:1
Regional Total	**405**	**16,030**	**30,298**	**14,913**	**122,458**	**89**	**1.9:1**

Table 34. Analysis of staff gaps based on simple averages in each country

Country	Total Area Included in Analysis for Staff	No. of PAs Included in the Analysis	Existing No. of Staff of Sample	Benchmark Staff of Sample	Staff Gap of Sample	National Gap	% of Understaffing
Cambodia	3,324,606.00	23	891	3,255	2,364	2,364	265
China	5,860,118.85	58	4,650	46,083	41,433	655,216	891
Indonesia	1,739,587.08	49	1,588	69,645	68,057	880,198	4,286
LaoPDR	3,545,300.00	20	644	1,696	1,052	1,171	163
Malaysia	1,449,498.51	44	607	34,142	33,535	45,172	5,525
Philippines	1,509,557.30	79	259	7,535	7,276	26,115	2,809
Thailand	5,308,862.26	79	4,481	12,249	7,768	15,018	173
Vietnam	1,614,258.00	53	2,910	15,761	12,851	17,505	442
Regional Total	24,351,788.00	405	16,030	190,366	174,336	1,642,757	1,088

Note: Refer to the notes in Table 29 for the explanations of the column headers.

Table 35. Comparison of three methods of calculation of staff gaps at the country level

Country	% of Understaffing Using Simple Averages	Method 1		Method 2		Percentage Diff (Method 2 minus Method 1)
		Ratio of Benchmark to Existing Staff	Percentage of Understaffing	Ratio of Benchmark to Existing Staff	Percentage of Understaffing	
Cambodia	265	1.5:1	50	1.5:1	53	+3
China	891	2.2:1	122	2.1:1	113	–9
Indonesia	4,286	2.2:1	119	2.3:1	131	+12
Lao PDR	163	2.7:1	166	2.7:1	166	0
Malaysia	5,525	1.7:1	74	1.7:1	67	–7
Philippines	2,809	2.6:1	159	3.3:1	230	+71
Thailand	173	1.6:1	63	1.7:1	68	+5
Vietnam	442	1.7:1	65	1.7:1	67	+2
Average	*1617*	1.9:1	*102*	1.9:1	*100*	–3
Regional Total	1,088	1.5:1	91	1.5:1	89	–2

5.3.2 Gap analysis of full-time staff at the regional level

The intent of deriving the above estimates was to show the differences between the estimates done at the country level versus the estimates of pooled regional PA data. The same method of benchmarking was applied at the regional level, but this time, by taking the highest and average benchmarks of clusters of pooled PAs in the region. Table 36 shows the results of calculations using Method 1 applied to the regional pooled data. The percentage of understaffing was at least three times that of existing staff. The Philippines had the highest staffing gap and the lowest was China with 720% and 211%, respectively.

Table 37 shows the results of the calculation of staff gaps of pooled data using Method 2. The results of using this method of calculation were higher absolute numbers and percentages of understaffing. However, the pattern was not the same among countries; some declined while others increased.

Table 38 shows the resulting percentage differences and ratios of benchmark to existing staff of the two methods using pooled PA data. The results were not similar across countries. The largest and smallest changes were for the Philippines and Malaysia with 180% and 1% reduction, respectively. The average reduction for the eight countries was 28%. However, there was a 15% increase in the regional total. In Method 1, the Philippines and China had the highest and lowest ratios of benchmark to existing staff with 8.2:1 and 3.1:1, respectively. However, in Method 2, the Philippines and Cambodia had the highest and lowest ratios between benchmark and existing staff at 6.4:1 and 3.0:1, respectively.

Table 39 shows the comparison of staff gaps using the country-level estimates and pooled data for both methods. The difference in estimates at the regional level, in view of the different benchmarks, was almost three times the country-level estimates; the averages of the differences between country level and regional level were 296% and 263% using Methods 1 and 2, respectively. This comparison between country level benchmarking and regional level benchmarking provided a number of lessons:

1. The regional benchmark against which the PAs were compared was at least three times higher than country level estimates.
2. The total gaps increased because of the larger number of small PAs that increased the aggregated benchmark.
3. The pooling of data at the regional level to arrive at a benchmark by which individual PAs would be compared against overestimated the fiscal gap more than a single regional benchmark based on simple averaging.
4. There was a need to increase the number of clusters to minimize the effects of wider gaps between average and highest benchmarks.

Table 36. Estimates of staff gaps based on pooled data (Method 1)[1]

Country	Total Area of PAs Included in Analysis	No. of PAs Included in the Analysis	Existing No. of Staff	Bench-mark Staff of Sample	Staff Gap of Sample	National Gap	% of Under-staffing
Cambodia	3,324,606	23	891	3,028	2,137	2,137	240
China	5,860,119	54	5,257	16,334	11,077	175,175	211
Indonesia	1,565,947	43	1,582	5,732	4,150	72,071	262
Lao PDR	3,545,300	20	644	3,651	3,007	3,345	467
Malaysia	1,673,582	44	1,044	4,206	3,162	3,689	303
Philippines	1,509,557	79	259	2,122	1,863	6,687	720
Thailand	4,811,091	79	4,448	17,113	12,665	27,018	285
Vietnam	1,614,258	53	2,910	9,815	6,905	9,405	237
Regional Total	**23,904,461**	**395**	**17,035**	**62,001**	**44,966**	**299,527**	**264**

Note: [1]The total number of full-time staff of each PA was divided by the area in 1,000 ha to get the number of full-time staff per 1,000 ha. Then the averages of these values were calculated per cluster to get the average value of full-time staff per cluster.

Table 37. Estimates of staff gaps based on pooled data (Method 2)[1]

Country	Total Area of PAs Included in Analysis	No. of PAs Included in the Analysis	Existing No. of Staff	Benchmark Staff of Sample	Staff Gap of Sample	National Gap	% of Understaffing
Cambodia	3,324,606	23	891	2,629	1,738	1,738	195
China	5,860,119	54	5,257	18,746	13,489	213,309	257
Indonesia	1,565,947	43	1,582	5,697	4,115	71,465	260
Lao PDR	3,545,300	20	644	3,136	2,492	2,773	387
Malaysia	1,673,582	44	1,044	4,197	3,153	3,679	302
Philippines	1,509,557	79	259	1,656	1,398	5,016	540
Thailand	4,811,091	79	4,448	18,319	13,871	29,591	312
Vietnam	1,614,258	53	2,910	10,136	7,226	9,842	248
Regional Total	**23,904,461**	**395**	**17,035**	**64,517**	**47,482**	**337,413**	**279**

Note: [1]The average values were obtained by summing up all the numbers of full-time staff in each cluster divided by the sum of the total area of the sample PAs in the cluster divided by 1,000 to get the average full-time staff per 1,000 ha at the country level.

Table 38. Differences in understaffing gaps between Averaging Methods 1 and 2 using pooled PA data

Country	Averaging Method 1		Averaging Method 2		% Difference (Method 2 minus Method 1)
	% of Understaffing	Ratio of Benchmark to Existing Staff	% of Understaffing	Ratio of Benchmark to Existing Staff	
Cambodia	240	3.4:1	195	3.0:1	–45
China	211	3.1:1	257	3.6:1	+46
Indonesia	262	3.6:1	260	3.6:1	–2
Lao PDR	467	5.7:1	387	4.9:1	–80
Malaysia	303	4.0:1	302	4.0:1	–1
Philippines	720	8.2:1	540	6.4:1	–180
Thailand	285	3.8:1	312	4.1:1	+27
Vietnam	237	3.4:1	248	3.5:1	+11
Average	*341*		*313*		*–28*
Regional Total	**264**	**3.6:1**	**279**	**3.8:1**	**15**

Table 39. Comparison of country-level estimates versus pooled regional data on PA staff gaps

Country	Using Method 1			Using Method 2		
	Staff Gap of Country Level Estimates	Staff Gap of Pooled Regional Data Estimates	% Difference between Country Level and Pooled Data	Staff Gap of Country Level Estimates	Staff Gap of Pooled Regional Data Estimates	% Difference between Country Level and Pooled Data
Cambodia	449	2,137	376	467	1,738	272
China	89,529	175,175	96	83,273	213,309	156
Indonesia	24,511	72,071	194	26,984	71,465	165
Lao PDR	1,191	3,345	181	1,191	2,773	133
Malaysia	603	3,689	511	546	3,679	574
Philippines	1,478	6,687	353	2,137	5,016	135
Thailand	5,462	27,018	395	5,913	29,591	400
Vietnam	2,583	9,405	264	2,665	9,842	269
Average			*296*			*263*
Regional Total	**125,806**	**299,527**	**138**	**123,175**	**337,413**	**174**

5.4 Gap Analysis of PA Operating Expenses

The gap analysis for operating expenditure followed the same procedure as that of the PA staff. We limited the definition of operating expenditure by excluding the highly variable capital expenditure, which was not consistent on a year-to-year basis. A conversion of the OpEx using the purchasing power parity (PPP) rate was included in order to compare with the existing OpEx-adjusted using purely market exchange rates (MER). Table 40 summarizes the OpEx data of the eight countries covered by the study. The OpEx was adjusted using both MER and PPP rates.

Table 40. Total number of PAs and total OpEx included in the analysis

Country	Total Area Included in the Analysis of OpEx	Number of PAs Included in the Analysis	Existing MER-Adjusted OpEx of Sample	Existing PPP Rate-Adjusted OpEx of Sample
Cambodia	3,324,606	23	1,241,476	1,241,476
China	5,762,675	44	21,384,934	38,805,932
Indonesia	1,499,445	49	7,891,991	14,090,472
LaoPDR	3,545,300	20	1,325,475	3,355,829
Malaysia	1,100,177	28	6,919,310	13,737,455
Philippines	1,509,557	79	1,086,198	2,173,526
Thailand	5,308,862	79	13,320,677	27,126,650
Vietnam	1,614,258	53	8,010,997	21,693,963
Regional Total	**23,664,881**	**375**	**61,181,058**	**122,225,304**

Note: PPP = purchasing power parity; MER = market exchange rate

Of the 411PAs that responded to the survey, the total number of PAs included in this analysis was only 375 because some PAs did not have operating expenditure data. The results of the analysis are presented below.

5.4.1 Country-level estimates of OpEx gaps

The methods used to estimate the operating expenditure gaps were similar to the two methods employed in the full-time staff gap analysis. The results showed slightly different estimates of gaps for the sample PAs and extrapolation of the national gaps.

Results of Method 1 calculation at the country level. Tables 41 and 42 show the results of the country-level estimates of the operating expenditure gaps of the sample PAs and the extrapolation of the national gaps using Method 1. Malaysia and Philippines had the lowest and highest gaps with 25% and 216%, respectively. The average country estimate was 115%, which means that based on the current country benchmark, each country should at least double its current spending for operation of the PAs. The PPP-adjusted OpEx was approximately twice as large as the MER-adjusted OpEx.

Results of Method 2 calculation at the country level. Table 43 shows the results using the second method. The average for the eight project countries was 139%, which is 24% points higher than in Method 1. Malaysia had the lowest gap, while the Philippines had the highest at 28% and 324%, respectively.
These estimates indicate that the Philippines has to increase its operational spending by at least four times the current level. Again, the estimates also indicate that each country should at least double its current spending on PA operations, based on the country-level averages and highest benchmarks (refer to last columns of Tables 43 and 44 below).

Table 41. Comparison of country-level estimates of OpEx gaps using Method 1 (using MER[1], USD)

Country	Benchmark OpEx of Sample	OpEx Gap of Sample	National Gap	National Benchmark	% of Underfunding
Cambodia	2,462,881	1,221,405	1,221,405	2,462,881	98
China	43,128,092	21,743,158	349,657,482	693,554,268	102
Indonesia	20,499,599	12,607,608	189,170,447	371,773,401	160
LaoPDR	2,626,854	1,301,379	1,448,042	2,922,896	98
Malaysia	8,639,118	1,719,808	3,052,174	15,331,994	25
Philippines	3,431,377	2,345,179	8,417,039	12,315,492	216
Thailand	29,570,535	16,249,858	31,415,779	57,168,586	122
Vietnam	17,453,430	9,442,433	12,861,323	23,772,919	118
Regional Total	**127,811,886**	**66,630,829**	**597,243,691**	**1,179,302,437**	**109**

Note: [1]OpEx converted using MER for 375 sample PAs

Table 42. Comparison of country-level estimates of OpEx gaps using Method 1 (using PPP rates[1], USD)

Country	Benchmark OpEx of Sample	OpEx Gap of Sample	National Gap	National Benchmark	% of Underfunding
Cambodia	2,462,881	1,221,405	1,221,405	2,462,881	98
China	78,261,912	39,455,980	634,502,057	1,258,550,531	102
Indonesia	34,364,108	20,273,635	304,195,105	515,615,138	144
LaoPDR	6,650,653	3,294,824	3,666,145	7,400,171	98
Malaysia	17,151,927	3,414,472	6,059,723	30,439,826	25
Philippines	6,866,325	4,692,799	16,842,836	24,643,798	216
Thailand	60,218,377	33,091,727	63,976,091	116,419,923	122
Vietnam	47,264,289	25,570,325	34,828,757	64,377,609	118
Regional Total	**253,240,471**	**131,015,167**	**1,065,292,119**	**2,019,909,878**	**107**

Note: [1]OpEx converted using PPP rates for 375 sample PAs

Table 43. Estimation of OpEx gaps using Method 2 (using MER[1], USD)

Country	Benchmark OpEx of Sample	OpEx Gap of Sample	National Gap	National Benchmark	% of Underfunding
Cambodia	2,394,086	1,152,610	1,134,788	2,357,068	93
China	51,073,454	29,688,520	477,428,945	821,325,731	139
Indonesia	20,681,979	12,789,988	191,906,966	310,322,091	162
Lao PDR	2,626,854	1,301,379	1,448,042	2,922,896	98
Malaysia	8,824,068	1,904,758	3,380,407	15,660,228	28
Philippines	4,602,954	3,516,756	12,621,925	16,520,377	324
Thailand	31,191,524	17,870,847	34,549,629	60,302,435	134
Vietnam	18,583,646	10,572,649	14,400,765	25,312,361	132
Regional Total	**139,978,564**	**78,797,507**	**736,871,466**	**1,254,723,187**	**129**

Note: [1]OpEx converted using MER for 375 sample PAs

Table 44. Estimation of OpEx gaps using Method 2 (using PPP rates, USD)[1]

Country	Benchmark OpEx of Sample	OpEx Gap of Sample	National Gap	National Benchmark	% of Underfunding
Cambodia	2,394,086	1,152,610	1,134,788	2,357,068	93
China	92,679,874	53,873,942	866,361,120	1,490,409,594	139
Indonesia	36,925,898	22,835,425	342,633,401	554,053,434	162
Lao PDR	6,650,653	3,294,824	3,666,145	7,400,171	98
Malaysia	17,519,123	3,781,667	6,711,392	31,091,495	28
Philippines	9,210,698	7,037,172	25,256,983	33,057,945	324
Thailand	63,519,409	36,392,759	70,357,961	122,801,794	134
Vietnam	50,324,940	28,630,976	38,997,600	68,546,452	132
Regional Total	**279,224,680**	**156,999,375**	**1,355,119,389**	**2,309,717,953**	**128**

Note: [1]OpEx converted using PPP rates for 375 sample PAs

Comparison of country-level estimation of gaps using Methods 1 and 2. Table 45 compares the country-level calculation of percentages of underspending and ratios of benchmark to existing OpEx per hectare using the two methods. The estimates using Method 2 for underspending of the countries, except in Cambodia, increased on average by 27%. The estimates for the Philippines using Method 2 increased by 108% or twice that of Method 1. In terms of ratios of benchmark and existing OpEx, the Philippines had the highest at 3.2:1 and 4.2:1 using Methods 1 and 2, respectively. Malaysia had the lowest with 1.2:1 and 1.3:1 using Methods 1 and 2, respectively.

The differences in gap estimates derived from the two methods were influenced by the average and highest values of OpEx per cluster. If the average value per hectare in the cluster was low, then more samples would be compared to the highest value per hectare. This would result in higher estimates of gaps, which was the case for Method 2. The highest value of OpEx per hectare was likewise a result of the conversion of the OpEx to per hectare values; small areas (below 1,000 ha) with very large OpEx translated to high per hectare values. These values became the benchmarks for the clusters. Computing the gaps using simple averages would further magnify these effects.

Table 45. Comparison of Methods 1 and 2 estimations of OpEx gaps at the country level

Country	Method 1		Method2		% Difference (Method 2 minus Method 1)
	% of Underfunding	Ratio of Benchmark to Existing OpEx	% of Underfunding	Ratio of Benchmark to Existing OpEx	
Cambodia	98	2.0:1	93	1.9:1	–6
China	102	2.0:1	139	2.4:1	37
Indonesia	160	2.4:1	162	2.6:1	18
Lao PDR	98	2.0:1	98	2.0:1	0
Malaysia	25	1.2:1	28	1.3:1	3
Philippines	216	3.2:1	324	4.2:1	108
Thailand	122	2.2:1	134	2.3:1	12
Vietnam	118	2.2:1	132	2.3:1	14
Average	115		139		23
Regional Total	**109**	**2.1:1**	**129**	**2.3:1**	**22**

5.4.2 Regional-level estimates of operating expenditure

A total of 375 sample PAs were included in the regional-level analysis of operating expenditure. In the country-level analysis of staff, 405 samples were included. The difference was due to missing or unavailable data on OpEx for some PAs, hence they were excluded from the OpEx estimations. Table 46 shows the corresponding total OpEx values converted using MER and PPP rates at the country level. The results of the OpEx gap estimation at the regional level follow.

Table 46. Summary of PAs, total area, and total OpEx (USD)

Country	Total Area of PAs Included in Analysis	No. of PAs Included in Analysis	Existing OpEx*	Existing OpEx**
Cambodia	3,324,606	23	1,241,476	1,241,476
China	5,009,620	44	26,256,491	47,646,049
Indonesia	1,449,445	38	7,890,722	14,088,206
Lao PDR	3,545,300	20	1,325,475	3,355,829
Malaysia	1,479,600	39	6,919,310	6,919,310
Philippines	1,509,557	79	1,086,198	2,173,526
Thailand	4,811,091	79	13,359,433	27,205,573
Vietnam	1,614,258	53	8,010,997	21,693,963
Regional Total	**22,743,477**	**375**	**66,090,101**	**124,323,932**

Notes: (1) *MER-adjusted; (2) **PPP rate-adjusted

Results of Method 1 calculation at the regional level. Tables 47 and 48 show the estimates of OpEx gaps using Method 1. China and the Philippines had the lowest and highest OpEx gaps at 218% and 918%, respectively. The average percentage gap was 494% which means that, on average, each country have to increase its operating expenditure by almost six times the current operating expenditure. The Philippines have to increase its operating expenditure by 10 times in order to match the average and highest benchmark in the region.

Results of Method 2 calculation at the regional level. Tables 49 and 50 show the operating expenditure gap estimates at the regional level using Method 2. The average OpEx gap was 455%, which means that each country needs to increase its operating expenditure by at least five times the current level. This relatively large increase required is due to the higher value of average and highest value benchmarks at the regional level against which the sample PAs were compared. The results of the PPP rate-adjusted values were almost twice the MER-adjusted values.

Comparison of regional level results of the two methods. Table 51 shows the percentage differences between Methods 1 and 2 and the ratios of benchmark to existing OpEx. The average OpEx gap declined by 39%. The estimates for China, Indonesia, Malaysia, Thailand, and Vietnam increased while the rest reduced by an average of 218%. When the MER-adjusted values were used, the Philippines had the highest ratio of benchmark to existing OpEx with 10.2:1 and 7.5:1 for Methods 1 and 2, respectively. When using the PPP rate-adjusted values (Table 52), Cambodia had the highest ratio. China had the lowest ratios at 3.2:1 and 3.5:1 ratios in Methods 1 and 2, respectively, using MER-adjusted values. Again, the two averaging methods showed significant differences in estimates. Method 2 had lower estimates of gaps compared to Method 1.

Table 47. OpEx gap estimates using Method 1 (using MER[1], USD)

Country	Benchmark OpEx	OpEx Gap (Sample)	OpEx Gap (National)	% OpEx Gap
Cambodia	9,129,323	7,887,847	7,887,847	635
China	83,602,219	57,345,727	1,060,817,348	218
Indonesia	34,830,968	26,940,246	418,168,149	341
Lao PDR	10,811,670	9,486,195	10,555,275	716
Malaysia	33,579,423	26,660,113	35,181,127	385
Philippines	11,056,653	9,970,455	35,784,775	918
Thailand	53,729,910	40,370,478	86,123,171	302
Vietnam	42,604,048	34,593,051	47,118,405	432
Average				494
Regional Total	**279,344,214**	**213,254,113**	**1,701,636,097**	**323**

Note:[1]OpEx adjusted using MER for 375 sample PAs

Table 48. OpEx gap estimates using Method 1 (using PPP rates[1], USD)

Country	Benchmark OpEx	OpEx Gap (Sample)	OpEx Gap (National)	% OpEx Gap
Cambodia	17,215,121	15,973,645	15,973,645	1,287
China	150,820,181	103,174,132	1,908,580,008	217
Indonesia	57,308,641	43,220,436	670,870,247	307
Lao PDR	20,445,725	17,089,895	19,015,901	509
Malaysia	25,085,406	18,166,097	23,972,282	263
Philippines	19,668,153	17,494,627	62,789,639	805
Thailand	110,146,020	82,940,447	176,938,562	305
Vietnam	100,602,511	78,908,548	107,479,533	364
Average				527
Regional Total	**501,291,758**	**376,967,826**	**2,985,619,817**	**303**

Note:[1]OpEx adjusted using PPP rates for 375 sample PAs

Table 49. OpEx gap estimates using Method 2 (using MER[1], USD)

Country	Benchmark OpEx	OpEx Gap (Sample)	OpEx Gap (National)	% OpEx Gap
Cambodia	6,958,775	5,717,299	5,717,299	461
China	93,046,501	66,790,009	1,235,523,619	254
Indonesia	36,915,768	29,025,047	450,528,553	368
Lao PDR	7,979,692	6,654,217	7,404,138	502
Malaysia	40,423,301	33,503,991	44,212,421	484
Philippines	8,177,926	7,091,728	25,452,788	653
Thailand	77,477,347	64,117,914	136,784,065	480
Vietnam	43,041,960	35,030,963	47,714,876	437
Average				455
Regional Total	**314,021,269**	**247,931,168**	**1,953,337,758**	**375**

Note:[1]OpEx adjusted using MER for 375 sample PAs

Table 50. OpEx gap estimates using Method 1 (using PPP rates[1], USD)

Country	Benchmark OpEx	OpEx Gap (Sample)	OpEx Gap (National)	% OpEx Gap
Cambodia	9,129,323	7,887,847	7,887,847	635
China	83,602,219	57,345,727	1,060,817,348	218
Indonesia	34,830,968	26,940,246	418,168,149	341
Lao PDR	10,811,670	9,486,195	10,555,275	716
Malaysia	33,579,423	26,660,113	35,181,127	385
Philippines	11,056,653	9,970,455	35,784,775	918
Thailand	53,729,910	40,370,478	86,123,171	302
Vietnam	42,604,048	34,593,051	47,118,405	432
Average				455
Regional Total	**548,594,289**	**424,270,357**	**3,273,648,900**	**341**

Note:[1]OpEx adjusted using PPP rates for 375 sample PAs

Table 51. Comparison of OpEx gaps using Methods 1 and 2 (using MER[1],USD)

Country	Method 1		Method2		% Difference (Method 2 minus Method 1)
	% of Underfunding	Ratio of Benchmark to Existing OpEx	% of Underfunding	Ratio of Benchmark to Existing OpEx	
Cambodia	635	7.4:1	461	5.6:1	–175
China	218	3.2:1	254	3.5:1	36
Indonesia	341	4.4:1	368	4.7:1	26
Lao PDR	716	8.2:1	502	6.0:1	–214
Malaysia	385	4.9:1	484	5.8:1	99
Philippines	918	10.2:1	653	7.5:1	–265
Thailand	302	4.0:1	480	5.8:1	178
Vietnam	432	5.3:1	437	5.4:1	5
Average	*494*		*455*		*–39*
Regional Total	**323**	**4.2:1**	**375**	**4.8:1**	**52**

Note:[1]OpEx adjusted using MER for 375 sample PAs

Table 52. Comparison of OpEx gaps using the Methods 1 and 2 (using PPP rates[1] ,USD)

Country	Averaging Method 1		Averaging Method 2		% Difference (Method 2 minus Method 1)
	% of Underfunding	Ratio of Benchmark to Existing OpEx	% of Underfunding	Ratio of Benchmark to Existing OpEx	
Cambodia	1,287	13.9:1	948	10.5:1	–339
China	217	3.2:1	225	3.2:1	8
Indonesia	307	4.1:1	375	4.8:1	68
Lao PDR	509	6.1:1	345	4.4:1	–164
Malaysia	263	3.6:1	341	4.4:1	79
Philippines	805	9.0:1	577	6.8:1	–228
Thailand	305	4.0:1	448	5.5:1	143
Vietnam	364	4.6:1	383	4.8:1	19
Average	527		*455*		*–38*
Regional Total	**303**	**4.0:1**	**341**	**4.4:1**	**52**

Note: [1]OpEx adjusted using PPP rates for 375 sample PAs

5.4.3 Comparing country- vs. regional-level estimates

Tables 53 and 54 show that the regional-level estimates of operating expenditure gaps were higher by 418% and 368% for Methods 1 and 2, respectively. These results show that regional comparisons produced higher values than national estimates. This means that using regional averages and highest values as benchmarks at the regional level would tend to produce higher estimates and possibly overestimate the OpEx gap. PAs are defined and classified differently, thus, researchers should be careful when interpreting results for all types of PAs. Some country reports recommended a regional analysis of PAs by type of PA. PAs in the region vary widely in size. This finding proved to be the turning point of the study toward a more complex analysis of resources gaps and presented slight complications in the analysis. Nonetheless, this research has contributed to PA financing literature by providing insights on the different forms of estimation using clustering of PAs by size.

Financial support and income of PAs come from varied sources—from local to international, from private businesses to NGOs, and from user fees. Using simple averages of response indicators produced higher estimates of resource gaps while clustering the PAs into three or four size classes produced much lower estimates. The former happened when the response indicators of small-sized parks were transformed to per 1,000 ha. The difference between the simple-average estimates and clustered PA estimates was more than 200%. Fiscal gaps, in terms of staff, varied widely when using simple averages versus clustered PAs. Fiscal gaps, in terms of operating expenditure, had the same pattern of results, with large differences between simple-average and clustered PAs estimates.

Table 53. Comparison of country- and regional-level OpEx gaps using Methods 1 and 2 (using MER[1], USD)

Country	Method 1			Method 2		
	Country Level	Regional Level	% Diff	Country Level	Regional Level	% Diff
Cambodia	1,221,405	7,887,847	546	1,134,788	5,717,299	404
China	349,657,482	1,060,817,348	203	477,428,945	1,235,523,619	159
Indonesia	170,377,901	418,168,149	145	191,906,966	450,528,553	135
Lao PDR	1,448,042	10,555,275	629	1,448,042	7,404,138	411
Malaysia	3,052,174	35,181,127	1,053	3,380,407	44,212,421	1,208
Philippines	8,417,039	35,784,775	325	12,621,925	25,452,788	102
Thailand	31,415,779	86,123,171	174	34,549,629	136,784,065	296
Vietnam	12,861,323	47,118,405	266	14,400,765	47,714,876	231
Ave % Diff			418			368
Regional Total	**578,451,145**	**1,701,636,097**	**194**	**736,871,466**	**1,953,337,758**	**165**

Note:[1]OpEx adjusted using MER for 375 sample PAs

Table 54. Comparison of country- and regional-level OpEx gaps using Methods 1 and 2 (using PPP rates[1], USD)

Country	Method 1			Method 2		
	Country Level	Regional Level	% Diff	Country Level	Regional Level	% Diff
Cambodia	1,221,405	15,973,645	1,208	1,152,610	7,887,847	937
China	39,455,980	103,174,132	201	53,873,942	57,345,727	128
Indonesia	20,273,635	43,220,436	121	22,835,425	26,940,246	139
Lao PDR	3,294,824	17,089,895	419	3,294,824	9,486,195	251
Malaysia	3,414,472	18,166,097	296	3,781,667	26,660,113	364
Philippines	4,692,799	17,494,627	273	7,037,172	9,970,455	78
Thailand	33,091,727	82,940,447	177	36,392,759	40,370,478	269
Vietnam	25,570,325	78,908,548	209	28,630,976	34,593,051	190
Ave % Diff			363			295
Regional Total	**131,015,167**	**1,701,636,097**	**180**	**156,999,375**	**424,270,357**	**142**

Note:[1]OpEx adjusted using PPP rates for 375 sample PAs

6.0 CONCLUSIONS

Several conclusions can be drawn from this research project. At the country level, the results showed direct correlations between internal and external pressures on the response indicators, but mostly these were weak positive correlations. Operating expenditure was found to have positive correlation with population within 5 km of the PA; visitors per 1,000 ha; and number of inhabitants per 1,000 ha within the PA. In some countries, the length of roads per 1,000 ha also showed a direct positive relationship, but mostly the relationship was weak. Full-time staff, on the other hand, had positive correlation with number of visitors per 1,000 ha; population within 5 km of the PA; and number of roads and trails per 1,000 ha.

The analysis of regionally pooled data showed weak direct positive correlation between the untransformed data of the pressure and response variables. However, by removing outliers and by transformation of the data, these variables showed positive and strong direct relationships, similar to the results of a Malaysian country study.[3]

The Pearson correlation tests for selected pressure and response indicators showed weak negative and positive correlations. The signs of the Pearson coefficient were, however, consistent with expectations. Scatter plots of the original untransformed data also indicated weak positive relationships between pressure and response variables. Transforming the pooled data of pressure and response variables, particularly for PA visitors, into $\log_2$ or $\log_{10}$, and subsequent scatter plots showed positive and direct correlations between the indicators. The normality tests on visitors, staff, and OpEx data showed skewed distributions suggesting non-normality. These skewed patterns were deemed relevant in the analysis of the fiscal gaps. If the outliers were real occurrence, then they could affect estimates of fiscal gaps by either bringing down or raising the estimated values of the indicators.

In the analysis of fiscal gaps, estimations using simple averages at the country level exhibited relatively high estimates of understaffing and underfunding because of the influence of several outliers. Clustering of the indicators was deemed necessary after further analysis of the scatter plots. Hence, the data for both country and regional levels of analysis were clustered. Clustering of the PAs showed consistent positive relationships, which indicates that using simple averages would overestimate the fiscal gaps.

The canonical correlation analysis established the relationship between the identified pressure and response variables. The variables full-time staff, number of patrol stations, and operating expenditure were useful in analyzing the pressure-response relationships. However, operating expenditure did not show a concrete correlation as a response variable to length of roads and trails. This indicates that operating expenditure, which is commonly provided by governments, is not responsive to pressures on PAs.

Based on the results of the analyses at the country level, PAs in Southeast Asia and China are understaffed by 50%–230%, respectively. The ratios of country benchmarks to the existing number of full-time staff ranged between 1.5:1 and 3.3:1. The use of straightforward averages (Method 2) within clusters and a three-step averaging method (Method 1) showed different directions of estimates. For some countries, Method 2 showed high estimates; for other countries, Method 1 showed high estimates of fiscal gaps. Nonetheless, the results suggest that countries in SEA and China should increase their PA staff by 1.5–3.0 the times existing numbers.

Based on the results of the regional benchmarking, the understaffing gap was between 195% and 720% or an average between 313% and 341%. The ratio of the regional benchmark to existing staff numbers was between 3:1 and 8.2:1. The Philippines was consistently the highest in terms of understaffing. Based on the regional benchmark, it will need to increase its present staffing level by eight times. Using the regional benchmark, countries in the region will need to increase their staff force by three to eight times the existing levels.

The results of the operating expenditure gap analysis at the country level showed that PAs in the region were underfunded in the range of 25% (as in the case of Malaysia) and 324% (as in the case of the Philippines). The average underfunding gap was between 115% and 139%. The ratios of the national

[3] A study by Laplante and Lee (2009) using 43 samples indicated a strong positive relationship of identified pressure and response variables, the latter being full-time staff and operating expenditure.

benchmarks to current OpEx levels were between 1.2:1 and 4.2:1, with Malaysia at the lower end and the Philippines at the higher end. The use of simple averages produced very high estimates of gaps.

The results of the OpEx gap analysis at the regional level showed that the percentage of underfunding was between 218% and 918% with China and the Philippines having the lowest and highest gaps, respectively. The ratios of benchmarks to existing OpEx levels were between 3.2:1 and 10.2:1 with the same pattern as the percentages.

The regional level estimates were consistently higher than the country-level estimates because the benchmark against which all the PAs were compared was higher than the country level benchmarks, and there were a large number of small-sized PAs being compared to average and highest benchmarks.

The estimates of the fiscal gaps differed significantly when using simple averaging (unclustered PAs) and when the PAs were clustered by size. This finding is very useful in validating the results of other cross-country analyses of resource gaps in managing PAs.

7.0 POLICY IMPLICATIONS AND RECOMMENDATIONS

This research produced significant results at the country and regional levels. These results should be widely shared to support policy and decision making related to PA management as well as for future research.

The weak relationship between the pressure and response indicators suggests that PA managers' responses in terms of staff allocation and operating expenses for PA management are inadequate. The limited financial resources of national government agencies likely constrain the allocation of resources. In such a scenario, decision makers need to consider other forms and structures of PA management, which include involving the participation of local government units as well as the nongovernmental sector and private entities. In particular, the allocation of resources to large PAs is inadequate. In line with the inadequate response to pressures, the results indicated that the allocation of resources was not congruent with PA size increase. National actions should go beyond formalizing policies and implementation structures and provide sufficient resources to effectively manage large PAs.

Some concrete recommendations are put forward for policy and decision makers and researchers to consider:

1. Resources for biodiversity conservation in ASEAN countries and China should be increased. The results of this study indicate that staff numbers and operating expenses should be increased by at least twice to up to three or four times current levels.
2. External sources of financing should be found to offset deficits in funding by government institutions. Many of the PAs included in the study had no or very limited external funds. Majority of those with external funding had unique features or global benefits hence attracting international donors. Small-sized PAs rarely had funds coming from external sources.
3. Internal sourcing of funds for staff and operating expenses should be sought by promoting user charges, fees, and other payment mechanisms. As part of the diversification of resources for PAs, managers need to look for internal opportunities to charge fees and market special features of the PAs to solicit support from local settlements and PA visitors. Comparing PAs across the region using simple averages is not advisable because it will tend to overestimate the resource gaps. Instead, clustering of data for analysis is recommended. The clustering should take into account the different types and sizes of PAs.
4. This research compiled a significant amount of information, which can be further expanded to create a useful database for further analysis over time. For instance, apart from the correlation analysis that focused on evaluating the relationship between two indicators, pressure-response analysis using multiple regressions (and econometric analysis) may be undertaken to assess such explanatory variables like employment of full-time staff or allocation of operating expenditure. In addition, apart from resource gap information, this research obtained useful data on the incomes of PAs that can be

analyzed at the regional level. The data, however, need to be adjusted for exchange rates, price differences, and wage and income levels.

5. There are other pressure and response variables that were not included in the regional analysis, but which were found to have significant impact at the country level. Analyzing other pressure and response variables at the regional level in order to compare with country level analyses is therefore recommended.

6. Future research could compare the results of this research with studies from other regions of the world. However, researchers should be careful when comparing information that was collected using different methods. This research used primary data from a survey of PA managers, supplemented with interviews with national government agencies and information from the worldwide web. The benchmarking process was also different. In view of the limited information there was on regional benchmarks, an internal benchmark was set where averages and highest PA indicators were used to estimate fiscal gaps.

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