

# Analytic network process (ANP)-based spatial decision support system (SDSS) for sustainable tourism planning in Cameron Highlands, Malaysia

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**Abstract** Sustainable approach to tourism development is rarely addressed among authorities and participants. This research presents an approach based on an integrated use of analytic network process (ANP) and geographic information system (GIS) for sustainable tourism planning in Cameron Highlands, Malaysia. ANP was utilized to evaluate the relative priorities for the sustainable tourism development of the highlands based on chosen criteria. ANP results were then transferred into GIS environment and attached to their respective criterion maps. Subsequently, GIS-based sustainable tourism map was generated, which defines the various types of tourism activities that are compatible with the highlands according to the sensitivity of the highland's environment. The final output was validated using Cameron Highlands Local Plan.

**Keywords** Sustainable tourism planning · Analytic network process (ANP) · Geographic information system (GIS) · One-at-a-time (OAT) sensitivity analysis · Nature conservation

## Introduction

Tourism—a sector which has continuously recognized the natural environment as an important attraction of many destinations—is also one that can be utilized as a significant resource product (Farrell and Runyan 1991). Nevertheless, the sector is associated with pollution, indigenous culture loss, deforestation, habitat and biodiversity loss—some of the negative impacts which have caused an enduring damage to pristine environments. Tourism is the main environmental burden in some of its destinations (Tubb 2003). Indeed, this pressure destroys the natural values of the protected areas thus leading to lower amenity value for visitors.

The development of tourism facilities such as accommodation, infrastructure, and recreational facilities have led to soil erosion (Sunlu 2003), thus resulting in water pollution (EEA 2000). Furthermore, tourism-related activities such as urbanization, agricultural activities, and insufficient waste water treatment have caused pollution of surface and ground water at tourism destinations. This has negatively affected the quality of freshwater resources (Kotios et al. 2009). According to European Environmental Agency (EEA), 7% of all pollution in the Mediterranean basin is contributed by tourism (EEA 2000).

Continued growth of tourism would further damage such ecosystems. The consequences in sustaining long-term development and human well-being are serious, unless appropriate action is taken. Unfortunately, although currently available, tourism planning processes lack the refined modeling and simulation tools used in predicting potential outcomes. In addition, authorities in-charge lack decision making tools, essential tools that provide them with value-added information on remote locations and unexploited potentials.

Tourism has been acknowledged as the contributor to environmental degradation of natural areas and that it could be

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self-destructive (Eagles and McCool 2002). Contrastingly, the sector has also been acknowledged to have the potential in leading significant enhancement of the environment and economic situation of destinations (Herath 2002). Hence, tourism should be used as a means to attain sustainable development, not as an aim in itself. Many scholars have been advocating for a certain type of tourism—one that contributes to biological diversity conservation, protection of local culture, environmental education to tourists, and economic development for inhabitants and destinations (García-Melón et al. 2012).

A major tool for conservation of natural areas and raising environmental awareness among residents and visitors is sustainable tourism, which conserves both natural and cultural assets (Muhanna 2006), besides providing mechanisms required to preserve threatened areas as well as protecting wildlife. To enhance this type of tourism planning, appropriate tools such as the geographic information system (GIS) is applied. A valuable tool to environmentalists in locating areas requiring immediate attention, GIS allows for the experimentation of various management approaches in working with those resources, without risking them in the process. Spatial data are useful in exploring conflicts, examining impacts, and assisting decision making (Bahaire and Elliott-White 1999).

GIS and analytic network process (ANP) of multi-criteria evaluation (MCE) has been discovered to be compatible. In fact, GIS is further strengthened when working with ANP. Decision makers who need to translate environmental, economic, and social issues into manageable units of information would find ANP useful. Possessing the capability to evaluate physical processes—for, e.g., expert opinion on biodiversity conservation and tourism development—ANP is able to select the best among variables considered. These tools, besides offering even more tools, could further facilitate the process of sustainable tourism planning and decision making.

Past studies on the subject matter (Table 1) show that some researchers only focused on identifying the potentials of tourism destinations in relation with tourism development, without concentrating on destination conservation from tourism and related development perspectives. Furthermore, some of the past studies used only the GIS without any decision support system, such as MCE. However, this gap has been filled by certain studies that utilized an aspect of the MCE—the analytic hierarchy process (AHP), which has been criticized to be insufficient in handling complex decisions such as sustainable tourism. It is asserted that AHP is associated with hierarchical structures that assume criteria to be independent of alternatives (Schoner et al. 1993). Nekhay et al. (2009) stressed that AHP's assumption rarely occurs in real-life situation. Belton and Gear (1983) also proclaimed AHP's possible rank reversal phenomenon, meaning changes of the relative rankings of the other alternatives after an alternative is added or deleted.

Hence, for these reasons, the method has been widely criticized by a number of researchers (Barzilai 1998; Goodwin and Wright 1998; Leung and Cao 2001; Wang and Elhag 2006). These authors, in general, attribute AHP's failure to this fact—the weight of each criterion is independent of the evaluations of available alternatives with respect to this criterion, which is caused by the way in which the method elicits these weights from decision makers.

This study, therefore, employs the application of a GIS-based ANP for sustainable tourism planning, which is a more general form of AHP in MCE that would provide a significant benefit to sustainable tourism planning. This is because ANP could model complex decision problems where AHP is not sufficient, besides allowing interaction and feedback within clusters (inner dependence) and between clusters (outer dependence) (Neaupane and Piantanakulchai 2006). Like in many real-world situations, ANP considers elements and alternatives to be interdependent with each other thus making accurate predictions. Furthermore, ANP provides a thorough framework to include clusters of elements connected in any desired way to investigate the process of deriving ratio scale priorities from the distribution of influence among elements and among clusters (Saaty 2003). ANP, through its feedback mechanism, is able to better capture the complex effects of interplay in human society and, subsequently, guides researchers in selecting the best choice in a way that matches the common sense.

## Case study

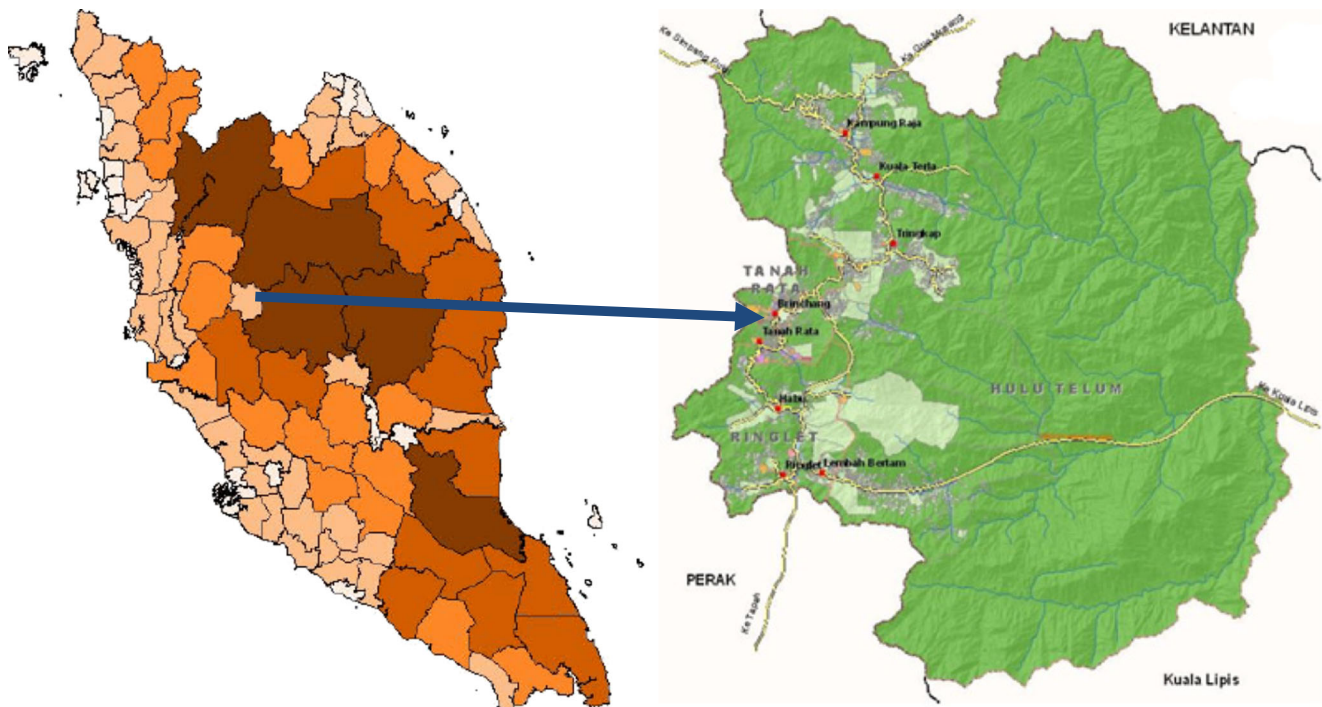
Cameron Highlands, a hill resort located on the main mountain range of Peninsular Malaysia, is situated in the state of Pahang. Its geographical coordinates are 4° 19' 16"–4° 37' 6" North, 101° 19' 59"–101° 36' 35" East, at an altitude of 1829 m above sea level. It covers an area of 712 km<sup>2</sup> (MM2H 2012) and has three townships—Brinchang, Tanah Rata, and Ringlet. Cameron Highlands is bordered by Kelantan to the north and Perak to the west (Fig. 1). Situated at the northwestern tip of Pahang, the highlands is approximately 121 km east of Ipoh (Perak State) and about 214 km north of Kuala Lumpur (Pahang Tourism 2011). Temperature at the highlands seldom rises above 25 °C during the day, while at night it could sometimes drop to as low as 9 °C.

## Materials and methods

The research approach is divided into two segments, which include ANP and spatial analysis. These segments and the major processes involved are depicted in Fig. 2.

**Table 1** Past studies

Author and year of publication	Method and tools	Purpose	Study area	Findings
Boers and Cottrell (2007)	GIS	Sustainable tourism infrastructure planning	Sinharaja Forest Reserve, Sri Lanka	Mapping of nature and cultural tourism trail networks are based on sustainability criteria. It provided directives for sustainable trail development within the reserve.
Berry (1991)	GIS	Island resource planning	US Virgin Islands	Conservation areas, ecological research areas and, areas of residential and recreational development were defined. For conflict resolution among competing uses, a fourth model was applied.
Butler (1993)	GIS	Suitable ecotourism areas identification	Northern Ontario, Canada	Different sites were ranked according to the developed criteria; sites with the best potential were also identified.
Minagawa and Tanaka (1998)	GIS and AHP	Tourism development planning	Lombok Island, Indonesia	Potential sites for tourism development were identified.
Beedasy and Whyatt (1999)	GIS and AHP	Spatial decision support system development	Mauritius	A spatial decision support system for tourism planning was developed.
Williams et al. (1996)	GIS	Tourism resource inventory information record and analysis	British Columbia, Canada	A tourism capability map indicating areas of high, moderate and low capability for specific tourism activities was developed.
Abed et al. (2011)	GIS and AHP	Evaluation of suitability for sustainable tourism destinations	Guilan Province Coast, Iran	Sustainable coastal tourism sites were determined and prioritized.
Bunruamkaew and Murayam (2011)	GIS and AHP	Identification and prioritization of potential ecotourism sites	Surat Thani Province, Thailand	Ecotourism site suitability map was developed.
Dye and Shaw (2007)	GIS	Tourist activities matching personal preferences & constraints planning	Great Smoky Mountains National Park (GSMNP), USA	An easy-to-use and flexible system was developed to assist GSMNP visitors in effectively choosing trails that better match their preference, in order to increase their satisfaction in experiencing the visit.
Zha and Wang (2010)	GIS and DBMS	Regional tourism planning and spatial decision supporting system development	Anhui Province, China	The system developed was a prediction and optimization tool for tourism planning in Anhui Province.
Fishwick and Clayson (1995)	GIS	Exclusion of certain areas from tourism development	Lake District National Park, UK	Areas that are detrimental for tourism development were generated.
Ólafsdóttir and Runnström (2007)	GIS	Evaluation on GIS potential in planning for ecologically sustainable tourism	Southeast Iceland	A tourism impact factor map was developed. The map will aid decision makers to plan and manage sustainable tourism in areas facing the risk of being subjected to ecological or cultural degradation.
Othman et al. (2010)	GIS	Database development to analyze data associated with tourist accommodations	East coast states of Malaysia	The database was developed by mapping selected components of lodging establishments in the study areas as data layers.
Abomeh and Nuga (2013)	GIS	Modeling of accessibility for tourist attractions	Lagos, Nigeria	Routes for tourist movements, i.e., from hotels to tourist attractions and restaurants in the study area, were generated.
Harun and Samat (2016)	GIS and AHP	Identifying environmentally sensitive areas to be incorporated into the process of selecting suitable sites for tourism development.	Langkawi Island, Malaysia.	Determination of environmentally sensitive areas for tourism development sites.
Shah and Wani (2015)	GIS	GIS technology for the promotion of tourist industry	Srinagar City, India	Identification of tourism destinations and tourism related facilities.



**Fig. 1** Cameron Highlands

### Analytic network process development and decision making

This approach comprises processes involved in developing the ANP model towards sustainable tourism development, which is explained in a series of steps below.

#### *Expert opinion survey*

Expert opinions were obtained using a questionnaire survey. The questionnaire was developed through a systematic way so as to capture interactions and feedback among criteria. This is in accordance with previous studies on a GIS-based ANP (Neaupane and Piantanakulchai 2006; Nekhay et al. 2009). In this study, questionnaires were distributed to the experts (Table 2). Given the complex nature of the method under consideration, follow-up interviews were conducted to ensure that the respondents fully understood the questionnaire content.

#### *Analytic network process*

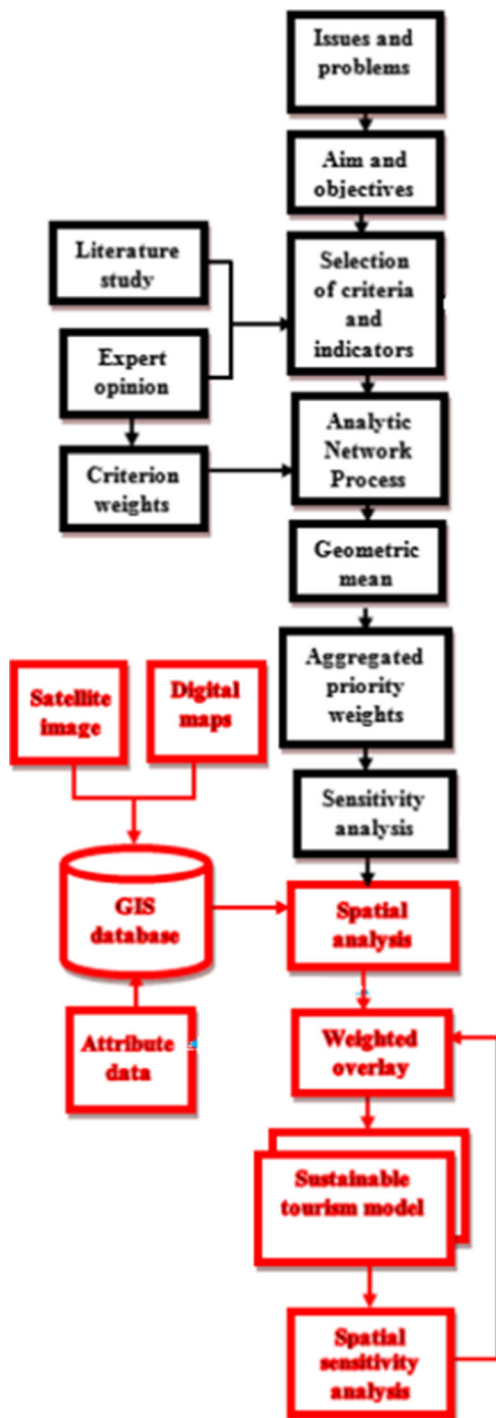
Generally, a standard ANP application is carried out in a sequence of steps as follows:

**Model construction** This step is used to classify clusters and generate network topology of the ANP model for the problem studied on (Zhang 2013). The model is represented by a network structure that indicates all dependences among clusters

and determines the direction of influence. As seen in Fig. 3, connections can be set among criteria (nodes) within a cluster (i.e., inner dependence), as indicated by a self-loop on that cluster. Connections can also be set between nodes in different clusters (i.e., outer dependence), as indicated by a line between the clusters, with an arrow on it from the cluster containing the parent node or from both clusters when there is a mutual influence.

The ANP model for the study has been defined with its corresponding clusters and criteria. The clusters for the study include accessibility, cultural heritage, ecosystem diversity, and wildlife. Accessibility cluster has two criteria (node)—proximity from main road and proximity to eco-trail; cultural heritage cluster has aboriginal settlement and cultural ground as criteria; ecosystem diversity cluster criteria are elevation, viewshed, water quality, slope, open space, and forest reserve; and lastly, wildlife cluster has species habitat, rare flora, and endangered fauna as criteria (Fig. 3).

**Pairwise comparison and relative weight estimation** The ANP control hierarchy provides overriding criteria for comparing each type of interaction in the network. Saaty (1999) proposed four basic control hierarchies, namely, Benefits, Opportunities, Costs, and Risks (BOCR). Nevertheless, it is not necessary to include all four control hierarchies in a model as it all depends on criteria relevance (Neaupane and Piantanakulchai 2006). Relative weights in ANP are determined based on pairwise comparison as in the standard AHP. Pairwise comparison of elements at each level is



**Fig. 2** Methodology framework (black segment, ANP; red segment, GIS)

conducted with respect to their relative importance towards their control criterion. Saaty (1980) suggested a scale of 1–9 when comparing two components.

The score of  $a_{ij}$  in the pairwise comparison matrix represents the relative importance of the component on row (i) over the component on column (j), i.e.,  $a_{ij} = w_i / w_j$ . The score of 1

represents equal importance of two components and 9 represents extreme importance of component i over component j. The reciprocal value of the expression  $(1 / a_{ij})$  is used when component j is more important than component i.

After all pairwise comparisons were completed, the priority weight vector was computed (Eq. 1).

$$Aw = \lambda_{\max} w \tag{1}$$

Where  $\lambda_{\max}$  is the largest eigenvalue of the matrix. The priority vector is often normalized by  $\alpha = \sum i^n = 1 w_i$ . Tegou et al. (2010) included two measures of consistency in their approach: a consistency index (CI) and a consistency ratio (CR). The CI can be measured using Eq. 2 (Saaty 1977).

$$CI = \lambda_{\max} - n / n - 1 \tag{2}$$

Where  $\lambda_{\max}$  is the largest eigenvalue in the matrix and reciprocal matrix and  $n$  is the number of criteria. If there are no inconsistencies in the pairwise comparisons, then  $\lambda_{\max} = n$ . The CR measures coherence of the pairwise comparisons (Eq. 3).

$$CR = \frac{CI}{RI} \tag{3}$$

Where RI is the mean CI of a set of randomly generated comparison values (Saaty 1977), and generally a CR value greater than 10% indicates a significant inconsistency and suggests that the user re-evaluate the judgments of relative importance regarding the criteria (Tegou et al. 2010).

**Formation of unweighted supermatrix** Elements in ANP are entities that interact with each other in the system. The entities could be a unit of decision makers, criteria or sub-criteria, possible outcomes, or alternatives. Determination of relative weights discussed above is based on pairwise comparison. The weights are then placed into the supermatrix that represents the interrelationship of elements in the system (Neaupane and Piantanakulchai 2006).

**Formation of weighted supermatrix** The unweighted supermatrix consists of several eigenvectors where each of which sums to one; it must be transformed to a matrix in which each of its columns sum to unity. The weighted supermatrix was obtained by multiplying all elements in a component of unweighted supermatrix by the corresponding cluster weight (Saaty 2003). The eigenvector obtained from cluster level comparison with respect to the control criterion is applied as the cluster weight. This results in a matrix in which its columns sum to unity.

**Table 2** Profile of experts

Experts	Organization	Qualifications	Experience	Profession
Expert 1	UniversitiTeknologi Malaysia	Ph.D	0–10	Academician
Expert 2	University of Arak, Iran	Ph.D	0–10	Academician
Expert 3	UniversitiTeknologi Malaysia	Master’s degree	0–10	Researcher
Expert 4	UniversitiTeknologi Petronas, Malaysia	Master’s degree	0–5	Researcher
Expert 5	UniversitiTeknologi Petronas, Malaysia	Master’s degree	0–5	Researcher
Expert 6	UniversitiTeknologi Malaysia	Master’s degree	0–5	Researcher
Expert 7	Private Sector, Oman	Bachelor’s degree	5–10	Private practitioner
Expert 8	Private Sector, Oman	Bachelor’s degree	0–5	Private practitioner
Expert 9	UniversitiTeknologi Malaysia	Master’s degree	0–10	Researcher
Expert 10	UniversitiTeknologi Malaysia	Master’s degree	10–20	Researcher
Expert 11	UniversitiTeknologi Malaysia	Master’s degree	0–10	Researcher
Expert 12	UniversitiTeknologi Petronas, Malaysia	Master’s degree	5–10	Researcher
Expert 13	Regional Environmental Awareness for Cameron Highlands	Bachelor’s degree	30–40	Environmentalist
Expert 14	Regional Environmental Awareness for Cameron Highlands	Advanced diploma	40–50	Environmentalist
Expert 15	Regional Environmental Awareness for Cameron Highlands	Diploma	20–30	Environmentalist

**Calculation of global priority vectors and weights** In the final step, the weighted supermatrix is raised to limiting power to get the global priority vectors (Eq. 4).

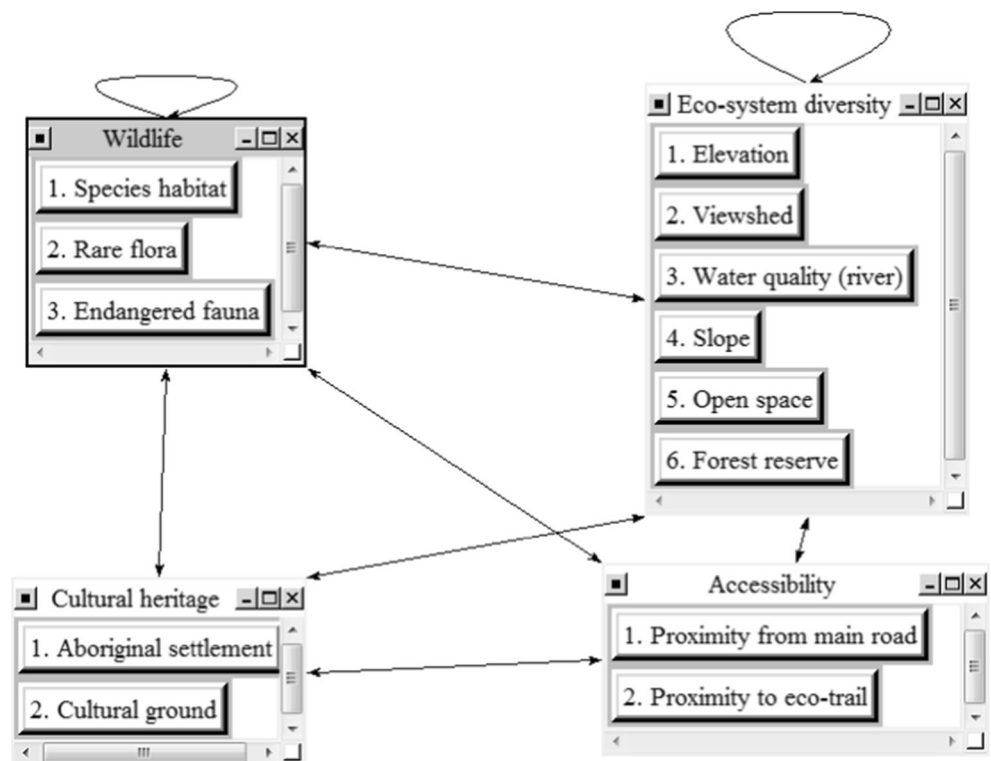
$$W^\infty = \lim_{k \rightarrow \infty} W^k \tag{4}$$

In this case, the limit is unique, and there is a column vector,  $w^\infty$ , for  $W^\infty$ . If other roots of unity exist

and the supermatrix has the effect of cyclicity, the limiting supermatrix is not only one. There are two or more limiting supermatrices in this situation. The limit matrix was normalized to obtain the priorities (Eq. 5) (Saaty 2003).

$$W^\infty = \lim_{k \rightarrow \infty} \left( \frac{1}{N} \right) \sum W_i^k \tag{5}$$

**Fig. 3** ANP model for sustainable tourism planning



Where  $W_j$  is the  $j$ th limiting supermatrix. The Cesaro sum is used primarily for taking the limits when they are not unique. Otherwise, the supermatrix would be raised to large powers to get the priority weights (Yu and Tzeng 2006).

ANP computations were developed in super decisions software version 2.0.8. Priorities were aggregated using geometric mean method.

*Geometric mean computation*

Geometric mean refers to the average of a set of numbers different from arithmetic average. The geometric mean is calculated by multiplying all the numbers and taking the  $n$ th root of the total. Geometric mean applies only to positive numbers. As such geometric mean method was used to aggregate expert opinion (Basak and Saaty 1993), it was computed for the 15 respondents using Eq. 6. The aggregated values were transferred into GIS for weighted sum overlay.

$$((X_1) \times (X_2) \times (X_3) \dots \dots (X_N))^{1/N} \tag{6}$$

Where

- $X$  individual score
- $N$  sample size (number of criteria)

*Priority weights validation*

Two validation methods were used in order to check the precision or otherwise of the priority weights. The methods are sensitivity analysis and statistical analysis (Kolmogorov–Smirnov and T-test).

**Sensitivity analysis framework** Sensitivity analysis (SA) is a useful measure utilized in multi-criteria analysis approaches. SA provides understanding of sensitivity in the outputs to inaccurate assumptions or errors in the input values. SA helps in evaluating the accuracy and limitations of the model (Chen et al. 2010). This is because the criteria values are based on the opinions of various experts and decision makers, which are subjective in nature. Thus, the opinions were used for validating weights derived from multi-criteria evaluation.

Changing input factors one-at-a-time, i.e., the OAT method, has become a common approach in sensitivity analysis (Chen et al. 2010) in order to see how it affects the output. By changing one factor at a time, the remaining factors can be fixed to their baseline value, which increases comparability of results. OAT method is easy to implement and computationally cheap. This research employed the OAT method by changing each of the criterion weight in percentage. A range

of percent change (RPC) of  $\pm 20\%$  was applied to all criteria (Chen et al. 2010).

**Statistical analysis for priority weights validation** The study utilized two statistical analyses for the validation of sustainable tourism priorities derived from the ANP model. The tests are Kolmogorov–Smirnov test (K-S test) and  $t$  test. K-S test is a goodness-of-fit test for any statistical distribution (Weissstein 2014). Therefore, it was used to check if the priority weights from the individual experts were normally distributed. The second statistical test utilized was the  $t$  test, which assessed whether the mean of two samples were significantly related to each other. This is because experts tend to have a similar opinion with each other regarding criteria ranking. Hence, it is expected to have a significant relationship between the experts opinion. Statistical analysis was computed in Spatial Package for the Social Sciences (SPSS) software version 16.0.

**Spatial modeling**

Spatial data was sourced and used in creating the spatial models (maps). They were analyzed using spatial analyst tools such as distance operators, union, clip, viewshed, interpolation, conversion, and reclassification functions, besides extract by mask, mosaic, times, erase, and minus function tools. Spatial analysis was carried out in ArcGIS software version 9.3. Data layers were reclassified into a common scale of 1 to 4, with 1 being the lowest suitability score (not suitable) and 4 the highest (most suitable). ArcGIS Model Buildertool was utilized in generating results (maps) for the research.

*Data used and sources*

Data extraction was performed on satellite images with the aim to generate part of the vector data. Digital maps were imported into GIS, geo-referenced, and digitized into a GIS compatible format. Attribute data were captured into GIS as part of the database generation. Primary data were captured through a physical survey of the study area in order to confirm some points on the satellite image. Global positioning system (GPS) was also used to capture points of interest. Thematic layers acquired include Bertam River, other rivers (unstudied), topographic map, aboriginal settlements, eco-trail, endangered fauna, main road, mounts, rare flora, species habitat, land-use map, boundary map, cultural ground, water quality sampling stations, forest reserve, mountains, and landslide areas (Table 3).

### GIS and ANP integration

The key to using ANP for meaningful land suitability analysis

**Table 3** Data inventory for the study

Data	Scale	Source
Boundary map	1:25,000	Cameron Highlands District Council
Land-use map	1:25,000	Cameron Highlands District Council
Road map	1:25,000	Cameron Highlands District Council
Eco-trail	1:25,000	Faculty of Built Environment, UniversitiTeknologi Malaysia
Aboriginal settlements	1:25,000	Department of OrangAsli Development, Malaysia
Cultural area	1:25,000	Faculty of Built Environment, UniversitiTeknologi Malaysia
Topographic map	1:25,000	Department of Mineral and Geoscience, Malaysia
Bertam River	1:25,000	(Eisakhani and Malakahmad 2009)
Water quality sampling stations	1:25,000	Field survey with GPS
Forest reserve	1:25,000	Department of Forestry, Malaysia
Species habitat	1:25,000	Department of Wildlife, Malaysia
Rare flora	1:25,000	Department of Forestry, Malaysia
Endangered fauna	1:25,000	Department of Wildlife, Malaysia
Landslide areas	1:25,000	(Basith 2011)
Other rivers (unstudied)	1:25,000	Department of Mineral and Geoscience, Malaysia
Mountains	1:25,000	Cameron Highlands District Council

requires the integration of ANP results with a GIS (Fig. 2). This was achieved by assigning ANP-derived weights to the corresponding criterion maps. GIS, through weighted sum model, was then used in summing the criterion maps and eventually produced as one suitability map (sustainable tourism map) (Fig. 4).

### Spatial model validation

The end result of the study, which is a spatial model (map of sustainable tourism in Cameron Highlands) was validated in order to check its precision and limitation. This was carried out using the local plan (map) of Cameron Highlands. Its local authority, Majlis Daerah Cameron Highlands has come up with a guideline map that indicates the types of activities allowed in different parts of the highlands. This is contained in its local plan (CHLP 2008). The research final output was overlaid

with that of the study area local plan (map) in order to check its adherence to the local plan.

## Results and discussion

### Application of ANP in sustainable tourism planning

Comparison of all criteria with respect to the parent criteria was performed in the form of matrix. This means that for each record, the value was divided by the sum of the respective column and the average was calculated for the corresponding row. The average provides an estimate of the relative priorities of criteria being compared. This was done for all matrices. Since the inconsistency ratio for all the comparisons has shown to be less than 0.10, re-evaluation of judgments was not required. Results obtained from the relative priorities, as a result of the pairwise comparison, formed the unweighted supermatrix. Table 4 shows the result of the unweighted supermatrix which contains all local priority vectors of the comparison groups in the network. In other words, it comprises results of all pairwise comparisons made throughout the network.

The simplified cluster matrix is shown in Table 5. This causes the matrix to be column stochastic, i.e., each column sums to one. The cluster matrix result is the same for all opinions of experts as there was no cluster comparison.

Table 6 displays the result of weighted supermatrix. This was obtained by multiplying the values in the cluster matrix cell with corresponding values in each cell of the unweighted supermatrix. In other words, every component of unweighted supermatrix is weighted with its corresponding weight in the cluster matrix.

Table 7 shows result of the limit matrix where all rows appear to be the same as a result of weight convergence. The convergence took place by raising the weighted supermatrix to powers. This limit matrix result shows the relative importance of every factor in the model.

After the limit matrix had been computed, it was then normalized to obtain the priorities. Table 8 shows results of the ANP model. As obtained from the given illustration using response provided by one of the experts (R1), aboriginal settlement appears to be the most important factor (0.1886); this is followed by endangered fauna (0.1384). On the other hand, viewshed (0.0119) is depicted as the least important among factors under consideration.

### Geometric mean computation of expert opinion

Results of the computed geometric mean from the 15 experts (R) are shown in Table 9. An illustration from the first



criterion (proximity from main road) is used to demonstrate the computations of the geometric mean.

$$POWER (R1 \times R2 \times R3 \times R4 \times R5 \times R6 \times R7 \times R8 \times R9 \times R10 \times R11 \times R12 \times R13 \times R14 \times R15, 0.0666) = 0.0901 \rightarrow 0.0942$$

### Validation of sustainable tourism priorities

Results of validation for sustainable tourism priorities are presented under two methods, which include OAT sensitivity analysis and statistical analysis (Kolmogorov–Smirnov and *t* test). The OAT sensitivity analysis result shows that the criteria weight remained as they were or changed slightly despite variation in criterion weight. This depicts the criterion weight as accurate.

Results from K-S test shows that both the skewness and kurtosis from all experts are within the normal range of  $\pm 1.96$ . The test also shows that the priority weights from most of the experts (*R*'s) are normally distributed due to their *P* value being greater than 0.05; as such, the null hypothesis is accepted. *t* test computation shows that the *P* value is observed to be greater than 0.05 for all paired comparisons. Since the null hypothesis is accepted, the conclusion drawn is that there is no significant difference in expert opinion. This is because experts tend to have similar opinions with regard to criteria

ranking; hence, a significant relationship is expected. The opinions of experts were compared to each other, one at a time.

### Spatial analysis

Table 10 shows the suitability assessment criteria which are standardized in order to allow for their summation. It is seen from the table that the study criteria are classified into a common scale of “not suitable” (1) to “most suitable” (4).

#### GIS-based ANP model for sustainable tourism planning

Figure 4 shows a graphical representation of the sustainable tourism model, which comprises variables and processes involved. The number of processes varied based on the properties of the original dataset, conversion and transformation required to make them ready for weighted sum overlay.

Figure 5 was utilized in generating sustainable tourism maps. Benefits derived from the Model Builder of ArcGIS

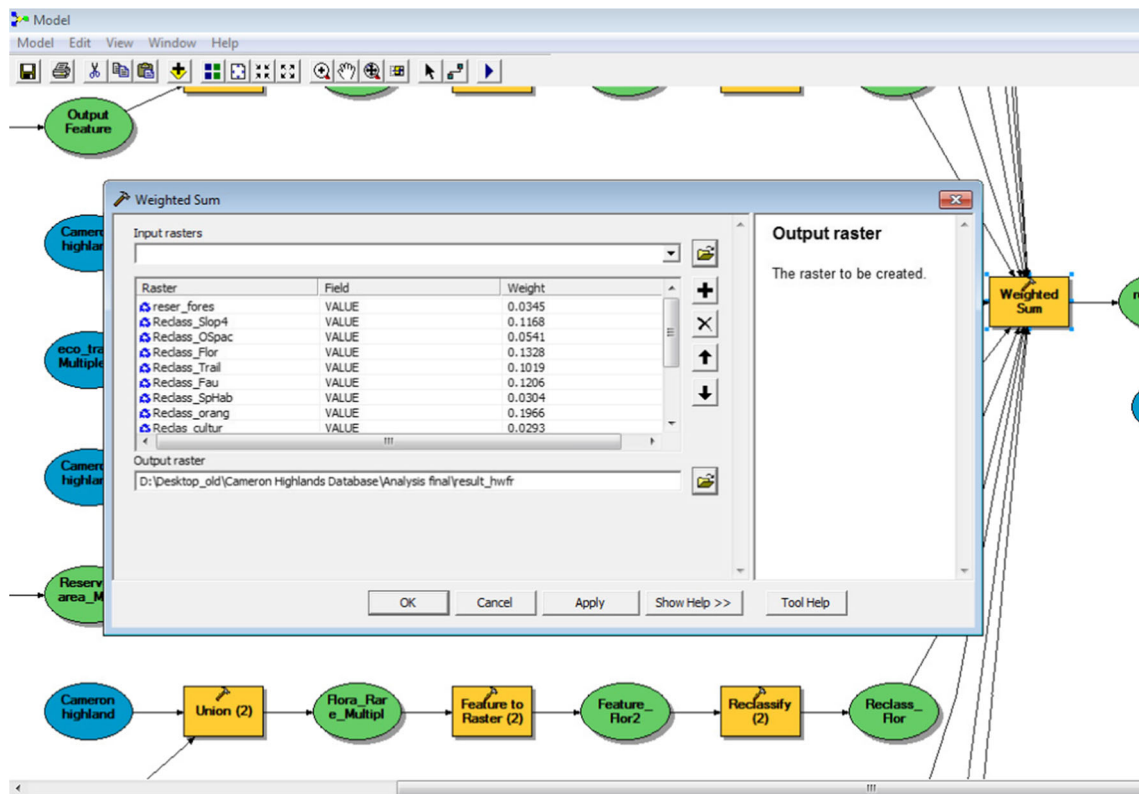


Fig. 4 Weighted sum model (spatial analyst)

**Table 4** Unweighted supermatrix

Clusters	Criteria (nodes)	Accessibility		Cultural heritage		Ecosystem diversity						Wildlife		
		PM	PE	AS	CG	EL	VS	WQ	SL	OS	FR	SH	RF	EF
Accessibility	1. Proximity from main road (PM)	0.0000	0.0000	0.5000	0.0000	0.3333	0.2500	0.2500	0.0000	0.5000	0.2500	0.6667	0.5000	0.6667
	2. Proximity to eco-trail (PE)	0.0000	0.0000	0.5000	0.0000	0.6667	0.7500	0.7500	0.0000	0.5000	0.7500	0.3333	0.5000	0.3333
Cultural heritage	1. Aboriginal settlement (AS)	0.9000	0.9000	0.0000	0.0000	0.9000	0.9000	0.9000	0.0000	0.9000	0.9000	0.8333	0.8333	0.8333
	2. Cultural ground (CG)	0.1000	0.1000	0.0000	0.0000	0.1000	0.1000	0.1000	0.0000	0.1000	0.1000	0.1667	0.1667	0.1667
Ecosystem diversity	1. Elevation (EL)	0.6382	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1000	0.2372	0.2484	0.3285
	2. Viewshed (VS)	0.1955	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0518	0.0561
	3. Water quality (river) (WQ)	0.1015	0.6667	0.0000	0.0000	0.0000	0.6667	0.0000	0.0000	0.2500	0.0000	0.0580	0.0466	0.0400
	4. Slope (SL)	0.0000	0.0000	0.5936	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9000	0.6335	0.6531	0.5754
	5. Open space (OS)	0.0648	0.3333	0.2493	0.0000	0.5000	0.3333	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	6. Forest reserve (FR)	0.0000	0.0000	0.1571	0.0000	0.5000	0.0000	0.6667	0.0000	0.7500	0.0000	0.0712	0.0000	0.0000
Wildlife	1. Species habitat (SH)	0.0000	0.0000	0.0000	0.0000	0.0000	0.6370	0.0000	0.0000	0.0000	0.0000	0.0000	0.2500	0.2500
	2. Rare flora (RF)	0.3333	0.7500	0.5000	0.0000	0.2500	0.1047	0.1667	0.0000	0.6667	0.2500	0.2500	0.0000	0.7500
	3. Endangered fauna (EF)	0.6667	0.2500	0.5000	0.0000	0.7500	0.2583	0.8333	0.0000	0.3333	0.7500	0.7500	0.7500	0.0000

**Table 5** Cluster matrix

Clusters	Accessibility	Cultural heritage	Ecosystem diversity	Wildlife
Accessibility	0.0000	0.3333	0.2500	0.2500
Cultural heritage	0.3333	0.0000	0.2500	0.2500
Ecosystem diversity	0.3333	0.3333	0.2500	0.2500
Wildlife	0.3333	0.3333	0.2500	0.2500

are worth highlighting. The tool allowed for the integration of a great volume of spatial data and expert opinion in a systemic

way. It has automated geo-processing workflows in producing quantified and visual outputs, helping to optimize and speed

**Table 6** Weighted supermatrix

Clusters	Criteria (nodes)	Accessibility		Cultural heritage		Ecosystem diversity						Wildlife		
		PM	PE	AS	CG	EL	VS	WQ	SL	OS	FR	SH	RF	EF
Accessibility	1. Proximity from main road (PM)	0.0000	0.0000	0.1667	0.0000	0.0833	0.0625	0.0625	0.0000	0.1250	0.0625	0.1667	0.1250	0.1667
	2. Proximity to eco-trail (PE)	0.0000	0.0000	0.1667	0.0000	0.1667	0.1875	0.1875	0.0000	0.1250	0.1875	0.0833	0.1250	0.0833
Cultural heritage	1. Aboriginal settlement (AS)	0.3000	0.3000	0.0000	0.0000	0.2250	0.2250	0.2250	0.0000	0.2250	0.2250	0.2083	0.2083	0.2083
	2. Cultural ground (CG)	0.0333	0.0333	0.0000	0.0000	0.0250	0.0250	0.0250	0.0000	0.0250	0.0250	0.0417	0.0417	0.0417
Ecosystem diversity	1. Elevation (EL)	0.2127	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0250	0.0593	0.0621	0.0821
	2. Viewshed (VS)	0.0652	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0130	0.0140
	3. Water quality (river) (WQ)	0.0338	0.2222	0.0000	0.0000	0.0000	0.1667	0.0000	0.0000	0.0625	0.0000	0.0145	0.0117	0.0100
	4. Slope (SL)	0.0000	0.0000	0.1979	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2250	0.1584	0.1633	0.1439
	5. Open space (OS)	0.0216	0.1111	0.0831	0.0000	0.1250	0.0833	0.0833	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	6. Forest reserve (FR)	0.0000	0.0000	0.0524	0.0000	0.1250	0.0000	0.1667	0.0000	0.1875	0.0000	0.0178	0.0000	0.0000
Wildlife	1. Species habitat (SH)	0.0000	0.0000	0.0000	0.0000	0.0000	0.1592	0.0000	0.0000	0.0000	0.0000	0.0000	0.0625	0.0625
	2. Rare flora (RF)	0.1111	0.2500	0.1667	0.0000	0.0625	0.0262	0.0417	0.0000	0.1667	0.0625	0.0625	0.0000	0.1875
	3. Endangered fauna (EF)	0.2222	0.0833	0.1667	0.0000	0.1875	0.0646	0.2083	0.0000	0.0833	0.1875	0.1875	0.1875	0.0000

**Table 7** Limit matrix

Clusters	Criteria (nodes)	Accessibility		Cultural heritage		Ecosystem diversity						Wildlife		
		PM	PE	AS	CG	EL	VS	WQ	SL	OS	FR	SH	RF	EF
Accessibility	1. Proximity from main road (PM)	0.1030	0.1030	0.1030	0.0000	0.1030	0.1030	0.1030	0.0000	0.1030	0.1030	0.1030	0.1030	0.1030
	2. Proximity to eco-trail (PE)	0.1052	0.1052	0.1052	0.0000	0.1052	0.1052	0.1052	0.0000	0.1052	0.1052	0.1052	0.1052	0.1052
Cultural heritage	1. Aboriginal settlement (AS)	0.1886	0.1886	0.1886	0.0000	0.1886	0.1886	0.1886	0.0000	0.1886	0.1886	0.1886	0.1886	0.1886
	2. Cultural ground (CG)	0.0271	0.0271	0.0271	0.0000	0.0271	0.0271	0.0271	0.0000	0.0271	0.0271	0.0271	0.0271	0.0271
Ecosystem diversity	1. Elevation (EL)	0.0499	0.0499	0.0499	0.0000	0.0499	0.0499	0.0499	0.0000	0.0499	0.0499	0.0499	0.0499	0.0499
	2. Viewshed (VS)	0.0119	0.0119	0.0119	0.0000	0.0119	0.0119	0.0119	0.0000	0.0119	0.0119	0.0119	0.0119	0.0119
	3. Water quality (river) (WQ)	0.0402	0.0402	0.0402	0.0000	0.0402	0.0402	0.0402	0.0000	0.0402	0.0402	0.0402	0.0402	0.0402
	4. Slope (SL)	0.1033	0.1033	0.1033	0.0000	0.1033	0.1033	0.1033	0.0000	0.1033	0.1033	0.1033	0.1033	0.1033
	5. Open space (OS)	0.0462	0.0462	0.0462	0.0000	0.0462	0.0462	0.0462	0.0000	0.0462	0.0462	0.0462	0.0462	0.0462
	6. Forest reserve (FR)	0.0366	0.0366	0.0366	0.0000	0.0366	0.0366	0.0366	0.0000	0.0366	0.0366	0.0366	0.0366	0.0366
Wildlife	1. Species habitat (SH)	0.0213	0.0213	0.0213	0.0000	0.0213	0.0213	0.0213	0.0000	0.0213	0.0213	0.0213	0.0213	0.0213
	2. Rare flora (RF)	0.1283	0.1283	0.1283	0.0000	0.1283	0.1283	0.1283	0.0000	0.1283	0.1283	0.1283	0.1283	0.1283
	3. Endangered fauna (EF)	0.1384	0.1384	0.1384	0.0000	0.1384	0.1384	0.1384	0.0000	0.1384	0.1384	0.1384	0.1384	0.1384

up the planning process. Model Builder graphical environment has made it easy to create, modify, and run the sustainable tourism model.

Figure 6 shows two scenarios (maps), depicting the final product of the study. They were generated from the sustainable tourism model. The distinguishing factor between the two scenarios is water quality component for the two seasons (high water flow, HWF, and average water flow, AWF). As such, the first scenario depicts sustain able tourism during high water flow, while the second scenario depicts sustainable tourism during average water flow.

As seen in Fig. 6, the “not suitable” category—otherwise referred to as “constraint”—depicts areas that are environmentally sensitive. These are high biodiversity areas (species habitat, rare flora, and endangered fauna) with the most fragile terrain (elevation greater than 1500 m above sea level and slope degrees greater than 35). This category also contains areas that are culturally sensitive (aboriginal settlement and cultural ground), hence requiring high level protection with regard to tourism and related development. As such, guidelines should be enforced and compliance ensured. The guidelines would include duration and number of visitors to this area that should be strictly controlled (Yaakup et al. 2006). This would ensure a significant amount of species are not hampered by tourism and related development, thereby ensuring a balance between tourism as a socioeconomic activity and preservation of natural resources (RSNP 2008). These locations would be allowed for research and education, but there should be compliance for carrying out such activities. This could be achieved by having a trained aborigine (OrangAsli) as tour guide, hence involving the local people and improving their well-being (Simmons 1994). This would

also ensure that the needs of the host inhabitants are met with regards to improved living standards in both short and long term (Cater 1993). The “not suitable” category also comprises built up area, landslide areas, and other rivers (unstudied), which are constraints to this study as they could not be utilized for sustainable tourism development.

The “less suitable” category is the highlands area adjoining the high biodiversity areas and the fragile terrain. As such, it serves as a breeding ground for some of the highlands species. Such areas include parts of the highlands that adjoins species habitat, rare flora, and endangered fauna; others include elevation in the range of 1000–1500 m above sea level, 26–34° slope. These areas need to be protected to ensure that valuable amount of the highlands species continue to persist. Thus, the

**Table 8** Priorities

Clusters	Criteria (nodes)	Limiting
Accessibility	1. Proximity from main road (PM)	0.1030
	2. Proximity to eco-trail (PE)	0.1052
Cultural heritage	1. Aboriginal settlement (AS)	0.1886
	2. Cultural ground (CG)	0.0271
Ecosystem diversity	1. Elevation (EL)	0.0499
	2. Viewshed (VS)	0.0119
	3. Water quality (river) (WQ)	0.0402
	4. Slope (SL)	0.1033
	5. Open space (OS)	0.0462
	6. Forest reserve (FR)	0.0366
Wildlife	1. Species habitat (SH)	0.0213
	2. Rare flora (RF)	0.1283
	3. Endangered fauna (EF)	0.1384

**Table 9** Geometric mean computation of expert opinion

Name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	Aggregates	Normalized weights
1. Proximity from main road	0.1030	0.1414	0.1165	0.1439	0.0822	0.0527	0.1553	0.0399	0.0490	0.0606	0.1159	0.0655	0.1507	0.0544	0.1683	0.0901	0.0942
2. Proximity to eco-trail	0.1052	0.0668	0.0906	0.0634	0.1253	0.1563	0.0527	0.1692	0.1579	0.1468	0.0907	0.1271	0.0576	0.1532	0.0397	0.0975	0.1019
1. Aboriginal settlement	0.1886	0.1914	0.1866	0.1882	0.1914	0.1934	0.1817	0.1935	0.1774	0.1904	0.1841	0.1894	0.1928	0.1873	0.1823	0.1882	0.1966
2. Cultural ground	0.0271	0.0233	0.0286	0.0266	0.0224	0.0215	0.0362	0.0215	0.0409	0.0238	0.0314	0.0422	0.0214	0.0282	0.0354	0.0280	0.0293
1. Elevation	0.0499	0.0455	0.0443	0.0441	0.0319	0.0219	0.0512	0.0173	0.0205	0.0215	0.0415	0.0279	0.0504	0.0229	0.0327	0.0328	0.0343
2. Viewshed	0.0119	0.0158	0.0103	0.0207	0.0102	0.0093	0.0169	0.0093	0.0098	0.0111	0.0100	0.0090	0.0126	0.0108	0.0253	0.0123	0.0128
3. Water quality (river)	0.0402	0.0417	0.0462	0.0377	0.0315	0.0320	0.0287	0.0660	0.0635	0.0627	0.0291	0.0400	0.0269	0.0330	0.0421	0.0398	0.0416
4. Slope	0.1033	0.1130	0.1269	0.1282	0.1332	0.0969	0.0876	0.0956	0.1021	0.1311	0.1327	0.1176	0.1154	0.1165	0.0884	0.1117	0.1168
5. Open space	0.0462	0.0468	0.0332	0.0387	0.0532	0.0800	0.0767	0.0464	0.0432	0.0402	0.0432	0.0632	0.0511	0.0682	0.0716	0.0518	0.0541
6. Forest reserve	0.0366	0.0257	0.0280	0.0196	0.0294	0.0479	0.0259	0.0534	0.0484	0.0225	0.0325	0.0490	0.0324	0.0371	0.0270	0.0330	0.0345
1. Species habitat	0.0213	0.0572	0.0481	0.0574	0.0177	0.0105	0.0569	0.0162	0.0142	0.0248	0.0519	0.0195	0.0529	0.0144	0.0555	0.0291	0.0304
2. Rare flora	0.1283	0.1555	0.1161	0.1328	0.0940	0.0865	0.1745	0.1309	0.1038	0.1324	0.1265	0.1250	0.1704	0.1033	0.1618	0.1271	0.1328
3. Endangered fauna	0.1384	0.0758	0.1247	0.0987	0.1776	0.1910	0.0557	0.1409	0.1693	0.1320	0.1106	0.1246	0.0654	0.1707	0.0699	0.1154	0.1206
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94	1.00

**Table 10** Suitability assessment of study criteria

Sustainable tourism elements		Unit	Suitability rating				References
Clusters	Criteria (node)		Not suitable/ constraints	Less suitable	Moderately suitable	Most suitable	
Ecosystem diversity	Elevation	Meter	>1500 (m)	1000–1500 (m)	500–1000 (m)	160–500 (m)	(Yuszyl 2008)
	Viewshed	Visibility values	0–1	1–3	3–5	5–12	(Bunruamkaew and Murayam 2011)
	Water quality	WQI	<32.0	32.0–51.9	51.9–76.5	76.5–92.7	(DOE 2002)
	Slope	Degree	>35	26–34	16–25	0–15	(CHLP 2008)
	Open space	Percentage	99.94	0.01	0.04		(Young 2005, personal communication)
Accessibility	Forest reserve	Buffer distance	90–120 (m)	30–60 (m)	0–30 (m)	60–90 (m)	(CHLP 2008)
	Proximity from main road	Buffer distance (m)	0–30 (m)	90–120 (m)	60–90 (m)	30–60 (m)	(Boyd et al. 1995)
	Proximity from eco-trail	Buffer distance (m)	30–40 (m)	20–30 (m)	10–20 (m)	0–10 (m)	(Tomezyk 2011)
Cultural heritage	Aboriginal settlement	Buffer distance (m)	0–30 (m)	30–60 (m)	60–90 (m)	90–120	(Blanca et al. 2007)
	Cultural ground	Buffer distance (m)	0–20 (m)	20–40 (m)	40–60 (m)	60–80	(Blanca et al. 2007)
Wildlife	Species habitat	Buffer distance (m)	0–30 (m)	30–60 (m)	60–90 (m)	90–120	(Alderson 2005, personal communication)
	Rare flora	Buffer distance (m)	0–10 (m)	10–20 (m)	20–30 (m)	30–40 (m)	(CHLP 2008)
	Endangered fauna	Buffer distance (m)	0–30 (m)	30–60 (m)	60–90 (m)	90–120	(USFWS 1996)

importance of forest reserve, water bodies, and watersheds should be maintained and preserved with the introduction of eco-recreational activities that are supported by appropriate facilities (CHLP 2008). This category also borders the rich cultural heritage area (aboriginal settlement and cultural ground). Consequently, the area needs some level of protection to guard the local people and their culture. This would ensure respect for the sociocultural authenticity of host communities and conservation of their built, living cultural heritage and traditional values (WTO 2004). As contained in the Cameron Highlands Local Plan, these locations would be provided with environmentally friendly facilities such as sky tram, towards ensuring minimum effect on Mother Nature. Sky tram is a tourism facility that soars smoothly and quietly through the forest area. It offers an endless view of the highlands ecosystem. The sky tram would be operated by an aborigine, having been trained as bilingual tour guide and facility operator. The aborigine would be skilled at starting and stopping the tram at any point—a feature of the facility that provides tourists with opportunities to take magnificent photographs and spot highlands birds. Other environmentally friendly facilities that would be provided at this part of the highlands are lookout areas for sightseeing and birdwatching. The lookout areas would be equipped with binoculars for magnification of some features. Also, suspended bridges would be erected at these locations to create a breathtaking experience of treetop view. All these would be achieved by imposing guidelines that limit the number of tourists and time of access. The guidelines should educate tourists on issues of environmental management and pollution control. This, in the long run, would ensure protection of such sensitive locations.

“Moderately suitable” category comprises less sensitive areas that are farther away from high biodiversity areas (species habitat, rare flora, and endangered fauna) and culturally sensitive locations (aboriginal settlement and cultural ground) of the highlands. These localities are characterized by a stable terrain (elevation of 500–1000 m above sea level and slope degrees of 16–25). These areas could be used for trail hiking. Nature trails provide a pathway through a protected area, bringing tourists into intimate contact with special features in that area (WWF-Malaysia 2002). A trained aborigine would act as tour guide monitoring these locations that could accommodate tourism infrastructure such as low density chalets, camping grounds, and public convenience. This would support the environmentally friendly tourism activities. However, erection of these facilities should be done based on environmental impact assessment (Yaakup et al. 2006).

“Most suitable” category is the farthest from high biodiversity and culturally sensitive locations, which are characterized by a more stable terrain surface (elevation of 160–500 m above sea level and slope degrees of 0–15). It also has a river area that is suitable for river recreational activities (WQI of 76.5–92.7; Class II). Descriptions of river water quality trends

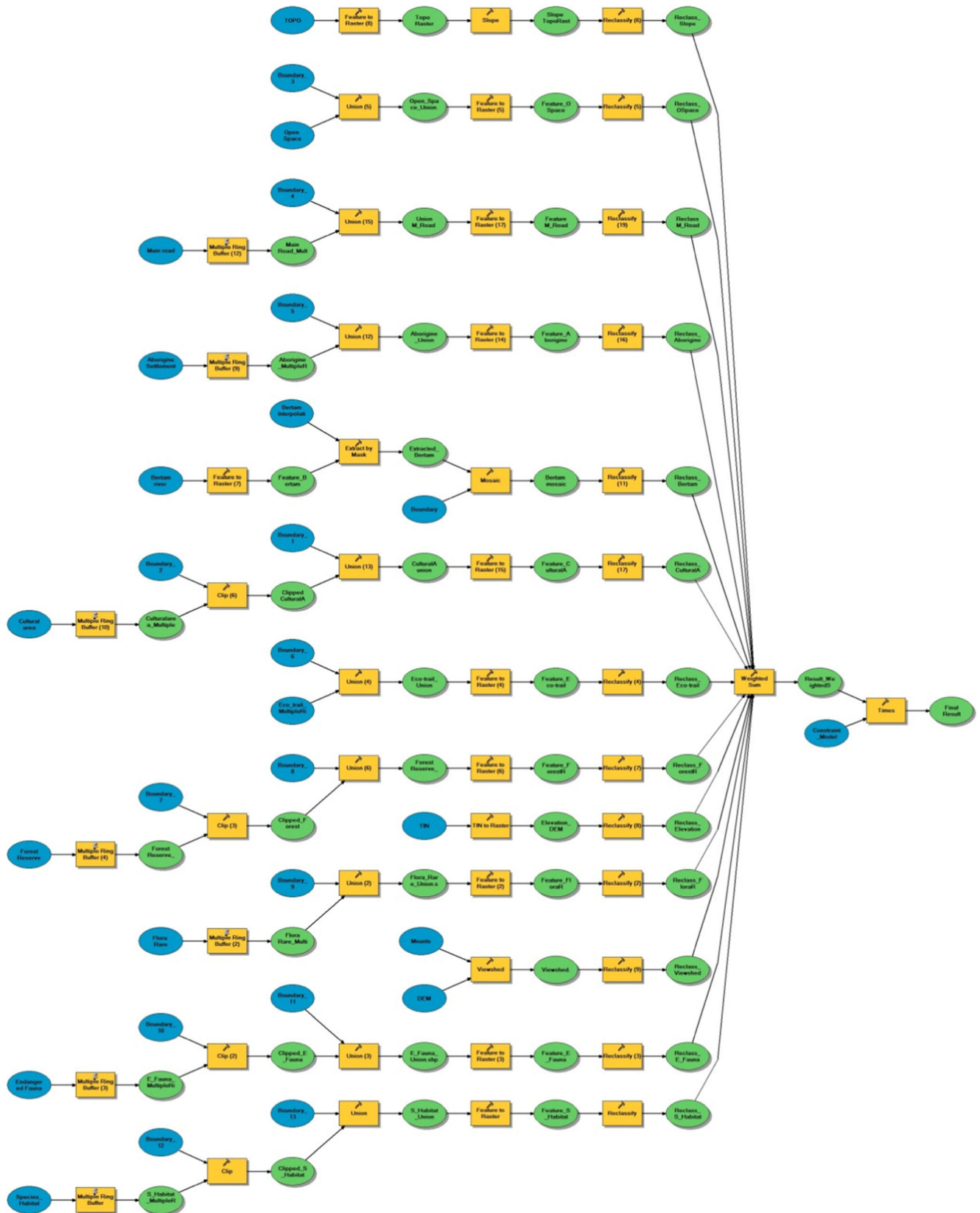


Fig. 5 Sustainable tourism model

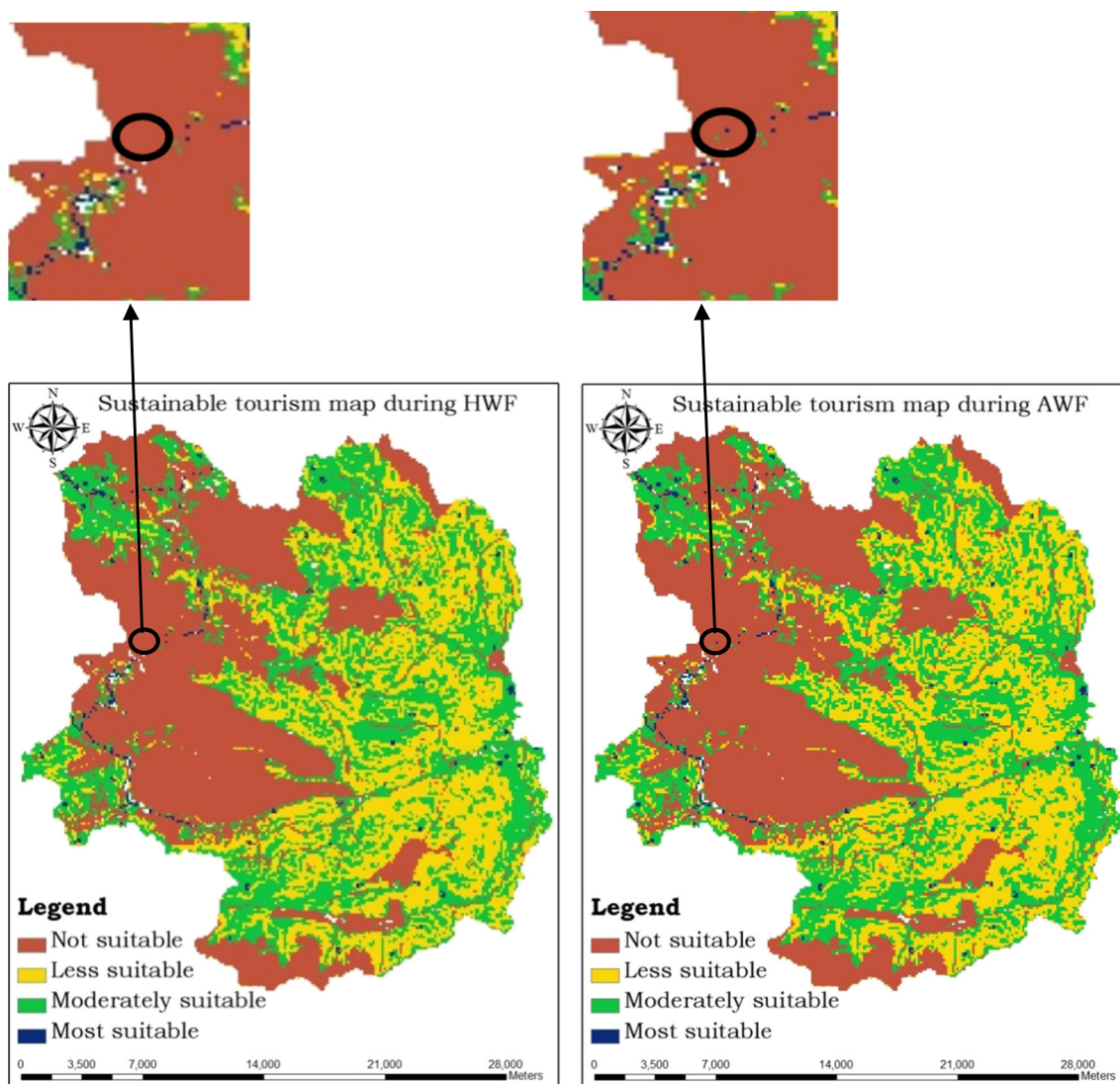


Fig. 6 Sustainable tourism maps during HWF and AWF

are based on the river classification system developed by the DOE (INWQS: Interim National Water Quality Standards for Malaysia). The classification system places rivers under specific categories ranging from Class I (rivers in pristine condition) to Class V (rivers which are heavily polluted); thus, this determines the suitable area for recreational activities where body contact is allowed (DOE 2002). This area could accommodate tourism infrastructure such as green hotels and restaurants, swimming and canoeing facilities in order to support sustainable tourism activities. Construction of the facilities should be done in such a way that it ensures a minimum

impact on the terrain, rivers, and other natural features of the highlands. “Most suitable” category has the smallest percentage of land area compared to other suitability categories (Table 11) thus depicting Cameron Highlands as a protected area.

It is evident from the two scenarios that “not suitable” category of HWF is slightly higher than that of AWF. This is because suitable areas for tourism activities could not be ascertained in the river during HWF due to high runoff that has had an adverse effect on water quality (Table 10). Also, there exists a difference in the “less suitable” category of the

Table 11 Sustainable tourism maps comparison (%)

	Not suitable (%)	Less suitable (%)	Moderately suitable (%)	Most suitable (%)
Sustainable tourism map (HWF)	39.69	28.91	30.82	0.56
Sustainable tourism map (AWF)	39.66	28.95	30.82	0.57

two scenarios. This is ascribed to the suitable areas for recreational activities that were determined in one of the sampling stations during AWF, which made this category to be marginally higher. The same situation is obtained in the “most suitable” category which appears to have the smallest percentage value, while the “not suitable” category has the highest percentage value. This portrays the highlands as a protected area.

*Spatial model validation*

The result obtained from the spatial analysis (sustainable tourism map) was validated using the provisions of Cameron Highlands Local Plan. Figure 7 depicts Cameron Highlands Local Plan map with the various forms of activities allowed on the highlands.

Result of the overlay between the final output of this study and the map from the local plan is shown in Fig. 8. As deduced from the map, result obtained from this study has, to a great

extent, adhered to the provisions of the local plan regarding sustainable tourism development in Cameron Highlands.

For further clarification, conformity of the research final output (sustainable tourism map) and local plan proposals with regard to sustainable tourism is further explained and translated in Fig. 9. The figure describes the kind of tourism activities that could be carried out on the highlands by utilizing both its natural and cultural heritage in a sustainable manner. It is evident that both sustainable tourism map and local plan map have identified Cameron Highlands forest reserve as a conservation area that has the potential to be developed for tourism. However, the local plan has not recognized the importance of elevation and slope in determining the suitability of such locations for tourism development. This study, however, has taken into consideration the elevation and the slope of Cameron Highlands in land suitability analysis for sustainable tourism development. Also, the Orang Asli (aborigines) settlements have been recognized by both sustainable tourism map and local plan map as having the potential to be

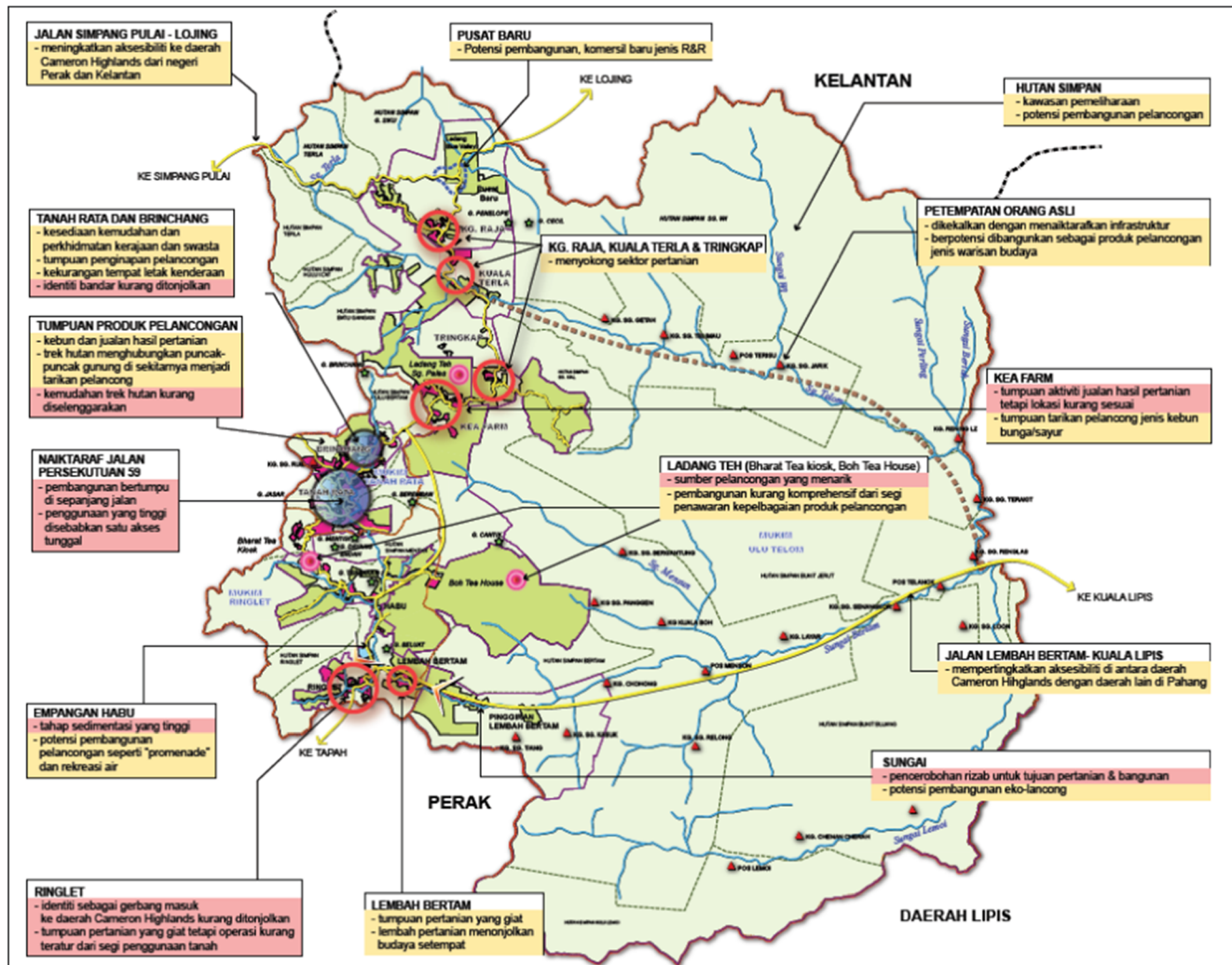


Fig. 7 Cameron Highlands Local Plan provision on tourism and other activities (Source, CHLP 2008)



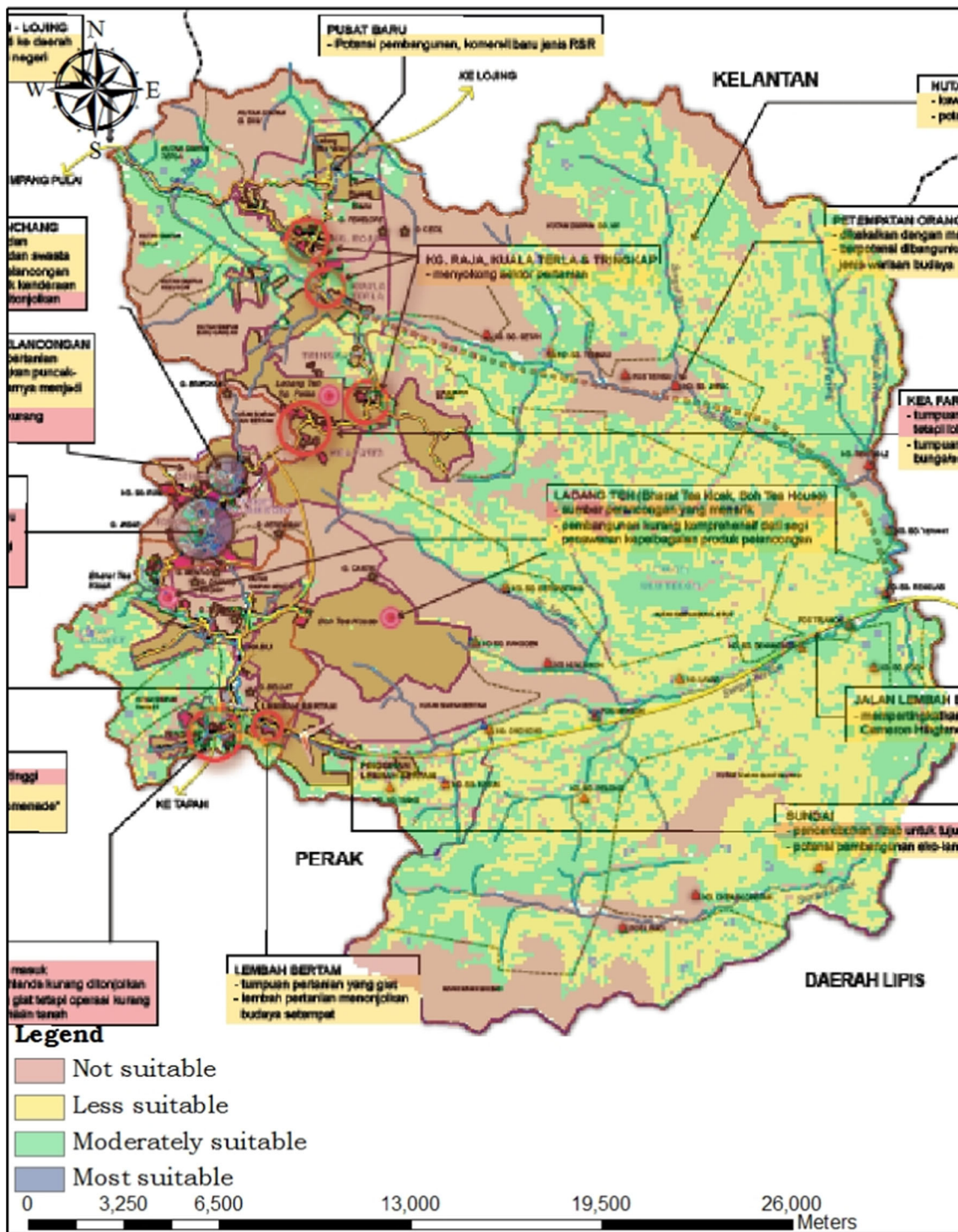
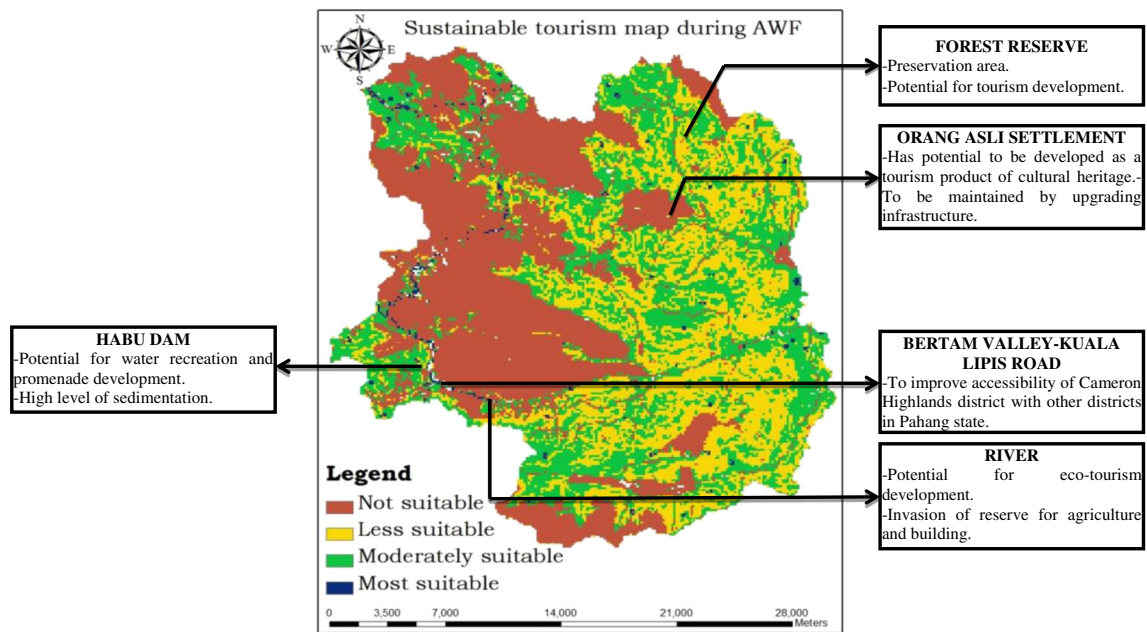


Fig. 8 Overlay of sustainable tourism map and local plan map

developed as a tourism product of cultural heritage. However, the local plan has failed to consider species habitat and cultural ground (area) surrounding some of the settlements. This needs to be considered when reviewing the local plan in the future. This research has categorized the surrounding of Orang Asli settlements as less suitable. This is to ensure that their built and living cultural heritage, as well as the species habitat

around some of the settlements are conserved. Furthermore, sustainable tourism map and local plan map have acknowledged the importance of Bertam River and Habu Dam to be developed for water recreational activities. To achieve this, the research has proposed a management framework to ensure that waters at these locations reach the status of being used for water recreational activities. The foregoing discussion has



**Fig. 9** Sustainable tourism map and the provision of Cameron Highlands Local Plan

highlighted parallelisms that exist between the sustainable tourism map and what is obtained from the guideline map of Cameron Highlands Local Plan, hence depicting the final result of the study as valid.

## Discussion and conclusions

This research presents an approach for sustainable tourism planning in Cameron Highlands, Malaysia, that is based on an integrated use of ANP of MCE and GIS. It depicts the method as hybrid in nature, combining expert opinion with spatial data.

MCE has demonstrated to be a valuable decision tool in the sustainable tourism development of the highlands environment. Because such type of planning involves the use of a multi-objective method, it leads to a well-conceived and acceptable management alternatives. Furthermore, MCE has shown to be a useful tool in quantifying the value of ecosystem in a non-monetary manner. ANP as an MCE technique has proven to be a reliable method in the identification of the most important criteria for sustainable tourism. The method has also proven to be having a better structure than AHP in handling complex decisions such as sustainable tourism. It has allowed interactions and feedback among factors responsible for sustainable tourism development thus depicting a better way of capturing happenings in the real world. The major shortcoming of the ANP network structure is the numerous pairwise comparisons required for its implementation; thus, even for a simple network structure for this case study, many pairwise comparisons had to be performed. Accuracy of the ANP generated priority weights must also be discussed in that

K-S and  $t$  test have shown to be useful tools in checking the subjective nature of expert opinion. The K-S test shows that both the skewness and kurtosis from all experts are within the normal range of  $\pm 1.96$ . K-S test also reveals that the priority weights from most of the experts are normally distributed, due to their  $P$  value being greater than 0.05.  $t$  test computation shows that the  $P$  value is observed to be greater than 0.05 for all paired comparisons. It is concluded that there is no significant difference in expert opinions, thus depicting the priority weights as valid. Furthermore, results of the sensitivity analysis show that the criteria weight remained the same or slightly changed despite the variation introduced. This portrays the criteria weights as highly stable.

Another important aspect is the development of a GIS-based ANP map for the sustainable tourism development of Cameron Highlands. Results obtained in this study indicate that the integration of GIS and ANP is useful in providing analytical tools for the spatial planning of Cameron Highlands with regards to sustainable tourism. GIS has provided a significant contribution in the evaluation of sustainable tourism development areas in the highlands based on established goals, plans, and standards of the parameters being studied. Evaluation of the study criteria has led to the generation of new information from existing datasets, therefore leading to the visualization of sustainability indicators which otherwise would not have been possible. This offers value-added information. Evaluation of sustainable tourism development areas has allowed for the characterization of the study criteria in a way that it ensures the safety of natural and cultural heritage of the highlands from tourism activities.

Areas for sustainable tourism development, which are mostly areas that are less sensitive to human interference, have

been determined in the study. Results obtained from the study shows that the “most suitable” locations for tourism development occupy only about 0.57%, thus portraying the motive of the study in trying to protect the highlands from tourism activities. It is ensured that tourism activities in these areas would be a viable one considering the guidelines imposed for carrying out such activities and the environmentally friendly facilities to be used. Constraint areas, which are areas that would be conserved from tourism and related development, have also been determined. These areas are highly sensitive to human interference, therefore only permitted for research and educational activities to ensure minimal effect on the highlands ecosystem.

In addition, the study has recognized the importance of Orang Asli as original inhabitants of the highlands; their indigenous knowledge should be acknowledged. Therefore, it is proposed that they should be part of the tourism activities as tour guides. However, it is necessary to provide them with proper training on how to perform their tasks in preparing them for the job (Saufi et al. 2014). Empowering the local communities especially the Orang Asli tour guides would help them sustain. In addition, previous studies have also shown that community-driven tourism approach has successfully achieved its targets in protecting and enabling the community (Muganda et al. 2013; Murphy 1988; Simmons 1994; Tosun 2006). This would ensure sustainable human development by improving the economic well-being and generating quality employment for the original inhabitants of the highlands. Subsequently, tourism in the highlands would result in higher revenue, thus increasing gross domestic product from tourism activities. Therefore, this research has fulfilled the three pillars of sustainable development, which are environmental protection (environment), local people inclusion in the tourism sector (social), and economic benefits derived from tourism activities (economy).

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