Sustainable Quality of Life Criteria for Ledang National Park Community: Fuzzy Approach

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ABSTRACT

Recently, there is a rising concern among researchers regarding the issue of sustainable criteria for quality of life (QoL). As it gains more interest, the issue becomes highly debated worldwide especially with regards to the national park community area. The aim of this study is to assess the identified sustainable criteria for QoL, particularly for the surrounding community of Ledang National Park (LNP) using the fuzzy Analytical Network Process (ANP). The fuzzy ANP was employed based on graded mean integration of representation and canonical representation of multiple operations to derive both local and global weights. To show the feasibility of the proposed method, three decision makers (DMs) were identified from the relevant agencies to assess three main criteria using linguistic evaluation via pairwise comparison process. In addition, nine sub-criteria were also investigated and analysed thoroughly using six steps of the fuzzy ANP towards achieving the sustainable criteria for QoL assessment. Based on the numerical analysis, it was found that the sub-criterion health(c32) has the highest global weight with a score of 0.184, which indicates that this sub-criterion is the biggest contributor to achieve the sustainability of QoL. The results also revealed the overall total score of 73.14%, thus placing LNP in the 'moderately sustainable' category. In the future, the entire investigated sub-criteria are suggested to be maintained and used to measure the sustainability of QoL. The findings from this study can be used to guide and assist the relevant authorities for future development planning in studied areas.

Keywords: *Fuzzy analytical network process, national park community, quality of life (QoL), sustainable criteria*

1.0 INTRODUCTION

According to World Health Organizations (WHO) Malaysia in 2002, quality of life is defined by social and environmental relationships, but sustaining and enhancing it involve health, economic and social developments. The government, non-profit organizations, researchers and the community are aggressively undertaking various effort to develop sustainable quality of life (QoL) in certain areas. Abdullah, Othman, Tarmudi and Low (2018) define sustainable development as a process to satisfy human development needs by fulfilling the natural resources and ecosystem services. The conducted study also stated that the definition of sustainable development somehow may differ according to different perspectives and constraints that come together with the concern of the study.

There were several studies pertaining to human QoL in various types of community. Ietto, Salvo and Cantasano (2014) studied the QoL condition with regards to environmental management specifically in the coastal area of Calabria, South Italy. They analysed how human QoL had been affected by the environmental condition. There were six criteria selected for this assessment: location, position, typology, economy, finance, and institution. Next, Boncinelli, Pagnotta, Riccioli and Casini (2015) conducted a study in rural areas with the focus on evaluating the heterogeneity of the QoL determinants. The criteria of assessment were narrowed to the opportunities addressed to rural populations, which are the availability of healthcare, education, economic opportunities, environmental conditions, human pressure, and accessibility of areas. In the study, the method used for data analysis was simultaneous quantile regression. In the following year, Hartter et al. (2016) did a research on perceptions of risk in communities near national parks in Africa. Three national parks were selected for the case study. The first is in Albertine Rift of Uganda: Kibale National Park, the second in Murchison Falls National Park, and the last one in Queen Elizabeth National Park. The objective of the study was to understand the nature of the local residents' perceived risks in order to allow conservation managers to devise suitable risk mitigation strategies in case the residents threaten the protected wildlife. While the paper did not specifically relate to QoL, the content of the assessment did measure the effect of several factors on the life of the communities around national park, which inadvertently relate to QoL. The three main criteria for evaluation were protected area, climate and health. Since the study was specifically on perceived risk, the employed method for data analysis was participatory risk mapping. In the same year, Gigović, Pamučar, Lukić and Marković, (2016) used the fuzzy approach to develop an evaluation model to assess the suitability of ecotourism of an area. The study was centred on Dunavski kljuc, an attractive region of Serbia known for its natural and anthropogenic tourist factors. It is also located in the border area between Serbia and Romania and is a zone of border cooperation between two national parks. A total of 16 ecotourism criteria were identified and further categorized into four main clusters (topographic, natural, environmental and socio-economic clusters). Another study related to communities around national park was done by Acquah, Rollins, Dearden and Murray (2016) to assess the concerns and benefits of communities living near Mole National Park, Ghana. Their research focused on the perception of the surrounding communities towards the national park which was determined by analysing how conditions originating from the national park influence the life of the community members. In another study, Grinde, Nes, MacDonald and Wilson (2017) had a concern about improving the society in order to achieve a better QoL in selected areas in United States and Canada. The study aimed to investigate the level of wellbeing among communities and decided that the important criteria to measure QoL of the communities are education, income of resident and tenure of living. In the same year, two other studies (Qing & Abdullah, 2017; Martin & Vinan, 2017) found that the main criteria in sustaining the QoL in their studied areas are social, economic and physical factors whereas the main concern was to find the indicator of satisfaction of the resident. The studies focused on the coastal area of Setiu Wetland, Terengganu and the

Region of Ecuador respectively. Recently, Muresan et. al. (2019) stated that to sustain rural development, the residents' QoL is important and the main concern in sustaining the QoL is the tourism development in that area. Based on the concern, the researcher stated a few criteria that may help in determining the quality of life, which include facilities, transportation, economy and safety.

Most of the aforementioned studies employed statistical tools to analyse the collected data. In recent years, some researchers started to favour fuzzy approach for measuring QoL. Gigović et al. (2016) stated that the weight of each criterion found above were analysed by using the Fuzzy Decision-Making Trial and Evaluation Laboratory (FDEMATEL) method. The study indicated that the FDEMATEL method is more flexible towards comparability and combination of network in decision-making process. Qing and Abdullah (2017), meanwhile, felt that the fuzzy approach dealt better with uncertainty in decision making problem along with the judgement process. Therefore, in determining the weight of QoL criteria for a coastal community in Setiu Wetlands Terengganu, the fuzzy analytic network process (Fuzzy ANP) was suggested. Martin and Vinan (2017) proposed to measure the QoL using Techniques for Order Preference by Similarity to Ideal Solution (TOPSIS) and highlighted that this method helps in better development of uncertain perceptions of the criteria. According to Lee, Chuang and Wu (2013), TOPSIS will help in finding the best results of all practical alternatives.

Based on these previous works (Hartter et al., 2016; Gigović et al., 2016; Acquah et al., 2016; Grinde et al., 2017; Qing & Abdullah, 2017; Martin & Vinan, 2017; Muresan et. al., 2019), the three common standards for evaluating QoL of a community in a certain area are locational, economic and social criteria, each with the following sub-criteria; a) facilities, accessibility and environment (location); b) income, tourism and location (economy); c) safety, health and security (society). The aim of this paper is to utilize the fuzzy approach namely fuzzy ANP based on the identified sustainable QoL criteria at LNP by equipping both operator tools which are the so-called graded mean integration of representation and canonical representation of multiple operations. It is believed that by equipping these operator tools in fuzzy ANP, the evaluation process can be performed more efficiently and is able to reduce the time consumed significantly without losing any information. To do so, this paper is structured as follows; Section 1 begins with a brief discussion in the introduction, followed by a review of the relevant literature. The significance of this research work is highlighted in section 2. Next, Section 3 presents a brief definition related to the proposed method and the fuzzy ANP and provides the step-by-step procedures to perform the proposed method. Section 4 focuses on the feasibility aspect by applying the method via a numerical example and lastly, the discussion and conclusion are presented in Section 5.

2.0 PROBLEM STATEMENT

The area of focus in this study is the zone around Ledang National Park, which is a known tourist spot for recreational activities such as hiking and camping. Based on the researchers' observation, the communities around the zone do not experience much development. Therefore, this leads to some residents relocating to nearby towns like Tangkak and Jasin. While research on socio-economy, tourism and ecosystem had been made by many local researchers such as Abdul et. al (2014), Onrizal, Ismail and Mansor (2019) and Wahab et. al (2019) none has addressed ways to curb this problem.

One of the key steps to addressing this issue is to understand the main concerns of the community members relating to their QoL and sustainable development. From there, one can start devising the suitable approach to be taken to improve the life of said community.

The determinants or criteria that lead towards sustainable QoL in a community may differ according to factors like location, climate and social factors. In order to decide on which criteria are relevant to the matter at hand, one would need to employ decision-making tools capable of evaluating the qualitative or quantitative information of multi-criteria decision making (MCDM) problems. There are two renowned fuzzy methods for tackling MCDM problems; the analytic hierarchy process (AHP) and the analytic network process (ANP). The AHP approach handles the multiplicity of choices of the decision problems through hierarchical structuring. However, this method is not entirely applicable as many decision problems cannot be analysed hierarchically due to their interaction and dependencies of higher-level elements in a hierarchy on lower-level elements. In contrast, the ANP method is a multi-criteria decision-making method where interdependencies amongst many diverse criteria are represented and analysed via a network. This method involves the utilization of pair-wise comparison matrices and constructing interdependencies among decision levels thus giving more reliable solutions. By employing ANP with fuzzy approach for the problem of Ledang community members relocating to nearby towns, one would be able to assess the importance of each studied QoL criteria along with their interdependency with each other.

3.0 MATERIALS AND METHOD

3.1 Preliminaries

For reference purposes, a brief explanation of the fuzzy set theory and TFNs are presented.

Definition 1 A fuzzy set $\tilde{A}$ in a universe of discourse *X* is characterized by a membership function $\mu_{\tilde{A}}(x)$ which associates with each element *x* in *X* that takes the value in the real number in the interval [0,1]. The function value $\mu_{\tilde{A}}(x)$ is termed the grade of membership of *x* in $\tilde{A}$.

Definition 2 A Triangular Fuzzy Number (TFN) $\tilde{A}$ can be defined by a triplet (l, m, u),

where l, m, and u are left, middle and right foot of TFNs, respectively. The membership function $\mu_{\tilde{A}}(x)$ is defined as:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < l, \\ \frac{x - l}{m - u} & l \le x \le m. \\ \frac{x - u}{m - u} & m < x \le u, \\ 0, & x > u \end{cases} \quad (1)$$

Definition 3 (Chou, 2003): Let $\tilde{A} = (a^l, a^m, a^u)$ and $\tilde{B} = (b^l, b^m, b^u)$ be two triangular fuzzy numbers. The *graded mean integration representation* between $\tilde{A}$ and $\tilde{B}$ as.

$$G_M(\tilde{A}) = \frac{1}{6}(a^l + 4a^m + a^u) \quad \text{and} \quad G_M(\tilde{B}) = \frac{1}{6}(b^l + 4b^m + b^u) \quad (2)$$

Meanwhile, the *canonical representation of multiple operation* on TFNs between $\tilde{A}$ and $\tilde{B}$ are defined as

$$G(\tilde{A} \otimes \tilde{B}) = G(\tilde{A}) \times G(\tilde{B}) = \frac{1}{6}(a^l + 4a^m + a^u) \times \frac{1}{6}(b^l + 4b^m + b^u) \quad (3)$$

For simplicity purposes, the mean of fuzzy numbers is used for scale values (SV) based on five linguistic variables as shown in Table 1 while the three definitions of sustainability category (Rashid, 2015) are given in Table 2.

Table 1: The five means of fuzzy numbers

Linguistic variables	Mean of fuzzy numbers
Very high (VH)	1
High (H)	0.75
Medium (M)	0.50
Low (L)	0.25
Very low (VL)	0

Table 2: The sustainability category

Total Score (TS), (%)	Sustainability category
$TS \geq 80$	Sustainable
$80 > TS \geq 50$	Moderately sustainable
$50 > TS$	Less sustainable

Source: (Rashid, 2015)

3.2 Fuzzy-Analytic Network Process (F-ANP)

Fuzzy approach has been recognised as one of the proven and successful methods in various applications. One of the popular methods is fuzzy ANP for solving multiple decision-making problems in uncertain environment. Some recent examples of applications that utilize this method quite successfully includes market value (Chang et al., 2016), supplier selection (Vinodh et al., 2011 & Babihabib et al., 2016), machine selection (Kumru & Kumru, 2015), outsourcing provider selection (Uygun et al., 2015), land-use planning (Najafinasab et al., 2015) etc.

Since Saaty in 1980 introduced the Analytic Hierarchy Process (AHP), this idea has then been extended and improved with a new method, referred to as the Analytic Network Process (ANP). This method has the added value which emphasises the network interrelationships and is able to handle the evaluation process with easy and efficient manner. Moreover, ANP has been found to have the ability to accommodate the interrelationships amongst the different tiers of functional activities (Abdullah, et al., 2018). Therefore, based on this advantage, this technique is then further extended by combining it with the fuzzy sets theory to suit the fuzzy decision-making environment. This effort gives a significant implication in terms of the evaluation process since most decision-making problems deal with uncertainty or ambiguity of information.

Thus, in this paper, the crisp scales from 0 – 5 were predetermined based on Saaty's recommendation scales and the experts' need to evaluate using the triangular fuzzy numbers (TFNs) to cope with the fuzzy environment (see Definition 2 as given in Table 3).

Table 3: The five degrees of importance and TFNs

Degree of importance	Crisp scale	TFNs	Reciprocal of TFNs
Just equal	0	(1, 1, 1)	(1, 1, 1)
Equally important (*EI*)	1	(1/2, 1, 3/2)	(2/3, 1, 2)
Weakly more important (*WMI*)	2	(1, 3/2, 2)	(1/2, 2/3, 1)
Strongly more important (*SMI*)	3	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Very strongly more important (*VSMI*)	4	(2, 5/2, 3)	(1/3, 2/5, 1/2
Absolutely more important (*AMI*)	5	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)

3.3 Procedure of Analysis

In this sub-section, the fuzzy ANP procedure (Wang et al., 2015) assessment of the sustainable criteria is given as follows:

Step 1: Identify the expected sustainable criteria and sub-criteria related to the National Park in Malaysia.
Step 2: Design and construct the ANP structure in different tiers consisting the goal, criteria and sub-criteria as first, second and third tier, respectively.
Step 3: Calculate the local weights of criteria and sub-criteria, respectively.
The pairwise comparison was used to evaluate the entire criteria and sub-criteria by the experts / DMs. The general structure of the matrices is given as follows:

$$M = \begin{bmatrix} (1,1,1) & (l_{12}, m_{12}, u_{12}) & \cdots & (l_{1n}, m_{1n}, u_{1n}) \\ (l_{21}, m_{21}, u_{12}) & (1,1,1) & \cdots & (l_{2n}, m_{2n}, u_{2n}) \\ \vdots & \vdots & \cdots & \vdots \\ (l_{n1}, m_{n1}, u_{n1}) & (l_{n2}, m_{n2}, u_{n2}) & \cdots & (1,1,1) \end{bmatrix} \quad (4)$$

where

$$l_{ij} = \frac{1}{u}; \quad m_{ij} = \frac{1}{m}; \quad u_{ij} = \frac{1}{l}$$

In this step, Chang's extent technique (1996) was employed to calculate the local weights of entire of criteria and sub-criteria.

Step 4: Calculate the inner dependence matrix of the criteria

The inner dependence matrix of the criteria can be determined by multiplying the local weights of the criteria (from Step 3) and the dependence of local weights in the inner matrix. Thus, the inner dependence matrix of criteria $(W_{criteria})$ is given as

$$W_{criteria} = \frac{1}{2}\left(\text{relative importance weights of criteria}\right)\times\left(\text{local weights of criteria}\right) \quad (5)$$

Step 5: Calculate the global weights each of the sub-criteria

The global weights can be calculated by multiplying local weights of sub-criteria with inner dependence weights that are related to the criteria as

$$G^{w}_{sc} = (L^{w}_{sc})\times(IN^{wc}_{dep}) \quad (6)$$

where

L^{W}_{sc} = local weights of sub-criteria, and IN^{wc}_{dep} = inner dependence weights of criteria

Step 6: Determine the total score weights which contribute to the QoL sustainability.

According to Yuksel and Dagdeviren (2010), the total score weights (TS_w) can be derived as

$$TS_w = (G^{w}_{sc})\times(SV)\times 100\% \quad (7)$$

where SV is scale values

Here, the score weights for entire of the sub-criteria can be determined and the highest score weights indicate the biggest contributor to the sustainability of the National Park community. Thus, the sustainability category can easily be determined based on the total score weights and sustainability category (see Table 2).

4.0 NUMERICAL EXAMPLE

Based on our best knowledge and investigations, there are no specific criteria and sub- criteria that have been agreed upon by researchers worldwide to measure the QoL in national park areas. Thus, this section used the most common criteria and sub-criteria based on the LRs which are believed to suit our LNP community area. Suppose three committee members of DMs from different relevant agencies were involved (di; i = 1,2,3), namely district officer (DO), (d^1), LNP senior manager (d^2), and national park expert from Department of Forestry of Malaysia (d^3), to evaluate sustainability QoL criteria for the LNP community. There are 3 main criteria considered namely location (C_1), economy (C_2), and society (C_3), whereas 9 sub-criteria (cij; i = 1, 2, 3; j = 1, 2, 3) are facilities (c_{11}), accessibility (c_{12}), environment (c_{13}) for location criteria and income (c_{21}), tourism (c_{22}), location (c_{23}) and safety (c_{31}), health (c_{32}), security (c_{33}) under economic and social criteria, respectively. Here, the step-by-step procedures that were proposed in the previous section are given as:

Step 1 & 2: Identify the sustainable criteria and sub-criteria of LNP community
Here, the three tiers have been structured for the identified criteria and sub-criteria. The three different tiers are goal, criteria and sub-criteria for first, second and third tier, respectively. Fig. 1 shows the complete three tiers of the structure.

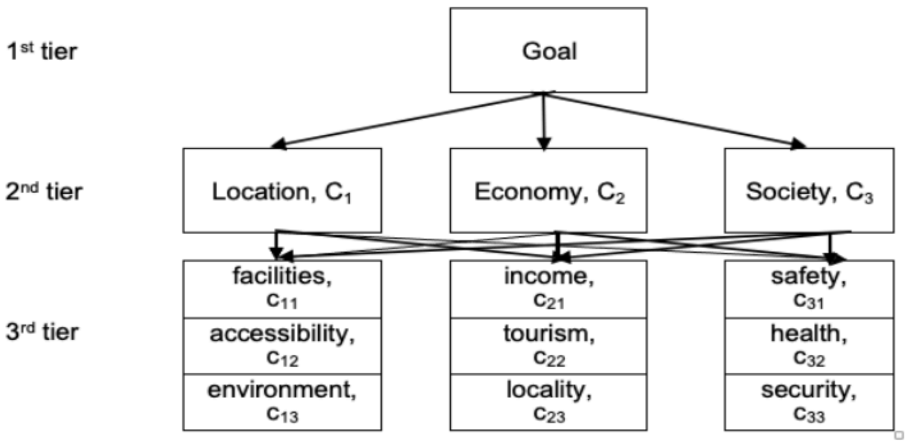

Figure 1: The three tiers of the structure

Step 3: Calculate the local weights of criteria and sub-criteria
Based on the measurement score in Table 3, a group of DMs evaluate the 2 different criteria using the pairwise comparison technique given as

Table 4: The DMs evaluation using pairwise comparison

	C_1			C_2			C_3		
	d^1	d^2	d^3	d^1	d^2	d^3	d^1	d^2	d^3
C_1		(1,1,1)		(2/3, 1, 3/2)	(2/5, ½, 2/3)	(3/2, 2, 5/2)	(2/3, 1, 3/2)	(1/3, 2/5, ½)	(1/3, 2/5, ½)
C_2	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(2/5,1/2, 3/2)		(1,1,1)		(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1/3, 2/5, ½)
C_3	(2/3, 1, 3/2)	(2, 5/2, 3)	(2, 5/2, 3)	(2/7, 1/3, 2/5)	(2/7, 1/3, 2/5)	(2, 5/2, 3)		(1,1,1)	

Table 5: The average evaluation derived from Table 4

	C_1	C_2	C_3
C_1	(1,1,1)	(0.856, 1.167,1.556)	(0.444, 0.600, 0.833)
C_2	(0.856,1.167, 1.833)	(1,1,1)	(1.778, 2.133, 2.500)
C_3	(1.556, 2.000, 2.500)	(0.857, 1.055, 1.267)	(1,1,1)

The local weights of criteria were calculated using Chang's extent technique (1996) and the results are presented in Table 6.

Table 6: Local weights of each criteria

Criteria	Local weights
C_1	0.174
C_2	0.431
C_3	0.395

Similarly, the entirety of the 9 sub-criteria with respect to each criterion can be obtained as shown in Table 7.

Table 7: Local weights of each sub-criteria with respect to each criterion

Criteria, C_i (i =1,2,3)	C_1	C_2	C_3
Sub-criteria, c_{ij} (i =1,2,3; j =1,2,3)	0.427	0.387	0.277
	0.354	0.165	0.498
	0.219	0.448	0.225

Step 4: Calculate the inner dependence matrix of the criteria
In this step, the concept of graded mean integration of representation and canonical representation of multiple operations (see Definition 3) were utilized to calculate the local weights of each criteria. Thus, Table 8 – 10 show the relative importance weights (RIW) of each criterion.

Table 8: The relative importance weights with respect to location(C_1)

Location, C_1	C_2	C_3	RIW
C_2	(1,1,1)	(1.778, 2.133, 2.500)	0.669
C_3	(0.857, 1.055, 1.267)	(1,1,1)	0.331

Table 9: The relative importance weights with respect to economic(C_2)

Economic, C_2	C_1	C_3	RIW
C_1	(1,1,1)	(0.444, 0.600, 0.833)	0.339
C_3	(1.556, 2.000, 2.500)	(1,1,1)	0.661

Table 10: The relative importance weights with respect to social(C_3)

Social, C_3	C_1	C_2	RW
C_1	(1,1,1)	(0.856, 1.167,1.556)	0.490
C_2	(0.856,1.167, 1.833)	(1,1,1)	0.510

Next, the inner dependence matrix of criteria $(W_{criteria})$ was calculated as

$$W_{criteria} = \frac{1}{2}\begin{bmatrix} 1 & 0.339 & 0.490 \\ 0.669 & 1 & 0.510 \\ 0.331 & 0.661 & 1 \end{bmatrix} \times \begin{bmatrix} 0.174 \\ 0.431 \\ 0.395 \end{bmatrix}$$

$$= \frac{1}{2}\begin{bmatrix} 0.514 \\ 0.749 \\ 0.737 \end{bmatrix} = \begin{bmatrix} 0.257 \\ 0.375 \\ 0.369 \end{bmatrix}$$

Step 5: Calculate the global weights of the sub-criteria

The global weights can be calculated using Equation (6) obtained as shown in Table 11.

Table 11: Global weights of each criteria

Criteria	Independent weights of criteria	Local weights of sub-criteria	Global weights
		c_{11}, 0.427	0.110
C_1	0.257	c_{12}, 0.354	**0.091**
		c_{13}, 0.219	0.056
		c_{21}, 0.387	**0.145**
C_2	0.375	c_{22}, 0.165	0.062
		c_{23}, 0.448	0.168
		c_{31}, 0.277	0.102
C_3	0.369	c_{32}, **0.498**	**0.184**
		c_{33}, 0.225	0.083

Step 6: Calculate the total score weights to determine the LNP sustainability. Thus, the total score weights (TSw) for each sub-criterion can be calculated using Equation (7) and the sustainability category easily identified as shown in Table 12.

Table 12: The total scores and the sustainability category

Sub-criteria	Global weights	DMs evaluation (d^1,d^2,d^3)	Average *SV*	Total scores (%), (TS_w)
Facilities, c_{11}	0.110	(*VH,H,M*)	0.750	0.0825
Accessibility, c_{12}	**0.091**	(*H,M,VH*)	0.750	0.0683
Environment, c_{13}	0.056	(*VH,VH,H*)	0.916	0.0513
Income, c_{21}	**0.145**	(*H,M,H*)	0.667	0.0967
Tourism, c_{22}	0.062	(*H,H,H*)	0.750	**0.0465**
Location, c_{23}	0.168	(*L,M,H*)	0.500	0.0840
Safety, c_{31}	0.102	(*VH,H,VH*)	0.916	0.0934
Health, c_{32}	**0.184**	(*VH,VH,M*)	0.833	**0.1533**
Security, c_{33}	0.083	(*M,M,VH*)	0.667	0.0554
Sustainability of total scores (%)				**73.14%**

At this stage (see Table 11) it was observed that the economic(C_2) factor shows the most significant criteria to achieve the sustainability of LNP with score weight of 0.375 as compared to other criteria. Also, the highest three sub-criteria can be easily identified which are health(c_{32}), income (c_{21}), and accessibility (c_{12}) with the global weights score of 0.184, 0.145, and 0.091, respectively. Meanwhile, from Table 12 (see last column), we can identify the three highest total scores of sub-criteria which are health (c_{32}) and safety (c_{31}) for social criterion and income (c_{21}) for economic criterion.

5.0 DISCUSSION AND CONCLUSION

This study employed a fuzzy ANP approach to assess the sustainable criteria on the problem of the LNP community residents who choose to relocate to nearby towns. The measure taken to curb this problem is by following the steps given by Wang et al. (2015), which is equipping operator tools known as the graded mean integration of representation and canonical representation of multiple operations (see Definition 3) in the evaluation process. It is clear that by equipping this tool in fuzzy ANP, the pairwise comparison evaluation process performs more efficiently and has significant reduction in the time consumption involved for the decision-making process without losing any information.

The LNP quality of life (QoL) and sustainable development criteria have been studied specifically on the most common criteria and sub-criteria which are believed to give extra information and are beneficial to them. Based on the proposed concept, the highest total score weights indicate the biggest contributor to achieve the sustainability of national park community in the Ledang area. The method of approach also provides a systematic procedure in structuring the criteria and sub-criteria so that it is possible to rank them from the most influential to the least significant factor of sustainable development around the research area. Three main criteria for promoting sustainability in the Ledang area were identified and weighted according to their importance as shown in Table 11. From there, it is clear that economy (c2) has the highest independence weight, thus indicating the biggest contributor to the QoL sustainability, followed closely by society (c3) and lastly location (c1). In addition, it was found that the sub-criterion health (c32) is the most influential factor, while tourism (c22) is identified as the least influential with total scores of 15.33% and 4.65%, respectively. This is somewhat in line with results from the study by Boncinelli et al. (2015) where health factor significantly affects the population availability in the area of study. On the other hand, Acquah et al. (2016) noted that communities involved in tourism perceived great economic benefits from tourism activities, implying that proper management in this area may improve economic opportunities for the community, thus increasing its sustainability.

Overall, the LNP community have achieved the ‘moderately sustainable’ category (see Table 2) for the entire investigated criteria assessment with average total score 73.14%. These results can provide an initial guideline and assist the relevant authority for a future development planning without damaging the sustainability development components. Although the application in this paper was meant specifically to identify the sustainable criteria and assess the QoL at LNP area, other applications are also expected to be capable of utilizing this approach. The next direction of this research will focus on how the fuzzy approach can develop the SD model towards achieving QoL with more comprehensive results in the national park community area. This is open to future research works.

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