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DEVELOPMENT OF CLIMATE HAZARDS DECISION SUPPORT SYSTEM: A STUDY OF CAMERON HIGHLANDS, MALAYSIA

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Abstract: Cameron Highlands is one of agricultural areas in Peninsular Malaysia. Changing climate has brought threats to this highland region and caused number of climate related disasters such as landslides and floods in recent years. These devastated extreme events had affected the socioeconomic of the local community. The main purpose of this study is to develop a climate hazard decision support system (DSS) for Cameron Highlands based on the driving forces, pressures, states, impacts and responses (DPSIR) framework. It aims to support stakeholders on the land use development and climate hazard reduction in Cameron Highlands. A case study approach was adopted whereas qualitative and quantitative methods were applied in the study. The methods chosen for this study were literature review, data collection, statistical analysis and synthesis, and climate hazard decision support system development. Apart from literature review, local community opinion survey, expertise interview and statistical analysis were the main research activities. Statistical analyses that are most appropriate in data interpretation were determined in the planning phase of this study. Three statistical analyses were carried out namely reliability test, principal component analysis (PCA) and sensitivity analysis. Indicators were extracted by principal component analysis (PCA). Each indicator was then given weightage based on expertise input to form a composite index. The pre-defined indicators were then given a weightage and rating by the 11 experts from different institutions. Reliability analysis was conducted and the Cronbach's alpha value of 0.952 (where $\alpha > 0.70$) was obtained in this study. It indicated a high level of internal consistency of survey outcomes. Based on the survey outcomes, total 25 indicators were extracted using Principal Components Analysis (PCA). These indicators were grouped into 13 subcomponents which are population, solid waste, land use changes, flood disaster, developments/investment opportunities, climate change indicators, health and sanitation, soil quality, disasters/mass movements, socioeconomic, environmental quality, private and public sectors, and individuals. With the outcomes of PCA and experts interview, weightage for each indicator was determined and further aggregated into a decision support system conceptual model as HADSS ver.1.0. Primary data was collected in order to pilot run the HADSS 1.0. It generated an output of −0.5573 and indicated that Cameron Highlands may be deteriorating and at high risk of climate hazards. The standardised beta value of sensitivity test for indicators was obtained as 0.967. The high beta value for indicators means that they are sensitive to changes of the model. The main contribution of HADSS ver.1.0 is to advise and aware the stakeholders about the contribution of their environmental, economic, and social impacts to sustainable development. This increases the transparency in decision making especially local plan development when everyone is involved and played their roles. The HADSS ver. 1.0 also provides a new solution to climate hazards in Cameron Highlands (floods and landslides) and demonstrating the solution's efficacy.

Key words: Climate hazards, decision support system, Cameron Highlands Malaysia

1. INTRODUCTION

Intergovernmental Panel on Climate Change (IPCC) concluded that climate change is occurring caused largely by human activities. As decision makers need to response to changing climate, better linkages between research and decision making are necessary. Climate change needed to be included in decisions across a wide range of human-environment systems. Although some decision makers are well acknowledged with scientific knowledge, it is still insufficient to address dynamic environment with integration of climate change dimension (NRC, 2010). Aideen (2018) highlighted different climate models can provide projection for future scenario and decision-makers who adopt these scenarios must recognise the inherent uncertainties of climate models. Thus, well-defined decision support system (DSS) can be used to improve process by providing a guideline for decision makers to develop an effective policy.

Decision support system (DSS) is recognised as a classical framework to support the decision-making process, but in some cases, incorrect development and usage may produce negative results. To develop a DSS effectively, Er (1988) emphasised the importance of better decision which will be made by an individual or a group based on single or multiple criteria. Arguably, how better and accurate decisions can be made by decision makers in a timely manner. Geurts (1994) identified a primary issue related to the use of inaccurate data in a decision support system. When input data is not accurate, the management may obtain illogical outputs. To prevent this problem, the climate change researchers must be able to oversee the accuracy of the source data. Santoro et al., (2013) state that lack of understanding of climate change information provided by scientists and the data required by regional and local stakeholders can be another drawback.

Tripathi (2011) stated that DSS model is required to be developed in different functionalities specifically to fit into various levels in an organisation. Furthermore, DSS end-user analysis can be performed to define the potential users, whether it is an individual or an organisation, for any selected case study area. There are various researchers have developed DSS and indicators in different sectors such as climate change indicators by US/EPA(2016), DSS for integrated water resources management by Sieker et al., (2006); Giupponi & Sgobbi (2013), integrated environmental DSS for water pollution by Zhang et al., (2014). Besides, decision support system related studies in Malaysia can also be found in Tan & Beh (2015), Aminu et al., (2014), Bani et al., (2011), Norida & Azizi (2011) and Yaakup et al., (2009). However, lack of DSS related to climate change hazards were developed in Malaysia.

Agricultural areas are vulnerable to climate change as the climatic related disasters such as drought and flood have always negatively affected both crop and livestock systems in most regions (Niknam et al., 2018). Climatic related hazards frequently occur associated with extreme weather events. When a natural disaster occurs, it harms human beings and loss of property. Azlee (2015) stated that the National Security Council (NSC) had identified two major reasons for these bizarre disasters in Malaysia: (i) changing climatic patterns and the unfavourable weather effects and (ii) resulting from the unregulated land management, shrinking forest, and abuse of land assets. According to a paper entitled “Malaysia Climate Change Scenarios” published by Malaysian Meteorological Department in the year 2012, the northeast monsoon in Malaysia has become more intense comparing to last century. There will be relatively drier spells corresponding to heavier rainfall within the same year (Khor, 2015). For example, the abnormal rain and strong wind affected most parts of Malaysia since mid-December 2014 until early January 2015. It caused 17 casualties and displacement of over 200,000 people in Kelantan, Terengganu, Pahang, Perak and Perlis, mostly in the northern and eastern regions (IFRC, 2015). The event has indicated that it is not one-off events but part of a national, regional and global pattern linked to climate change and extreme weather events.

In fact, the series of massive flood disasters occurred for last decades has raised the concern of local community to effectiveness of water resources management with the climate change dimension (Tan & Loh, 2017). Hence, effective decision making process to mitigate impacts of climate change can be informed by a wide range of analytical methods for evaluating expected risks and benefits, recognizing the importance of governance, ethical dimensions, equity, value judgments, economic assessments and diverse perceptions and responses to risk and uncertainty.

2. BACKGROUND OF STUDY AREA

Cameron Highlands was chosen as study area. It is located in the north-western corner of the Pahang State in Peninsular Malaysia as shown in Figure 1. It covers an area of 71,000 ha (Mazlan & Mumford, 2004) and has tropical climate which is suitable for planting highlands crops (Hamdan et al., 2014). Based on the weather monitoring station, has recorded a temperature ranging between 15.2°C and 25.3°C along with the highest number of rainy days in a month of 29 days (MetMalaysia, 2017). The mean monthly rainfall is 230.9 mm with the maximum of 463.2 mm and a minimum of 80.6 mm (MetMalaysia, 2013). Since year 2013, Cameron Highlands experienced a series of climate hazard events such as landslides and mud floods. The opening of the reservoir sluice was a safety protocol, but it has caused a disaster in Cameron Highlands.

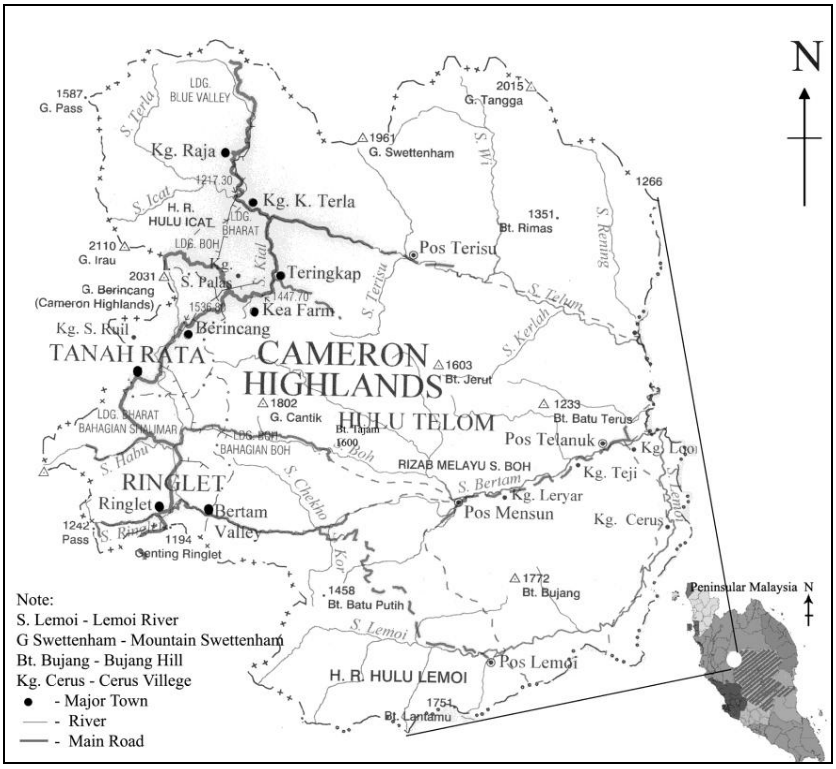

Figure 1. Location of Cameron Highlands (Source: edited from JUPEM, 2002)

This calamity destroyed infrastructure near the river bank and caused death. Hill (2013) identified a number of contributing factors. These include a more rapid rise in water level than usual, owing to deforestation, increasingly intensive agricultural activities and in some cases poorly managed agricultural practices in the dam's catchment area. This is coupled with poor land use practices and the encroachment of urban development into the flood plain below the dam.

Siltation and increased runoff had been an on-going concern in Cameron Highland since 1990an. According to news report; Hazmi (2016) identified three areas which are prone to floods. There are Bertam Valley, Terisu, and Kampung Raja. Hence, it is essential to identify the vulnerable indicators for Cameron Highlands based on driving forces – pressures – states – impacts – responses (DPSIR) framework. The indicators can be aggregated in order to develop a climate change hazard decision support system conceptual model. The conceptual model guides and support decision makers in the level of small highland watershed in order to reduce the flooding impacts on local communities due to climate change.

3. METHODOLOGY

A case study approach was adopted whereas qualitative and quantitative methods were applied in the study. Through the case study method, the researcher can go beyond the quantitative statistical results, through the actor's perspective to understand the behaviour of the situation (Zainal, 2007). The methods chosen for this study were literature review, data collection, statistical analysis and synthesis, and climate change hazard decision support system (HADSS) conceptual model development. Three statistical tests were carried out in Statistical Package for the Social Sciences (SPSS), namely reliability test, principal component analysis (PCA) and sensitivity analysis.

This study focused on development of climate change hazard decision support system for Cameron Highlands based on driving forces, pressures, states, impacts and responses (DPSIR) framework. Apart from literature review, local community opinion survey and expertise interview were the main research activities.

Focus group sampling method was chosen which direct interactions with individuals on a one-to-one basis using personal interviews were applied in this study. Based on Santoro et al., (2013), the survey was conducted on decision support system (DSS) end-users' understanding of climate change impacts. Three main survey fields were investigated namely climate change, climate hazard, integrated water resources management and DSS application.

Individuals or groups that may affect or be affected by the developed climate change hazards decision support system (e.g. District Council officers or Department of Environment officers for town planning and management) were identified as the potential end users for Cameron Highlands. The questionnaire was designed in two main parts: Part A obtained information on the demographic profile of respondents, whilst Part B collected information pertaining to the respondents' perception on the climate hazard indicators for Cameron Highlands. The questionnaire that was set for this research consists of "close-ended" questions. The close-ended questions are in the form of multiple choice answers to give a selection. The focus group survey was conducted with 85 respondents from the local community. It was conducted in April, May and June 2016 in four major townships of Cameron Highlands namely Ringlet, Kampung Raja, Brinchang, and Tanah Rata.

Reliability analysis was conducted to determine the reliability of the questionnaire. Cronbach's alpha value of 0.952 (where $\alpha > 0.70$) indicated a high level of internal consistency of the questionnaire. This finding showed that the responses from the local community is reliable and contains a high level of internal consistency. Thus, the opinion survey is valid for principal component analysis (PCA).

The indicators were extracted by principal component analysis (PCA) with varimax rotation. The purpose of principal component analysis was to reduce the dimensionality of survey dataset by without compromise the intrinsic information. The indicators were extracted with loadings of similar subspaces and grouped into the DPSIR component. Each indicator was then given weightage based on expertise input to form a composite index. The pre-defined indicators were then given a weightage and rating by the 11 experts from different institutions, that are from National University of Malaysia, University of Malaya, University Putra Malaysia, University of Science Malaysia and University Teknologi Petronas. Based on this method, weightage was given to show the applicability of the indicators. Experts may add or remove desired indicators. After the experts' adjustment, several indicators were omitted and some indicators were reworded and simplified.

4. RESULTS AND DISCUSSION

The PCA focuses on only a few principal components (PCs) versus different variables. In this study, the number of PCs were determined by including all those principal components up to a pre-determined total percent of variance explained, that is not less than 50 %. Hair et al., (1998) recommended the significant component loadings to be 0.60 with a sample size of 85 respondents.

Three PCs were loaded in Drivers component with 53.63% of total variation for 10 variables. PC1 (21.456%) explains industrial activities that increase the number of landfills. Meanwhile, PC2 (18.349%) describes economic activity that increase energy consumption and PC3 (13.825%) explains the deforestation problem for Cameron Highlands.

Two PCs were loaded in Pressures component with 53.56 % of total variation for 10 variables. PC1 (31.106 %) expresses that flood disaster may trigger the rehabilitation and reconstruction of infrastructure in the flood-affected districts and PC2 (22.454 %) illustrates that economic growth increases housing demand.

Four PCs were loaded in State component with 62.31% of total variation for 16 variables. PC1 (24.039%) explains that climate change can affect base flow hydrology, watershed topography, soils, and land use. PC2 (16.798 %) explains that human's health can be disturbed by water pollutants when they consume contaminated surface water. Furthermore, PC3 (12.368 %) and PC4 (9.107 %) are related to the monthly summary of climate-related events collected on both a global and national scale.

Two PCs were loaded in Impacts component with 53.56 % of the total variation. PC1 (31.106 %) shows that elucidates flooding or additional slides may occur after a landslide or mudflow during the occurrence of intense storms and rainfall. PC2 (22.454 %) expounds uncontrolled conventional tourism poses potential threats to the environment.

Two PCs were retained in Responses component with 55.44 % of total variation for 9 variables. PC1 (29.776 %) reveals that poor law enforcement and poor regulations led to illegal deforestation. PC2 (25.663 %) explains that recycling can assist in energy and resources saving by reducing the amount of waste going into the landfills.

Based on the PCA outcomes on DPSIR component, total 25 indicators and 13 sub-components were extracted in this study. Those indicators were extracted with loadings of similar subspaces categorised into the 13 sub-components with similar characteristics namely (i) population, (ii) solid waste, (iii) land use changes, (iv) flood disaster, (v) developments/investment opportunities, (vi) climate change indicators, (vii) health and sanitation, (viii) soil quality, (ix) disasters/mass movements, (x) socioeconomic, (xi) environmental quality, (xii) private and public sectors, and (xiii) individuals. It was further aggregated as indices with different weightages as shown in Table 1. The output for each indicator is obtained using the equation as below:

$$\text{Output} = \text{Interpretation} \times \text{Weightage}$$

Where:

Interpretation = Relative change from each subcomponent

Weightage = Design weightage given by experts

Assumptions were made during the construction of this climate hazard decision support system (HADSS ver. 1.0). The interpretation for each sub-indicator was taken as the percentage change. It compared baseline to monitoring values. It showed how much a situation has been changed by external and internal factors. The ratio of baseline and monitoring value was the values which actually observed (what actually happened). Baseline values were benchmarks that were used as foundations for measuring or comparing current and past values. Both the choice of monitoring data and baseline data were governed by the availability of the required relevant data. The basic of operation was given as addition and subtraction. If the relative change increase gives a positive impact, addition is acquired. If the relative change increase gives a negative impact, subtraction is acquired. If the relative change increase gives a negative impact, subtraction is acquired. The final output for the model was obtained using the equation below:

$$x = -D_{1.1}(W_{D1.1}) + D_{2.1}(W_{D2.1}) - D_{3.1}(W_{D3.1}) - D_{3.2}(W_{D3.2}) - D_{3.3}(W_{D3.3}) - D_{3.4}(W_{D3.4}) - D_{3.5}(W_{D3.5}) - P_{1.1}(W_{P1.1}) + P_{2.1}(W_{P2.1}) + P_{2.2}(W_{P2.2}) + P_{2.3}(W_{P2.3}) - S_{1.1}(W_{S1.1}) - S_{1.2}(W_{S1.2}) - S_{1.3}(W_{S1.3}) + S_{2.1}(W_{S2.1}) + S_{2.2}(W_{S2.2}) - S_{3.1}(W_{S3.1}) - I_{1.1}(W_{I1.1}) - I_{1.2}(W_{I1.2}) - I_{1.3}(W_{I1.3}) + I_{2.1}(W_{I2.1}) + I_{3.1}(W_{I3.1}) + R_{1.1}(W_{R1.1}) + R_{1.2}(W_{R1.2}) + R_{2.1}(W_{R2.1})$$

Where:

x = Model output
D_n = Driver indicators
P_n = Pressure indicators
S_n = State indicators
I_n = Impact indicators
R_n = Response indicators
W_{in} = Weightage for each indicator

In order to pilot run the HADSS ver. 1.0, interpretations of each sub-components were generated when comparing observed data to a baseline data. The scale of output is either positive or negative: a positive value is an increase/positive impact, a negative value is a decrease/adverse impact. Available observed data which could be obtained in Cameron Highlands were considered in this study. These may include population number, temperature and precipitation, individual solid waste generation rate and reservoir storage capacity. The current situation in Cameron Highlands of which data is available is used to interpret whether the development happening is sustainable. A summary of a pilot test for HADSS is showed in Table 1. However, for the pilot test of the model, the monitoring values are to be computed as predicted data or expected values. The baseline data are available data that is appropriately close to a chosen reference year. This conceptual model is recommended to conduct the checking on a regular basis as well as a need basis (e.g. on a yearly basis and/or after a change of key indicators' data).

Sensitivity analysis was conducted on the decision support system conceptual model after pilot run to investigate the potential changes and errors and their impacts on conclusions. Pannell (1997) proposes that using sensitivity analysis for decision support can identify suitable recommendation, to sum up the implications of the model. The main purpose of sensitivity analysis is to test the model for validity or accuracy. In this case, the sensitivity analysis demonstrated that outputs are highly sensitive to changes in indicators. The standardised beta value for Indicators is 0.967 and for Weightage is 0.087. This means Indicators has the most impact and is making a significant contribution to the model.

Three scenarios were also developed for HADSS ver. 1.0 to analyse the possible future events in Cameron Highlands. A positive output indicates a good, affirmative, or constructive quality or attributes for the particular indicator and vice versa. Based on ideal conditions, the range of the model output should be −1.00 to +1.00. When sustainable development is implemented where developments in Cameron Highlands will not deplete the natural resources, the output value is +1.00. Overdevelopment gives an output value of −1.00 due to excessive consumption. Unsustainable development is likely to bring more disasters (Mileti & Gailus, 2004). Table 2 shows the three different scenarios in Cameron Highlands. The computed output value found to be − 0.5573 indicated Cameron Highlands may be gradually being deteriorated. The on-going development of the area has brought many climate change hazards such as floods and mudslides. The local residents have to bear the brunt of this massive environmental destruction.

By breaking down DPSIR framework into individual component, Figure 2 shows the radar chart of the outcomes of HADSS 1.0 model. The responses component contributed the positive reaction while impacts component recorded the largest negative deficit. It means that the government and relevant parties have been taking progress to response the climate disasters in the study area. However, it does not effectively to reduce the disaster impact to the communities such as loss of property and poor water quality condition. It may due to the negative driving forces, pressures and states component because high land development activities were observed in the study area.

Table 1. Climate Change Hazard Decision Support System (HADSS ver. 1.0)

Components	**Sub-components**	**Indicator description**	**Unit**	**Interpretation**	**Weightages**	**Output**
Drivers	D1-Population	1.Changes in population	No.	$\frac{\text{Observed(2010)}-\text{Baseline(1991)}}{\text{Baseline(1991)}} = \frac{36{,}978-25{,}555}{25{,}555} = 0.45$	0.029	0.0131
	D2-Solid waste	1. Individual solid waste generation	kg/capita/day	$\frac{\text{Observed(CH)}-\text{Baseline(MY)}}{\text{Baseline(MY)}} = \frac{0.78-1.10}{1.10} = -0.29$	0.027	-0.0079
	D3-Landuse changes	1. Land area for recreational purpose	%	$\frac{\text{Observed(2015)}-\text{Baseline(2003)}}{\text{Baseline(2003)}} = \frac{0.09-0.06}{0.06} = 0.50$	0.025	0.0123
		2. Land area for transportation purpose	%	$\frac{\text{Observed(2015)}-\text{Baseline(2003)}}{\text{Baseline(2003)}} = \frac{0.31-0.33}{0.33} = -0.06$	0.029	-0.0018
		3. Land area for agricultural use	%	$\frac{\text{Observed(2015)}-\text{Baseline(2003)}}{\text{Baseline(2003)}} = \frac{10.54-8.01}{8.01} = 0.32$	0.031	0.0099
		4. Land area for residential development	%	$\frac{\text{Observed(2015)}-\text{Baseline(2003)}}{\text{Baseline(2003)}} = \frac{0.42-0.40}{0.40} = 0.05$	0.029	0.0014
		5. Land area for commercial/industrial development	%	$\frac{\text{Observed(2015)}-\text{Baseline(2003)}}{\text{Baseline(2003)}} = \frac{0.08-0.09}{0.09} = -0.11$	0.029	-0.0033
Pressure	P1-Flood Disaster	1. Number of floods events	No.	$\frac{\text{Observed(2011)}-\text{Baseline(2008)}}{\text{Baseline(2008)}} = \frac{15-4}{4} = 2.75$	0.056	0.1531
	P2-Developments /Investment Opportunities	1. Gross domestic product in primary sector	%	$\frac{\text{Observed(2015)}-\text{Baseline(2000)}}{\text{Baseline(2000)}} = \frac{12.7-34.2}{34.2} = -0.63$	0.050	-0.0314
		2. Gross domestic product in secondary sector	%	$\frac{\text{Observed(2015)}-\text{Baseline(2000)}}{\text{Baseline(2000)}} = \frac{6.9-8.2}{8.2} = -0.16$	0.047	-0.0074
		3. Gross domestic product in tertiary sector	%	$\frac{\text{Observed(2015)}-\text{Baseline(2000)}}{\text{Baseline(2000)}} = \frac{82.4-69.6}{69.6} = 0.18$	0.048	0.0088
States	S1-Climate Change Indicators	1. Average daily maximum precipitation	mm/yr	$\frac{\text{Observed(2015)}-\text{Baseline(1990)}}{\text{Baseline(1990)}} = \frac{69.8-84.7}{84.7} = -0.18$	0.040	-0.0070
		2. Annual minimum temperature	°C	$\frac{\text{Observed(2015)}-\text{Baseline(1990)}}{\text{Baseline(1990)}} = \frac{11.9-11.6}{11.6} = 0.03$	0.034	0.0009

		3. Annual maximum temperature	°C	$\frac{\text{Observed(2015)}-\text{Baseline(1990)}}{\text{Baseline(1990)}} = \frac{25.2-26.7}{26.7} = -0.06$	0.038	-0.0021
	S2-Health and Sanitation	1. Number of health facilities (hospital/clinic)	No.	$\frac{\text{Observed(2016)}-\text{Baseline(2009)}}{\text{Baseline(2009)}} = \frac{12-9}{9} = 0.33$	0.025	0.0083
		2. Drinking water supply by PAIP	m^3	$\frac{\text{Observed(May)}-\text{Baseline(Feb)}}{\text{Baseline(Feb)}} = \frac{349{,}981-245{,}141}{245{,}141} = 0.43$	0.028	0.0121
	S3-Soil Quality	1. Sediment deposition rate in Ringlet Reservoir per year	kg/yr	$\frac{\text{Observed(2008)}-\text{Baseline(1965)}}{\text{Baseline(1965)}} = \frac{139{,}712-25{,}000}{25{,}000} = 4.59$	0.035	0.1628
Impacts	I1-Disaster/Mass Movement	1. Total populations affected by flood per year	No.	$\frac{\text{Observed(2014)}-\text{Baseline(2013)}}{\text{Baseline(2013)}} = \frac{150-38}{38} = 2.95$	0.041	0.1221
		2. Total loss of properties	RM (million)	$\frac{\text{Observed(2014)}-\text{Baseline(2013)}}{\text{Baseline(2013)}} = \frac{8-2}{2} = 3.00$	0.042	0.1270
		3. Money spent to repair landslide-prone slopes	RM (million)	$\frac{\text{Observed(2016)}-\text{Baseline(2015)}}{\text{Baseline(2015)}} = \frac{20.8-34}{34} = -0.39$	0.042	-0.0164
	I2-Socio-economy	1. Number of tourist visit to Cameron Highlands	No.	$\frac{\text{Observed(2014)}-\text{Baseline(2013)}}{\text{Baseline(2013)}} = \frac{590481-728131}{728131} = -0.19$	0.036	-0.0068
	I3-Environmental Quality	2. Water quality index	No.	$\frac{\text{Observed(2015)}-\text{Baseline(2012)}}{\text{Baseline(2012)}} = \frac{83-78}{78} = 0.06$	0.038	0.0024
Responses	R1-Private and Public Sectors	1. Law enforcement performance – illegal plantation estates	ha.	$\frac{\text{Observed(2015)}-\text{Baseline(2014)}}{\text{Baseline(2014)}} = \frac{2{,}258.16-6{,}000}{6{,}000} = -0.62$	0.061	-0.0383
		2. Number of trees replanting	No.	$\frac{\text{Observed(2015)}-\text{Baseline(2014)}}{\text{Baseline(2014)}} = \frac{4000-8000}{8000} = -0.50$	0.069	-0.0346
	R2-Individuals	1. Recycling rate	metric ton	$\frac{\text{Observed(2014)}-\text{Baseline(2009)}}{\text{Baseline(2009)}} = \frac{668.2-258.49}{258.49} = 1.59$	0.069	0.1098
					Output	**- 0.5573**

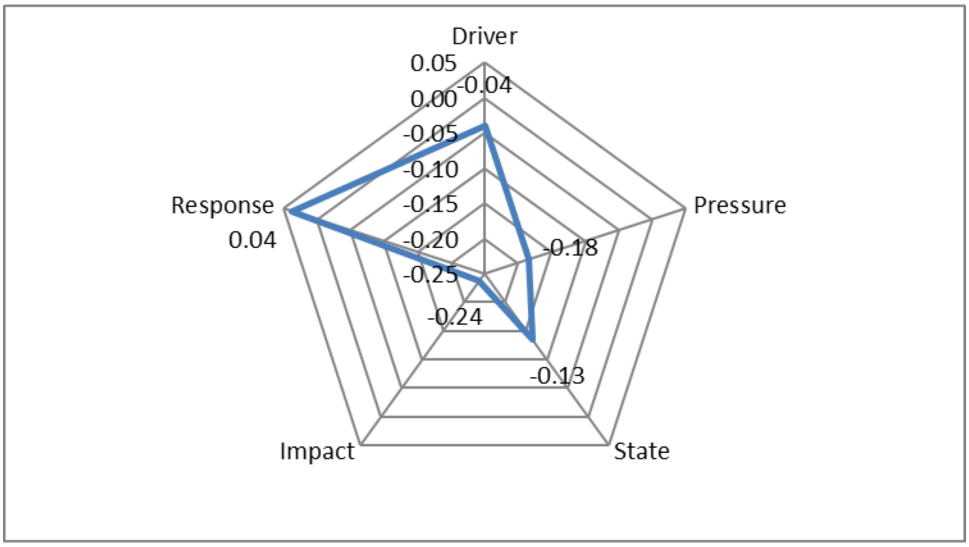

Figure 2. Performance of DPSIR components in HADSS ver. 1.0

Table 2. Scenarios of Climate Hazard Decision Support System (HADSS)

Output	Scenarios
−1.00	The −1.00 scenario describes a situation of rapid economic growth and development. It focuses on the negative consequences of excessive consumption. Cameron Highlands faces enormous development pressures resulted in major environmental issues e.g. local climate change. Climate related disasters are more likely to occur with unsustainable development i.e. irresponsible planning and environmental degradation. Over and unsafe development magnifies the impacts of hazards i.e. landslides and mud flood in Cameron Highlands. These impacts will be the greatest for the least vulnerable group i.e. farmers.
0.00	The 0.00 scenario describes a situation of balance circumstance. This scenario is also oriented towards ecological balance and social equity. The current relationship between development and climate hazard remain relatively stable and manageable.
+1.00	The +1.00 scenario describes a situation of economic, social, and environmentally sustainable. It will not deplete the natural resources of Cameron Highlands. The highland is well conserved and managed in a sustainable manner by authorities. It maintains environmental quality socioeconomic conditions. Existing natural resources stocks are well maintained and strengthened. Sustainable development practices are also able to reduce future hazard losses.

5. CONCLUSIONS

This study has developed a decision support system namely HADSS ver. 1.0 to support climate hazard reduction for Cameron Highlands. Sensitivity analysis was conducted on the decision support system conceptual model after pilot testing to investigate the potential changes and errors and their impacts on conclusions. The development and use of decision support system for Cameron Highlands is important as climate hazards are having a major impact on communities and economies. Losses due to natural disasters are expected to increase in the future along with climate change, populations and economic growth. Hence, climate risk reduction measure is actually more effective than response and recovery.

The main contribution of HADSS ver. 1.0 is to advise and aware the stakeholders about the contribution of their environmental, economic, and social impacts to sustainable development. This increases the transparency in decision making especially local plan development when everyone is involved and played their roles. The HADSS ver. 1.0 also provides a new solution to climate hazards in Cameron Highlands (floods and landslides) and demonstrating the solution’s efficacy.

However, design and development of computer user interface using the HADSS 1.0 conceptual model is recommended for future studies. The recommendations also include the climate hazards impacts and mitigation toolbox. Climate hazards related data and a series of mitigation measures should be make readily available to the public and up for viewing at the local town council.

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