

# GIS MODELLING IN RESOURCE PLANNING AND MANAGEMENT

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## ABSTRACT

Pressure for development has damaged the natural environment including the upland resource areas. It is envisaged that modelling and spatial analysis can enhance the efficiency of environmental assessment. Geographic Information System (GIS) is among the more effective tool for environmental assessment to aid decision making in the planning and management of the natural environment. This research attempts to integrate the Multicriteria Analysis (MCA) and the technique of Ultimate Environmental Threshold (UET) with GIS to plan and manage the upland resource areas. The main objective of the study was to determine the limits to development of the natural resource and the limits for socioeconomic activities in the District of Cameron Highlands. The analysis was undertaken in two stages. In stage one, the sensitivity levels of the natural resource was determined through spatial analysis under the MCA method. In stage two, limitations to development and socioeconomic activities was determined with the use of UET technique. A classification of permissible and non-permissible activities was obtained and the limitations to development and socioeconomic activities was spatially patterned out for the District of Cameron Highlands. A comparative analysis of the limitations to development and socioeconomic activities with existing land use and proposed land use had indicated the damaged done to the upland resource areas from development and agriculture. Hence, pressure from indiscriminate development and illegal agriculture activities has destroyed the upland resource areas. The integration of the MCA and UET can provide much needed information to aid the planning and management of upland resource areas.

## 1. INTRODUCTION

### INTRODUCTION

Natural resources management is more complex with the current development. It involves ecological element, economy, human and subsystems. The public became concerned about sustainable development especially after United Nation Conference on Environment and

Development in 1992 at Rio de Janeiro (Moffat, 1996). Pressures from rapid development and human involvement continue destroy the natural resources. Thus, natural resources management becomes more complicated in developing countries. Urban and regional planning is directly involved with natural resources management. Implementation of resources management systems is undertaken by development plans such as physical plan, structure plan, local plan, etc. A good methodology and appropriate tools are required for sustainable resources management systems. Activities of the resource area must be identified based on the sensitivity of the resource. Geographic Information Systems is one of the best tools to implement natural resources management. The most importance of GIS is about its capability to handle spatial data and attribute data (Ahris, 1994). The integration of the knowledge and GIS will contribute to better resources management. This paper will discuss the implementation of planning technique and GIS in natural resources management. The objective of this study is to identify the databases and modeling technique in order to manage natural resources. It also demonstrates the limitations of activities based on the sensitivity of the resources.

## 2. EXPERIMENT

### 2.1 Experimental Apparatus

The model is formulated by using GIS software. The study area for this study is the whole of Cameron Highlands district, and that is 71,218 km<sup>2</sup> (Figure 1). It is located at 1800 above mean sea level in Pahang state. Its temperature is about 13°C to 18°C. It is very popular as a main tourism place and for agriculture activities (flowers, tea, vegetables and fruits). The pressures from those activity has contributed a lot of problems in Cameron Highlands, and mostly from the agriculture and tourism activities. There is depletion are extinction of the natural resources occurred as soil erosion, lands and disruption of the utility systems.

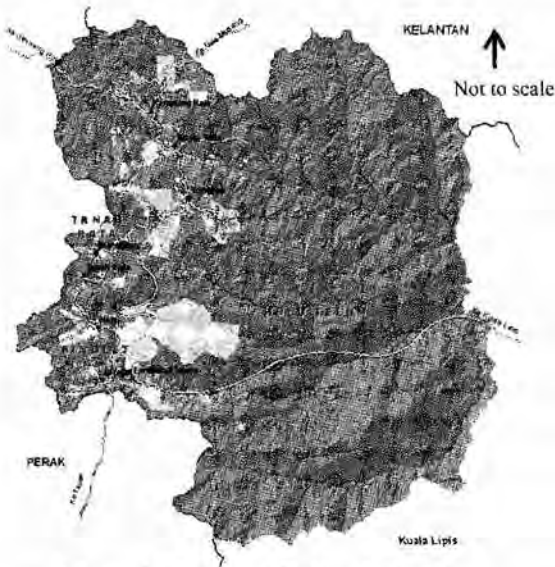


Figure 1: Cameron Highlands district



Figure 2: The topography of Cameron Highlands

## 2.2 Methodology and Technique

The few steps in this study includes data modeling, data acquisition and data analysis. A variety of techniques has been evaluated for use in this study. All the processes of the study is shown in Figure 4. GIS is the main tool in every step of study. GIS is to develop databases and analysis. At the analysis stage, two techniques was used to run the analysis. The first technique is MCA, which was used to determine the priority of the criteria. The second technique is UET, where by it determined the limitations of activities to the resource area. This process was carried out with the survey of the stakeholders and local community.

### 2.2.1 Model Analysis

The model analysis was designed based on literature review and survey. Various criteria have been considered for this study (Figure 6). The criteria were determined based on the study area.

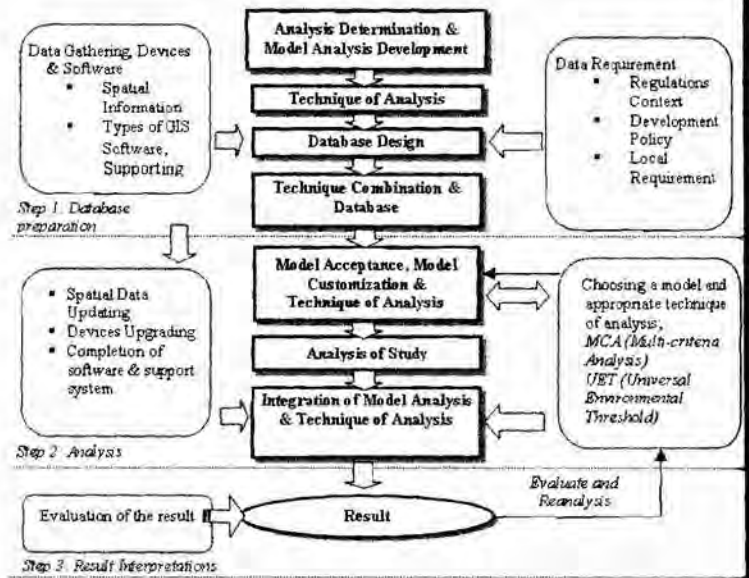


Figure 4: The methodology of the study

Each criteria it has a different weightage and the priority for each criteria was identified using MCA (Figure 5). This technique is able to synchronize all the criteria based on the significance to the study (Malczewski, 1999). This study found the forest as the most significant element in Cameron Highlands (Figure 6).

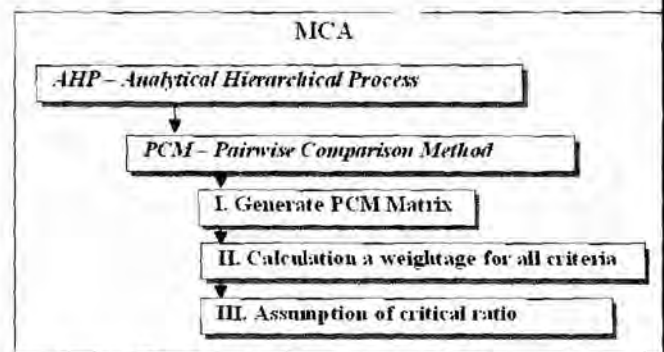


Figure 5: The calculation process of the criteria

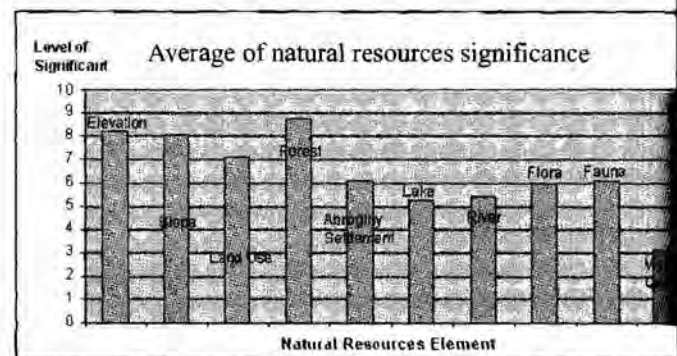


Figure 6: The priority of the natural resources element.

### 2.2.2 Data Modelling and Data Acquisition.

Data modelling in this study also based on literature review. Consideration on the purpose and level of study is used to model the data. All the suggested criteria evaluated were based on the suitability in Cameron Highlands. There are six classes of criteria, followed by sub-criteria. The classes are topography, forest area, land use, aborigine settlement, water body, flora and fauna. These criteria have been used to create the model analysis.

The data were obtained from several sources some were obtained from secondary sources such as the local authority, department of survey and other departments. Some data needed to develop include the visual quality area, new road and hazardous area. A field survey was made to get all the information using GPS (Global Positioning Systems). Interviews and survey forms were carried out to get information for the analysis.

The next step of study was to get response from stakeholders and local community. This task was basically to get their opinion about the level of activity's effect on the natural resources. The UET technique was applied to get the information from the respondent (Figure 8). The UET technique is able to identify the human activities based on the natural resources (Kozlowski and Hill, 1993). This technique demonstrates the opinions of the respondent.

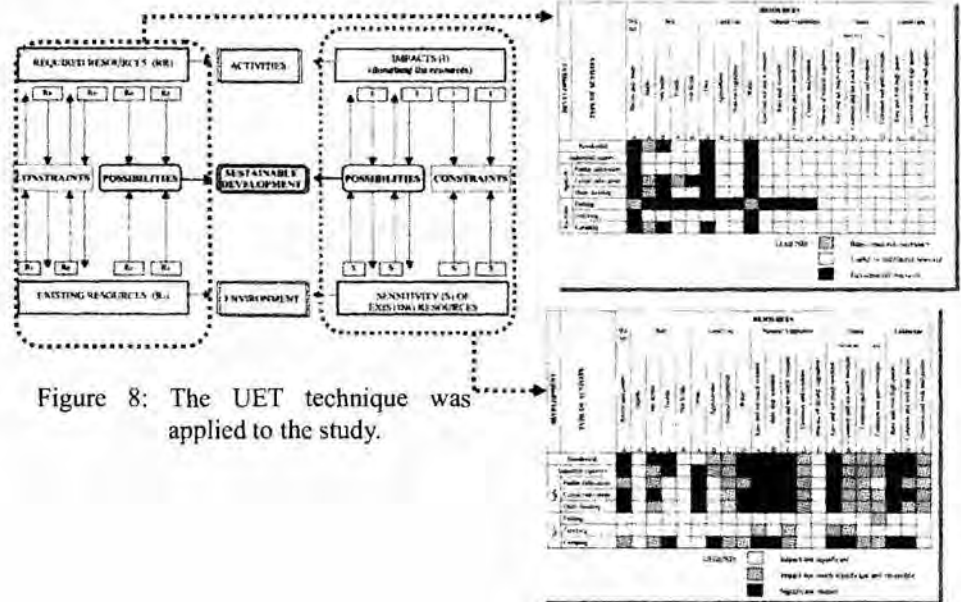


Figure 8: The UET technique was applied to the study.

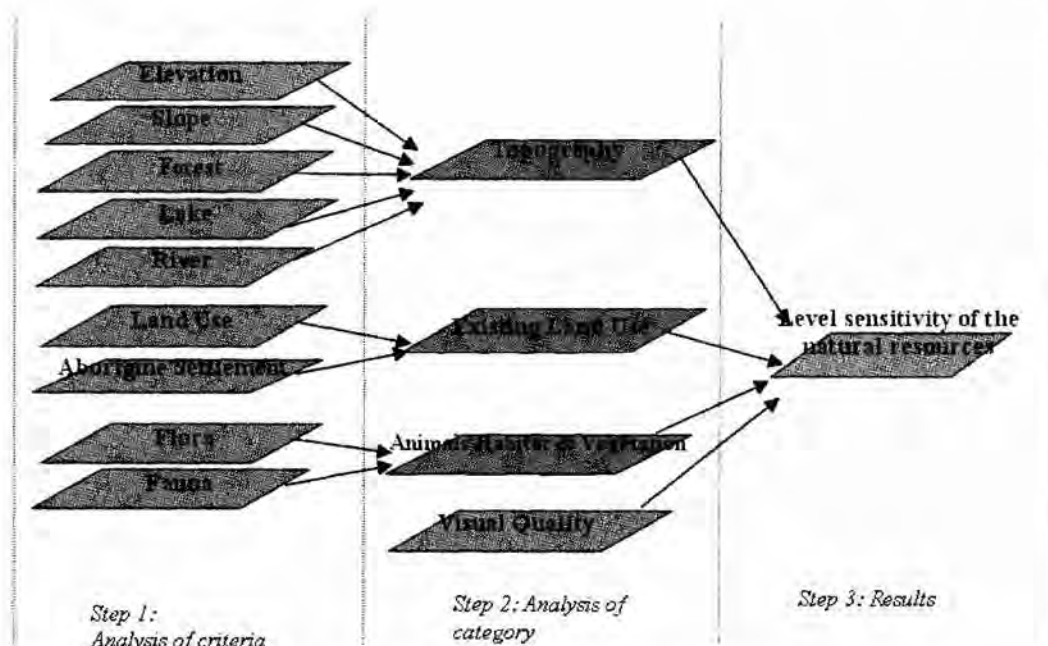


Figure 7: Model analysis to identify the sensitivity level of natural resources.

Results from the survey show the categories of environmental impacts from the socioeconomic activities. The categories of impacts have been classified as no impact, less impact, moderate impact and serious impact to the natural resources. Several main categories of activities have been considered in this survey such as physical development, agriculture (vegetables and tea farm), light agriculture (fruits and flowers) and tourism activity. The results show that physical development is the main factor giving a serious impact to the natural resources (Figure 9). In contrast, the tourism activity gives low impact to the natural resources.

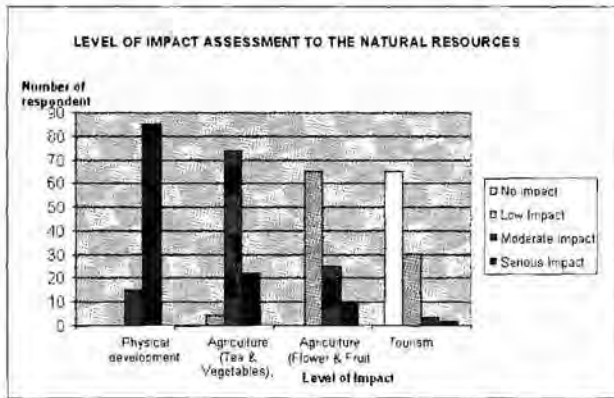


Figure 9: Level of socioeconomic activity's impact

Thus, activities must be allocated to particular natural resources area based on the sensitivity level of natural resources itself. The results from the sensitivity level of natural resources and the impact of socioeconomic activity is then analyzed in spatial form.

### 3. ANALYSIS

The first process is to obtain the sensitivity level of research area. Next is to find the limitations of socioeconomic activities based on the sensitivity level of the natural resources. The result is compared with existing land use and also future land use. The analysis is accomplished by using ArcGIS 9.1 software. It included 3D Analyst functions and also Spatial Analyst functions. The process of analysis implicated a raster format data. This form of data was used because the format is easy and the process of analysis is faster.

The first step is to run the model analysis to obtain the sensitivity level of the natural resources. This task was carried out using raster calculator in Spatial Analyst functions (Figure 10). Weightage for criteria was put together in running the analysis. From the analysis carried out the results show the sensitivity level of the natural resources in Cameron Highlands (Figure 11). Table 1 shows the area for each class of sensitivity.



Figure 10: Raster calculator in running the model analysis.

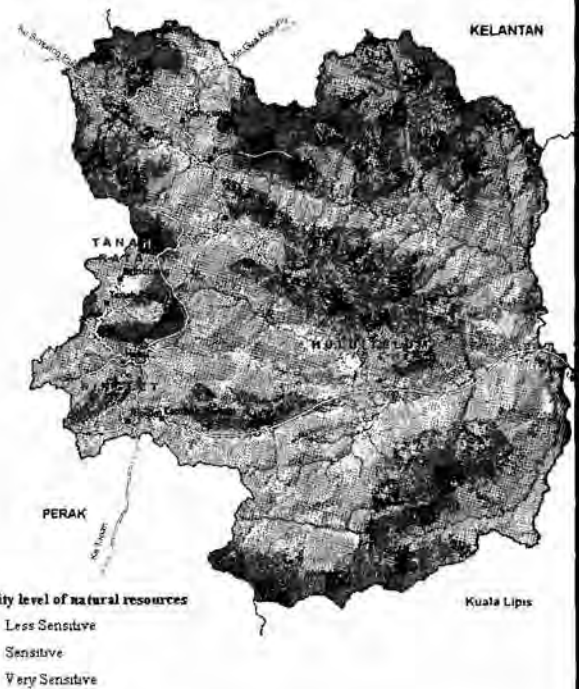


Figure 11: Sensitivity level of natural resources in Cameron Highlands

Table 1: Area of sensitivity class

| Sensitivity Level | Area (hectare) |
|-------------------|----------------|
| Less Sensitive    | 9141.00        |
| Sensitive         | 43801.00       |
| Very Sensitive    | 18276.00       |
| Total             | 71218.00       |

Table 1 shows that the sensitive level of natural resources as the biggest area in Cameron Highlands. This area is 43,801 hectares from the whole. In contrast, the less sensitive area is only 9,141 hectare from the whole of

Cameron Highlands. The very sensitive area shown it covers 18,276 hectares. Thus, there is very limited area for high impact development in Cameron Highlands. Next, the results was analyzed on the socioeconomic activity to identify a suitable area for each activity.

This second analysis was carried out using ArcGIS 9.2 software. The analysis was done by using weighted overlay where by every activity was given a number based on its impact on the natural resources. The socioeconomic activities was transformed in a spatial format and covered the entire district. This analysis again used the raster calculator. The analysis shows the different results for each activities (Figure 12, 13, 14).

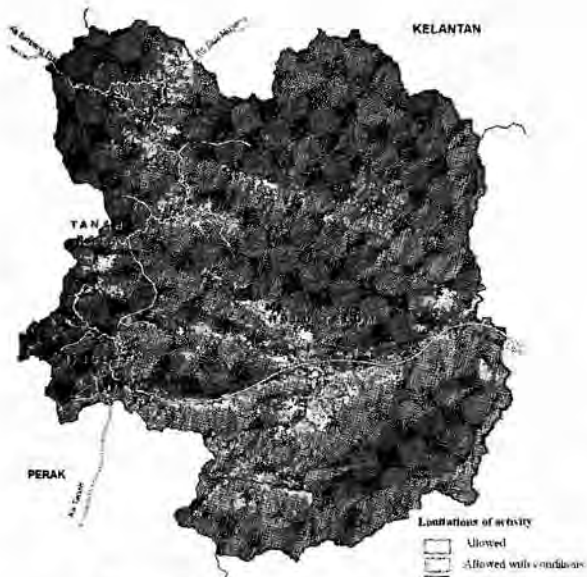


Figure 12: Limitations of tourism activities.



Figure 13: Limitations of agriculture activities.

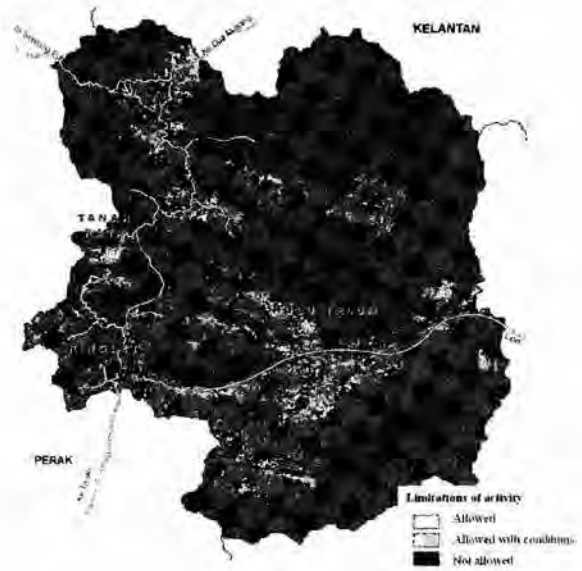


Figure 14: Limitations of physical development activities.

Those figures show the different activities allowed based on the sensitivity level of natural resources. Physical development is the main activity not allowed in Cameron Highlands. There are some small areas allowed to develop with physical development but with a condition (Figure 14). In contrast, tourism activities are allowed for the entire area of Cameron Highlands (Figure 12). Agriculture activities give a moderate impact on the natural resources and its limitations are only at the certain areas. In such cases it still needs to consider the impact to the resources.

The third analysis compares the limitations of activities to the existing land use and future land use. The purpose of this process is to determine the area that is not appropriate with current development. Thus it will show the potential areas that will be facing problems. The analysis was done by using raster overlay. The existing land use was compared to every limitation of activities. Next the comparison to future land use will shows the conflicts in planning areas in Cameron Highlands. Figure 15 shows the process of the comparison analysis. The analysis shows the results in Figure 16 and Figure 17.

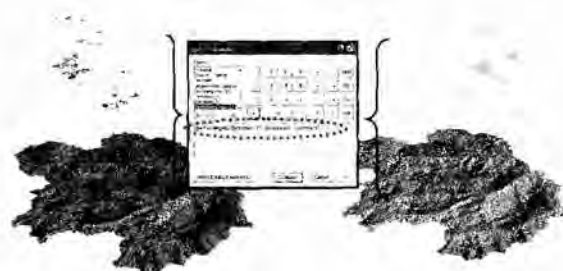


Figure 15: The process of analysis using raster overlay.

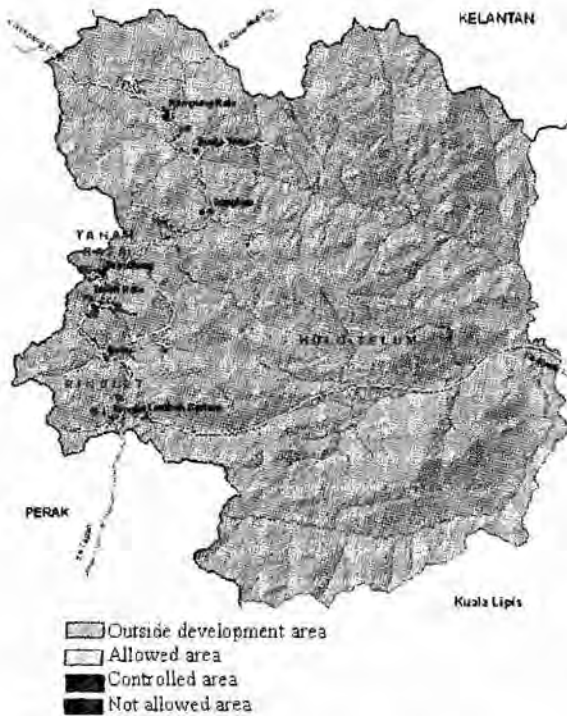


Figure 16: Comparing limitations of activities and existing land use.

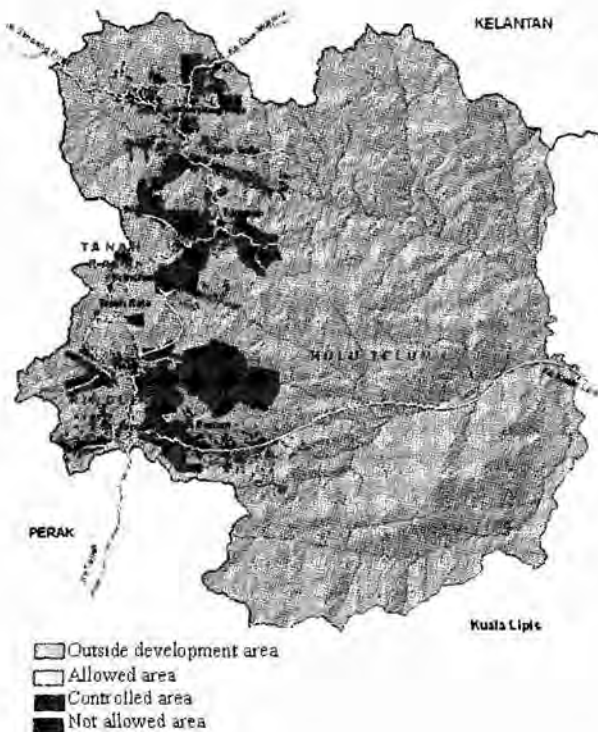


Figure 17: Comparing limitations of activities and future land use.

The result from figure 15 shows that some areas were developed at unsuitable areas. There were a conflict area at Brinchang and Tanah Rata where by a group of

unsuitable activities to the natural resources are shown. The problem occurred due the lack of the current development. Comparison between the limitations of activities with future land use shows that there are many areas that will be developed under the controlled area. In fact, some areas will be developed under the not allowed areas. Such conflicts will contribute problems to the natural resources. Future land use plans need to be reviewed before the implementations. Such action will keep the serenity of natural resources and directly avoid accidents to that particular area.

#### 4. CONCLUSION

In conclusion, the study has helped to manage the natural resources in Cameron Highlands in a proper way. It also shows the limitations of socioeconomic activities based on the sensitivity level of natural resources. All the activities were considered based on their impacts on the natural resources. Thus, the serenity of natural resources can be maintained. Lack of current development has brought a lot of problems to Cameron Highlands. The future land use shows the lack of development as well. Many areas will be developed under the unsuitable areas and this will bring problems. The methodology of the study shows a particular method in achieving sustainable resources management. Resources management is very important to maintain and rejuvenate to the current situation. Sustainable resources management is important because we do not inherit the resources but borrow it from our children.

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