AN EXPERT SYATEM FOR FOREST RESOURCES MANAGEMENT

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1.0 Introduction

Forest resources would be defined as all that is provided by the forests in their various functional aspects. Thus, it would include in timber forest resources, non-timber forest resources, the forest's potential for recreation as well as its potential for providing important scientific information, drinking water and other services (Gan and Weinland, 1996).

The forestry sector in Malaysia plays an important role in the socio – economic development of the country (Forestry Department Headquarters, 1997). It is estimated that the total export value of timber and timber products, which includes rattan and wooden furniture is recorded at RM 13.1 billion (USD 3.27 billion) or about 7% of total export receipt of the country in 1995. The total revenue derived from royalties, premium, forest development fund and others in 1995 amounted to about RM 2 billion (USD 0.5 billion), while total investment into wood-based industries in Peninsular Malaysia in 1995 was estimated to be about RM 2,549 million (USD 671 million). The forestry sector also provided employment, either direct or indirect for about 250,000 persons in 1995. A total of about RM 500 million are paid out as salaries for workers involved in the forestry sector. (Ginny, 2000).

Since early times the Malaysian forest played a significant role in man's relationship with his environment. Forests are important as a physical, economic resource, social, cultural and spiritual resource for livehoods as well as the basis of beliefs, identity and survival, by indigenous, environmentalist and forest-dependent peoples. Thus, proper forest management is vital to ensure next generations have the opportunity to get benefit from forest resources. Over the years, forest management in Malaysia has slowly been moving from the traditional single use, single-resource management of sustained yield towards a more holistic scope of multiple-value, multi-resource management. The current trend is not only looking towards sustaining the yield of the forest resource but also including environmentally appropriate and socially acceptable management of the forests (Ginny, 2000).

1.1 Decision Making in Forest Resources Management

Forest resource planning is a very complex problem mainly due to the multiplicity of wide-ranging criteria involved in the underlying decision-making process. Thus, every decision made affects criteria of different nature like economic issues (e.g., timber, forage, livestock, hunting, etc.); environmental issues (e.g., soil erosion, carbon sequestration, biodiversity conservation, etc.); and social issues (e.g., recreational activities, level of employment, population settlement, etc.) (Luis and Carlos, 2008).

With regards to the above considerations, apparently the concept and measurement of the sustainability of a forest system is a very complex problem, and there is no consensus about how to address it. In this respect, one of the most widely used orientations to measure the sustainability of a system is the so-called "indicators approach". Within this perspective, the main subject is to aggregate the different indicators used into a single index that measures the sustainability of the forest system as a whole. Analytically, the stated problem of aggregation fits in very well with a MCDM approach (Luis and Carlos, 2008).

However, the major problems in accessing a human expert in are scarcity of real experts and consultation may be very expensive for decision making process. Human experts are bounded by limitations and it is quite difficult for a human expert to consider all the essential factors while taking decision. Something is always escaped and remains unattended (Rajkishore and Ashok, 2005). Some tool or assistance is needed even for an expert to update his knowledge and get help in decision making process. Thus, developing an expert system prototype using Analytical Hierarchy Process (AHP) as a knowledge base is proposed to assist decision makers in selecting the best forest resources use with regard to SFM for specific areas.

2.0 Objectives

The general objective of the research was to develop an expert system for forest resources management. More specifically, it aims:

i. to structure a hierarchy of forest management problems into objective, criteria and alternatives which is important in decision making process.
ii. to develop of prototype of expert system that can be used in process of forest resources management.

3.0 Methodology

The methodology can be divided into two parts.

(i) Structural hierarchy using AHP

The AHP is a mathematical theory of value, reason, and judgment, based on ratio scales for the analysis of multiple-criteria decision-making problems (Saaty, 2001). An AHP model typically consists of an overall goal, a set of criteria to specify the overall goal decomposed to subcriteria, and finally, at the lowest level of the hierarchy, the decision alternatives to be evaluated. Beyond the decomposition principle, the AHP is based on pairwise comparisons of elements in a decision hierarchy with respect to the parent element at the next higher hierarchical level (i.e., among criteria and lower level elements). Pairwise comparisons are made on a scale of relative importance where the decision maker has the option to express the preferences between two elements on a ratio scale from equally important (i.e., equivalent to a numeric value of one) to absolute preference (i.e., equivalent to a numeric value of nine) of one element over another (Saaty, 2001).

(ii) Development of prototype expert system

A definition of expert systems would be the interactive computer programs that mimic the decision making and reasoning processes of human expert advice, answering questions and justifying their conclusions (Chau & Albermani 2002). It utilizes observed or available information to reduce 'high grade' knowledge and solve problems by qualitative reasoning 'using the heuristic knowledge' (Hickey et al. 1990). Expert system development stages can be divided into (i) task analysis, (ii) knowledge acquisition process, (iii) prototype development, (iv) verification and validation. Most of expertise for forest resources domain is acquired from text (manuals and books), research publications (journals and proceedings), field observation and interview of experts. The performance of prototype expert system can be tested by using case study.

4.0 Result and Discussion

4.1 AHP Development

In this paper, the structure of AHP model is presented. It uses a hierarchical structure which is dividing into three hierarchy levels with the goal of "Selecting the Best Forest Resources Use for SFM". Goal, criteria and alternative are chosen based on literature reviews and from interaction with expertise in forest management. A few expertises from various agencies that involved in forest resources management are selected for knowledge acquisition process (Table 3). The hierarchy structure for problem research is shown in Figure 1. At the top level, a goal is specified; that is "Selecting the Best Forest Resources Use for SFM. At the second level, all the criteria are listed, as shown in Table 1. At the bottom level, all the decision alternatives are presented, as listed in Table 2.

Decision making in forest management is basically to construct forest management planning and forest policy. The first step for integrated forest management planning is the zoning of the forest according to functions (production, protection and social needs). Where forests are managed for protection and social needs, forest operations are not permitted (Gan and Weinland, 1996). Forest for production is perhaps the most popular alternative nowadays. In 2003, the area of natural-forest Permanent Forest Estate for production forest was 11.18 million hectares which comprised 77.8% of total area, compared to areas reserved for protection forest, which only comprised 3.21 million hectares (22.3%) (Ministry of Primary Industries, 2004).

Forest for protection and forest for social needs may be equally important or even more important than forest for production. This is due to the fact that the richness of biological biodiversity in tropical forest of Malaysia, where it is estimated to have 12,500 species of flowering plants and more than 1,100 species of ferns, not to mention the endangered species. This has complied Malaysia to be one of the twelve mega-diverse countries in the world (Ministry of Primary Industries, 2004). Other than that, the importance of soil and water in protection forest should be emphasized as it is important for climate regulation, water flow regulation, watershed protection and etc. Forest for social needs protect the rights of indigenous peoples to exploit the forest resources, as long as not for commercial use. Though their rights are recognized by laws, sometimes the forests they are depend on, are being logged and harvested. Forest for social needs also provide recreational services and functions for research and developments, educations and amenity. These are the values that people incapable to evaluate with numerical value. Thus, it is significant to put the forest for protection and forest for social needs as the alternatives in the constructed hierarchy.

4.2 Architecture of Expert System

The consultation process involved in the prototype can be summarized in Figure 2. The consultation process with the expert system begins once the users key in value into the pairwise comparison matrix interfaces to evaluate criteria over goal and alternatives over criteria as shown in Figure 3 and Figure 4. The result then will be retrieved after users completed the key in process in pairwise comparison matrices. However, the consistency ratio must be equal or lower than 0.1 or 10% in order to ensure the input values were accepted; otherwise the pairwise comparison matrix process has to be evaluated repeatedly until the consistency ratio reached 0.1 or lower. The prototype will give recommendations and suggestions after all the process above has been performed.

5.0 Significance of Findings

This research is tried develop a computer system, which can assists manager to manage their forest resource effectively. Therefore, it will integrate a few field of knowledge such as expert system technology and Analytical Hierarchy Process (Multi-Criteria Decision Making methods) in order to solve forest resource management problems. This ensures that forest resource management will take into account the numerous relevant criteria including tangible and intangible factors and their relative importance in an objective manner. Expertise in the knowledge base was acquired from multiple sources such as textual sources, reputed journal publications and forest practitioners in Malaysia. In developing countries where expertise and resources are scarce, this inexpensive system is particularly useful in avoiding adhoc or ill-informed decisions which can be unnecessarily costly.

Table 1. Set of criteria for the hierarchy

Criterion	Details
C1	Compliance with laws and FSC Principles
C2	Tenure and Use Rights and Responsibilities
C3	Indigenous Peoples' Rights
C4	Community Relations and Worker's Rights
C5	Benefits from the Forest
C6	Environmental Impact
C7	Management Plan
C8	Monitoring and Assessment
C9	Maintenance of High Conservation Value Forests

Table 2. Set of alternatives for the hierarchy

List of Alternatives	Details
Protection	Biodiversity
	Water and Soil
Production	Timber Resources
	Non-timber Resources
	Research and Development
Social / Needs	Education
	Landrights
	Recreation
	Amenity

Table 3. List of Experts

Name	Organization
Dr Alias Mohd Sood	Faculty of Forestry, UPM
En. Ridza Awang	Forestry Department of Peninsular Malaysia
Mr. Harnarinder Singh	Malaysian Timber Certification Council (MTCC)
Sabrina Wu Chor San	Malaysian Timber Certification Council (MTCC)
Dr. Abd Rahman b. Kassim	Hill Forest Silviculture & Management Unit, FRIM

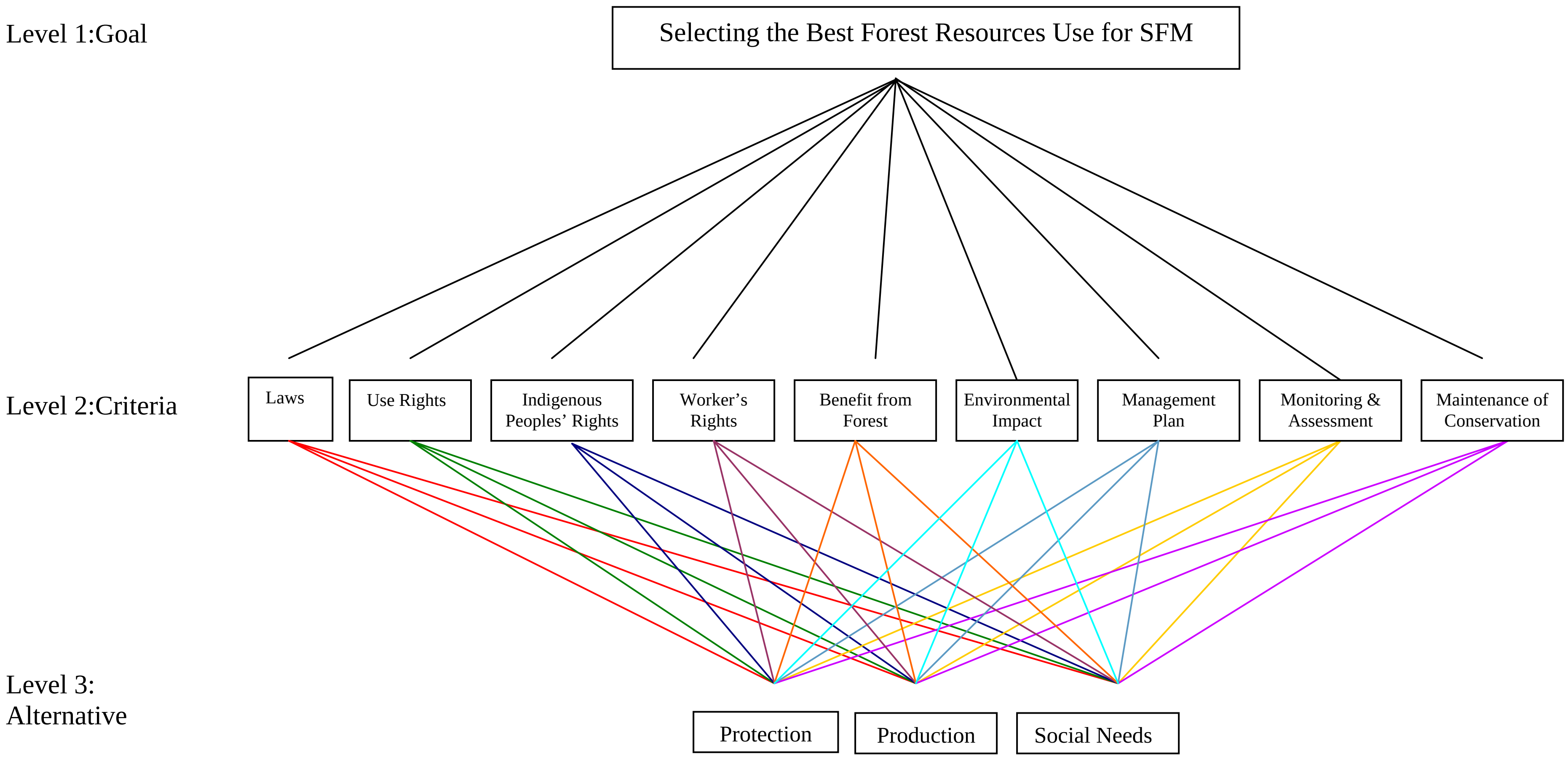

Figure 1. Hierarchy structure to choose the best management for forest resources

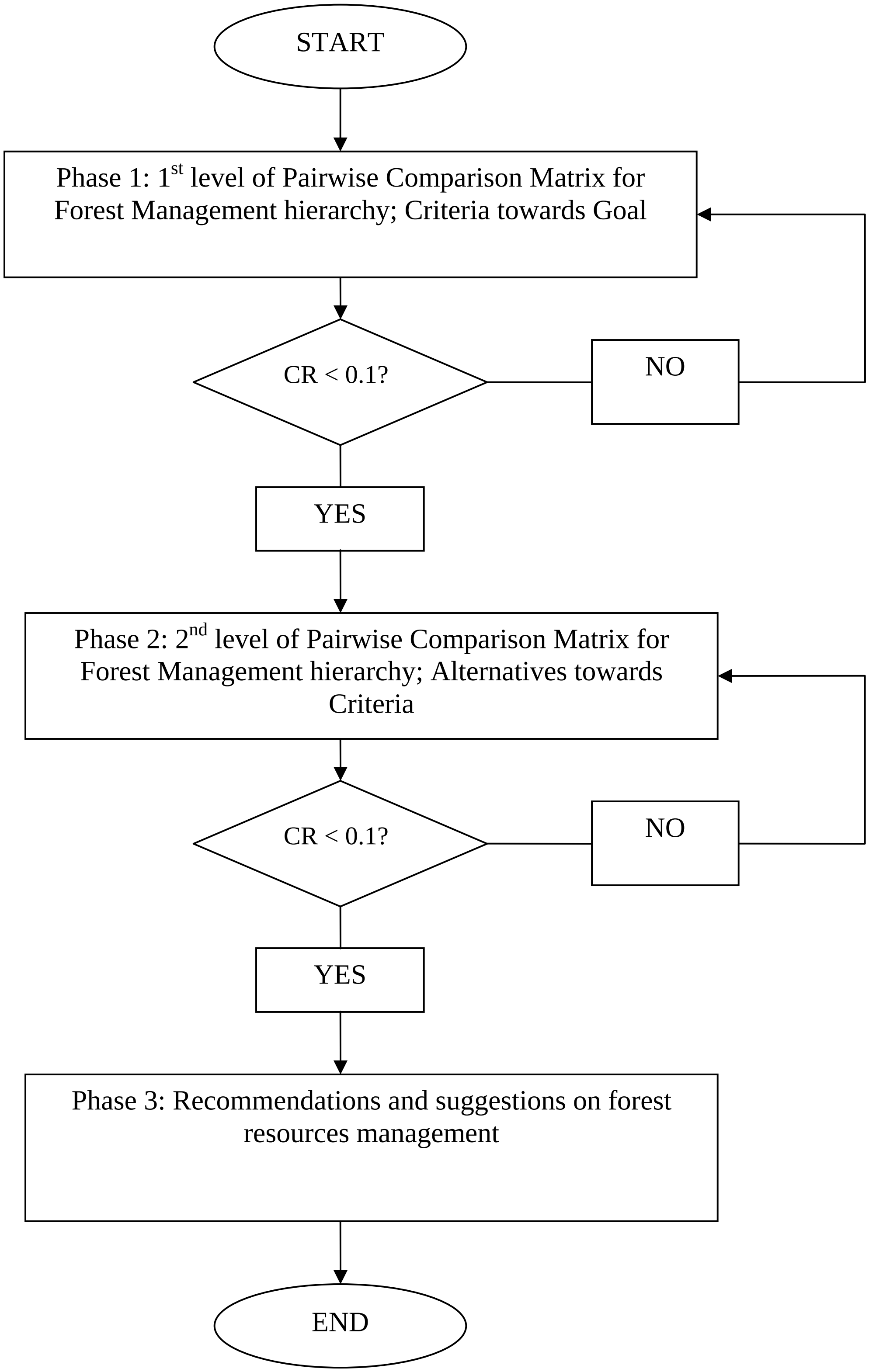

Figure 2: Flow Chart of Consultation Process

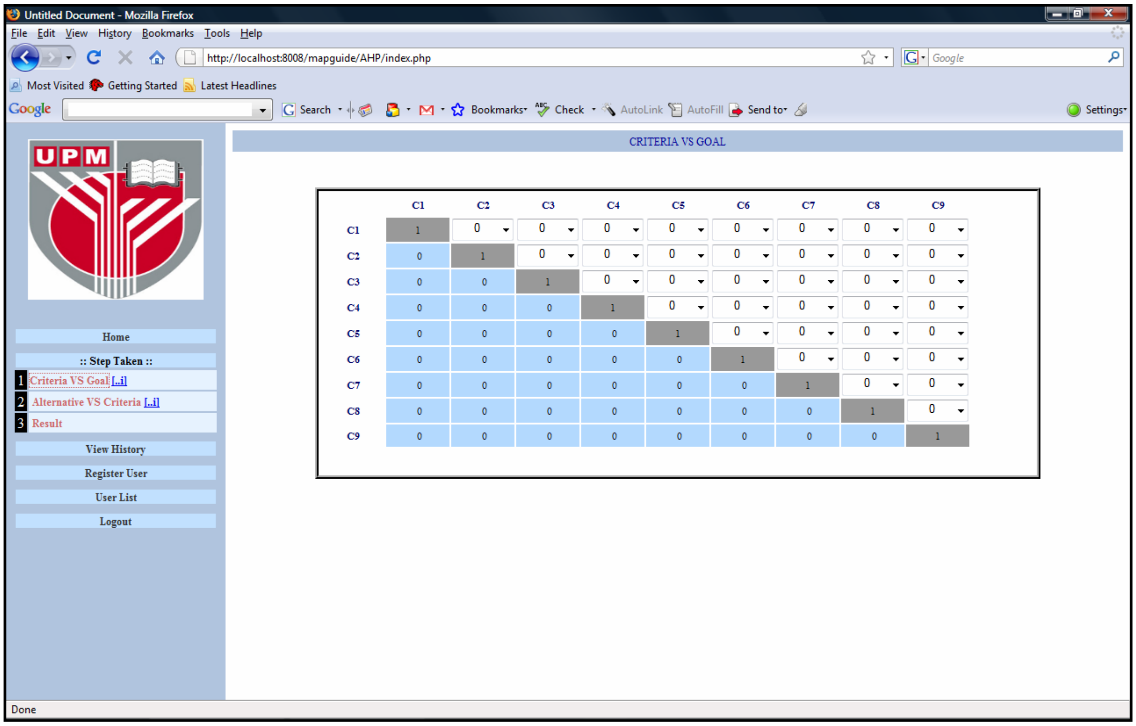

Figure 3: Interface of Pairwise Comparison: Criteria to Goal

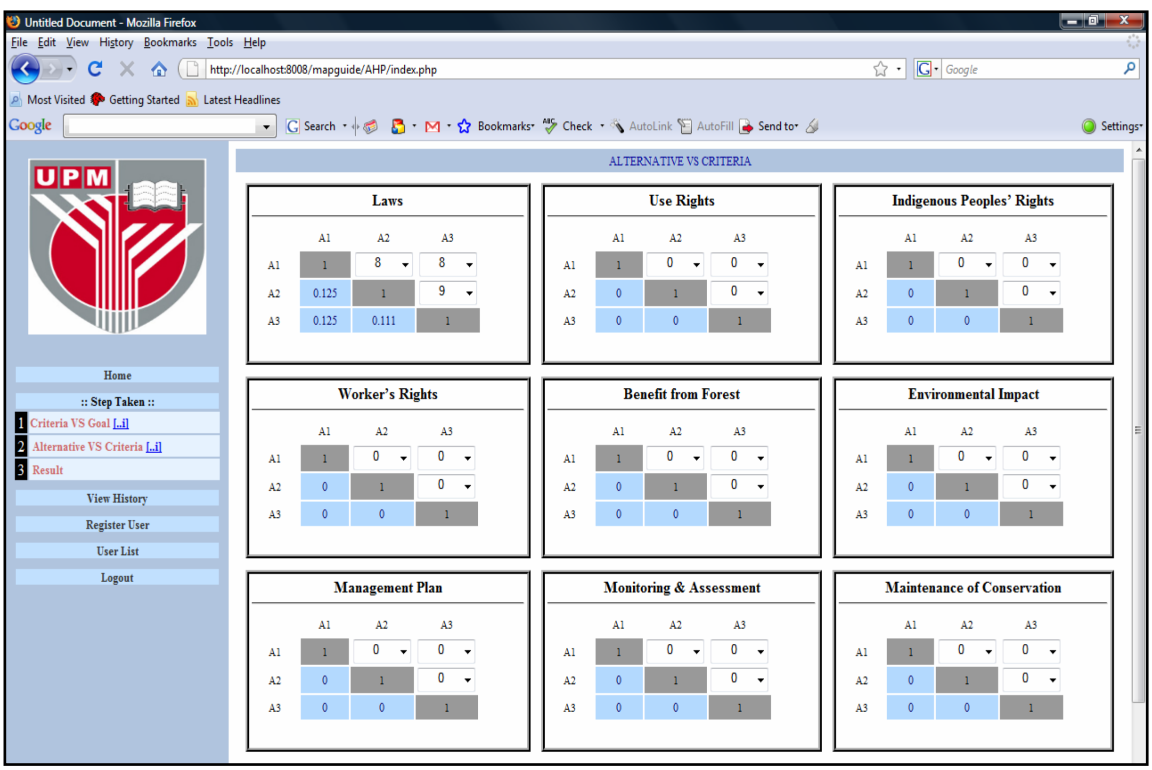

Figure 4: Interface of Pairwise Comparison: Alternatives to Criteria