# MULTI-CRITERIA DECISION MODEL-BASED DECISION SUPPORT SYSTEM FOR SELECTING AREAS FOR SUSTAINABLE ECOTOURISM DEVELOPMENT

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## ABSTRACT

The main objective of this paper is to present a Decision Support System (DSS) that can be used for selecting areas for sustainable ecotourism development, taking into consideration the associated economic, environmental, and social factors that will be involved in the development. The computational algorithm of the DSS is based on the Multi-Criteria Decision Analysis (MCDA) model of this particular category of selection problems. The specific MCDA technique used in modeling is the Analytic Hierarchy Process (AHP). The DSS is implemented in a spreadsheet and is developed around the AHP model and its solution algorithm to facilitate the analysis and solution process. The criteria built into the model were obtained from the literature and from interviews and observations. The DSS can only be used for this particular category of selection problems but has a built-in option to delete or add criteria. To test the usability and correctness of the system, a theoretical problem of similar dimension was solved using the system. The system should be a good decision-making aid for government tourism and environmental planners and policy makers.

**Keywords:** Sustainable Ecotourism, MCDA, AHP, DSS, Selection

## 1. INTRODUCTION

Ecotourism is one of the most important and sought-after industries in any country or community because of the many benefits that it brings. Not only will ecotourism create more businesses and employment and improve the living conditions in the area involved, it will also promote and encourage the preservation of the natural scenic beauty of its environment and the area's cultural heritage and the conservation of its environment's natural resources.

As defined by some authorities, ecotourism is responsible travel to natural areas that conserves the environment and improves the welfare of local people (Hull, 1998); and also, from the perspective of tour providers, ecotourism is defined as tourism characterized by: a strong concern for the environment and local cultures where the tours are operated; by tour providers' contribution to local environmental and social causes; and by the education of both the tour operators and tourists about environmental preservation and protection (Lew, 1998). Encarta dictionary 2009 defined ecotourism as a form of tourism that strives to minimize the ecological or other damages to areas visited for their natural or cultural interest. In many areas around the world, ecotourism is viewed: as a win-win development strategy that encourages conservation of

natural ecosystems while providing local populations with a sustainable economic base (Hall & Lew, 1998; Place, 1998); as a promising strategy for providing sustainable development (Hall & Lew, 1998); and as a mechanism for sustainable economic development (Hull, 1998).
For ecotourism in an area to be sustainable, the area's economic, environmental, and social goals must be pursued concurrently and equally because the programs based on these three goals are the components or foundations of sustainable development (Rogers, et. al., 2006; Hauschild, et. al., 2008; Agyeman & Evans, 2003). There can be no real development if only one or two of these foundations are progressing while the other two or one is regressing. However, this big task of balancing the development of the three components of sustainable development is undoubtedly not an easy undertaking because ideal economic goals will always come in conflict with the ideal environmental goals and with the ideal cultural/social goals (Hall, 1998; Rogers, et. al., 2006). So that trade off among these goals will have to be carried out in order to avoid as much conflict as possible and avert obstruction to the smooth progress and attainment of sustainable development goals of the area. These conflicting goals are interrelated and intricately linked that it creates what they call a complex problem (Rogers, et. al., 2006; Hall & Lew, 1998). Complex problem, as described in literature, is a problem that involves multiple conflicting objectives with a mix of quantitative and qualitative factors and criteria to be considered in the analysis. Complex problems of this kind are dealt with a multi-criteria analysis technique. In the problem of selecting the area/s for ecotourism development, the main factors and criteria to be considered are those related to the economic, environmental, and social factors. These factors are vital to the successful development of sustainable ecotourism, as mentioned above. Since the candidate areas for selection will have different states and levels with regards to these factors, the selection will be complex and difficult. The area with the bigger potential for generating higher economic and social benefits but lower environmental and social harm will certainly be a good candidate for selection for ecotourism development.

In this study, the analysis of this kind of selection problems which involve multiple criteria is dealt with by using the Analytic Hierarchy Process (AHP), a multi-criteria decision analysis technique. But, since using AHP for solving the above-mentioned selection problem is a very tedious and wearisome undertaking, a Decision Support System is built around the AHP model of the said selection problem to facilitate the use of AHP.

## 2. ANALYTIC HIERARCHY PROCESS (AHP)

The AHP is a computational method conceived to solve complex multi-criteria decision problems (Saaty 1982; Wikipedia 2011; Forman & Selly2001). This method was developed in the early 1970's by Thomas L. Saaty, a world-renowned mathematician and an operations research specialist, at the Wharton School, University of Pennsylvania (webeditor@katz.pitt.edu, 2011; Forman and Selly 2001). It is a very popular MCDA/MCDM (Multi-Criteria Decision-making) technique used for finding solutions to many complex multi-criteria decision problems worldwide (Wikipedia 2011; Ho 2008; Forman & Selly 2001; Chou, et. al. 2008).In their study of the MCDM researches and applications conducted over fifty years, Forman & Selly (2001) reported that AHP is the methodology that has emerged as theoretically sound, practical, and widely successful. AHP is well suited to the problem of selecting areas for sustainable ecotourism development because, as mentioned above, this kind of problem involves both qualitative and quantitative criteria for selection. The AHP process converts the qualitative and quantitative data into a single uniform dimensionless measure called priorities in the AHP terminology.

The AHP procedure requires the decomposition or breaking down of the complex problem into a multilevel hierarchic structure of objectives, criteria, sub-criteria, and alternatives (Saaty, 1990). The hierarchy is usually formed with the overall objective at the topmost level and the criteria, sub-criteria, and alternatives at lower levels cascading in that order. The alternatives are evaluated with respect to each sub-criterion or criterion which is at a hierarchy level immediately above them, in order to derive their individual priorities. The same is done with the sub-criteria with respect to each associated criterion, and the criteria with respect to the overall objective – all for the purpose of deriving their individual priorities. All evaluations are done in a matrix where the evaluated elements (that is, areas, sub-criteria, and criteria) will be compared with each other, two at a time, as to their importance or significance with respect to an element in the hierarchy level immediately above them upon which they are subject to. The importance or significance values are subjectively judged by the analyst or decision maker.

A sample comparison matrix of the AHP is shown in Table 2.1 below. Using that matrix table and starting with Alternative 1, pairwise comparison is done by comparing Alternative 1 at the leftmost column against each Alternative listed on the topmost row, one at a time. But judgment values is entered only in the cells above the diagonal cells because the cells below the diagonal cells should automatically be filled with the reciprocal of the corresponding value above the diagonal cells. The same pairwise comparison process is done for Alternatives 2 to 5 at the leftmost column. Comparing an element against itself is given a value of one (1), so that the diagonal cells are filled with the value of one (1).

**Table 2.1 Sample comparison matrix for five alternatives with respect to criteria 1**

| Criteria 1 | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|
| Alternative 1 | 1 | 2 | 5 | 4 | 7 |
| Alternative 2 | ½ | 1 | 3 | 2 | 5 |
| Alternative 3 | 1/5 | 1/3 | 1 | 5 | 3 |
| Alternative 4 | ¼ | ½ | 1/5 | 1 | 6 |
| Alternative 5 | 1/7 | 1/5 | 1/3 | 1/6 | 1 |

AHP provides a number scale of 1 to 9 with corresponding verbal definitions to represent judgments. But in this study, the author believes that any rational number can be used because in his own personal experience, it is easier and more accurate to judge the relative strength of one element against another by simply saying that one element is this number of times more important than another element, than by being limited to the number scale of 1 to 9.

The priorities of the qualitative criteria will be derived from the analyst or decision maker's judgment or preference values when comparing elements through a matrix while the priorities of the quantitative criteria will be derived from their numerical measures through normalization. Priorities for qualitative criteria are derived using Geometric Mean when the number of elements in the matrix is three, and Power Method when the number of elements in the matrix is more than three. After all the priorities of the qualitative criteria have been derived, a consistency verification has to be done on the comparison matrix in order to check if the judgment values are consistent. If the judgment values are not consistent, a review and revision of judgments in the pairwise comparisons has to be done until the consistency is acceptable. The final priorities of the alternatives represent their rankings with regards to the attainment of the overall objective.

## 3. DECISION SUPPORT SYSTEM (DSS)

A Decision Support System (DSS) is a set of related computer programs and varied data that is used to assist in the analysis and decision-making within an organization (https://www.google.com.ph/#q=decision+support+system+definition, 2013). It is described to consist of a logic model and a data model interacting together through a computer and linked to the user through a human-computer interface (Finlay, 1990). Its primary purpose is to provide easy, fast, and efficient computing capability to decision makers for the ultimate goal of helping them in their problem solving tasks and aiding them in their decision-making. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions (Information builders https://www.informationbuilders.com/decision-support-systems-dss, 2013).

## 4. METHODOLOGY

The DSS is developed around the AHP model of the above-mentioned selection problem, hence, its computational algorithm (the logic model) is that of the AHP computational algorithm. The DSS is implemented in Microsoft Excel (a spreadsheet software) using its Visual basic macro functions, to facilitate the evaluation, analysis, and ranking process. The author chose Excel because it is the most popular and is the acknowledged premier spreadsheet software used by most in the industry and business world (Triola, 2007).

The DSS data model will consist of the analyst's judgment values on the qualitative criteria, and the numerical data of quantitative criteria inputted by the analyst or decision maker. The criteria and sub-criteria embedded inside the AHP model of the above-mentioned selection problem were obtained from the literature, from interviews, and from personal knowledge and observations. The main criteria for selecting the best area are: economic, environmental, and social – these three being the foundations of sustainable development. The sub-criteria that are considered to be necessary for the attainment of sustainable development in an area under each of the three main criteria are listed in Table 4.1 below. As shown, the economic criterion has seven sub-criteria, the environmental criterion has five sub-criteria, and the social criterion has six sub-criteria.

**Table 4.1 Criteria and sub-criteria for selecting the area for sustainable ecotourism development**

| Criteria / Sub-criteria | | Definition |
|---|---|---|
| Code | **Economic** | Involving income & cost |
| Ec1 | Number of cultural, spiritual, & historical attractions | Festivals, historical buildings & sites, etc. attract tourists |
| Ec2 | Number of natural tourist spots | More tourist spots means more tourists |
| Ec3 | Attractiveness of natural tourist spots | Attractive tourist spots means more tourists |
| Ec4 | Accessibility of the area | Easily accessible area means more tourists |
| Ec5 | Area's population size & skills | More people means more tourist service providers |
| Ec6 | Proximity to urban area/s | Closer to urban areas means more tourists, fast access to & cheaper raw materials, equipment, supplies, etc. for the tourist service providers; |
| Ec7 | Cost of living in the area | Cost of lodging, food, goods, & services |
| | | |
| Code | **Environmental** | Involving environment |
| En1 | Number of protected areas | No protected area is good |
| En2 | Climate conditions | Good climate conditions means more tourists |
| En3 | Number of hazardous areas | No flood prone areas, landslide prone areas, storm prone, earthquake prone, etc.is good |
| En4 | Presence of natural drainage systems | Presence of natural canals, rivers, etc. is good |
| En5 | Existing local environmental regulations | Local environmental regulations are good |
| | | |
| Code | **Social** | Involving peoples' welfare |
| So1 | Peace and order situation of the area | Terrorist or rebel infested areas are bad |
| So2 | Local gov't's interest in & attitude | Willingness to: grant business permit; upgrade road infrastructure to the level required, etc. – are good |
| So3 | Availability & quality of public services | Police & Fire services – are good |
| So4 | Availability & quality of water utility | Availability is good |
| So5 | Availability & quality of electric utility | Availability is good |
| So6 | Availability & quality of communication utility | Availability is good |

Figure 4.1 below shows the hierarchy of the objective (select the best area), the identified criteria and sub-criteria for accomplishing the objective, and the sample alternative areas (three areas are shown as an example just to complete the hierarchy). This hierarchy is the AHP model of the above-mentioned selection problem that is embedded in the DSS. But, new sub-criterion or alternative area can be added and existing sub-criterion or alternative area can be deleted from the said AHP model if desired.

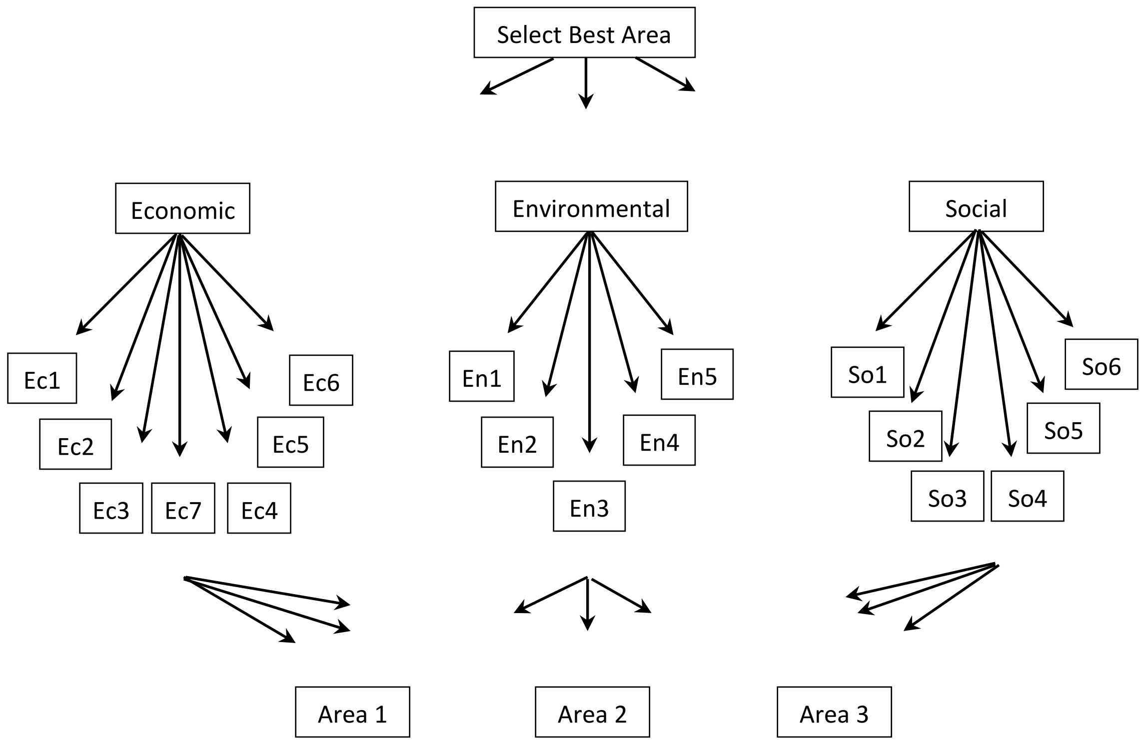
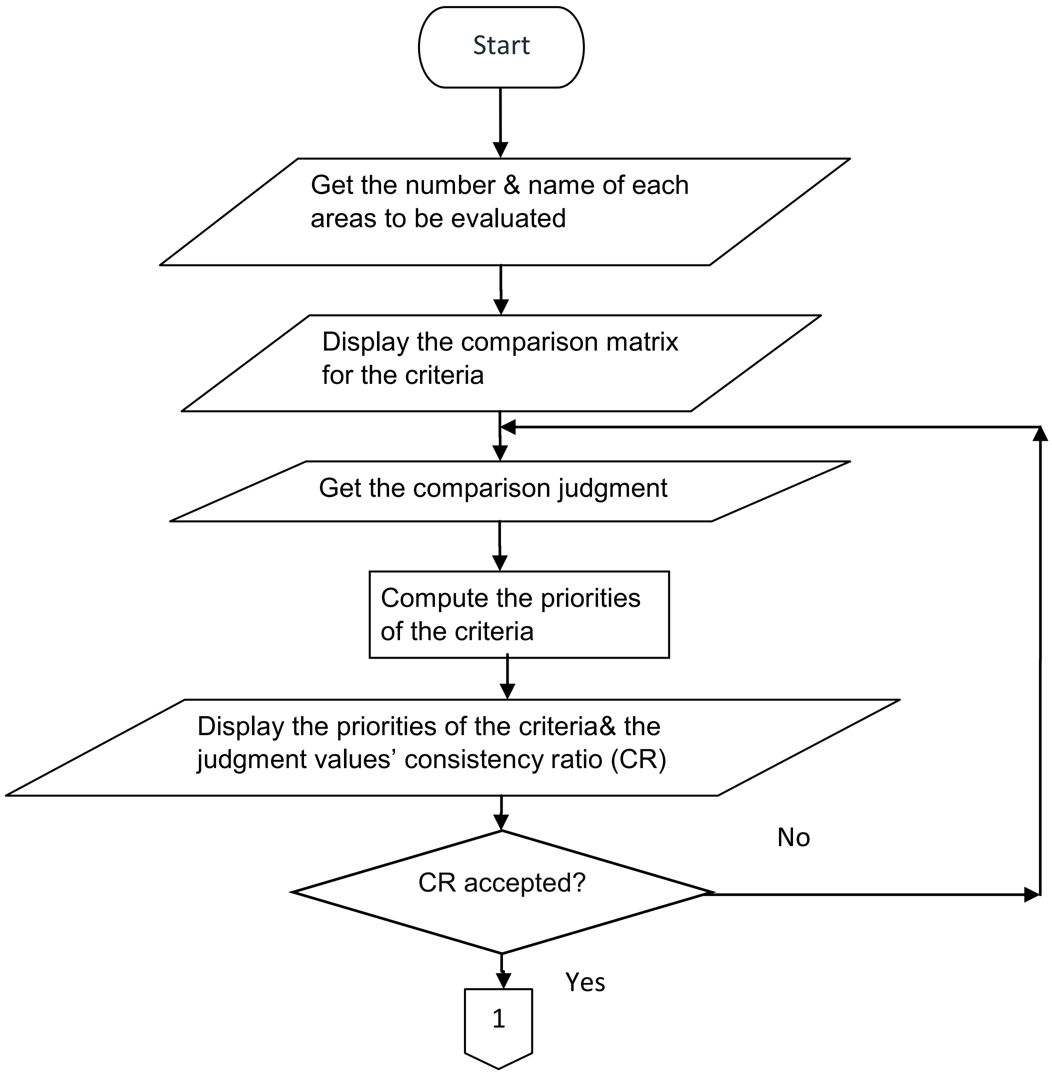
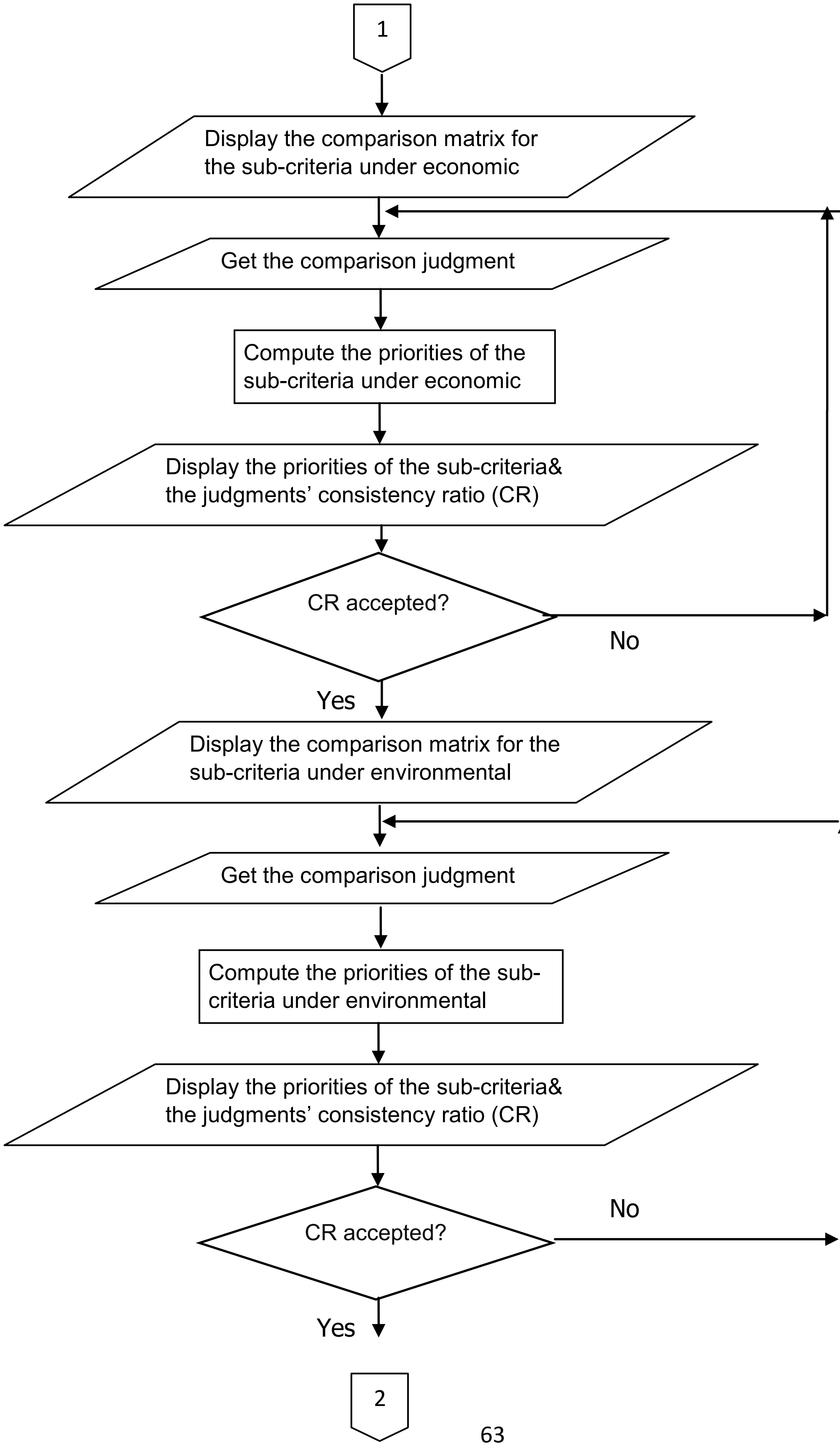



**Figure 4.1 Hierarchy of the area selection problem**

## 5. RESULTS

Whenever a user of the DSS runs its macro, the DSS first ask for the number and name of the areas to be evaluated. After the number and name of the areas are inputted, the macro will first display the comparison matrix of the economic, environmental, and social criteria with respect to the objective of selecting the best area. In this matrix, the user will enter his/her judgment values regarding the importance of each criterion compared to another criterion with respect to the objective. After all the judgment values have been entered, the macro will display the priorities of the criteria and the consistency of the judgment values. If the user is not satisfied with the consistency ratio, he/she may redo the pairwise comparison until satisfied. When the user accepts the consistency ratio, the DSS will then display the comparison matrix of each set of sub-criteria, one criterion at a time. The same process is carried out up to the alternative areas. The flowchart for this DSS process is shown in Figure 5.1 below.


Start
Get the number & name of each areas to be evaluated
Display the comparison matrix for the criteria
Get the comparison judgment
Compute the priorities of the criteria
Display the priorities of the criteria& the judgment values' consistency ratio (CR)
CR accepted?
No
Yes
1


1
Display the comparison matrix for the sub-criteria under economic
Get the comparison judgment
Compute the priorities of the sub-criteria under economic
Display the priorities of the sub-criteria& the judgments' consistency ratio (CR)
CR accepted?
No
Yes
Display the comparison matrix for the sub-criteria under environmental
Get the comparison judgment
Compute the priorities of the sub-criteria under environmental
Display the priorities of the sub-criteria& the judgments' consistency ratio (CR)
CR accepted?
No
Yes
2

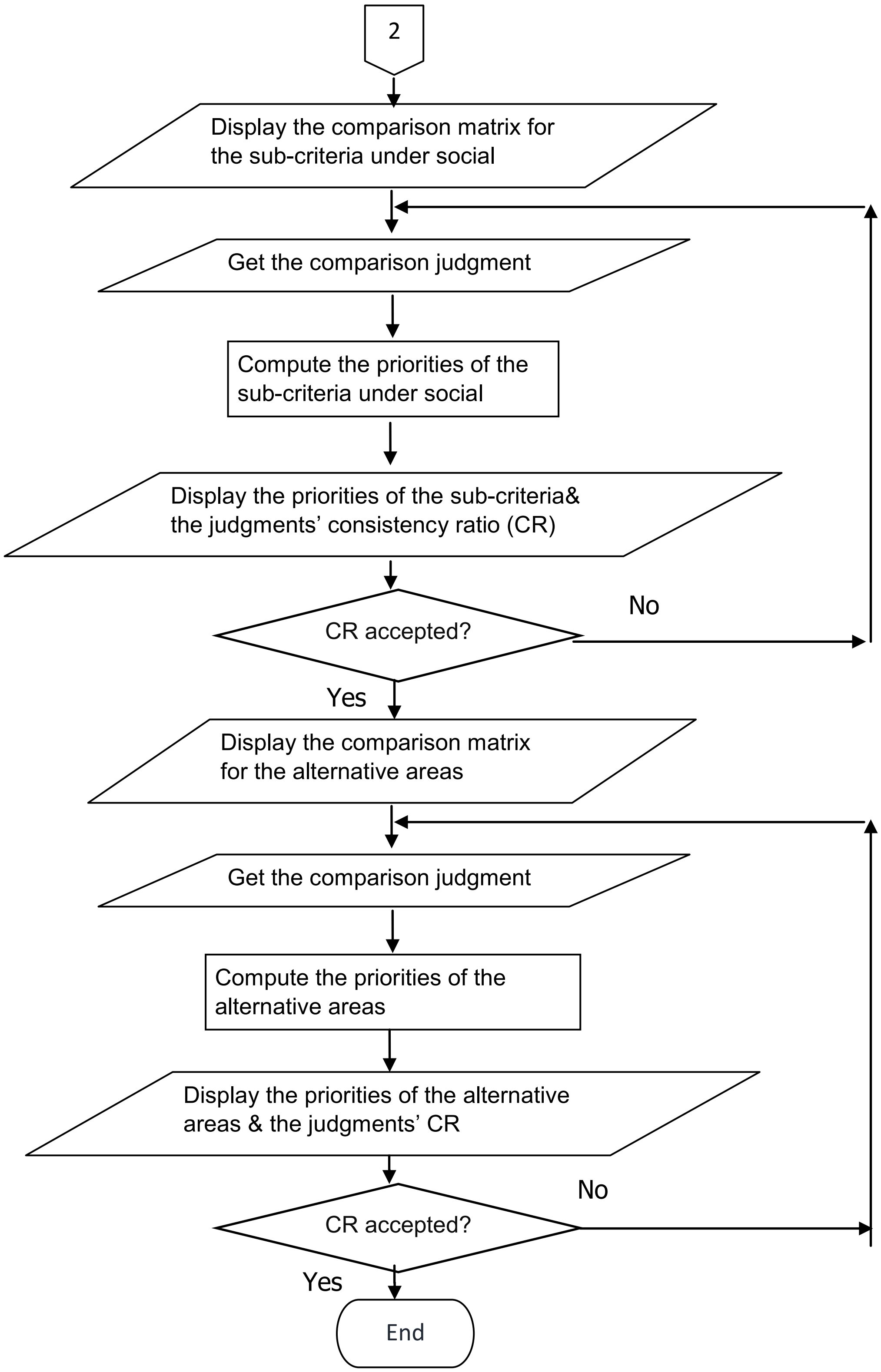



**Figure 5.1 Process flowchart of the DSS**

To test the usability and correctness of the system, a theoretical problem of similar dimension was solved using the DSS, and then using manual solution. The solutions from both means were the same proving the usability and correctness of the DSS. From this result, it is deemed that the system should be a good decision-making aid for government tourism and environmental planners and policy makers.

## 6. CONCLUSION

There is no other way to model the above-mentioned selection problem satisfactorily than to do it through a Multi-Criteria Decision Analysis methodology (MCDA) because as mentioned above, the said selection problem is complex. And the best MCDA methodology that is currently available is the Analytic Hierarchy Process (AHP) which can handle the combination of qualitative and quantitative criteria systematically and relatively simply.

The said AHP model-based DSS greatly facilitates the resolution of the above-mentioned selection problem for two obvious reasons. First is because the DSS, being computerized, is a lot faster than the manual method. Second is because of the inherent outstanding capability of the AHP technique to handle qualitative and quantitative criteria simultaneously.

Any rational number can be used in judging the relative strength of one element against another in the pairwise comparisons to get correct priorities. It is easier and more accurate to judge the relative strength of one element against another by simply saying that one element is this number of times more important than another element, than by being limited to the number scale of 1 to 9.

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