

Selection of Optimal Lodging Site in the City of Baños, Ecuador



Kleber Villa Tello 

Abstract This study presents a methodology that allows a tourist to select at their discretion the best lodging site in a given jurisdiction. Using pre-established criteria/factors through meetings held with the main tourist entities existing in said jurisdiction. These criteria/factors come from public census information from the 2010 Population and Housing Census, 2010 National Economic Census and a Tourist Census conducted in the jurisdiction. The jurisdiction under study is the city of Baños de Agua Santa in the Tungurahua province of Ecuador. For the development of the investigation, an integration of GIS techniques and multi-criteria decision techniques based on the Analytical Hierarchical Process (AHP) approach is used, with variation in the method validation process. The tourist assumes the role of the decision-maker, having to select the criteria/factors that he wishes to use according to his need, comparing them in pairs. The comparisons allow tourists to make weights between the criteria/factors, and based on them, the accommodation establishments with the highest percentage of compliance with said criteria/factors are determined. Finally, the selected lodging establishments are presented to the tourist and based on final criteria/factors, generally of an economic nature, they make their final decision. An application was developed to automate and validate the methodology, applying it to a certain number of tourists, the results being satisfactory, obtaining from most of them the acceptance of the accommodation selection process carried out in the city of Baños.

Keywords Selection of hosting site · Multi-criteria decision models · AHP

1 Introduction

The tourism market in Ecuador, according to data from the Ministry of Tourism (MINTUR) in its February 2015 Monthly Bulletin, refers to a growth of 105.46%

K. Villa Tello (✉)

Paris Lodron University of Salzburg, Hellbrunnerstrasse, 34 5020 Salzburg, Austria
e-mail: khvillat@gmail.com

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in the economic income generated by it based on the period 2014 versus 2013. This turns tourism into the third-best income product in Ecuador, surpassed only by Banana and Shrimp [19] tourism being an economic activity marked by a strong dynamic of growth and generating wealth [5].

The city of Baños de Agua Santa, located in the Province of Tungurahua in Ecuador, is known as “El Pedacito de Cielo” [13]. It is the cantonal head of the canton that bears the same name, which has 14,653 inhabitants [15]. Of this population, 12.63% work in accommodation and food service activities [15], but it can be asserted that 90% of economic activities in the city are related to tourism [16], concentrating in the city 3.9% of accommodation establishments in Ecuador [18, 21]. Despite this great economic-tourist movement, the city currently does not have an adequate mechanism for locating and selecting lodging establishments.

Multiple services and tools that make a particular jurisdiction the favorite of tourists must support this growth. A tourist is defined as a person who is outside their usual environment. To carry out activities for leisure, business, and other reason [23], for this reason it is important to select a suitable lodging site, which makes he feels fully satisfied, and returns continuously to the place. Providing a given jurisdiction with economic income and jobs, based on these, the importance of carrying out and providing a methodology that allows selecting a suitable accommodation site to the needs and requirements of the tourist.

The selection of a site is a geographical problem and the different needs that a tourist may require of a certain place of accommodation, determine that it is chosen to integrate GIS and multi-criteria decision techniques to solve the problem of determining a place of accommodation.

The integration between AHP and GIS has been used in similar investigations: Using both vector and raster cartography as a source [2, 20]. With explicitly spatial criteria/factors such as distance or implicitly spatial factors such as population density [4]. Under conditions of uncertainty and certainty [14]. With decision processes by a single decision-maker or a group of decision-makers [6, 17]. In these investigations, it has proven its consistency and validity, making it possible for the decision-maker to use geographic information and its evaluations.

This study presents the AHP-GIS integration, using GIS techniques such as Buffer, Union, Clip, Overlay, and raster transformations, which were combined with the AHP method. This research is carried out to Determine the socio-demographic and economic parameters or variables of greatest interest to tourists, which allow them to select the best lodging establishment. Establish the appropriate evaluation ranges within the selected variables that make it possible to qualify the suitability of a specific accommodation site and check the validity of the methodology by executing it for a specific group of tourists [7, 28].

The methodology proposed here, as well as its data will be for public use, through agreements either with the Indoamérica Technological University or through the Provincial Council of Tungurahua, through their respective web platforms, transforming this methodology into a publicly available technological tool on the website where you are staying. It is therefore evident that the main beneficiary of this research will be the tourist who wishes to visit the city of Baños de Agua Santa, in addition to

the entire population of this city that economically depends on or is related to tourism activity [16], concentrating 3.9% of accommodation establishments in Ecuador in the city [18].

2 Study Area

Baños de Agua Santa is the cantonal head of the canton of the same name, which has an area of 1,065km². It limits to the north with the Province of Napo, to the south with the provinces of Chimborazo and Morona Santiago, to the east with the Province of Pastaza, and to the west with the cantons of Tungurahua, Patate, and Pelileo (Fig. 1). According to the 2010 Population and Housing Census [15], it has 14,653 inhabitants in the cantonal head; 1,658 live in rural areas and 12,995 live in urban areas, consisting of 38 urban census tracts and 13 dispersed census tracts [15].

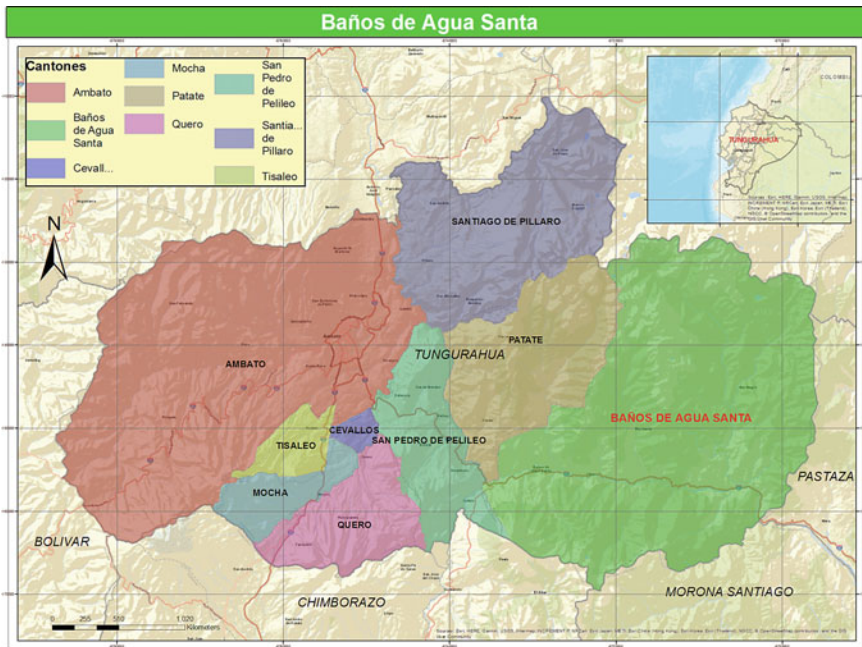


Fig. 1 Location of the Canton Baños de Agua Santa

3 Methodology

A comparative study of Multi-criteria Decision Methods was carried out, which is summarized in Table 1 [9], opting in this study to use the AHP approach taking into account its characteristics, the data that is available and the conditions of the decision-maker. This table compares five MCDA methods that cover three approaches such as the one based on the utility of the information, the one based on ranges and the one based on decision rules. It analyzes research that uses MCDA, although it is carried out for sustainability evaluation, it helps us to evaluate the methods in a general way.

Below are important reasons why the use of the AHP method integrated with GIS is a combination that allows us to provide an efficient solution to the problems addressed in this research:

AHP is characterized by being a compensatory method, in this way it is guaranteed that no criteria/factor and no alternative are discarded [9]. With this characteristic, it is guaranteed that all the criteria/factors selected by the tourist are valued and that all the lodging establishments of the city under study have the option of being selected by a certain tourist.

The AHP in its methodology has an internal process to test its validity. Allowing it to be redefined as many times as necessary until reaching a valid selection process so that the decision-maker [3], who in this case is the tourist, can repeat/debug the process until you find a valid option for applying the methodology and for yourself.

AHP is a method considered difficult, but it has a high coverage in tools which have a quality graphic representation [3], which makes AHP an understandable and easy process to perform, and can also be implemented in Most widely used GIS programs such as IDRISI, ArcGIS, and QGIS.

The AHP allows to work with uncertainty (ignorance of the work environment) which is necessary [9], since the decision-maker is the tourist who does not know a certain jurisdiction. Being the tourist a general user who wants to value his decision to feel satisfied with the place where he will stay. It is necessary to highlight the importance of the respective training that must be provided to the decision-maker so that he/she chooses his/her own preferences adequately with the pre-established criteria/factors.

The AHP-GIS methodology presented in this document asks tourists to select the criteria/factors among the pre-established, which best suit their accommodation needs and in turn are required to establish ranges of values according to the Saaty scale [25]. That is, to compare in pairs of criteria/factors providing values (weights) to each of these pairs.

With the criteria/factors selected by the tourist, vector layers are generated according to the defined values (weights) on Saaty scale. These vector layers during the process are transformed into raster layers whose evaluation is given at the cell level according to the user's preferences. Finally, the AHP method is applied using the raster calculator, in order to have the best option at the census sector or census sector level. Then, on the selected census sector or sectors, accommodation establishments

Table 1 Comparison of multi-criteria decision methods

Comparison criteria domain		Comparison criteria	MAUT	AHP	ELECTRE	PROMETHEE	DRSA
Scientific soundness	Related to input data	Use of qualitative and quantitative	Possible	Possible	Possible	Possible	Possible
	Related to calculation method	Life cycle perspective Weights typology	Possible Trade-offs	Possible Importance coefficients Trade-offs	Possible Importance coefficients	Possible Importance coefficients	Possible Not needed
Feasibility		Threshold values	Not possible to possible	Not possible	Possible	Possible	Possible, obtained from the decision
		Compensation degree	Full	Full	Null	Partial Full	Null
		Uncertainty treatment/Sensitivity analysis	Possible	Possible/Partially possible	Partial/Possible	Possible/Partially possible	Possible
Utility		Robustness	No rank reversal is possible	Rank reversal can occur	Rank reversal can occur	Rank reversal can occur	Possible for the choice and ranking problems
		Ease to use	High to Low	NHigh/Medium/Low	Low	Medium	High
		Learning dimension	Difficult	Difficult to Possible	Difficult	Simple with scenario analysis	Difficult

Note Adapted from Consistency in the Analytic Hierarchy Process: A new approach, 15 May 2006

are placed with their price per person or any other variable of interest for the tourist to make their final decision.

To analyze the effectiveness of the proposed methodology, a test was carried out with the help of the computer tool developed AHP-SIG, applying it to 20 tourists visiting the city of Baños de Agua Santa. These people were staying in some establishments in the city and they were encouraged to carry out the test in order to observe the results that it produced. Of these 20 tourists, 14 were domestic tourists and 6 were foreign. The majority of visitors from the city of Baños de Agua Santa were Ecuadorians from the Sierra 12 region since they were on vacation at the dates the tests were conducted and 2 from the Litoral region.

Three processes were carried out in the study:

The first is the operation carried out for the tourist census, in this the tourist entities that issued the information requirements to be collected were MINTUR, INEC, the Tourism Chamber, and the main universities in the jurisdiction. The criteria/factors used were defined with these actors, so that they are selected and evaluated by tourists according to their preferences.

The second process is the integration of the alphanumeric bases from the censuses with the census cartography. The INEC 2010 census mapping is found in the WGS 1984 UTM Zone 17 South coordinate system at a scale of 1: 50,000. The bases of the Population Census and Economic Census are in REDATAM format [8], REDATAM Process version 5 was used to extract the information to be transformed. The tourist base is in SQL Anywhere 10, native SQL was used to extract the information to transform. Once the information was extracted at the geographic level of the census sector, it was joined to the cartography at the same level using ArcMap 10.1.

The third process presents the tourist as the decision-maker, according to the AHP method, the problem was decomposed hierarchically defining the basic levels, the first the objective, the second the criteria/factors, and the last the alternatives as shown in Fig. 2. The tourist according to their needs chooses the criteria/factors. Each criterion/factor generates a vector layer according to the values (weights), assigned by the decision-maker, which in our case is the tourist, an expert in their preferences. The weights are assigned based on the distance to the selected census sector or sectors, according to the chosen parameter.

These vector layers during the process are transformed into raster layers whose valuation is given at the cell level. The AHP method is applied to obtain the best option at the census sector level. On the selected census sector or sectors, the lodging establishments are presented with some additional variable for the tourist to make their final decision (See Fig. 2).

To validate the selection, the AHP method's own validation process was used with certain modifications proposed by Alonso and Lamata [3]. This form of calculation is simpler and computationally efficient since the traditional method generates too many calculations.

The calculation method of Alonso and Lamata [3] was used in investigations such as [1, 2, 12, 29, 30].

According to Alonso and Lamata [3] the equation to calculate the Consistency Range (CR) is

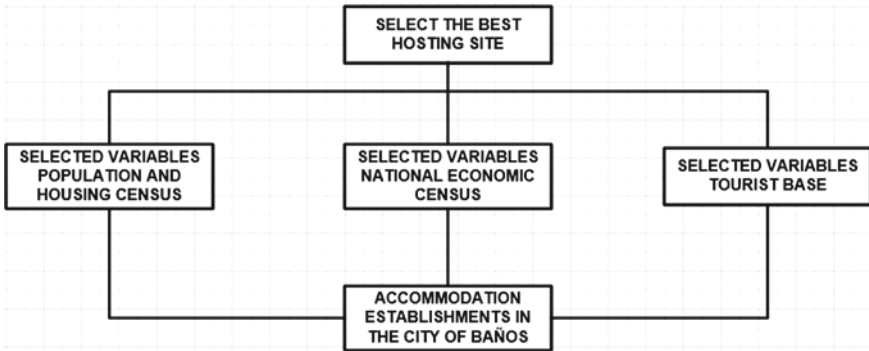


Fig. 2 Hierarchy applied in the accommodation selection process

$$CR = \frac{CI}{RI} \tag{1}$$

where

CR = Consistency Range.

CI = given matrix consistency index.

RI = Random matrix consistency index.

For the calculation of CI, the following equation proposed by Alonso and Lamata [3] was used:

$$CI = \frac{(t - n)}{(n - 1)} \tag{2}$$

where

n = Number of parameters.

t = Represents the weighted score for each row of the matrix.

t is calculated as follows:

$$t = \frac{(matrizponderada/matrizpesos)}{n} \tag{3}$$

where

matrizponderada = Multiplying the original matrix by the weight vector.

matrizpesos = Initial weight vector.

n = Number of parameters.

The methodology was automated using an application for Windows environments called AHP-SIG. The database design was done in Sybase PowerDesigner

16.1.0.3637 [27], for the database PostgreSQL 9.4 [24] was used, Sybase PowerBuilder 12.5 for the interface [26], MapObjects 2.3 from Environmental Systems Research Institute (ESRI) to display mapping in the interface [11] and Python 2.7 with ArcGIS 10.1 libraries for batch processing of geographic operations.

4 Results

The application of the AHP-SIG tool was made to 20 tourists over 18 years of age visiting the city of Baños de Agua Santa (National tourists 70%, 10% from Germany, 10% from the Netherlands and 10% from the United States). These tests were carried out randomly in the accommodation establishments near the Sanctuary of the Virgen de Agua Santa (Hotel Acapulco, Hostal Los Nevados, Hotel Alborada, and Hotel Achupalla), both to observe the way of understanding the process as well as to analyze the results obtained. With the execution and obtaining of results with the preferences of each tourist, the validity of the methodology was tested as well as the operation of the developed tool.

From the set of variables previously selected through meetings with institutions related to Tourism in the province of Tungurahua, whose origin comes from the Population and Housing Census 2010, the National Economic Census 2010, and the Tourist Census carried out. They were analyzed in the test with tourists, who ratified the understanding of their meaning and objective for all the variables used in the Population and Housing Census as well as the Tourist Census. But in the variables from the National Census Economic little acceptance of the variables is observed, this due to the non-daily use of this type of information, which is economic information related to productive activities, which indicates that different variables of this census should be included in a future version, with which they would get better results (50%). The variables of the Population and Housing Census and the Tourist Census are in common use in a home or on a trip, for this reason their acceptance and higher percentage of use.

Regarding the evaluation of the pairs of criteria/factors using the Saaty scale [25], the majority of tourists accept (80%) the same, the rest of tourists (20%) mention percentage scales, but it would not be applicable to the model.

For the validation of the methodology, the procedure that follows was explained to the tourist and that the system would reject if it found a matrix with an initial tendency, to which 60% agreed, but 15% disagreed in validating your options as they think that it is not necessary to do so. 25% disagree, mentioning that what was valued by them should be respected initially, despite the fact that it was explained that it is necessary to do it to be sure that the answer is valid.

5 Discussion

There was a tendency for tourists to select variables from the Population and Housing Census, chosen in all the processes carried out. This confirmed the importance of choosing the criteria/factors to make a correct decision and just as important is that the decision-maker is familiar with each of these [25].

It should be borne in mind that different tourists who face the same decision and that even if they use the same criteria/factors, when using the proposed methodology they can reach different conclusions [10], this because each one of them evaluates based on their preferences, the important thing is that each of them satisfied with the decision.

To apply the AHP-SIG methodological proposal in another jurisdiction, the following points should be taken into account:

- The questions that appear in a population census is a standard of questions worldwide [22].
- The universe of the National Economic Census included jurisdictions with 20,000 or more inhabitants, so the jurisdiction to apply must have this number of inhabitants, if you want to include these variables.
- The tourism research was carried out in the Tungurahua province and can be executed in any jurisdiction, although as mentioned it is possible to include or exclude the variables of a certain research, but the developed system must be parameterized accordingly.
- The cartography used is the public cartography of the INEC at the census sector level, where there are jurisdictions throughout the country Ecuador. Several statistical institutes have cartographic information at the census sector level and make it available to the public.
- The tools used must be configured, especially the access to the PostgreSQL database and the location of the cartography next to its temporary processing directories.
- The use of AHP is standard with a variation in the validation methodology that is proposed by Alonso and Lamata [3].
- Additional research information may be included, but these should have results at the census sector level.

The proposed methodology and supported by the developed tool allows to incorporate additional variables and of diverse origins. The key to the AHP methodology is the inclusion of criteria/factor weightings based on the tourist's own objectives, and being a compensatory method, does not rule out any option, thereby ensuring the participation of all criteria/factors and lodging alternatives.

In the implementation of the methodology in which through spatial analysis together with the public information used. It is possible to clearly identify census sectors in which tourists according to their requirements should stay, it is also clear to identify the sectors census in which you should not, in order to feel satisfied with

your accommodation and this becomes a factor for your return to the jurisdiction where you stayed.

Regarding the main objective of the research, which is the generation of a methodology for the optimal selection of a hosting site based on public information. This was accomplished through the generation of cartographic models. The adaptation of alphanumeric and geographic information of public origin. The evaluation of the results and the development of a computer tool that integrated these processes. The methodology, as discussed in this section, can be used for similar selection processes for site selection.

The criteria/factors proved to be adequate, even when tourists had a higher tendency in the criteria and factors of the Population and Housing Census and Tourist Census. This being understood because they are variables referring to a trip, home, and person that are of daily use for a person, the detail of these variables converted into criteria/factors. Additional variables of the Tourist Census as price per person, if the accommodation includes breakfast or not, from the Population and Housing Census, people by age ranges, and from the National Economic Census, the existence of shopping center-type establishments can be included without modification in the system.

In the methodology, the pairwise comparison of the criteria/factors is essential to obtain a satisfactory result [25], even being comparisons between criteria/factors of different origin and nature, and whose evaluation is subjective for the tourist decision-maker, the methodology generates geographic and mathematical processes that trigger the selection of sector/sectors objects of preference. The methodology has and was implemented within the tool that automates it, the validation process of the resulting matrix of criteria/factors, thereby guaranteeing the quality of the result.

Currently there are applications that implement AHP, such as QGIS, ArcGIS, and Idrisi Selva, but it was decided to make a tool of their own to facilitate tourist use and to personalize according to the requirements of the proposed methodology.

The cartography used, since it is cartography used in research such as the Population and Housing Census, the National Economic Census, the Living Conditions Survey, the Income and Expenditure Survey, and the various investigations carried out by INEC and of public origin. The processing of the variables together with these layers was carried out using Python scripts without presenting difficulties either due to their weight and quality. Even the display of the result layer presented no problem for MapObjects that was used for it.

With what has been indicated and through the use of the proposed methodology, it is possible to obtain the target census sector (s), and it is emphasized that being a compensatory methodology does not rule out any criteria/factor or any alternative (lodging establishment) (See Fig. 3).

In the present study, experts have not been used for decision-making, but the results have shown that the methodology is valid for the stated objective, which is the Selection of a hosting site. A tourist is the expert on his own preferences.

The methodology developed presents potentialities in this type of decision, it must continue to be refined to include criteria/factors of various and diverse investigations that are carried out in a given jurisdiction, the new variables would increase the

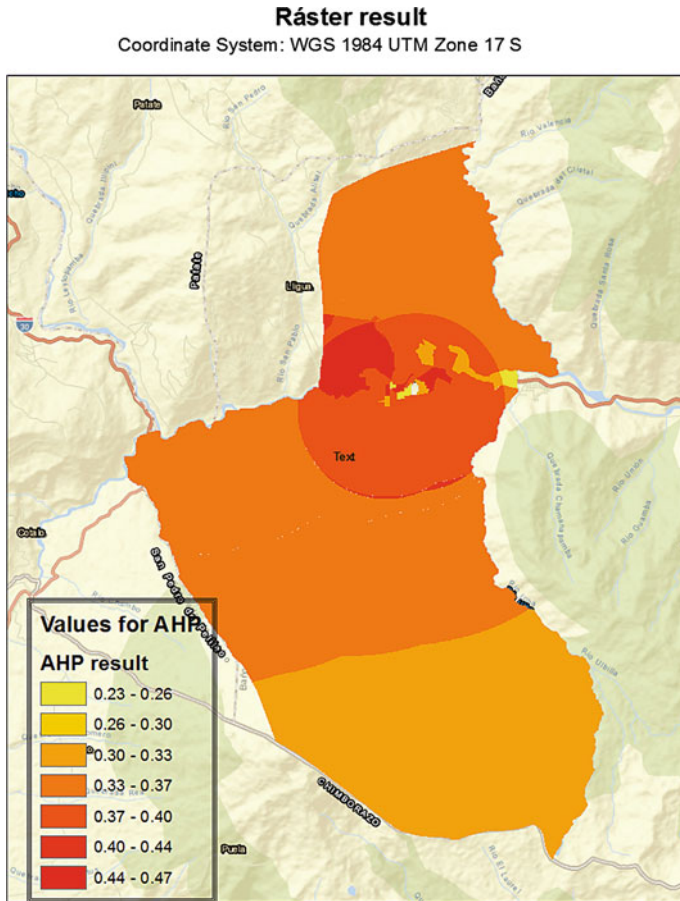


Fig. 3 Raster result of an example of the application of the methodology

perspective of the tourist to make their decision. It is recommended to carry out this study in languages that allow Web and GIS integration.

The process of selecting a lodging site integrates multiple criteria/factors for a tourist, the techniques or tools such as GIS and MCDA individually have certain limitations to provide a complete solution, so when integrating these limitations they are eliminated by providing the tourist with an innovative approach to decision-making. The proposed methodology uses only distance as a geographic factor, in future research geographic factors will be diversified and the application developed will be migrated to the web.

6 Conclusions

The pre-established variables between the MINTUR, the Chamber of Tourism, the representative Universities, and the INEC are the correct ones since they were accepted.

Both the scale and the AHP validation method facilitated the development of the investigation and allowed tourists to redefine the evaluations of each pair of criteria/factors until finding a valid matrix.

The cartography used provided reliability. The proposed methodology to integrate public census information and tourist information with the AHP multi-criteria method and GIS techniques, demonstrated that it is possible to select a census sector or census tracts that contain the best lodging site for a given tourist, according to their needs.

The previously selected variables proved to be optimal in providing the tourist with a wide range of usable characteristics for their selection process. And the ranges used in them in a similar way were easily interpreted by tourists by standardizing the use of the spatial parameter of distance to evaluate them.

The proposed methodology improves its applicability, depending on the good definition of preferences by the tourist, as well as the correct transfer of these preferences to maps. The methodology carried outcomes to provide a selection of the best hosting site at the census sector level, this due to the level of cartography used, it could be reached at the block level using the proposed methodology.

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