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Abstract: This paper proposes a methodology for the location of thalassotherapy resorts to promote sustainable tourism in Galicia, N.W. Spain. Thalassotherapy is the medical use of seawater and the marine environment as a form of therapy. The proposed methodology is based on a multicriteria evaluation approach that integrates the economic, environmental and social factors that determine the best locations for this activity. A Geographical Information System is used to manage evaluation data and to visualize the results. A total of 211 potential sites were identified, from which 19 suitable locations were selected by applying a conjunctive method based on five criteria. The suitable sites were ranked from the point of view of different stakeholders using a multicriteria evaluation procedure. Results show that the ranking of alternative sites for thalassotherapy resorts is different for promoters, clients and Administration insofar as it is strongly influenced by the weighting of criteria. Accordingly, the proposed multicriteria approach can help stakeholders select the best site according to their interests or objectives and analyze the consequences of the decisions made.

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A Multicriteria Approach to Support the Location of Thalassotherapy (Seawater Therapy) Resorts: Application to Galicia region, NW Spain

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Research Highlights

- A multicriteria methodology based on conjunctive and subtractive summation techniques can be used for the ranking of alternative sites for thalassoterapy resorts
- Optimal location for thalassotherapy resorts varies for each stakeholder as it is strongly influenced by the weighting of criteria
- Promoters prefer locations with large buildings in good condition
- Clients prefer locations with good environmental quality, services and infrastructures
- Administration gives priority to legislation, infrastructures and heritage value
- The proposed methodology can help stakeholders select the best site according to their interests

1. Introduction

Thalassotherapy is the medical use of seawater and the marine environment as a form of therapy and, by extension, the range of associated services. French regulations define thalassotherapy as the use of natural seawater and sea products under medical supervision, at a temperature around 38ºC in a marine environment, with appropriate staff and technical resources. Thalassotherapy is included in health or spa tourism, which already represents a $156 billion global industry but is still an emerging and rapidly growing sector, since industry in this sector is growing but not widespread (Johnston et al., 2011) and the enthusiasm for spas and health resorts should lead to a potential market (Cockerell, 1996). Specifically, Johnston et al. (2011) estimated that there were 17.6 million international spa trips in 2007, with an additional 124.2 million domestic spa trips and 17 million international spa tourists. Furthermore, health or spa tourism is currently one of the tourism products with the highest rates of growth (Farnos, 2003).

For these reasons thalassotherapy provides an opportunity to maximize the potential for tourism in the coast regions within a planned and environmentally respectful framework. Such a framework would enhance the use of coastal resources by providing a distinct tourism product that contributes to sustainable local development. The proposed strategy for the development of thalassotherapy combines the exploitation of the landscape and of coastal natural resources with the use of the architectural, archaeological and ethnographic heritage of coastal areas, among which former whaling stations and shellfish farms, fish canning plants, fish salting factories, mills or cloisters. Often, these buildings are abandoned and at risk of loss.

Seawater and the marine environment are particularly important in Galicia, a region in NW Spain with over 2500 km of coastline that is better preserved than the rest of the Spanish coastline because, unlike Southern Spain, Galicia is not a common destination for mass tourism (Shaw and Williams, 2002). Within health tourism, thalassotherapy activities allow for the deseasonalization and decentralization of tourism by creating new destinations in ‘cold’ coasts. Now that the viability of the traditional sun-and-beach tourism in the coast of Spain is being questioned and that considerable pressure is being exerted on the provision of housing and industrial facilities, thalassotherapy provides a possibility for sustainable development that combines the natural assets of the area and the preservation of the coastal heritage.

Because thalassotherapy activities have a great potential for tourism, a number of thalassotherapy projects have recently been implemented or planned in Galicia. Hence, thalassotherapy may become an important economic activity in the region as a source of income and employment (Charlier and Chaineux, 2009). However, thalassotherapy activities are growing totally unplanned (Farnos, 2003), and appropriate planning, monitoring, evaluation and management are required to provide an economic boost that is compatible with sustainable development (Deng et al., 2002). To achieve sustainable tourism, tourism activities must be planned and their impact minimized. Thalassotherapy does not deplete natural resources insofar as it uses marine resources in the context of environmental renewal (Charlier and Chaineux, 2009). Consequently, the main impact of thalassotherapy activities is the use of the land for tourism facilities. For this reason, the strategy presented in this paper proposes the use of existing unused facilities, which may contribute to the recovery of heritage features.

Because site selection is a key factor in the success and sustainability of thalassotherapy activities, a methodology for the ranking of alternative sites according to their degree of suitability for thalassotherapy activities is presented. Solving a location problem is usually a complex task that involves a large number of factors, many of which interact with each other. In this context, decision-making is facilitated by the implementation of models that structure and integrate all the information. Multicriteria evaluation (MCE) is frequently used in the design of such models (Anagnostopoulos et al., 2008; Malczewski, 2006; Voogd, 1983) because it provides a suitable framework for the integration of the economic, environmental and social factors that determine the best locations for an activity.

Multicriteria analysis is an ideal tool to: i) integrate the various aspects that must be assessed in site selection, ii) structure the problem and iii) support decision-making because the ideal solution, i.e. the option that performs best for all the criteria selected, is seldom among the alternatives considered and, therefore, it is necessary to find a compromise among the criteria considered. Multicriteria evaluation is an effective technique for the identification of trade-offs between criteria with the ultimate goal of achieving a compromise. For this reason, the solution provided by multicriteria evaluation techniques is 'justified' but not 'optimum' (Cavallaro and Ciraolo, 2005). The main contribution of multicriteria evaluation is to provide a structured process that helps reduce the complexity of the problem.

MCE techniques have been used in optimum site selection for industries (Ataei, 2005; Lin et al., 2007), aquaculture (Hossain et al., 2009; Lane et al., 2008; Radiarta et al., 2008), protection areas (Geneletti and van Duren, 2008; Wood and Dragicevic, 2007) or undesirable facilities as landfills (Erkut et al., 2008; Geneletti, 2010; Moeinaddini et al., 2010; Sener et al., 2010), among others. Because these decision-making problems have a spatial component, Geographical Information Systems (GIS) are often used (Carver, 1991). When the objective of research is the continuous evaluation of the whole study area, MCE techniques and GIS have been integrated (Beedasy and Whyatt, 1999; Hossain et al., 2009; Sener et al., 2010; Wood and Dragicevic, 2007) and simple MCE methods such as the weighted linear combination have been frequently used. When the objective of research is the discrete evaluation of a finite number of locations, more complex techniques such as AHP (Ataei, 2005), PROMETHEE (Lin et al., 2007), linear programming (Erkut et al., 2008) or the Regime method (Kitsiou et al., 2002) can be used, whereas GIS are used only for the elaboration and management of input data or the visualization of results (Chang et al., 2008; Kitsiou et al., 2002).

MCE can help decision-making in different areas of tourism management. For instance, Proctor and Drechsler (2006) developed a deliberative multicriteria evaluation process for the selection of a suitable option for tourism management in an area of Victoria, Australia. Yet, MCE techniques have seldom been applied to the selection or ranking of tourism sites. De Montis et al. (2007) evaluated the territorial quality of a set of seven particular territories with reference to tourism. Beedasy and Whyatt (1999) combined a number of MCE techniques with a GIS to identify potential sites for tourism related activities, whereas Kitsiou et al. (2002) used multicriteria methods and GIS for ranking coastal areas in the island of Rhodes. Reichel et al. (1998) and Chou et al. (2008) used multicriteria decision models for hotel site selection.

However, the decision making process regarding the location of thalassotherapy resorts is more complex than that of hotels due to the need of specific natural resources and of location in coastal areas which usually have high landscape and environmental value. That is why the aim of this paper is to use MCE techniques to support the selection and evaluation of potential sites for thalassotherapy activities. The MCE evaluation is used to find locations with minimum environmental impact in which the tourism, and thus the economy of the area, could benefit from thalassotherapy activities and locations that were most operational because of the availability of and accessibility to the required natural resources. To this end, an exhaustive study of the coast of Galicia has been performed based on a comprehensive land survey that was supported by a

GIS. Data collection and elaboration for the construction of the GIS is presented in the following section. Then, the multicriteria methods and techniques used for site evaluation are described. In the Results section, MCE techniques are applied to identify the best sites for thalassotherapy activities in Galicia under different scenarios. Finally, the conclusions drawn from this application are presented.

2. Data collection and elaboration

GIS datasets of coastal resources and characteristics were collected from different sources, among which: i) 1:5000 digital maps with topographic, hydrologic and road data, ii) the Survey on Local Infrastructure and Facilities (EIEL; http://sit1.lugo.usc.es/), iii) orthophotos, iv) plot maps, v) town plans, vi) maps of protected areas, vii) an unpublished study of silt and other marine derivatives in Galicia, and viii) an unpublished study of water quality for thalassotherapy activities in Galicia. The GIS database was used for the collection, integration and management of input data for multicriteria analysis, as well as for the elaboration of new data layers: the buildings of the containers were digitized from orthophotos; the distances from each site to the nearest sea, beach, river, water treatment plant, airport, road or seaport were calculated; a 10-m resolution Digital Elevation Model for each site was derived from digital topographic maps with contour lines at five meter intervals and used to calculate the viewshed and the incident radiation; a landscape index was calculated from the proportion of each land use in the viewshed; and the area of sea and length of coastline visible from each site were determined.

Fieldwork involved a survey of the whole coast of Galicia. Such a survey was aimed at the identification of all the sites potentially suited for thalassotherapy resorts. Every site should have buildings of considerable dimensions near the sea, unused or with no productive use, and preferably with a heritage value that could be recovered. All sites that met the first two conditions were considered as potential sites, such that a total of 211 sites were identified (fig. 1). For each potential site, graphical (photographs) and alphanumeric information about location, accessibility, proximity to the sea, building characteristics, former and current use and state of preservation of the facilities was collected.

<Figure 1>

Based on this data, we developed a GIS layer in which the potential sites for thalassotherapy activities were located. The description of the main characteristics of every potential site was entered into the GIS database and combined with additional data layers that included the physical, social and economic factors that may affect thalassotherapy activities. Data about the identified potential sites was complemented with data provided by the 'Record and mapping of marine buildings suitable for tourism use in Galicia', available from the official Tourist Board of the Galician government. Table 1 shows the information layers included in our GIS and the associated attributes. These layers formed the core information from which the evaluation criteria described in section 3.2.1 were derived and scored.

<Table 1>

3. Methodology for the location of thalassotherapy activities

In this research, multicriteria evaluation techniques were applied for the first time to the selection and evaluation of the best sites for thalassotherapy resorts. The suitability of the sites was determined based on environmental, functional and tourism criteria. Multicriteria evaluation of potential sites comprised two steps (Fig. 2): i) identification of suitable sites by using a number of constraints, and ii) ranking of suitable sites according to their attractiveness for thalassotherapy activities.

<Figure 2>

3. 1. Identification of suitable sites

In Galicia, spatial planning legislation establishes an area of protection along the entire coastline that includes land parcels located less than 200 m from the seashore. In this area, building is not allowed. However, the construction of new buildings is allowed if such buildings are used for thalassotherapy activities. Yet, with a view to promoting sustainable tourism and to limiting the impact of tourism on the natural environment, our strategy proposes the use of the existing buildings, many of which have great heritage value and are currently abandoned or underutilized.

Suitable sites were defined as the sites that met some minimum standards for thalassotherapy activities. The identification of suitable sites was carried out by using the conjunctive method (Hwang and Yoon, 1981), which is frequently used in the first stage of multicriteria evaluation procedures with the aim of screening alternatives that do not meet the minimum standard on attributes (Berger, 2006; Wadhwa et al., 2009). The conjunctive method assigned a minimum acceptable score for each criterion, and the alternatives (sites) that did not exceed that score were eliminated. The minimum criteria and scores were defined by spa tourism experts and spa owners as follows: i) area of the container over 800 m^2, ii) distance to an urban settlement with >10000 population over five kilometers, iii) distance to a national seaport over five kilometers, iv) distance to a water treatment plant or outfall over one kilometer, and v) distance to the sea under 150 m.

3.2. Ranking of suitable sites

The steps followed to rank suitable sites matched the steps of any multicriteria evaluation procedure:

3.2.1. Definition and selection of criteria. Criteria represent the factors based on which the alternatives are compared and evaluated. Because criteria selection is essential to the results of the evaluation, a coherent and justified set of criteria must be defined. The European Spas Association sets the following minimum standards for thalassotherapy: i) location immediately by the sea, ii) use of seawater, iii) use of marine products, iv) good air quality, v) heliotherapy, vi) exposure to coastal climate, and vii) associated health-promoting measures. Such standards were considered in the factors included in the following groups: 'resources', 'environmental quality' and 'impacts'. In this strategy, evaluation criteria were defined based on previous scientific studies about hotel location (Chou et al., 2008; Gray and Liguori, 1998, Pan, 2002; Reichel et al., 1998) or tourist attractiveness evaluation (Deng et al., 2002; Fry et al., 2009), and on the specific requirements of thalassotherapy resorts, which were identified based on authors' experience and on the studies by San José (2002) and Farnos (2003). Table 2 shows the evaluation criteria selected.

<Table 2>

When the number of evaluation criteria is too large, it is often necessary to break criteria down into groups in order to make meaningful measurements (Proctor and Drechsler, 2006). Usually, each group of criteria is associated with a goal. In addition, grouping criteria into sub-models allows for a better understanding of criteria (Hossain et al., 2009). In the design of the hierarchical structure of evaluation, we have tried to find the right balance in the number of criteria included in each group. The lowest level of the structure corresponded to quantitatively or qualitatively measurable criteria, known as indicators. As shown in Table 2, the global attractiveness of a site for a thalassotherapy resort comprises six aspects: natural resources for thalassotheraphy, facilities, legislation, container, environment and impacts.

Natural resources for thalassotherapy are raw materials that are essential for thalassotherapy activities. The natural resources used in thalassotherapy comprise seawater, seaweeds, sea silt or mud (peloids), sea air and sea events (aerotherapy), bittern, sea sand, and marine climate (heliotherapy) (San José, 2002). The following indicators were used to assess the availability of these natural resources in each site: i) water quality, which suggests the availability of seawater and seaweeds suitable for thalassotherapy, ii) peloids, which indicate the distance to the nearest area in which sea silt and mud can be used for thalassotherapy, iii) intertidal distance, because an increase in intertidal distance involves an increase in the availability of sea sand suitable for thalassotherapy, iv) annual direct incident radiation, because although marine climate was similar in all the sites evaluated in this study, a higher degree of sunlight exposure was considered positive.

Facilities contribute to providing better accessibility to the location. Accessibility was measured by the factors ‘distance to roads’ and ‘distance to nearest airport’. In addition, facilities can provide services or add elements of tourist interest, which was evaluated through the factors ‘existence of non-state seaports’ and ‘distance to nearest urban settlement’. Factors such as ‘distance to airports’, ‘distance to urban settlements’ and ‘accessibility by road’ have often been used in studies of hotel location (Chou et al., 2008; Gray and Liguori, 1998; Pan, 2002), and the factor “existence of non-state seaports’ has been added due to the specific characteristics of the evaluated activity, which is closely related to the sea and to water activities.

Legislation is not a constraint for thalassotherapy activities, but it may condition the characteristics of thalassotherapy resorts. Regional or zone regulations such as height limit of buildings are often considered in hotel location (Gray and Liguori, 1998; Reichel et al., 1998). In this sense, two factors were evaluated: i) protected areas: a site was evaluated positively if located within a protected area because thalassotherapy activities are allowed in such areas, which are indicative of the environmental and landscape quality of the area, and ii) urban planning: each site was evaluated based on the requirements that the buildings of thalassotherapy resorts must satisfy according to each land use class. Thus, the highest scores were assigned to sites located in urban land, intermediate scores were assigned to sites located in rural land with standard protection, and the lowest scores were assigned to sites located in rural land with coastal protection.

The characteristics of containers affect the construction costs of thalassotherapy resorts and their potential characteristics, among which built-up area and distribution of buildings. Accordingly, the highest scores were assigned to the containers with the largest building and parcel area and with cultural heritage value because of the increased design possibilities of such containers. Moreover, because the condition of the buildings and their current use affect the costs of building restoration or reconstruction, the scores assigned to containers progressively decreased according to whether their condition was good, adequate or poor. The highest scores were assigned to buildings without a current use, intermediate scores were assigned to buildings used as warehouses, and the lowest scores were assigned to buildings with residential or religious current use. In addition, the location of containers is essential because the maximum distance to the sea allowed for thalassotherapy resorts is 1000 m (Farnos, 2003). For this reason, sites near the sea with direct access to the sea were given more weight.

The environmental quality and fine visual perception of the environment are common criteria for the evaluation of hotel location (e.g. Chou et al., 2008) and tourist attractiveness (e.g. Fyhri et al., 2009) and are related to the fourth requirement of SPAS Association for thalassotherapy activities, according to which air quality in the area must ensure that long stays in the open air represent a relieving factor. Based on the available information for the study area, the following criteria of environmental and landscape quality were selected: i) Area of sea visible from the site, because it has been assumed that viewing the sea increases landscape quality, ii) length of coastline visible from the site, because coastal areas are assumed to have high landscape quality, iii) landscape quality index, calculated according to the land uses present in the viewshed of the site by multiplying the proportion of every land use by a factor that assessed the degree of naturalness of the site and ranged zero (urban systems) to 10 (natural and indigenous complex structures that have not undergone soil modification or human exploitation), iv) beaches: good accessibility to beaches was considered a positive factor because beaches provide an excellent space for the development of activities that enhance the beneficial effects of marine climate, and v) distance to wetlands, because proximity to wetlands involves proximity to areas of high ecological value.

Determining the location of impacts is essential to place resorts in undegraded and uncontaminated spaces. According to San José (2002), thalassotherapy resorts must not be located near seaports, sewage outfalls, heavy industries (with effluent discharge) or river mouths. Consequently, distance to water treatment plants, fish farms, state seaports and river mouths has been minimized.

3.2.2. Standardization of criteria scores. In order to compare the scores of the various criteria, the same unit of measurement must be used for all the criteria. To this end, a standardization process is required. For quantitative criteria, two linear standardization methods were used (Janssen et al., 2001); i) the "interval" method, by applying Eq. 1 to Benefit criteria (positive) and Eq. 2 to Cost criteria (negative), and ii) the "maximum" method, by applying Eq. 3 to Benefit criteria and Eq.4 to Cost criteria:

$$X' = (X - X_{min})/(X_{max} - X_{min}) \quad \text{(equation 1)}$$

$$X' = (X_{min} - X)/(X_{max} - X_{min}) \quad \text{(equation 2)}$$

$$X' = X/Xmax \quad \text{(equation 3)}$$

$$X' = (-X/Xmax) + 1 \quad \text{(equation 4)}$$

where X' is the standardized score of criterion X, X is the raw score, and X_{max} and X_{min} are the maximum and minimum scores of criterion X. The interval method emphasizes small differences in criterion scores while the maximum method keeps the ratio between the original and the standardized scores (Geneletti, 2008). For qualitative criteria (Current use, building condition and use class), a ranking was established. For the 'Current use' factor, the best value was 'abandoned', followed by 'warehouse' or 'warehouse-dwelling', whereas the worst values were 'dwelling', 'cloister' and 'fish salting factory', because the recovery of underutilized structures was given priority. For the 'building condition' factor, the best value was 'good', followed by 'adequate' and 'poor'. For the 'use class' factor, the best value was 'urban use', followed by 'rural land with standard protection' and 'land with special protection' because the constraints to building a thalassotherapy resort in these types of land decrease with the decrease in the degree of protection.

3.2.3. Evaluation matrix. The evaluation matrix contains the quantitative or qualitative scores of each alternative for every criterion, i.e., the matrix shows how the various alternatives perform on the basis of evaluation criteria.

3.2.4. Identification of dominated alternatives. An alternative is dominated if there is at least another alternative that scores better for at least one criterion and equal to or better than the rest of criteria. In such case, it is convenient to identify the dominated alternatives but not to eliminate them because we seek a ranked classification of all the alternatives, in which every inefficient alternative can be assigned a priority.

3.2.5. Allocation of weights to evaluation criteria. Evaluation criteria must be weighted according to their relative importance in terms of their effects on the suitability of each site for thalassotherapy activities. To reduce subjectivity in the selection of weights, two procedures were used: i) the use of questionnaires and ii) the expected value method.

Questionnaires were distributed among the attendees to a symposium on thalassotherapy as a driver for sustainable development in Galicia, held in the Museum of the Sea of Galicia on November 20, 2009. The symposium provided the opportunity to gather the opinions of the General Secretary for Tourism at the Galician Government, the Head of Sustainable Tourism at the World Tourism Organization, and of lawyers, doctors trained in spa tourism, chemists trained in peloids, tourism consultants, professionals working for bodies responsible for tourism, officials of environmental and cultural organizations, freelance professional urban planners, public administrators, managers of private companies (related mainly to spa activities and resorts), and researchers. Questionnaires were used to rank criteria within each group from the least to the most important based on the judgment expressed by 17 actors concerned with tourism policy and planning. The individual rankings of the various stakeholders were combined by using a slightly revised format of Borda's choice rule suggested by Malczewski (1996) to derive consensus among a group of individuals. The revised Borda rule is an election method in which each criterion receives a score according to the position assigned to it by each stakeholder. In this case, the score is equal to the ordinal position of the criterion. The scores of each criterion in all questionnaires are added to obtain the total score of each criterion. Then, an average ranking is established by assigning the first position to the criterion with the highest total score, the second position to the criterion with the second highest score and so on. This average ranking was used in the expected value method to obtain a quantitative weight of each criterion such that the summation of the weights of all criteria was 1. In the expected value method, ordinal criterion scores were replaced by quantitative scores by using a transformation procedure aimed at deriving the centroid of a convex polyhedral set that was consistent with the underlying ordinal information (Munda, 2008).

3.2.6. Ranking of alternatives. A number of techniques can be used to aggregate the scores of the different criteria considered and determine the overall attractiveness of each alternative, among which the ELECTRE family of methods (Roy, 1991), PROMETHEE (Bran et al., 1986), ORESTE (Roubens, 1982), TOPSIS (Hwang and Yoon, 1981), AHP (Saaty, 1980), REGIME (Hinloopen and Nijkamp, 1990) or MACBETH (Bana and Costa, 1995). In this paper, the subtractive summation technique (Voogd, 1983) implemented with the EVAMIX method in the DEFINITE software (Janssen et al., 2001) has been used. The subtractive summation technique was selected because it allows for the combination of qualitative and quantitative criteria scores. The subtractive algorithm maintains the essential features of quantitative and qualitative criteria and combines the results of both types of criteria into a single score, which allows for the use of all the data available in its original form.

The subtractive summation technique generates a ranked classification of alternatives by calculating a dominance score. Firstly, the quantitative dominance score ($D_T(j, k)$) is computed from Eq. 3 for each pair of quantitative alternatives (j, k):

$$D_T(j,k) = \sum_{i=1}^{N} w_i (s_{ij} - s_{ik}) \quad \text{(Equation 3)}$$

where s_{ij} and s_{ik} are the scores of criterion i for alternatives j and k, respectively, and w_i is the weight of criterion i. The quantitative dominance scores compose the quantitative dominance matrix. Secondly, the qualitative dominance score ($D_L(j, k)$) is computed for every pair of qualitative alternatives (j, k). To this end, the sign ($sign_i(j, k)$) for every pair of alternatives (j, k) and every criterion (i) is calculated as follows:

$sign_i(j, k) = +1$ if $s_{ij} > s_{ik}$

0 if $s_{ij} = s_{ik}$

-1 if $s_{ij} < s_{ik}$

where +1 suggests that alternative j is better than alternative k for criterion i. Then, the qualitative dominance score is computed from Equation 4.

$$D_L(j,k) = \sum_{i=1}^{N} w_i \times sign_i(j,k) \quad \text{(Equation 4)}$$

The set of qualitative dominance scores for the various alternatives composes the qualitative dominance matrix. The quantitative dominance matrix is standardized by dividing the matrix by the sum of the absolute dominance-scores in the quantitative dominance matrix (Eq.5), whereas the qualitative dominance matrix is standardized by dividing the matrix by the sum of the absolute dominance-scores in the qualitative dominance matrix (Eq. 6).

$$\hat{D}_T(j,k) = D_T(j,k) / \sum_{\substack{j,k=1 \\ j \neq k}}^{M} abs(D_T(j,k)) \quad \text{(Equation 5)}$$

$$\hat{D}_L(j,k) = D_L(j,k) / \sum_{\substack{j,k=1 \\ j \neq k}}^{M} abs(D_L(j,k)) \qquad \text{(Equation 6)}$$

The total dominance score is calculated as the weighted sum of the qualitative and quantitative dominance scores (Eq. 7). Total dominance scores compose the total dominance matrix.

$$D(j,k) = \hat{D}_L(j,k) \times \sum_{i=1}^{N} w_i + \hat{D}_T(j,k) \times \sum_{i=1}^{N} w_i \qquad \text{(Equation 7)}$$

The final score for an alternative is the total of rows in the total dominance matrix (Eq. 8).

$$score(j) = \sum_{\substack{k=1 \\ k \neq j}}^{M} D(j,k) \qquad \text{(Equation 8)}$$

The final score determines the ranking of alternatives from best to worst.

3.2.7. Sensitivity analysis. Sensitivity analysis is widely used to explore the impact of uncertainty on the results of an analysis. In this case, sensitivity analysis is used to explore the sensitivity of the rank ordering of potential sites to the standardization method used and to the variability of the weights assigned to evaluation criteria.

Sensitivity analysis of weights was performed by designing scenarios that represented the views of the various actors involved in thalassotherapy projects, such as the promoters of thalassotherapy resorts, who represent the economic point of view; the clients, who represent the tourism point of view; and the Administration, which represents the environmental and social points of view (Table 6). Promoters give priority to the characteristics of the containers, which determine the type of resort that can be built; to resources, insofar as the availability of natural resources near the resort reduces costs; and to impacts, insofar as correcting the impacts involves an increase in costs. Clients prefer locations with good environmental quality and availability of natural resources, in which impacts are minimum and the best services and infrastructures are offered. In contrast, the main objective of the Administration is to comply with urban and spatial planning legislation, to locate resorts in areas with infrastructure and services, and to stimulate the conservation of buildings with heritage value.

<Table 3>

4. Results and discussion

As a result of the first-level selection of the locations that satisfied the minimum standards, 19 suitable sites were identified (Fig. 1). For the ranking of these suitable sites two evaluation matrices with the standardized scores of the 19 alternative sites for the 26 criteria were completed. Each matrix corresponds to a standardization method. Due to the size of these matrices (494 elements each matrix), only a sample with four alternative sites and the criteria of the Resources group are shown in Table 4. In these matrices, no dominated alternatives were found. Significant differences in criterion scores between both standardization methods were found only for the “Annual direct incident radiation” criterion. For the remaining criteria, the differences between both methods were in the same range as for the “Distance to silt areas” and “Intertidal distance” criteria, with the exception of the “Distance to nearest airport” and “Landscape index” criteria, for which slightly higher differences were found.

<Table 4>

For criteria weighting, we calculated total score and average ranking in the 17 questionnaires for each group of factors and each individual factor, as well as the quantitative weight of each factor that resulted from the expected value method (Table 5).

<Table 5>

Table 6 shows the final ranking of sites according to the weights derived from questionnaires and to each standardization method using the EVAMIX method in the DEFINITE software. Three sites were ranked in the first position with both standardization methods: two of them (MAN3 and MUR1) matched, whereas the third site varied according to the method used. Thus, ORTO1_3 was ranked in the first position with the interval method and RIBA2 was ranked in the first position with the maximum method. The reason behind this variation was the value of the "Annual direct radiation" criterion. With the interval method, annual direct radiation amounted to 0.79 for ORTO1_3 and 0.05 for RIBA2, while with the maximum method the difference in the value of this criterion for both sites was 0.06. The average variation in the ranking of the remaining sites was less than two positions. Such differences in the ranking of alternative sites according to standardization method were due to the high weight (the second highest weight) allocated to the "Annual direct radiation" criterion. We have verified that when a weight below 0.02 is allocated to annual direct radiation, no differences are found in the resulting ranking of sites.

Figure 3 shows some pictures of the two sites (MAN3 and MUR1) selected by both standardization methods with the weights derived from questionnaires. Such a weighting of factors has led us to select two sites with very different characteristics. The selection of these sites cannot be explained according to a specific set of criteria. MAN3 has better natural resources than MUR1, while MUR1 has better facilities and container, and both have similar environmental quality and impacts.

<Table 6>

<Figure 3>

For this reason, a sensitivity analysis was performed in order to assess the influence of weighting on site selection. In this analysis, the interval method was used for standardization because it emphasized the differences among annual radiation scores. Annual radiation scores were similar and high for all sites (because annual radiation is the radiation accumulated over the year), but small differences in the value of this criterion were significant. Sensitivity analysis was performed by designing scenarios (Table 3) that represented the point of view of the promoters of thalassotherapy resorts (economic scenario), the clients (tourism scenario) and the Administration (social and environmental scenario).The results for each scenario are presented in Table 7.

<Table 7>

Site CAR9_12 (Fig. 4) is made up of many abandoned buildings –most of them (80%) with cultural heritage value– which amount to a total built area over 4000 m^2. In addition, site CAR9_12 is located immediately by the beach and shows good availability of natural resources for thalassotherapy and good water quality. Moreover, there are peloids in nearby areas and intertidal distance is the second greatest distance within the evaluated locations. Consequently, site CAR9_12 has good scores for most of the indicators included in the groups ‘containers’ and ‘resources’, which are the factors that are given priority in the economic scenario. Site CAR4_5 (Fig. 5) is made up of a number of buildings located next to each other immediately by the beach in an environment with high landscape quality (the landscape index of this site is the second highest index), low incidence of impacts and good accessibility. All these factors are highly appreciated by the clients of thalassotherapy resorts. Site BUE3 (Fig. 6) is composed of a single building with heritage value, located in an urban area with good accessibility to roads and urban settlements. Consequently, site BUE3 satisfies the main requirements of the Administration for this type of resorts.

<Figure 4>

<Figure 5>

<Figure 6>

5. Conclusions

A strategy for ranking potential sites for thalassotherapy resorts based on scientific methods has been proposed. Such a strategy allows for sustainable planning of thalassotherapy activities and contributes to the tourism promotion of the region, to the recovery of heritage and landscape values, and to minimizing the environmental impact of tourism. The strategy presented in this paper provides a reference framework to help decision-makers analyze location factors and select the most suitable sites according to objective criteria. In addition, the method described in the above sections allows decision-makers to consider all the criteria simultaneously and to gain a deeper knowledge of the problem and of the relationships between the criteria considered.

By integrating multicriteria evaluation techniques and expert knowledge, 19 suitable sites have been identified and classified according to different points of view represented by different schemes of evaluation criteria weighting. The ranked classification of the sites obtained by combining the weightings of different stakeholders with different points of view has not allowed us to identify a clear trend in site selection. However, sensitivity analysis has revealed that our strategy allows for the consideration of the different interests of decision-makers, as represented by the different weights assigned to criteria, in the selection of the most suitable sites according to their interests.

Overall, the analysis of results shows that multicriteria evaluation is strongly influenced by the weighting of criteria and that the selection of the final site is largely subjective, particularly when various stakeholders with different interests or objectives are involved. For this reason, the model must be adapted to each stakeholder (hotel developers, tourists, planners, local people, ecologists¸ technical advisers, among others), such that the consequences of the decisions made can be analyzed. The system for the evaluation and classification of alternative sites can help current stakeholders select the best site and encourage new investors to consider investing in thalassotherapy activities in a responsible and sustainable manner. From 1998 the Department of Tourism of the Government of Galicia has funding programs for private entities directed at promoting tourism through the development of spa and thalassotherapy resorts and at the construction or recovering of buildings for thalassotherapy resorts within a program to support spa and health tourism. The proposed framework could be used for the evaluation and selection of projects of thalassotherapy resorts as beneficiaries of these funding programs. In addition, the results of our analysis can help managers to better know the characteristics of potential sites and, consequently, to plan their actions better. This methodology can be applied in other locations adapting the criteria to the specificities of the area. Further research should be focused on capturing the preferences of local people through social research techniques and on integrating the results of these techniques as new evaluation criteria in the multicriteria methodology.

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List of Tables

Table 1. *Data layers and attributes stored in the GIS*

LAYER	INFORMATION	ATTRIBUTES
RESOURCES		
Water quality	Location of areas with good water quality	Name of beach, Municipality
Silt	Location of areas for potential use of silt	Area, Class
Intertidal	Intertidal zone	
FACILITIES		
Sea farms	Sea farms	Name, Province, Municipality, Location
Seaports	Seaports of Galicia	Name, National Seaport, Offices, Fishing harbour, Marina
Airports	Location of Galicia airports	
Roads	Highways, major roads and regional roads	Code, Ownership, Management, Road signs, Pavement, Condition, Width, Dimensions
Settlements	Urban settlements	INE Code, Name, X-coordinate, Y-coordinate, Population
Water treatment plants	Wastewater treatment plants	Ownership, Management, Capacity, Problems, Primary treatment, Secondary treatment, Tertiary treatment, Sludge treatment
ENVIRONMENT		
Wetlands	Protected wetlands	Name, Category, Date
Natural monuments	Natural monuments	Name, Category, Date
Natural parks	Natural parks	Name, Category, Date
Protected areas	Areas in which natural values require special protection	Name, Category, Date
Land uses	Land uses	Code, Land use
Viewsheds	Area of land/coastline visible from each site	
Hydrography	Main rivers	
DEM	Digital Elevation Model	Elevation
Radiation	Incident solar radiation (wh/m^2)	
CONTAINERS		
Buildings	Buildings pertaining to each site	Code, Municipality, Parish, Place, Location, Surface area, Description, X-coordinate, Y-coordinate, Former use, Current use, Heritage value, Condition, Access to the sea, Distance to the sea, Distance to beaches
Parcels	Parcel in which the buildings pertaining to each site are located	Surface area, Use class

Table 2. *Criteria for the evaluation of potential sites for thalassotherapy activities*

GROUP	FACTOR	INDICATOR	Unit of measurement	Benefit/ Cost	Source
RESOURCES	Water quality	Areas with characteristics of good water quality	Yes / No	B	*'Resources of the coast of Galicia for use in thalassotherapy activities'* (unpublished material)
	Peloids	Distance to areas for potential use of silt (m)	Quantitative	C	*'A study of the applications of silt and other marine derivatives in thalassotherapy'* (unpublished material)
	Intertidal distance	Distance to the 5 m contour line (m)	Quantitative	B	Authors' calculations based on 1:5000 topographic map
	Sunlight	Annual direct incident radiation (wh/m^2)	Quantitative	B	Authors' calculations based on 1:5000 topographic map
FACILITIES	Infrastructure	Distance to nearest roads (m)	Quantitative	C	Authors' calculations based on 1:5000 topographic map
		Distance to nearest airport (km)	Quantitative	C	Authors' calculations based on 1:5000 topographic map
		Distance to nearest non-national port (m)	Quantitative	C	Authors' calculations based on 1:5000 topographic map
	Services	Distance to nearest urban settlements (km)	Quantitative	C	Authors' calculations based on 1:5000 topographic map
LEGISLATION	Planning	Use class	Qualitative	-	www.planeamentourbanistico.xunta.es
	Protected areas	Nature 2000 networking program, SPA, natural parks	Yes / No	B	www.siam-cma.org/siam/
CONTAINERS	Surface area	Area of the parcel (m^2)	Quantitative	B	Cadastral map
		Area of the building (m^2)	Quantitative	B	Authors' calculations based on orthophotos
	Use	Current use	Qualitative	-	Obtained from fieldwork
	Condition	Building condition	Qualitative	-	Obtained from fieldwork
	Heritage value	Heritage value	Yes / No	B	Obtained from fieldwork
	Sea accessibility	Distance to the sea (m)	Quantitative	C	Authors' calculations based on orthophotos
		Access to the sea	Yes / No	B	Obtained from fieldwork
ENVIRONMENT	Landscape	Area of sea visible from each site (ha)	Quantitative	B	Authors' calculations based on 1:5000 topographic map
		Length of coastline visible from each site (m)	Quantitative	B	Authors' calculations based on 1:5000 topographic map
		Landscape index	Quantitative	B	Authors' calculations based on land use map
	Beaches	Distance to nearest beach (m)	Quantitative	C	Authors' calculations based on orthophotos
	Wetlands	Distance to wetlands (km)	Quantitative	C	Authors' calculations based on orthophotos
IMPACTS	Water treatment plants	Distance to water treatment plants and outfalls (km)	Quantitative	B	Authors' calculations based on EIEL (http://sit1.lugo.usc.es/)
	Fish farms	Distance to fish farms (km)	Quantitative	B	Authors' calculations based on orthophotos
	Rivers	Distance to nearest river mouth (m)	Quantitative	B	Authors' calculations based on 1:5000 topographic map
	Seaports	Distance to state seaports (km)	Quantitative	B	Authors' calculations based on 1:5000 topographic map

Table 3. *Ranking of criteria according to promoters (E - economic scenario), clients (T – tourism scenario) and the Administration (S – social and environmental scenario)*

Group	**Rank**			**Subgroup**	**Rank**			**Factor**	**Rank**			**Weight**		
	E	T	S		E	T	S		E	T	S	E	T	S
Resources	2	2	5					Areas with good water quality	1	1	1	0.060	0.126	0.011
								Distance to peloids (m)	1	3	1	0.060	0.025	0.011
								Intertidal distance (m)	1	3	1	0.060	0.025	0.011
								Annual direct incident radiation (wh/m^2)	1	2	1	0.060	0.065	0.011
Facilities	4	4	2					Distance to roads (m)	1	1	2	0.033	0.054	0.065
								Distance to nearest airport (km)	4	4	3	0.004	0.006	0.025
								Distance to non-state seaports (m)	3	3	3	0.009	0.015	0.025
								Distance to urban settlements (km)	2	2	1	0.017	0.028	0.126
Legislation	4	5	1					Urban planning	1	2	1	0.032	0.011	0.306
								Protected area	1	1	2	0.032	0.033	0.102
Containers	1	5	3	Building	1	2	1	Area of the building (m^2)	1	2	3	0.077	0.002	0.007
								Current use	1	2	2	0.077	0.002	0.025
								Building condition	1	2	2	0.077	0.002	0.025
								Heritage value	1	1	1	0.077	0.006	0.062
				Surroundings	2	1	2	Area of the parcel (m^2)	1	2	2	0.034	0.004	0.008
								Distance to the sea (m)	1	1	1	0.034	0.015	0.024
								Access to the sea	1	1	2	0.034	0.015	0.008
Environmental quality	4	1	5					Area of sea visible (ha)	2	3	1	0.009	0.050	0.009
								Length of coastline visible (m)	2	3	1	0.009	0.050	0.009
								Landscape index	1	2	1	0.029	0.105	0.009
								Distance to nearest beach (m)	2	1	1	0.009	0.186	0.009
								Distance to wetlands (km)	2	4	1	0.009	0.016	0.009
Impacts	3	3	4					Distance to water treatment plants and outfalls (km)	1	3	1	0.040	0.023	0.026
								Distance to fish farms (km)	1	2	1	0.040	0.043	0.026
								Distance to river mouths (m)	1	4	1	0.040	0.010	0.026
								Distance to state seaports (km)	1	1	1	0.040	0.082	0.026

Table 4. Sample of standardized evaluation matrices

		BUE3	CAN1	CAN2	CAN4_6
Evaluation criterion	**Standardization method**				
Good water quality		1	1	1	0
Distance to silt areas	Interval	0.27	0.02	0.00	0.15
	Maximum	0.26	0.02	0.00	0.14
Intertidal distance	Interval	0.43	0.46	0.59	0.40
	Maximum	0.44	0.48	0.60	0.42
Annual direct incident radiation	Interval	0.60	0.27	0.18	0.72
	Maximum	0.97	0.94	0.93	0.98

Table 5. *Total score and average ranking in the 17 questionnaires for each group of factors and each factor and weights of each factor*

GROUP/FACTOR	TOTAL SCORE	AVERAGE RANKING	WEIGHT
RESOURCES	35	1	
Areas with good water quality	19	1	0.213
Distance to silt areas (m)	46	3	0.060
Distance to 5-m contour line (m)	53	4	0.026
Annual direct incident radiation (wh/m2)	41	2	0.111
FACILITIES	66	5	
Distance to roads (m)	28	1	0.032
Distance to nearest airport (km)	46	3	0.009
Distance to non-state seaports (m)	55	4	0.004
Distance to urban settlements (km)	30	2	0.017
LEGISLATION	74	6	
Use planning	30	2	0.007
Nature 2000 networking programme, SPA, parks…	21	1	0.021
CONTAINER	60	4	
BUILDING	21	1	
Area of the building (m^2)	48	4	0.005
Current use	43	3	0.011
Building conditions	29	1	0.040
Heritage value	37	2	0.021
SURROUNDINGS	27	2	
Area of the parcel (m^2)	44	3	0.003
Distance to the sea (m)	23	1	0.016
Access to the sea	28	2	0.007
ENVIRONMENTAL QUALITY	52	2	
Area of sea visible (ha)	39	2	0.062
Length of coastline visible (m)	40	3	0.038
Landscape index	27	1	0.110
Distance to nearest beach (m)	44	4	0.022
Distance to wetlands (km)	69	5	0.010
IMPACTS	53	3	
Distance to water treatment plants (km)	30	1	0.082
Distance to fish farms (km)	36	2	0.043
Distance to rivers (m)	51	4	0.010
Distance to state seaports (km)	40	3	0.023

Table 6. *Scores of sites resulting from the weights derived from questionnaires*

Site	**Dominance score**		**Ranking**	
	Interval	Maximum	Interval	Maximum
BUE3	-0.01	-0.02	5	7
CAN1	-0.01	0.01	5	4
CAN2	-0.01	0.01	5	4
CAN4_6	-0.01	-0.03	5	8
CAN7	-0.06	-0.07	9	10
CAN10	-0.02	-0.05	6	9
CAR4_5	0.02	0.01	2	4
CAR9_12	0.02	0.04	2	2
CAR13	0.01	0.01	3	4
CAS9	0.00	-0.01	4	6
CEE2_3	0.01	0.03	3	3
FER1	0.02	0.00	2	5
MAN3	0.04	0.05	**1**	**1**
MUR1	0.04	0.05	**1**	**1**
OGR9	-0.03	-0.05	7	9
OIA2	-0.01	-0.05	5	9
ORTO1_3	0.04	0.01	**1**	4
RIBA2	0.01	0.05	3	**1**
RIBA3	-0.04	0.00	8	5

Table 7. *Scores of sites for the three scenarios*

	Economic scenario		Tourism scenario		Social scenario	
	Score	Ranking	Score	Ranking	Score	Ranking
BUE3	-0.03	8	0.00	8	**0.04**	**1**
CAN1	-0.01	6	-0.01	9	-0.01	6
CAN2	-0.02	7	-0.02	10	0.00	5
CAN4_6	-0.01	6	-0.03	11	0.00	5
CAN7	0.01	4	-0.07	12	0.02	3
CAN10	-0.03	8	-0.07	12	-0.01	6
CAR4_5	0.00	5	**0.07**	**1**	0.03	2
CAR9_12	**0.05**	**1**	0.06	2	0.03	2
CAR13	-0.01	6	0.00	8	-0.04	8
CAS9	-0.01	6	0.01	7	0.01	4
CEE2_3	0.02	3	0.03	5	-0.04	8
FER1	-0.05	9	-0.02	10	-0.04	8
MAN3	0.00	5	0.03	5	-0.04	8
MUR1	0.02	3	0.05	3	0.03	2
OGR9	0.00	5	-0.03	11	0.03	2
OIA2	0.01	4	-0.07	12	0.03	2
ORTO1_3	0.04	2	0.02	6	0.03	2
RIBA2	0.01	4	0.04	4	-0.03	7
RIBA3	-0.01	6	0.00	8	-0.04	8

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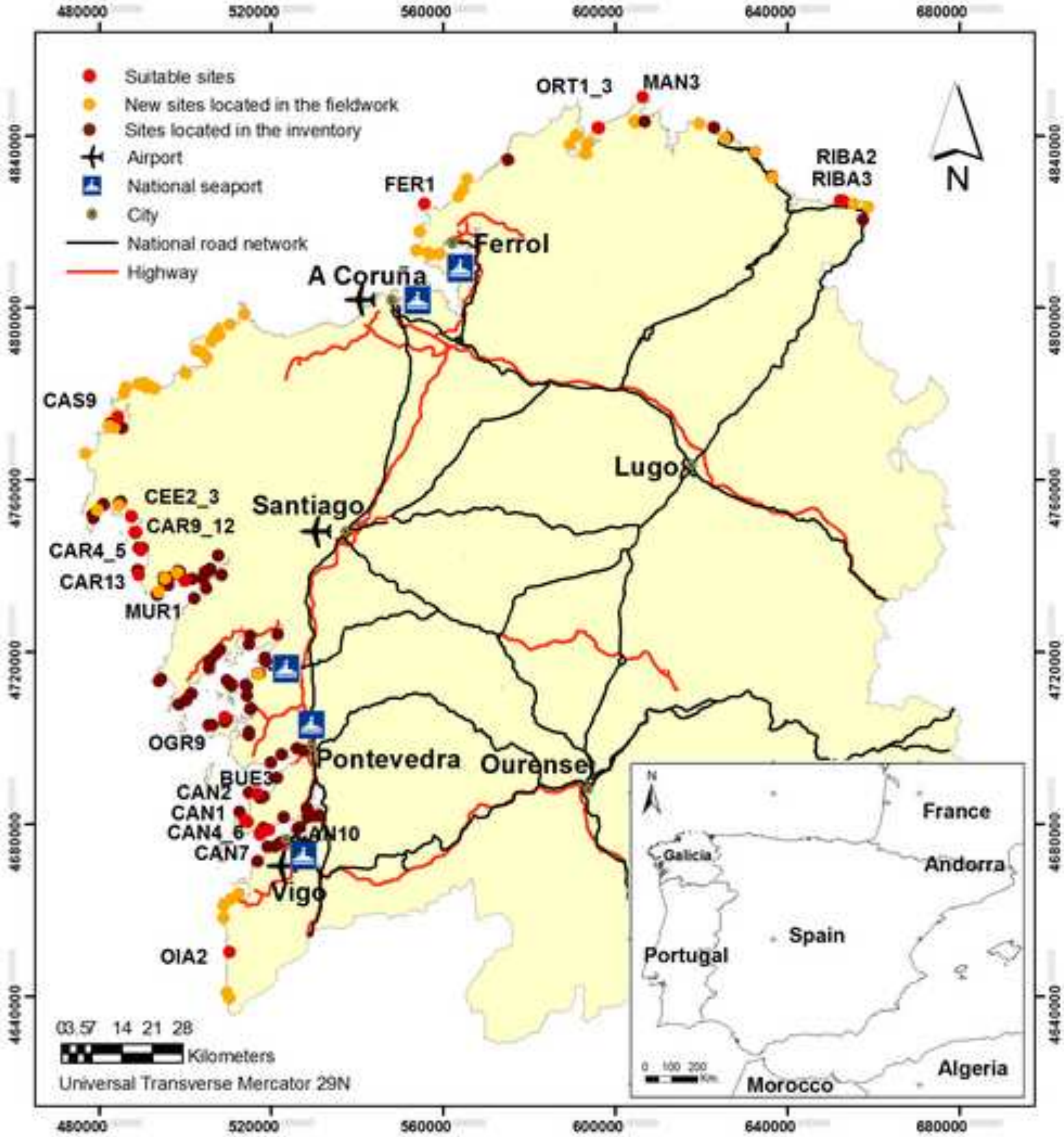

Figure2

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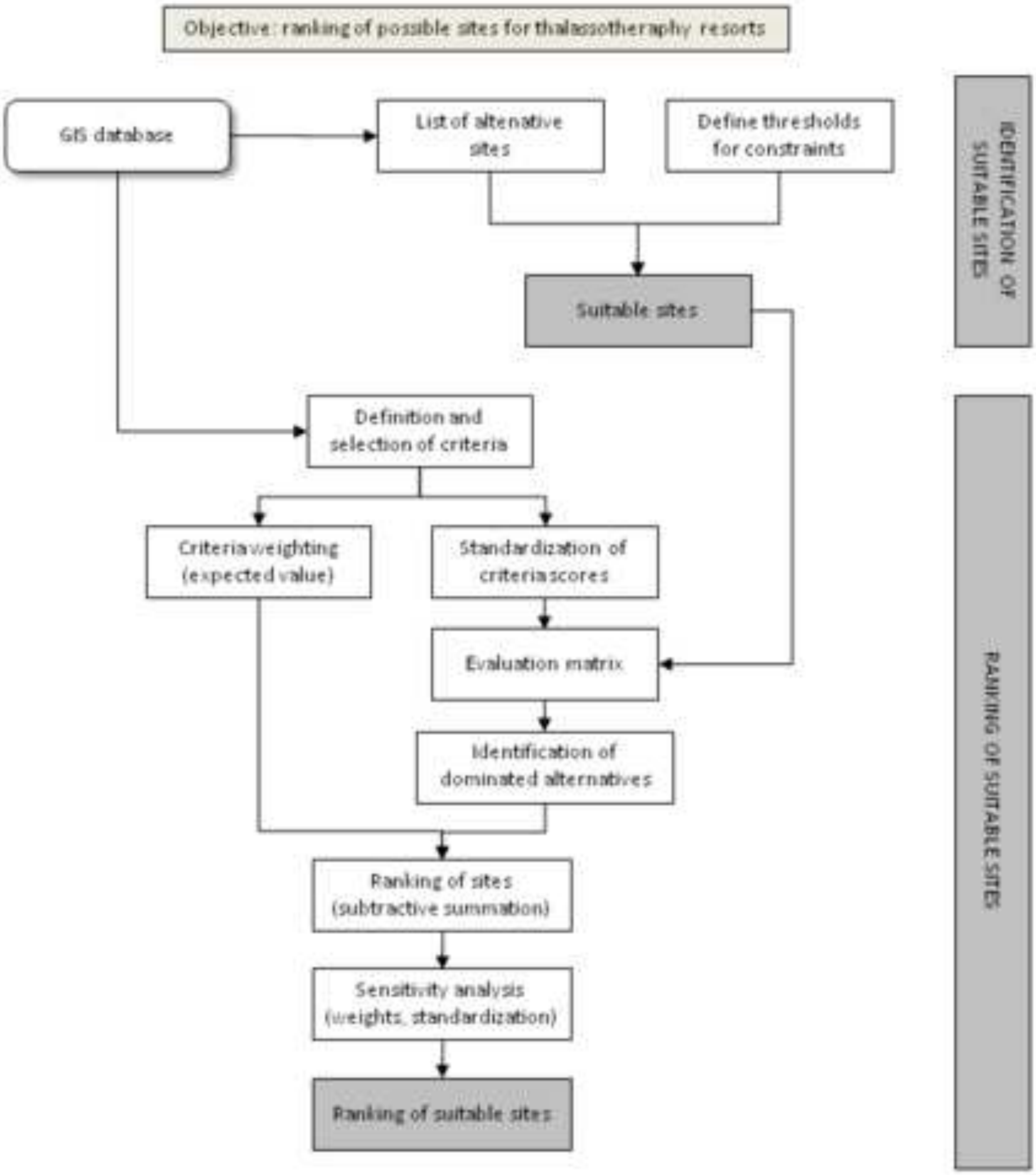

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