SITTING OF INTEGRATED WASTE MANAGEMENT FACILITIES – A METHODOLOGY WITH AN APPLICATION IN CRETE

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EXTENDED ABSTRACT

The sitting of a central Integrated Waste Management Facility (**IWMF**) for the Prefectures of Rethymnon, Herakleion and Lassithion in Crete has been the subject of several studies and to long lasting debates. As these efforts failed to produce results, the Region of Crete assigned this task to the Technical University of Crete.

To accomplish this task, a new methodology was developed and applied, with the objectives of (a) locating all potentially suitable sites within the study area though a technically sound and impartial procedure, (b) calculating the economic consequences, for each local authority and the region, of alternative choices (b) providing information and support to the local authorities for selecting with consensus one among the alternatives sites.

In line with the above, the following steps were followed for selecting the central IWMF site of Crete, preparing thus the ground for a Regional Summit to finalize the decision:

1. Definition of balanced set of site suitability criteria. Use of GIS, along with an extensive digital database for searching the **entire study area** for sites meeting all criteria of suitability. Though this procedure 23 sites were identified, all different from these proposed by previous studies.
2. Field inspection of sites by a team of experts, so as to exclude these with apparent geological or other problems. Though this procedure, 10 sites were found not to meet one or more suitability criteria and were excluded, reducing thus the number of available sites to 13.
3. Assessment of potential nuisance problems to neighboring region from available sites. For this purpose the visibility of each site from settlements, primary and secondary roads and archaeological sites, the number of nearby settlements along with their populations and distances, the possibility of site access without crossing settlements, and the character of the region were considered. From this procedure 4 sites were selected as the most suitable candidates for further examination.
4. Design of the optimal waste transportation system to each of the above alternative four sites, so as to provide detailed technical and economic data to each municipality and the Region as a whole, about the economic consequences of their choices.
5. Extensive deliberations with local authorities, the public and related government services for providing information and receiving feedback. Though this procedure, one site was proven to be near an archaeological area and was excluded. Through this procedure the ground has been prepared for the Regional Summit, in which the Local Authorities will have the opportunity to select one of the three remaining alternative sites.

KEYWORDS: sitting of waste management facilities, sitting of waste treatment facilities, sitting of landfills, site suitability criteria, site elimination criteria, waste transportation,

1. INTRODUCTION

For the sitting of Integrated Waste Management Facilities (**IWMF**), the existing regulations (KYA 114218/97) require (i) the location of at least two alternative sites that do not violate the applicable elimination criteria and (ii) the selection of the most appropriate among them. The location of alternative sites in the first step is a fairly simple operation, as the elimination criteria that have to be satisfied include only areas of archaeological and cultural interest, protected areas, settlements, airports and military installations. The site selection step that follows is more elaborate, as it is based on multi-criteria method using a multitude of dissimilar evaluation criteria (Hydrological, geological, environmental, landplaning, operational, economic, social etc.).

The quality of the site selected in the second step depends necessarily on the quality of the sites that happened to be located in the first step. Obviously, the deficiencies of the relaxed site location process in the first step cannot by covered by any site evaluation method in the second step. Even worse, the site selection process through the multi-criteria method is, according to the existing regulations, potentially biased (the study team is free to specify the sub-criteria of each criterion and to assign weighting factors and marks). The above procedure has often resulted in poor IWMF site selections that created social opposition, court contests and long implementation delays.

Several such studies have been conducted in the past for the sitting of a central IWMF for the Prefectures of Rethymnon, Herakleion and Lassithion in Crete. As these failed to produce results, the Region of Crete assigned this task to the Technical University of Crete. The Local Authorities agreed to accept the recommendations of the University team, on condition that the search method would be impartial and technically sound. In order to cope with these requirements and to improve the procedure that was followed so far, the present IWMF sitting method was developed and field tested in Crete.

2. METHODOLOGY

The key aspect of the present IWMF sitting methodology is the screening of the entire study area through GIS, so as to locate all potentially suitable sites, which satisfy all criteria of suitability. These sites are then subjected to a series of impartial evaluations and eliminations through which they are reduced to a small number. Among the latter, the Local Authorities can select the required ones, preferably with consensus.

The suggested procedure is illustrated in the diagram of Figure 1, which also shows the number of sites available after the completion of each step, as derived from the application of the present methodology in Crete. More specifically:

The first task is the definition of a carefully balanced set of suitability criteria. These must be strict enough for effective environmental protection, but not unduly strict so as to prevent the unnecessary elimination of potentially suitable sites. Following this, GIS can be use for searching the entire study area so as to locate the sites that meet all criteria. The GIS performs successive spatial operations using for this purpose spatial information relevant to the suitability criteria. The quality of the search results depends on the availability, completeness and accuracy of the required spatial information.

The second step involves a field visit to each selected site by a team of experts, so as to exclude sites with apparent geological or other problems. Ideally, this step could be omitted if the required spatial information is complete and accurate. This however, is rarely the case and, in any case, the experts will look for all sorts of problems, even for these that are not addressed by the suitability criteria. In addition to the above, the experts will

get a feeling about the area and the potential nuisance problems, and this is particularly useful for the next step.

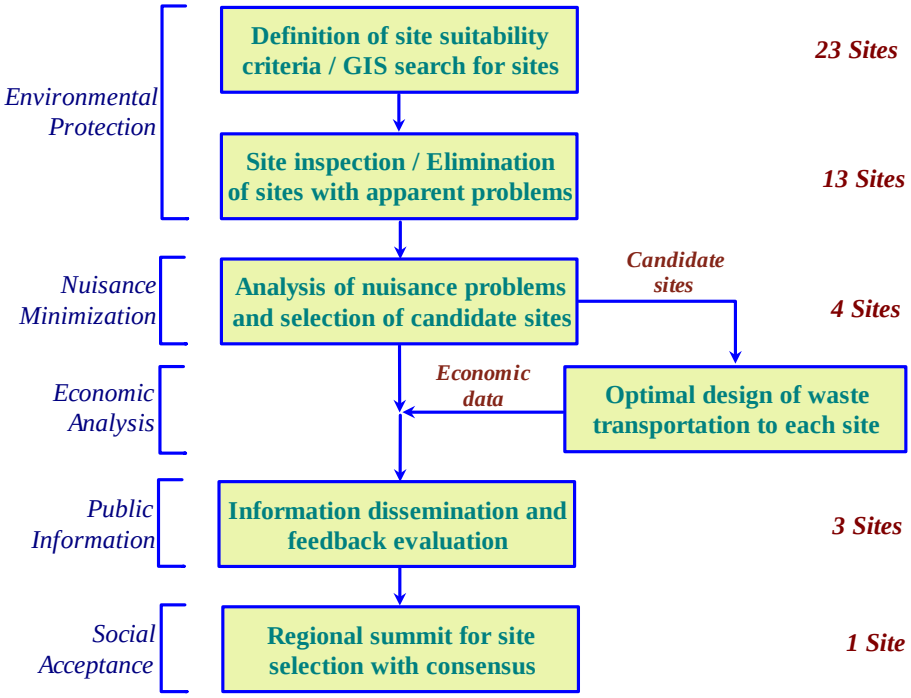

Figure 1: Proposed procedure for IWMF sitting.

The third step involves the analysis of the nuisance problems that each site can create to its neighboring region. A key criterion is the visibility of site from settlements, primary and secondary roads and archaeological sites. This task is aided by GIS, which can depict in local maps all areas with visibility to at least some part of the site under consideration. Additional criteria are the number of nearby settlements, along with their population and distance, as well as the possible accessibility of the site through roads that do not pass through settlements. The evaluation procedure is aided by GIS, through which local maps are produced and tables with summary data are constructed. An additional criterion is the morphology and nature of the surrounding physical environment, the compatibility of the IWMF installations within it and the existence of conditions that may affect adversely the dispersion of odors and emissions. This evaluation task is assisted by the field visits as well as by GIS maps that depict the surrounding area with elevations and the spatial information of interest. The objective of this exercise is the selection of the candidate sites that fulfill the above criteria to the fullest possible extent.

The fourth step involves, in the general case, the development of the optimal waste management scheme and sensitivity analysis, Economopoulou at al. (2005). This will define the sites that can be best used, and for each site the type and capacity of installations and the Local Authorities served. It will also provide a detailed cost analysis and the total annual costs for each Local Authority and the region as a whole. The sensitivity analysis will provide the technical and economic consequences of alternative selections in sites, technologies, capacities etc. In cases where the study area is relatively small, so that the use of a single site is apparently optimal (Economopoulou and Economopoulos, 2005), and the management scheme is already defined, the fourth step can be limited to the optimal design of the waste transportation to each alternative site. This will provide, as in the previous case, detailed technical and economic data to each Local Authority and the region, about the economic consequences of alternative site selections.

The fifth step involves the dissemination of information to the Region, the Prefectures, the Local Authorities, to related government services (archaeological and forestry) and to interested people, along with an invitation to the active evolvement of the latter. Sufficient time and energy should be devoted to this activity and the feedback information should be collected and evaluated. This procedure is likely to reveal additional problems (e.g. from plans and study results that have not been considered) and may result to the elimination of some candidate sites.

The sixth and final step is for the Local Authorities to select the management scheme or the site of their preference, taking into consideration the technical and economic data generated in the fourth step. This decision can be formalized in a Regional summit, in which incentives can be offered and negotiated until a decision is reached, hopefully with the concession of all parties involved.

The above IWMF sitting procedure needs to be followed by Environmental Impact Assessment (EIA) studies, as required by law. Each such study will examine the suitability of the site in more detail and will define the technical measures that may be required to remedy existing problems. In cases where the suitability of the candidate sites is questionable (e.g. in areas with significant geological or hydrological ambiguity), the EIAs might be have to be conducted prior to the sixth step above.

3. APPLICATION IN CRETE

The Region of Crete assigned the task of applying the above methodology to the Technical University of Crete, so as to locate suitable sites for a central IWMF, able to serve the Prefectures of Rethymnon, Herakleion and Lassithion.

3.1. Definition of site suitability criteria

The suitability criteria were defined in accordance with the first step of section 2. The definition of these criteria, which ought to cover all requirements of KYA 114218/97, was the subject of considerable analysis and included detailed specification of the conditions of their applicability and buffer zones. The definition of most criteria was based on generic considerations, but for some of them (e.g. for the important water intake zones) local data and expert opinions had to be considered.

The suitability criteria used in the present study are listed below, but without details about the conditions of their applicability, buffer zones etc.:

(i) Hydrological, geological and hydrogeological criteria:

- Water supply works, surface and ground waters (springs, boreholes, important water intake zones, rivers, springs, lakes, reservoirs, water basins, stagnant waters, flooding areas).
- Geological characteristics (soil permeability).
- Tectonic and seismic characteristics (faults, active faults, active seismic faults, seismic zones).

(ii) Environmental criteria:

- Coastal zone.
- Forest and reforestation zones.
- Areas of ecological and esthetic significance (NATURA, RAMSAR, wild life sanctuaries, controlled hunting areas, game breeding stations, national woodland parks, natural monuments and landmarks, areas of significant natural beauty, significant gorges).

(iii) Land planning criteria:

- Residential areas (cities, settlements, development areas, touristic areas).
- Areas for industrial and commercial activities.
- Areas of archaeological and cultural interest (antiquities, monasteries, churches).
- Infrastructure and installations (institutions, museums, airports, ports, military installations, industrial installations, power plants, power lines, mining areas, roads, trail E4).
- High productivity agricultural land.

(iv) General Criteria:
Site characteristics (height above sea level, mean slope, minimum area).

From the above it would appear that the suitability criteria were organized in four groups, covering hydrological and geological, environmental, land planning and general suitability aspects. These groups comprised additional criteria to be taken into consideration in the nuisance analysis step (see section 3.3 below) and by the EIA studies to follow.

3.2. GIS search for suitable sites

A major difficulty for the application of the above suitability criteria was the collection of the related spatial information. Spatial data about Local Authorities, Prefectures, cities and settlements, roads, rivers and lakes, cultivations, forestry etc. could be purchased. Additional data were made available from project partners. In both cases, most of the data collected had significant deficiencies and they had to be carefully checked and supplemented to the extent possible, and this required a major effort. The remaining data had to be digitized from maps, including these in development studies, thematic books (e.g. for monasteries, churches, archaeological and cultural sites) and Ministerial or other decrees (e.g. from the definition of archaeological sites).

The GIS system used the above data to generate maps with the areas that meet each suitability criterion. The overlay of the latter yielded the maps of Figures 2 to 5 showing the areas that meet all suitability criteria of groups (i) to (iv) respectively (see section 3.1).

The union of the maps in Figures 2 to 5 yields the map of Figure 6, which defines the areas that meet all suitability criteria listed in section 3.1. Through this procedure, 23 potentially suitable sites were identified within the study area. The combined surface area of these sites is a small fraction (about 0.0001) of the study area, proving that the location of the truly suitable sites by any other method, including that defined by KYA 114218/97, is highly unlikely. It is thus not surprising that none of the sites identified by the present study coincides with the sites located by the previous studies.

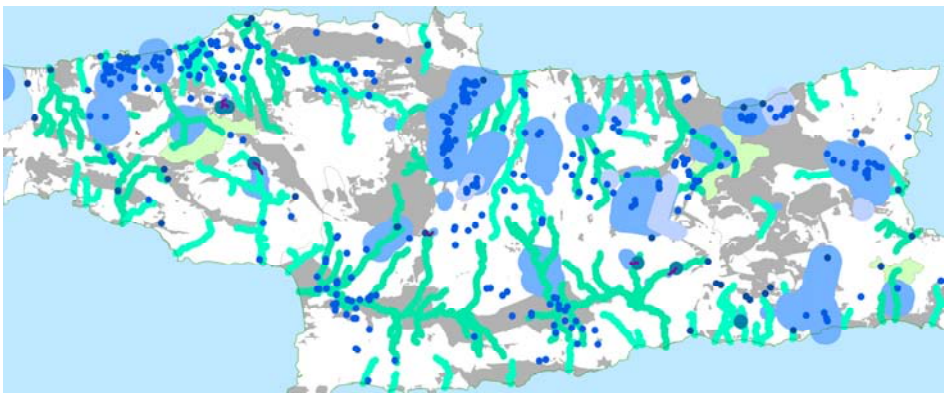

Figure 2: Exclusion areas (colored) from the application of hydrological, geological and hydrogeological criteria

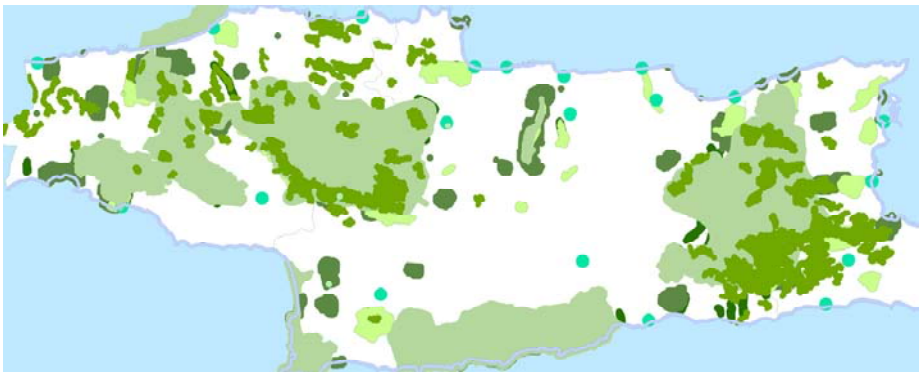

Figure 3: Exclusion areas (colored) from the application of environmental criteria.

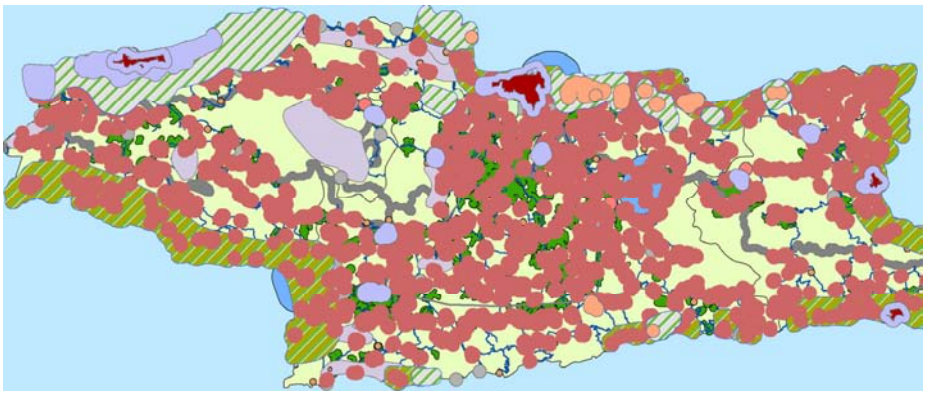

Figure 4: Exclusion areas (colored) from the application of land planning criteria.

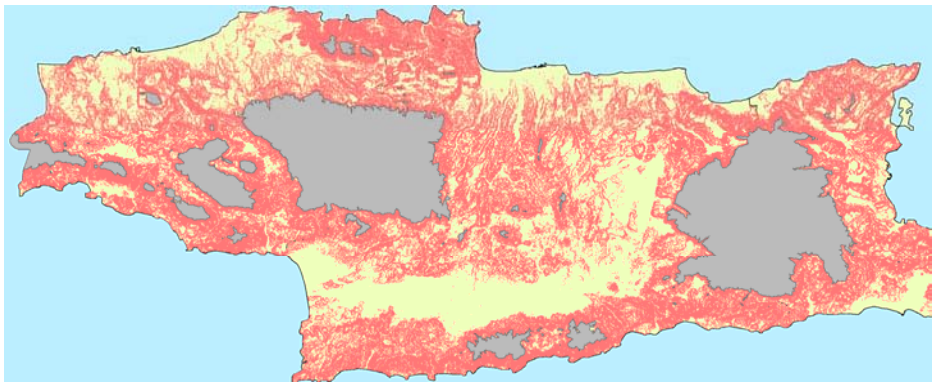

Figure 5: Exclusion areas (colored) from the application of site suitability criteria.

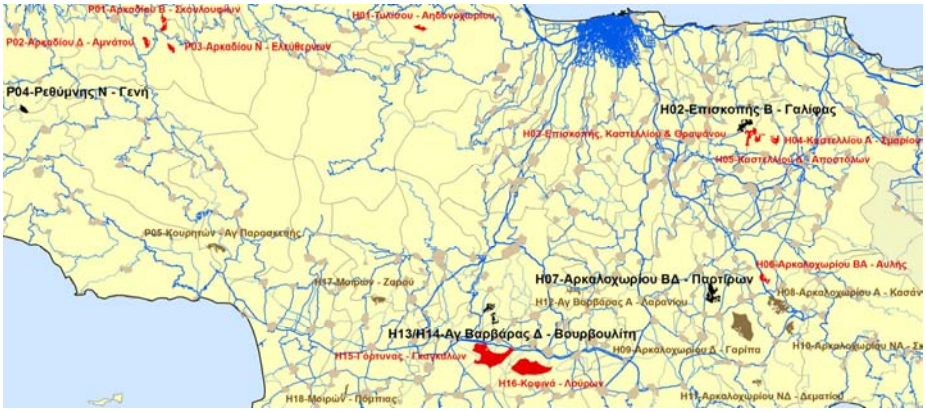

Figure 6: Map with sites that meet all suitability criteria.

3.3. Site inspection and elimination of sites with apparent problems

All potentially suitable sites defined in section 3.2 were visited by a team of experts and, in accordance with the second step of section 2 above, ten of these sites were eliminated as they were found not to fulfill one or more of the suitability criteria. The eliminated sites are shown with red color in the map of Figure 6.

3.4. Assessment of nuisance problems and selection of candidate sites

The nuisance problems were evaluated in accordance with the third step of section 2. For this purpose, GIS maps were produced showing the areas with visibility to each site and the settlements, roads and archaeological sites within them. Maps were also produced showing the morphology of the area, with elevations and selected spatial information. The GIS was also used for extracting data about the nearby settlements, populations and distances from each site, and summary tables were produced. The above information, supplemented by pictures and observations from the field visits, enabled the selection of four sites as the most appropriate. These are shown in black color in the map of Figure 6.

3.5. Optimal design of the MSW transportation to each alternative site

In accordance with the fourth step of section 2, the MSW transport system to each alternative site was optimized and the solution for one of the sites is presented in Figure 7.

Figure 7: Graphical presentation of the waste transport to the IWMF of H02-Episkopi.

The resulting economic data were presented analytically in tables and graphically in diagrams, such as that of Figure 8. The above serve to provide information to the Local Authorities about the technical and economic consequences of their alternative choices.

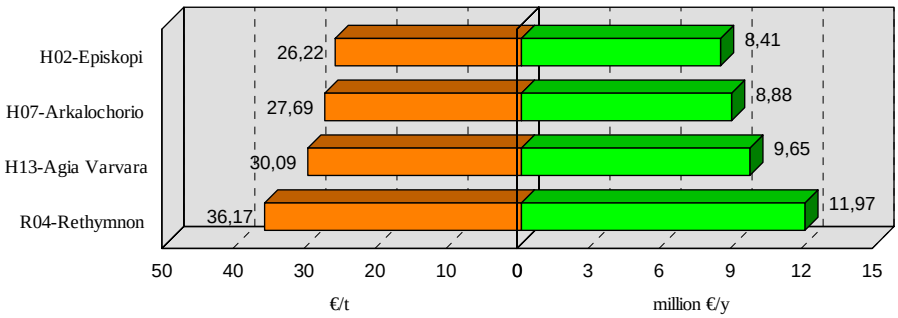

Figure 8: Overall economic impact of alternative IWMF site selections.

3.6. Information dissemination and feedback evaluation

The activities described in the fifth step of section 2 lasted for 6 months and were instrumental in creating a spirit of understanding with the Local Authorities, including most of

these that were directly affected. Feedback from the Archaeological service regarding the proximity of antiquities to site R04-Rethymon resulted to the exclusion of the latter. Hence, three sites remained available for the Local Authorities to choose from.

4. DISCUSSION AND CONCLUSIONS

The activities described in section 3 prepared the ground for a Regional summit, scheduled for October 2008. The incentives for the hosting Local Authority could be particularly strong, including lower transportation costs due to proximity to the IWMF, free MSW treatment and disposal, priority in the hiring of personnel for the IWMF (more than 400 new jobs can be created), significant road infrastructure improvements, compensation fees of at least 1 million €/y (corresponding to 3 €/t of MSW), etc. These, coupled with the particularly suitable location of sites and the good spirit from the preparatory phase, created favorable conditions for a site selection with concession from all parties involved.

However, the Local Authorities and the people objected very strongly the use of waste incineration technologies and were unwilling to accept an IWMF in their neighborhood without knowing the treatment method to be used. The selection of the treatment method emerged thus as the major topic of the forthcoming Regional summit. At his point the discussion on the selection of the central IWMF site seized, and the Regional summit is yet to be convened. It would appear that the questioning of the existing Regional waste management plan of 2005, which approved the use of biological drying of the MSW and the incineration of the SRF produced, is not welcomed at this time. Nonetheless, this plan is expensive and inherently incompatible with EU Directives, Economopoulos (2009).

To cope with this situation, the biological drying units are likely to be built in various locations (the first one is under construction in the transfer station site of Herakleion) and the SRF incineration plant in the existing landfill site of Fodele in Rethymnon. The MSW and the rejects will continue to be landfilled in Fodele for two or three more years and after that in some other location. This solution, restricts severely the waste management options, obstructs the implementation of the new EU Directives and perpetuates the problem. It is interesting to note that in the present case, responsible for the delay to build the central IWMF appears to be the administration and not the Local Authorities or the people and their often blamed NIMBY syndrome.

5. CREDITS

Mr. N. Stappas, geologist, was responsible for the analysis and definition of geological, hydrogeological and water resources data, Dr. V. Despotakis, surveyor engineer, supplied spatial data and Mr. G. Makrypodis, environmental engineer, collected information from local services.

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