STRATEGIC ENVIRONMENTAL ASSESSMENT OF ALTERNATIVE INFRASTRUCTURE LOCATION IN COMPLEX LANDSCAPE (ARGENTINA).

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ABSTRACT

In the context of Regional Development Planning for Gral. Madariaga County (prov. Buenos Aires, R. Argentina), we identify potential areas for the location of urban service infrastructure (waste treatment plants, landfill), using ecological and environmental information organized in a Decision Support System (DSS) integrated in a Geographic Information System (GIS). The results include: i) a Regional Ecological Fragility Map of the county (1:50.000); ii) a suit of environmental criteria for the definition of an Optimal Location Site (OLS); iii) a Map of OLS (1:10.000); and iv) a suit of environmental recommendation for the adjustment of future project design and for the EIA of executive project. The ecological fragile areas in the county are the Coastal dunes (water reservoir, landscape), natural Tala Forest (Biodiversity), and wetlands (ecosystems services, tourism). The DSS estimate OLS based on landscape, physical, ecological, infrastructure and social features that were combined through a multicriteria methodology into a single index (OLS) and mapped using GIS. The DSS allow the modification of criteria and/or project features for the assessment of environmental impact of different project location within the Gral. Madariaga County. This can also be done with the incorporation of public opinion through people participation. The spatially explicit GIS-DSS is an excellent tool for an early incorporation of environmental issues, and the assessment and management of ecological and environmental issues in the context of landscape and regional planning.

1. INTRODUCTION

In the context of Regional Development Planning for Gral. Madariaga County (province of Buenos Aires, R. Argentina; Fig. Nº 1), the **general objective** of this work was to provide environmental information and criteria to identify potential areas for the location of major urban service infrastructure (waste treatment plants, landfill), using ecological and environmental information organized into a Decision Support System (DSS), spatially explicit using Geographic Information System (GIS) (UNLP, 2005).

The specific objectives were to produce:

i) a Regional Ecological Fragility Map of the county (1:50.000);

ii) a suit of environmental criteria for the definition of an Optimal Location Site (OLS);

iii) a Map of Optimal Location Site (OLS) (1:10.000); and

iv) a suit of environmental recommendation for the adjustment of future project design and for the EIA of executive project.

The early incorporation of environmental aspects into a Regional Development Plan can help to avoid, minimize or control potential environmental impacts of major urban service infrastructure. In this sense, the identification and mapping of natural (climatic, geomorphological, hydrological, ecological) and socioeconomic features (population distribution, economic activities, land use, etc.), may be useful for taking decisions on the best location of this type of urban services.

As the evaluation of service area location alternatives is prior to the definition of the project itself, it is useful to establish conditions and recommendations to be incorporated in the development of the executive project. In this study, environmental recommendations have been drawn up to be taken into account both for the preparation of the project and for the study of its environmental impact.

2. METHODOLOGICAL APPROACH

The early incorporation of the environmental variable in the project cycle improves decision-making within the framework of sustainable development. Specifically, an adequate territorial location of urban service areas can promote the benefits of balanced urban development. In order to evaluate alternatives location site for urban service areas, we elaborate:

- A regional analysis of the county of Gral. Madariaga.
- A generic analysis of the environmental impacts of the service areas.
- The definition of the ecological characteristics of the Optimal Location Site (OLS).
- The identification of sites that meet the defined criteria (mapping).
- The preparation of recommendations for the executive project and its Environmental Impact Study.

Tasks performed included a recognition trip to the study area, interview with local key social actors, and the elaboration of the Multicriteria Model (SISEDE): collecting and processing local and regional information; definition of conditions, criteria and factors; implementation of the model through the SIG and generation of maps and report (Guerrero B. et al, 2005).

3. RESULTS

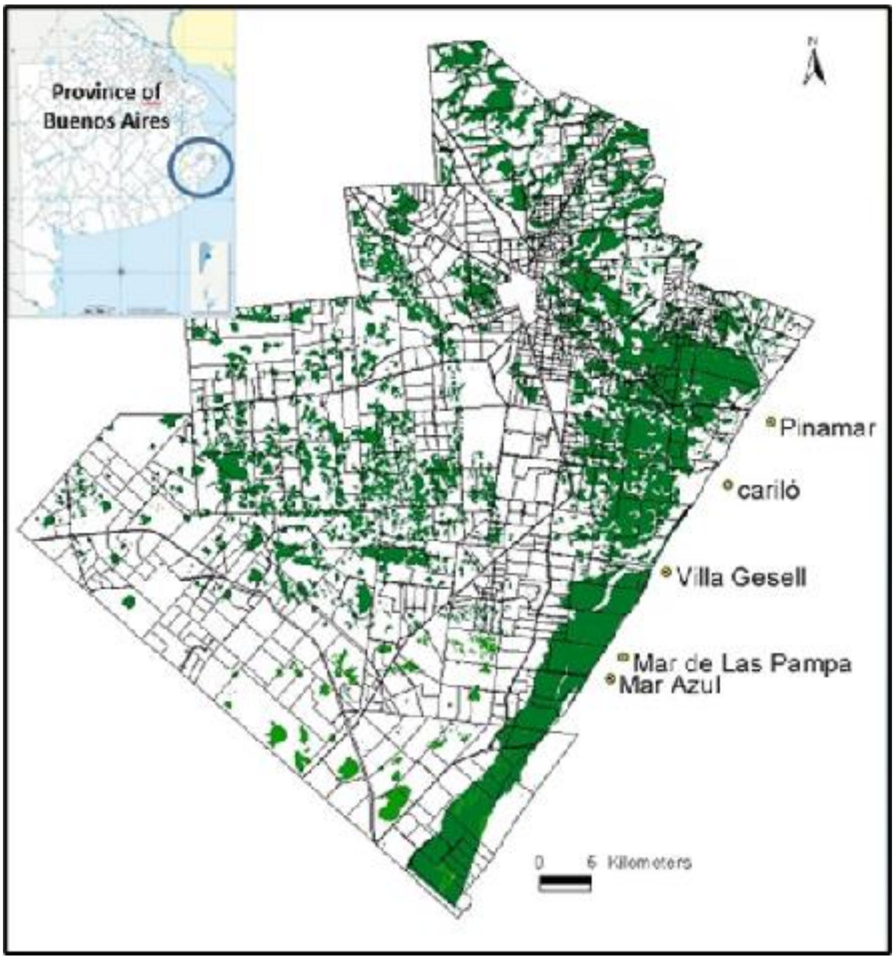
3.1. Regional Ecological Analysis of Gral. Madariaga County

Based on previous studies (UNLP, 2005), and strictly related to the ecological characteristics of Gral. Madariaga County, the following ecological elements can be recognized: natural resources, natural risks and environmental fragilities, whose spatial location determines ecologically sensitive areas in the territory. The Regional Ecological Fragility Map of the county (Fig. Nº 1; 1:50.000; 2.964 km²) identify different fragility areas (green), that includes fresh water resources (regionally scarce, located in the coastal dunes); soils of good aptitude; biodiversity (native Tala forest) and floodplains.

Among the resources, fresh water sources (drinkable), with adequate conductivity values for human, animal, irrigation or industrial use, is the most critical natural resource in the area. The most valuable areas as a reservoir of fresh water are the coastal dunes and the underground freshwater lenses. Soils of good productive aptitude are located in high sectors, with agricultural-livestock aptitude. The district has an important biological diversity (native flora and fauna), especially birds associated with permanent or temporary bodies of water (wetlands), coastal dune areas and natural forest dominated by the “Tala” (*Celtis tala sp.*). These resources are important in relation to their potential use as landscape resources through various activities associated with tourism (sport fishing, ecotourism, etc.) that are complementary to the activities that can be developed in coastal sectors.

On the other hand, the most important recurring natural phenomenon in the region is flooding, whether due to excess local rainfall, impediments to regional surface runoff or income from extra-local contributions through natural or artificial channels.

Figure Nº 1: Ecological Fragility Map of Gral. Madariaga County. Most fragile areas in green.



3.2. Generic analysis of the environmental impacts of the service areas

Urban service areas (specifically sewage treatment plants or urban solid waste treatment plants; MSW) are potential sources of environmental impact. This is so because, depending on their location, design and operation, they can have various negative effects, such as:

- Air pollution (particulate matter, unpleasant odors; noise) and water pollution (both superficial and underground);
- Deterioration of fauna (increase in harmful or dangerous species); landscape quality (waste, bad smells, noises, etc.); or social environment (increase in marginal activities);
- Loss of land value nearby service centers (due to deterioration in the quality of the landscape and social life).

Although there are design, maintenance and operation measures to minimize most of these environmental impacts, some of them (deterioration of the landscape; odors; alteration of social life), can only be mitigated with an adequate location of the service areas.

3.3. Definition of the ecological characteristics of the Optimal Location Site (OLS)

After the identification of environmental impact of generic major urban services infrastructure, we defined a "**Optimal Site Location (OSL)"**, by a set of natural or anthropic conditions an area should meet to mitigate most of the potential environmental impacts. The **OSL in the area**, should have the following **conditions:**

- Proximity to urban centers to be served (within a radius of no more than 10 km).
- Accessibility / proximity to consolidated routes or roads.
- Away from residential or tourist-recreational areas, and from underground water extraction areas for consumption.
- Topographically high area, with good drainage and a deep-water table.
- Preferably not located in the dunes sector or natural forest sector, that have an important conservation value for regional biodiversity.
- Close to a contingent tipping area.

3.4. Identification and mapping of OLS

The selection of the most suitable areas for the location of urban services (OSL), was based on the development and implementation of a **multi-criteria model (using the GIS)** conforming a **Spatialized Decision Support System (SISEDE; 1:10000).**

These variables were spatialized (mapped) and implemented in a GIS. All the information layers were brought into raster or matrix type formats and standardized to normalized values ("ranked") between 0 and 255; from the Fuzzy function of the IDRISI-32 system where the highest fitness values are represented by the set of all pixels with values close to 255, decreasing fitness to zero. Each unit of information ("pixel") represents an area of 900 m2 on the ground.

The first step in the multicriteria evaluation is defined by the way in which the information from the criteria is combined to obtain a simple evaluation index. In the case of the conditioning criterion (Boolean map), it was generated from the conversion of the potential coverage map to a logical type map, where the unsuitable areas were assigned the value 0 (zero) and the rest of the coverages 1 (one), all territorial units of information ("pixels") with values equal to 0 being excluded from the analysis through the Boolean AND intersection of the GIS.

The multi-criteria evaluation was based on the **aggregated linear combination of criteria**, with a **standardized variable weighing**. In this procedure, the factors are combined from the sum of them by a weight assigned to each one (a different combinations of factors and weight can be applied). The result is a value assigned to each pixel, **obtaining a map that, in our case, identify the OSL for urban service centers.**

$$A = \sum w_i x_i$$

Where A = Aptitude w_i = weighing factor I x_i = value of factor i

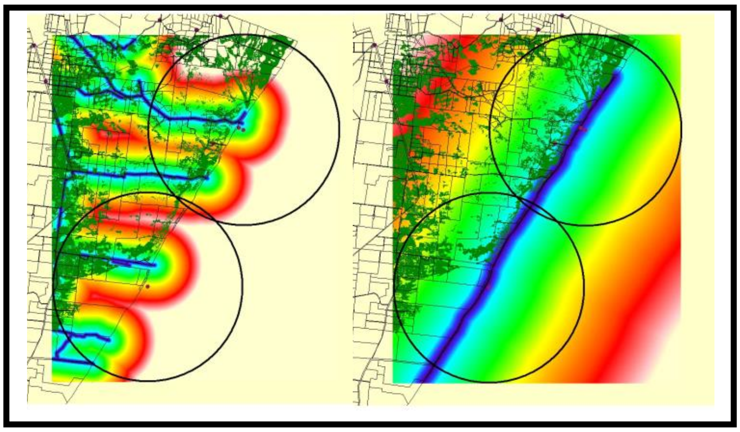
In the event that a conditioning factor is applied, the procedure is modified by multiplying A by the conditioning factor.

$$A = \sum w_i x_i * \prod c_j$$

Where $\prod$ = product c_j = value of criterion j

In the model developed, the **criteria established were the following: a) Criteria of proximity or distances (Factors):** Distance to permanent bodies of water, to major regional roads (Route No. 11), to driveways to tourist centers and to residential areas; b) **Ecological criteria (Conditioning):** Zones without potential restriction; and areas less than 10 km away from urban centers. Figure Nº 2 show some examples of the application of singular criteria: distance to roads and tourist centers (Left), and distance to major regional highway (Right), as depicted by the SISEDE model.

Figure Nº 2: Distance to roads and tourist centers (Left) and to major regional road (Route No. 11) (right). In blue the driveways and Route Nº 11; green, yellow and red, are buffer areas.



3.5. Results of the multicriteria model:

The implementation of SISEDE in the Gral of the Gral Madariaga County (UNLP, 2005) allowed the identification and spatialization of areas with different degrees of aptitude for locating urban service centers (Fig. Nº 3). Different alternative results vary depending on the relative weight of factors. Notice that major cities (Pinamar, Villa Gesell, etc.) are outside of the area because they belong to another county (although they are served by the county system).

Figure Nº 3: Identification **and mapping of potential sites (OSL)** of higher suitability (red), lower (green) and unsuitable (white). Different results of SISEDE modeling.

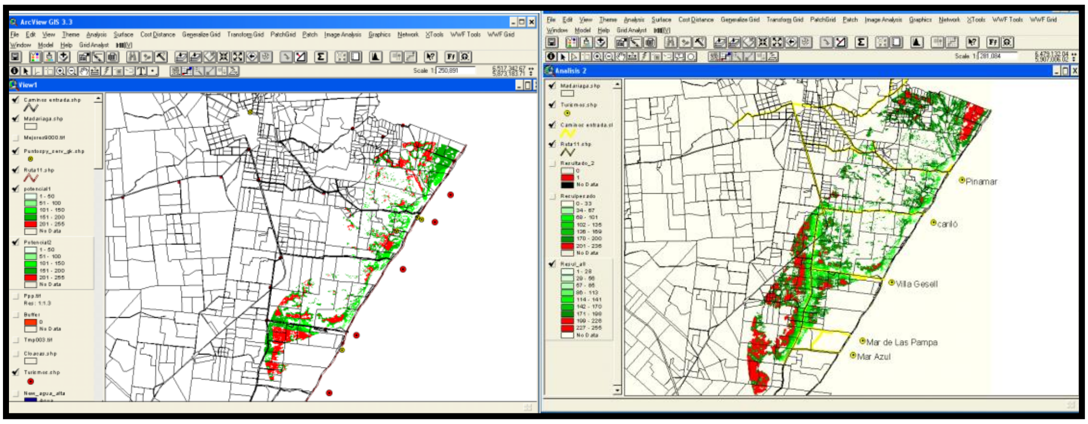


Figure Nº 4 shows the identification and **mapping of potential sites (OSL)** with higher suitability (red), lower (green) and unsuitable (white), superimposed on satellite image and water risk map (in which the flooded areas in a situation of maximum flood are highlighted). In **red the areas of greatest aptitude** There are 2 best potential sites (OSL; Alt) for Pinamar City (Northern area) and 6 potential sites (OSL; Alt) for the Villa Gesell city (southern part of the county).

3.6. Recommendations for the Executive Project and the Environmental Impact Study.

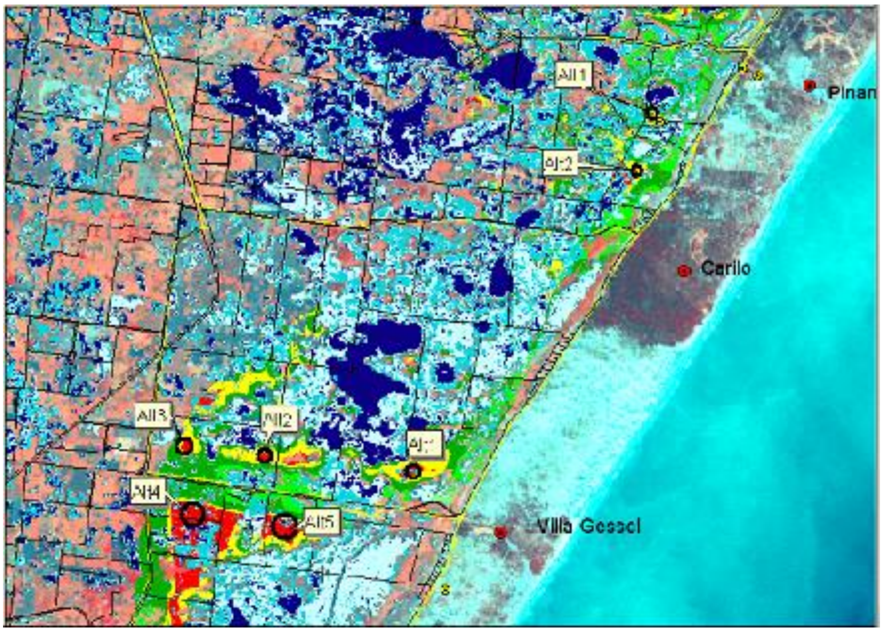
In addition to an adequate location of urban service centers, it is important to consider in the formulation of the executive project, some environmental measures aimed at avoiding, reducing or controlling the environmental impacts associated with this type of urban infrastructure.

I. Design measures: related to the area of land for the project; land use in adjacent sectors; landscape adaptation and preparation; gas evacuation system and leachate treatment (MSW).

II. Measures during construction: an Environmental Management Plan must be requested for the contractor company in charge of the construction of the establishment.

III. Measures during operation: Adequate maintenance of pump equipment; Quality control of gaseous and liquid effluents; Control of clandestine activities, and of harmful animals (vectors, pests); Security and control measures; Water quality monitoring; Contingency plan (chemical spill, fire, overturning, etc.) and Training program for personnel.

Figure Nº 4: Identification and mapping of potential sites (red: higher suitability; lower green; white: unsuitable), superimposed on satellite image and water risk map in which the flooded areas in a situation of maximum flood are highlighted (in red the areas of greatest aptitude).



4. CONCLUSIONS

The **DSS estimate OLS** based on landscape, physical, ecological, infrastructure and social features that were combined through a **multicriteria methodology** into a single index (OLS) and **mapped using the GIS.** The DSS allow the **modification of criteria and/or project features** for the assessment of environmental impact of different project location within the Gral. Madariaga County. This can also be done with the incorporation **of public opinion through people participation.**

The **spatially explicit GIS-DSS** is an excellent tool for an early incorporation of environmental issues, and the assessment and management of ecological and environmental issues in the context **of landscape and regional planning.**

5. REFERENCES

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