GIS Tools for Landscape Impact Assessment

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ABSTRACT

This paper present the main results obtained by the development of the Artemis Project "Design and Evaluation of Residential Patterns in the Mediterranan Region appropiate to sustainable development of environmentally deteriorated rural areas" 4th European Framework Program. Call ENVIRONMENT AND CLIMATE . ENV4-CT97-0656.) As results of the project an Integrated Landscape Assessment Model (AIAM) was created. AIAM is a resource modelling system focusing on the generation of a decision support system application oriented to provide criteria in order to evaluate effects and to optimise location of low density residential settlements. The Model includes a Landscape multicriteria analysis merged with spatial analysis tools set in a GIS Environment. The A.I.A.M. provides data structures, user interface components, and output mechanism witch allows the user to apply the knowledge acquired for Artemis Project. One of the main goals of the A.I.A.M is to give a landscape view of the territory including variables that are usually not considered in planning and environmental impact assessment processes. Also the models gives a sustainable support both to planner and designers projects. A.I.A.M. gives the data structure to define a residential patterns, the parameters through which a pattern is adequately described. This pattern definition allows comparison between the one's of the reference area and so, extract conclusions about divergence between them.

1 INTRODUCTION

This paper presents the AIAM model functionality (**A**rtemis **I**ntegrated **A**ssessment **M**odel) one of the main results of the *ARTEMIS* project "*Design and evaluation of residential patterns in the Mediterranean region that are appropriate for the sustainable development of environmentally deteriorated rural areas*" (Project ENV4-CT97-0656 financed by the ENVIRONMENT AND CLIMATE programme of 4th Research Framework program of the European Commission).

Artemis project objectives are based on the European Spatial Development Perspective (ESDP), but the origin of the project emerged after 25 years of experience in planning and territorial management activities in different places in the Mediterranean region. It responds to the need to give efficient solutions to the increasing problem of degradation of Mediterranean landscapes. The causes of this degradation can found

- on the colonisation by randomly selected settlements tourist patterns. These patterns are imported from countries with totally different environmental and socio-cultural conditions. In fact, the patterns of settlements that have been used until now in residential developments are almost wholly determined by

accessibility or land ownership typologies and hardly ever taking account of the visual impact produced or its consequences on biodiversity.

- or on the progressive abandonment caused by changes in the productive practices, with all well known environmental and social consequences.

The above mentioned problems usually occur in territories where the means of local administration for policy making are weak and in their majority, where pressure for land development is enormous. So, there is a serious demand for tools in order to offer alternative, efficient solutions.

In that context, the objective is the experimental design of a decision support system tool, the IAM or Integrated Assessment Model, which will be able to evaluate the impact derived by low-density residential developments on rural territories in the Mediterranean region.

Specifically IAM helps to:

− Analyse and map the environmental fragility of areas for residential development of low-density, excluding the non-building areas for legal and environmental reasons.
− Detect and map the environmental fragility of the areas to urban use.
− To identify and quantify the impacts derived of the implantation of an specific settlement pattern.
− To evaluate the divergence between the environmental preferences of settlement pattern and the land aptitude.

These objectives emerged from the need to renew existing rural areas that are in a process of degradation, respecting the identity and the quality of the landscape where it is not yet lost and still, considered valuable.

AIAM model includes a landscape multicriteria analysis merged with spatial analysis tools set in a GIS environment. The AIAM provides data structures, user interface components, and output mechanism, which allows the user to apply the knowledge acquired from *Artemis* project.

The elaboration of the AIAM has been developed co-ordinated with the other phases of *Artemis* Project. In order to develop the AIAM application has been necessary to translate to a computer language all the experiences and information collected throughout previous tasks.

Other of the main goals of the AIAM model is to give a landscape view of the territory including variables that are usually not considered in planning and for taking into account the likely impacts on the environment of a development before it is given consent to proceed (Environmental Impact Assessment). Also AIAM gives a sustainable support both to planner and designer to develop their tasks.

There are many references about spatial multicriteria decision analysis for location analysis and for environmental impact assessment. The main goal of AIAM compares with these systems is its approach based on the dynamic geographic scale of analysis. First AIAM runs like a typical spatial decision support system to assess aptitudes/impacts of urban settlement (planners and landscape architects task). At this

level is very common that Land-use planners make complex decisions within a short period of time when they must take account sustainable development and economic competitiveness. (Joerin et al. 2001).

Secondly AIM change the scale (increase the geographical view) and gives support to the design of an specific settlement pattern sustainable with the environment (architects tasks).

In last years, GIS has become commonplace in large-scale urban and regional planning, but it has been used far less frequently in project design. Al-Kodmany (2000) appoint several reasons: lack of data at the local level, citizens and planners are not interested in local land-use maps until an immediate event threatens, existing maps of local governments do not provide details at the local level because tye are focused on plans of substantial economic importance (infrastructure, transportation, water supply lines, etc.), the cost of equipment.

2 AIAM OVERVIEW

The AIAM provides an open decision support system oriented to the environmental evaluation of the insertion of a residential settlement pattern into an area. The pattern definition allows comparing it with the one's of the reference area and so, extracting conclusions about divergence between one and other.

The AIAM has been developed as an extension of ArcView (ESRI) Geographic Information System with the name of "Artemis". This extension must be activated to be used in a new ArcView session. The source languages of the program are in Avenue and Microsoft Visual Basic 6.0.

The implementation includes the application capabilities and data model structure, which allows the user to run the AIAM. AIAM describes the territory with geographic *variables*, which have an importance within planning processes, and the patterns with *parameters*, which are the most relevant and "measurable" aspects of the pattern.

The software system is an open system allowing users to modify data and associated values to suit their individual needs. AIAM is an open framework that accepts different geographic data that allows the user to use the data structure created by Artemis as well as to create new variables or new categories for the variables. The AIAM provides the functions to generate evaluations on the aptitude of a territory for the development of residential use and the contrast of divergence between area's variables and a concrete pattern. The model calculates this aptitude based on a evaluation of every category of the variable. Artemis provides the possibility to the user to introduce his valuation criteria (values/ weights etc). The Artemis project considers that evaluation process should emerge through collaboration between experts, politicians and society agents.

2.1. **System architecture**

The elements of the AIAM spatial decision support system model are:

➢ **Reference Areas**

Territories, which are described by a set of GIS layers, which are the concrete values of the variables in the area. (By default 20x20 km, 10x20 km)

➢ **Reference Area Variables**

They are the geographic variables that allow to describe the Reference Area's aptitude for low density residential development. These variables are represented as a LAYER: a raster map (ArcView grids). Every variable is an assembly of different elements in a land, which never superpose one another. These elements are called CATEGORIES.

Then, categories are classifications of the possible values of variables.

➢ **Patterns:**

They are the low-density residential patterns created by Artemis, or could be concrete settlements projects/proposals. Each pattern is described by rules, which are the concrete values of the parameters of a pattern.

➢ **Pattern Parameters:**

The pattern is defined by **Parameters, that** are a set of rules that define the pattern.

Database structure

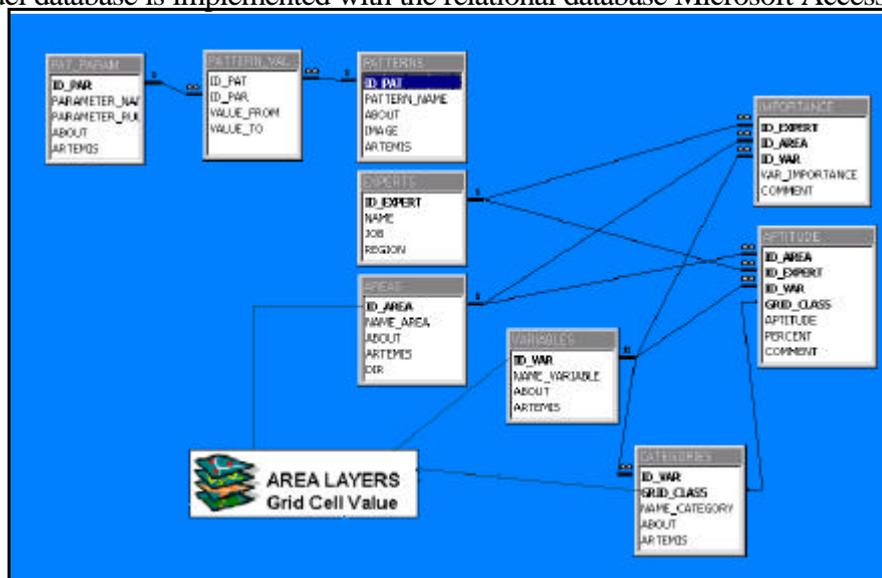The model database is implemented with the relational database Microsoft Access.

Figure 1. **Database structure**

2.2. **Core functionality**

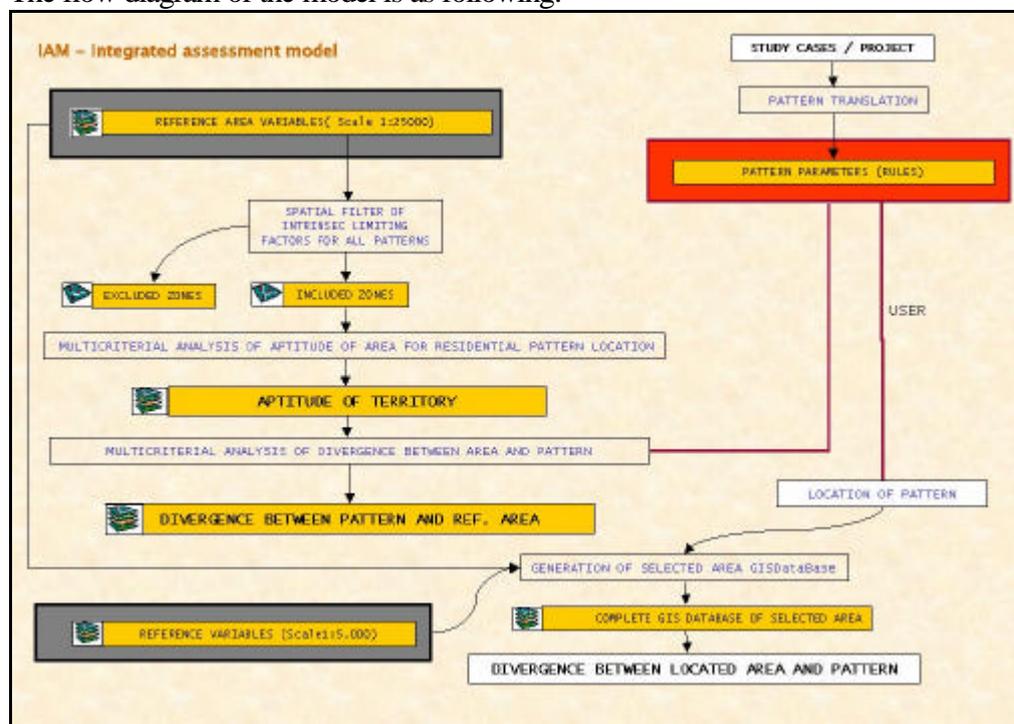The flow diagram of the model is as following:

Figure 2. **Flow diagram of the model**

Diagram shows the functions implemented by the AIAM. Though, first, users should set the variables, categories, layers and patterns according to their individual needs/preferences. Before the user runs the model it is necessary to use some functions, which allow adapting better to the data structure. These functions are:

➢ **Variables Management**

Artemis provides a set of variables with their categories which can be used directly by the user. The system is open to incorporate new variables or new categories in existing variables.

The system provides a user's interface to create this new variables and categories.
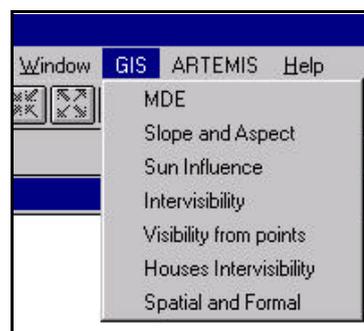
Figure 3. **variables menu**

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➤ Pattern Management
The system provides data structures and user's interface that allows the user to define the pattern to evaluate.
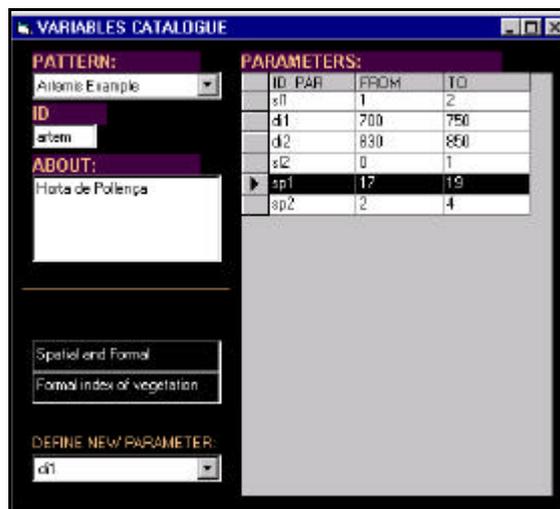

Figure 4. **Pattern description**

➤ Setting importance and aptitude
AIAM programme allows the user to generate these parameters from cad layers and some other inputs, specific for each pattern parameter. When the data structure is set, another kind of function oriented to allow the users to set the variable importance and the categories aptitude is provided.
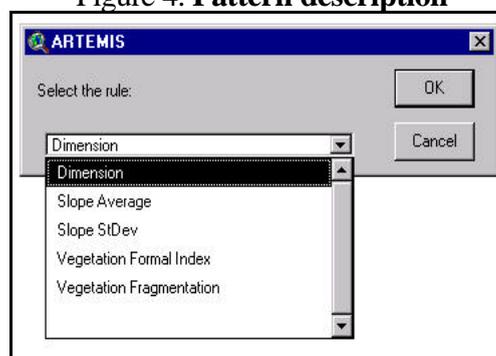
Figure 5. **Pattern parameters extraction**

The system provides a user's interface that allows the user to define the aptitude of the territory for the development of residential settlement patterns. AIAM includes a spatial multicriteria analysis based in a weighted model. The AIAM programme allows the user to define the aptitude of the territory in terms of distance to a territorial element, and in terms of visibility. The user should set:

VARIABLE IMPORTANCE: It is the importance that a variable could have in order to define the aptitude of reference area. It can be 1 (indifferent), 2 (quite important) and 3 (very important). The user should define this importance. Artemis provides within the user's interface the possibility to consult the importance assigned to a variable in the reference areas used by Artemis.

CATEGORIES APTITUDE: It is an evaluation, (between 0 and 10) of the aptitude that has each category. This aptitude is calculated on the basis of the loss of environmental value that would be produced when inserting a residential pattern of low density in the area of study. This aptitude depends on the category, but also can depend on the distance to specific zones or elements of the reference area. Therefore, three different forms can define it:

- Absolute values: when the aptitude depends only on the category.

- Based on the distance: When the aptitude depends on the distance to elements of other categories.
- Based on the visibility: when the aptitude depends on the visibility of a zone respecting to the areas of interest.
- Combining two variables

The user should define this aptitude; Nevertheless, Artemis provides within the user's interface the possibility to consult the aptitude assigned to a category in the reference areas used by Artemis.
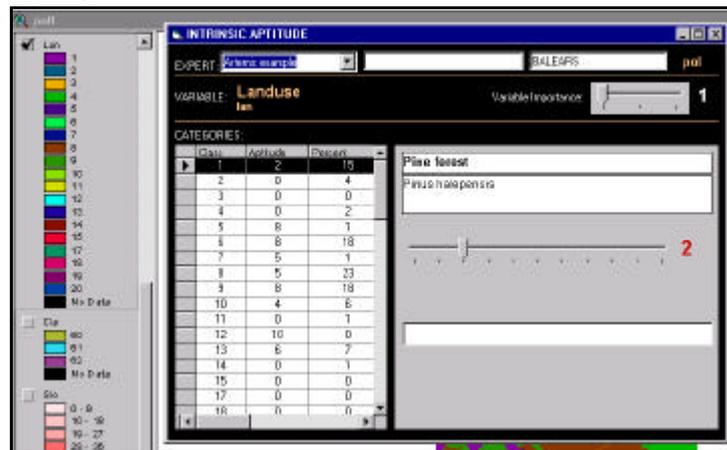

Figure 5. **Multicriteria Analysis**

> **Reference Area Aptitude for a low-density residential development**

The AIAM classifies the reference area in different zones according to their aptitude to establish a low-density residential pattern. It generates an aptitude map with excluded zones and gradient for the rest of the areas of the development. This process can be carried out with all the variables or only with the selected by the user; in this last case the result is an aptitude map extracted from the analysis of these variables. The result is a map where the values near 0 have the lowest aptitude for urbanisation (for the variables and experts selected). Also, a graphic is generated summarising the count of every value of aptitude, if the majority of the columns are near zero, then, our reference area has a few apt to building development.
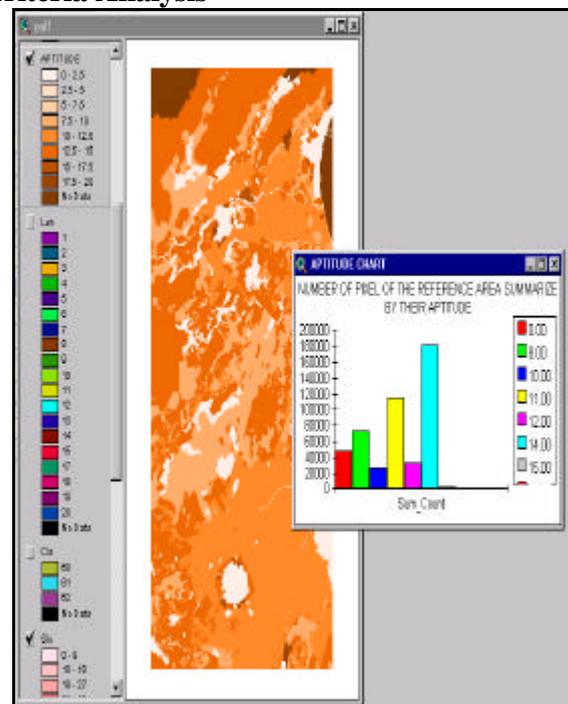

Figure 6 **. Land Aptitude**

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➢ Reference Area's Divergence with a concrete pattern

The programme provides the user's interface in order to analyse the divergence between pattern's parameters and Reference Area's variables. The result is a map of divergence of the territory and the pattern. This process can be developed with all the variables or just with the ones selected by the user. The program calculates the selected rules for the reference area using a filter with the dimension of the pattern. After that calculates de difference between the value of the rule for the pattern and for every pixel of the previous map. Then the values are normalises. Finally, is generated a map with these values.
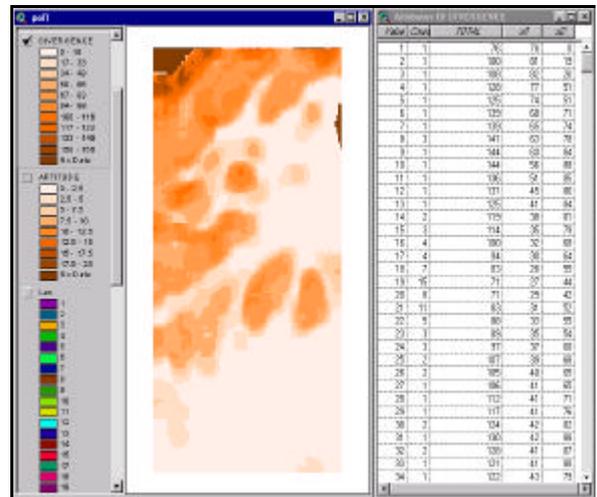

Figure 7**. Divergence Map**

➢ Pattern Location

The system allows the user to locate a pattern on the reference area and repeat the process to calculate aptitude and divergence between this reduced area, and the pattern. This process allows the user to precise his/her information on the territory, working in a scale of 1:5.000 and also introducing new variables.

For this second level of information layers with grids smaller than 20x20m should be used. The model runs again with all variables selected by the user, but this time, the result is not a map of divergence. It is a collection of indexes, graphics and tables which permit to compare aspects of the area and the pattern.

With this table is possible to make the graphics, statistics, and comparisons wanted by the user.
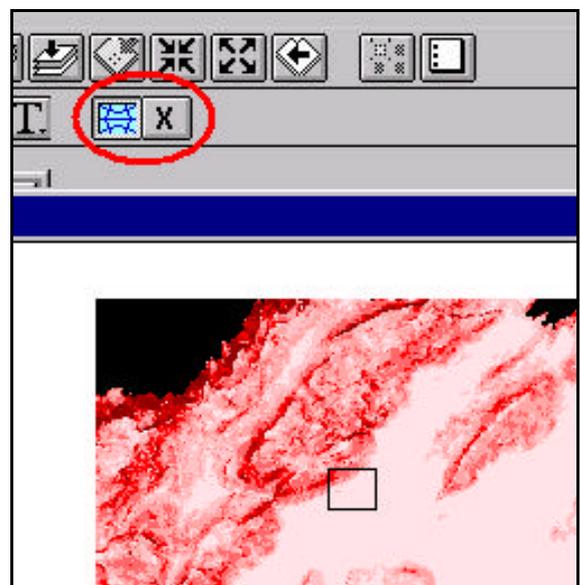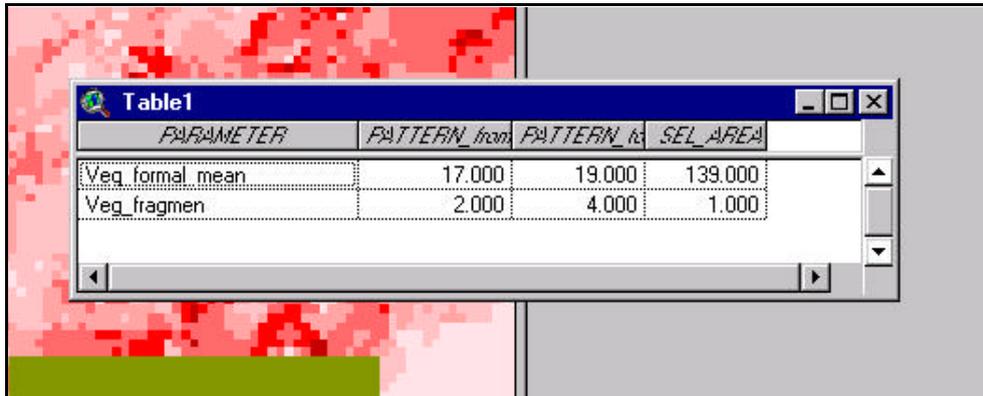

Figure 8**. Pattern location**

Figure 9**. Pattern Impacts**

4 ACKNOWLEDGES

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6 SOFTWARE REFERENCES

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