SPATIAL ANALYSIS, DECISION SUPPORT SYSTEMS (DSS) AND LAND USE DESIGN: THE CASE-STUDY OF ANTIQUE VIABILITY SYSTEM IN SAN MARTINO VALLEY (LOMBARDY, ITALY)

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ABSTRACT

This paper concerns the development of a Decision Support System (DSS), which is a system able to support temporal and spatial choices about land use design, in order to project and manage the antique viability system in San Martino valley (located in Lombardy, Italy)

The main purpose is providing to a project manager necessary information to help him to understand problems (in particular concerning the spatial system of viability), therefore assists him to analyze the question from different points of view.

This process needs a particular informative architecture, based on a complex and relational structured system (DSS) able to produce response for the whole decision process. The DSS is interfaced with a GIS in order to manage cartography and alphanumeric files with geo-referenced data.

It works on information which are supposed to be indispensable for the planners of the San Martino valley.

1 INTRODUCTION

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The main purpose is providing to a project manager necessary information to help him to understand problems (in particular concerning the spatial system of viability), therefore assists him to analyse the question from different points of view.

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It works on information, which are supposed to be indispensable for the planners of the San Martino valley.

It is important to know this system doesn't replace the planner and its abilities to analyse and interpret the elements, and it doesn't limit artistic or creative abilities, but it is a particular informative architecture that helps the planner to choose a solution.

The organization of this paper start with a general view of San Martino valley (located in Lombardy, Italy) where we analyse the main aspects of territory; then we describe the principal tools to support operations of public administration (GIS).

The next step is explaining the main characteristic of a Decision Support System .

Finally we present the results of this work, reached objectives, future implementation and future developments on the base of the requirements of the public administration of San Martino Valley (namely Mountain Community of San Martino Valley - CMVSM)

2 A NOTE ON SOCIAL-ECONOMIC-TERRITORIAL CHARACTERISTIC

San Martino Valley is situated in the province of Lecco (Lombardy, Italy) in south-east position regarding the city, it has an extension a little more than 37 km^2 and it counts about 22,000 people.

It is constituted by six municipality: Calolziocorte, Carenno, Erve, Monte Marenzo, Torre de' Busi and Vercurago.

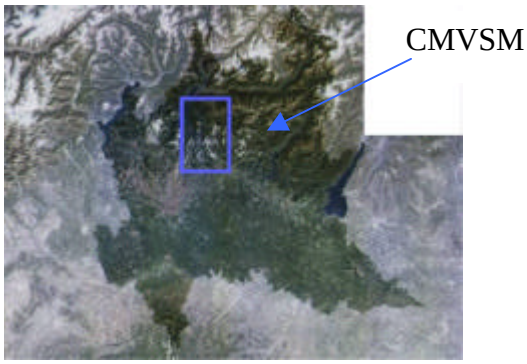


Figure 1: General view of the Mountain Community of San Martino Valley.

The territory is characterized by existence of two very different environments which coexist. This dichotomy consists in the development of the zone located near river Adda, which opposes itself to the problems of mountainous territory.

To intervene on the antique viability system in San Martino valley, can't be considered as a single episode, independent from the problematic of the territory, but it is necessary to analyse all the factors that interest this uncomfortable territory.

The management and the project of the historical viability don't consist in a simple recovery of the street, but they consider a lot of important aspects that valorise the whole environment.

For these reasons the information system will be a dynamic system which avoid the loss of important values.

Figure 2: Sight of the Mountain Community of San Martino Valley.

3 THE OPERATIVE CONTEXT: INFORMATIC TOOLS

Public administration uses GIS to develop their projects. GIS is an English acronym: Geographic Information System; according to one of the most commonly used definition, accepted to describe it, GIS is a powerful tools to acquiring, store, recover, transform, analyse and reproduce spatial data referred to the territory.

These important functionalities describe geometry and localization of various elements contained in a map and use topological analysis, which is a discipline that studies different spatial relations (interconnection, inclusion, etc.) between points, lines, areas, etc…, within a given space.

In fact, a purpose of GIS is not only to acquire and manage information, but also generate new important information, in order to manage a technological network and plan the space.

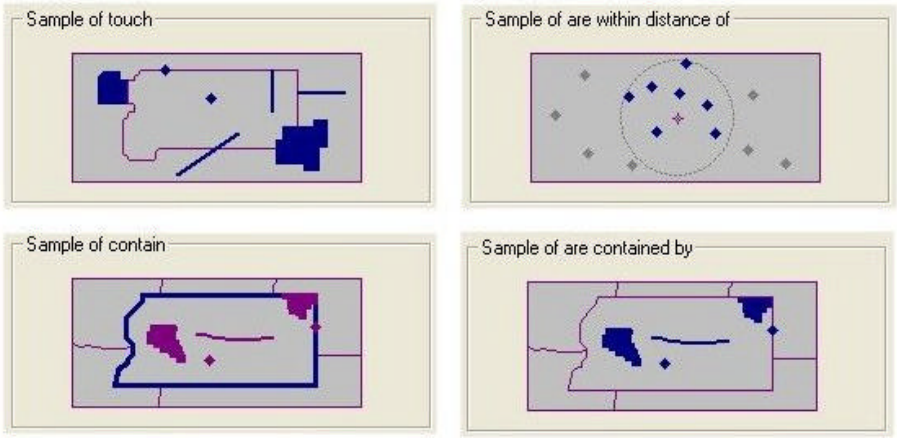


Figure 3: Topological analysis of data.

In a GIS system the elementary graphical elements of cartography (that are geometric primitives or entities) are constituted by points, arcs and polygons (it isn't infrequent to meet other terminologies like nodes, lines, areas).

Moreover a GIS contains textual data linked with topological elements, that supply other details. This information is permanently stored in a database.

The application fields of the GIS can be associate to 3 types of specific requirements, related with the territory: the decisional support, the planning and the management.

The configuration of a GIS can be:

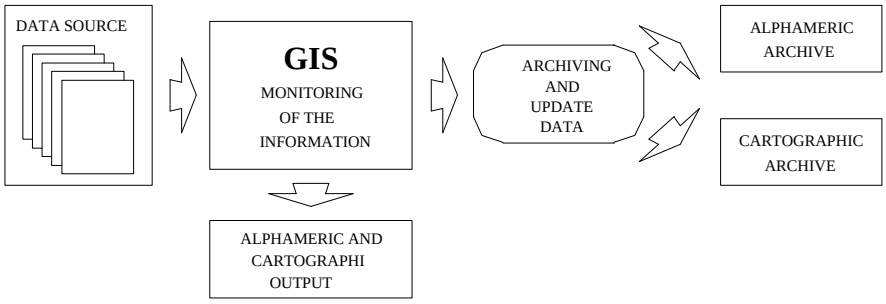


Figure 4: Configuration of a GIS.

4 THE OPERATIVE CONTEXT: TERRITORIAL INFORMATIVE SYSTEM (SIT)

The SIT of old viability system in San Martino valley represents the beginning of the creation of the present Decision Support System (DSS), that it can be considered as evolution of the entire territorial informative system.

To create the SIT we have considered:

- FEASIBILITY STUDY

The feasibility study for the realization of the SIT is used for identification of the product to realize: means purposes, categories of users, tools, management and operating costs.

- ANALYSIS

Analysis consists in the following steps:

- to determine position of antique viability system;
- to define the operation to promote;
- to detect realized, in course or future actions.

- PLANNING AND VERIFICATION

In conformity with the structure of the GIS, a cartographic archive and an alphanumeric archive have been planned.

About graphic presentation we have chosen the best geometry related with elements (i.e. for the distance we have chosen the line), while a database, containing alphanumeric information, has been structured defining the typology of information that can be contained.

- INITIALISATION AND APPLICATION

The phase of initialisation of an informative system has been developed by insertion of a lot of elements in cartographic and alphanumeric archive.

From this moment the phase of application starts, it is managed by the Mountain Community.

In the development of the original core of the system, we have create a flexible system, so we are able to gradually develop the tool, based on the requirements that can be originate from the territory.

5 DECISION SUPPORT SYSTEM (DSS): GENERAL ORGANISATION

Decision Support System is a particular computer architecture which supports the user on taking the decision, without to replace him.

The main objective is to supply to the planner all the necessary information to understand a determined problem, therefore the possibility to analyse from various points of view this problem, based on user requirements.

An important point, which has absolutely to respect, is to realize a flexible DSS, because planners have different competence and different cognitive abilities, and this implies a differentiation of information that users would like to consult.

We have associated to the Decision Support System a Geographic Information System (GIS), to allow the management of alphanumeric archive containing geo-referenced data

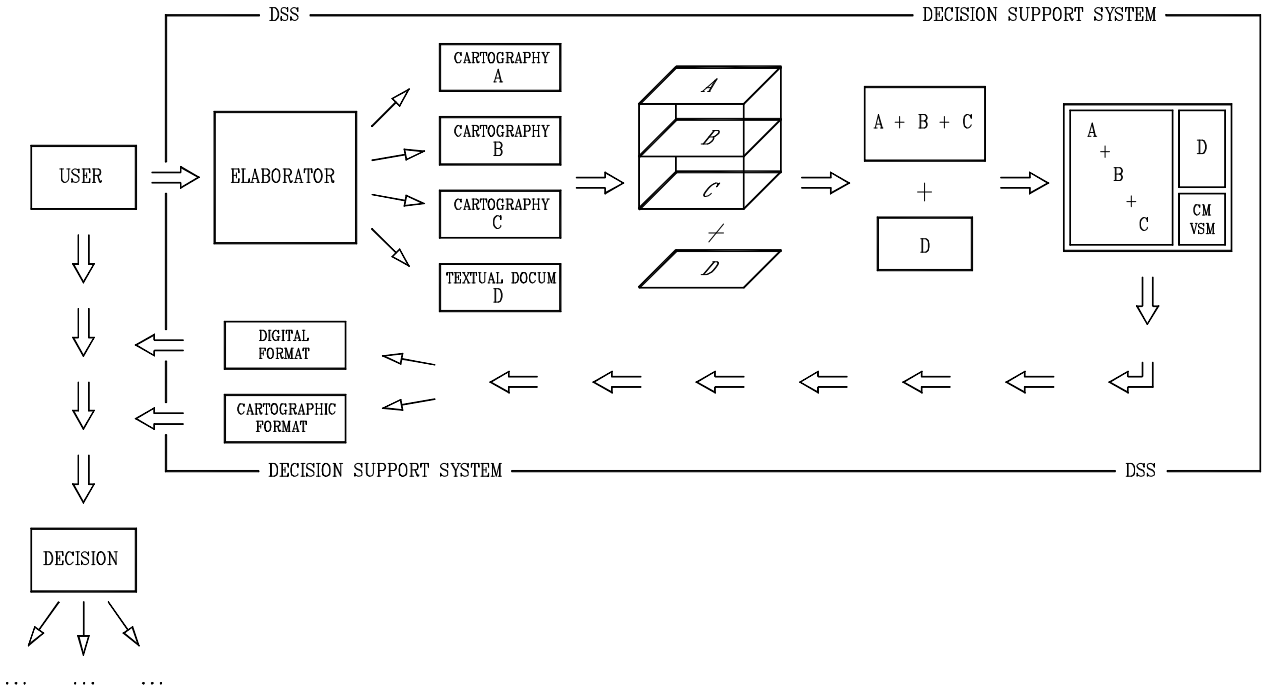
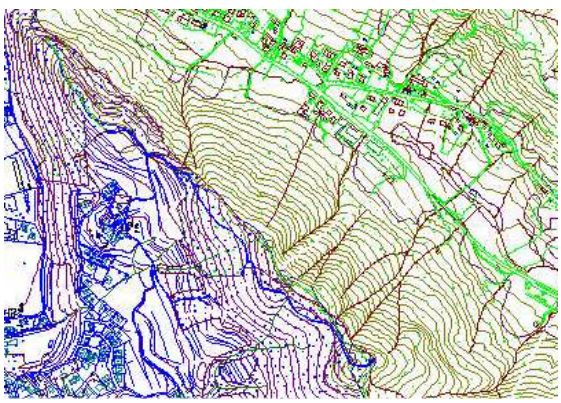


Figure 5: Plan of operation type of the DSS.

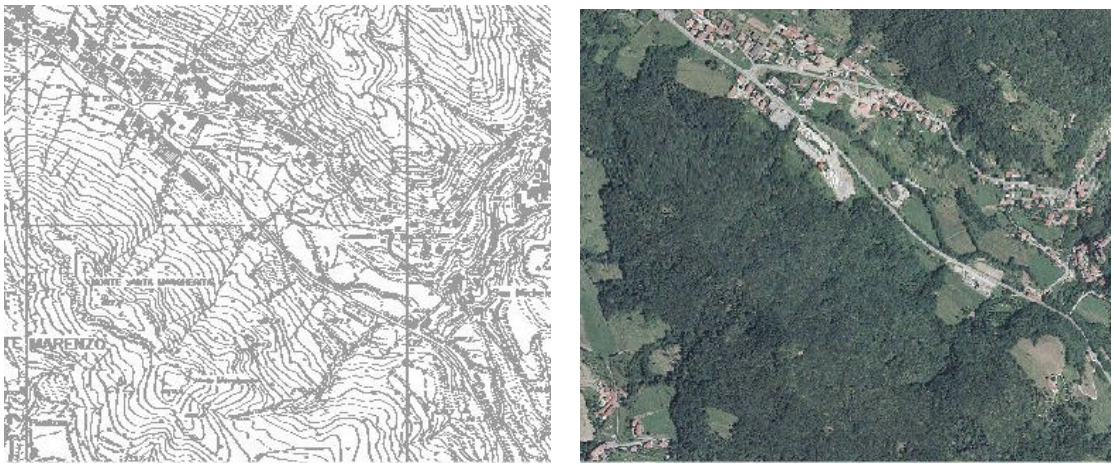
The user demands information elaborated in the part of the system, which it gives back an output formed by different cartographies, for instance A, B, C, and by a textual document, D; these maps are overlaid automatically, as if they were of the transparent sheets with a trace of the information, after that, the system in an automated way associates a cartographic base, chosen by the user, i.e. the technical regional Italian map, "aerophotogrammetric", the cadastral map, the regional plan or the aerial images of all the territory, some of these maps are shown in the following figure (all the cartographic bases are geo-referenced therefore the overlap is precise and immediate).

The last step is the phase of pagination, that is the positioning of graphical and textual elaborates in the final plan.

At this time the user can consult all plans from PC or using a simple command, it is also possible, through a plotter, to have the work on paper.



a - aerophotogrammetric b – cadastral map



c – technical regional Italian map 1994 d - aerial image

Figure 6: Examples of cartographic bases used from the DSS.

The general architectural of the DSS, to be realized, is based on three main points subdivided in other points, as shown in the following figure:

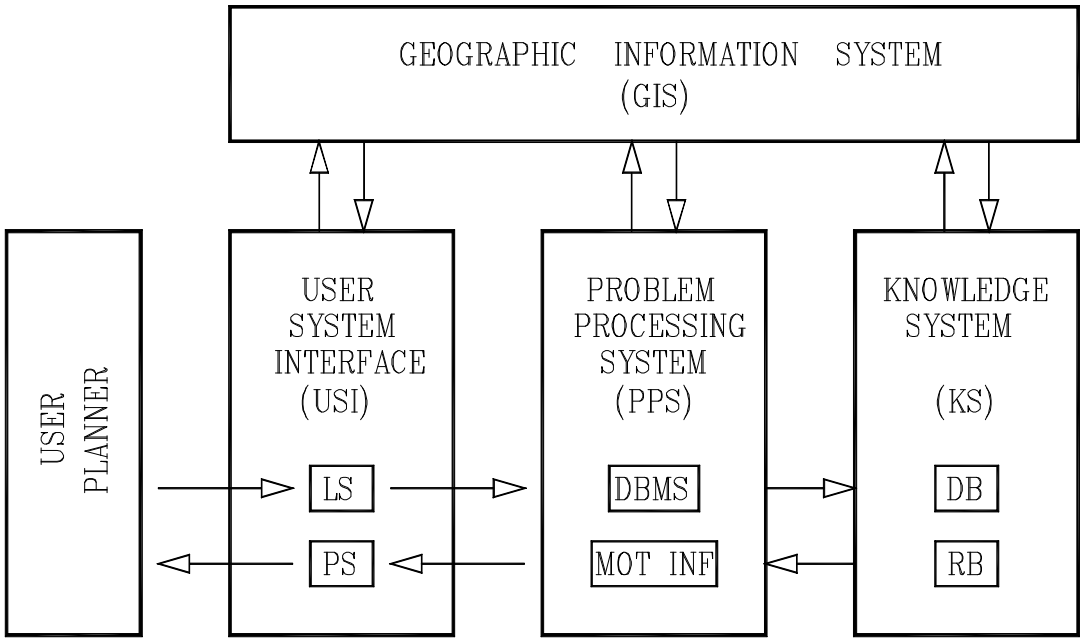


Figure 7: Architecture standard of the Decision Support System.

Now we analyse the parts of scheme, starting from right rectangle:

KS - KNOWLEDGE SYSTEM:

The KS encloses all the information in the Mountain Community and is constituted by:

DB - DATABASE (alphanumeric and geo-referenced data)

RB - RULE BASE (logical rules and relations for qualitative inference)

PPS - PROBLEM PROCESSING SYSTEM:

The PPS is constituted by complex elaborations that generate answers for the whole decisional process through the systematic manipulation of the necessary information contained in the KS. And it's divided in:

DBMS - DATABASE MANAGEMENT SYSTEM (acquisition, modification, integration of data)

ENG INF - ENGINE INFERENCIAL (functions of artificial intelligence to manage RB)

USI - USER SYSTEM INTERFACE:

USI is the mechanism of the main interaction between the planner and the Decision Support System, is constituted by:

LS - LANGUAGE SYSTEM (manage input data)

PS - PRESENTATION SYSTEM (manage output data)

The inputs of this computer-based architecture are a series of information or of demands from the user, that can be simply queries on general argument, or particular demands about determinate elements.

The questions of the planner, made through interface (LS), are forwarded to the Problem Processing System (PPS), that being based on relations between Database Management System (DBMS), Engine Inferencial (ENG INF), and information contained in the informative system of the public administration (DB and RB), generates an output that is a series of easy answers related to the studied problem easy also for people that don't work with GIS, because this results are explained with maps and textual documents.

- **MAIN PURPOSE OF THE DSS**
  - to support planning of the system of route;
  - to support planning of elements correlated to system of route: cultural assets, receptive structures and others;
  - to support the regional planning;

- to support the operation of Mountain Community.

- **SECONDARY PURPOSE OF THE DSS**
  - to perform tourist promotion;
  - to educate tourists to respect the environment.

- **CATEGORIES OF USERS**
  - Mountain Community of San Martino Valley – CMVSM;
  - public and private administration;
  - planners;
  - other customers.

6 SETTING OF THE DECISION SUPPORT SYSTEM

Database created for the Decision Support System, and in particular to perform Knowledge System (KS):

NAME	PROCEDURE	TYPE	DATA TYPE	VALUE
ID	Automatic	Effective	Auto number	Automatic number
Number of route	Primary	Effective	Character	Number, number and letter
Global denomination	Primary	Effective	Character	Name
Local denomination	Primary	Effective	Character	Name
Municipality	Primary	Effective	Character	Calolziocorte, Carenno, Erve, Monte Marenzo, Torre de' Busi, Vercurago
…				
Surface of route	Primary	Effective	Character	Stone, natural, gravel, pavement, asphalt, cement
…				
Structure of route	Primary	Effective	Character	Route with scarp, route with delimitation, combination scarp/delimitation, complex situation
…	…	…	…	…
PRG	Primary	Hyperlink	Character	Document General Regulator Plan
Aerofotogram-metrico	Primary	Hyperlink	Character	Document aerofotogrammetrico
Cadastral map	Primary	Hyperlink	Character	Cadastral document

Figure 8: Extracts table of the database of the route.

In order to update and implement the existing database, we have realized a standard simplified protocol (with closed field forms) to be compiled by people not expert in GIS, but who know very well the territory of the San Martino valley:

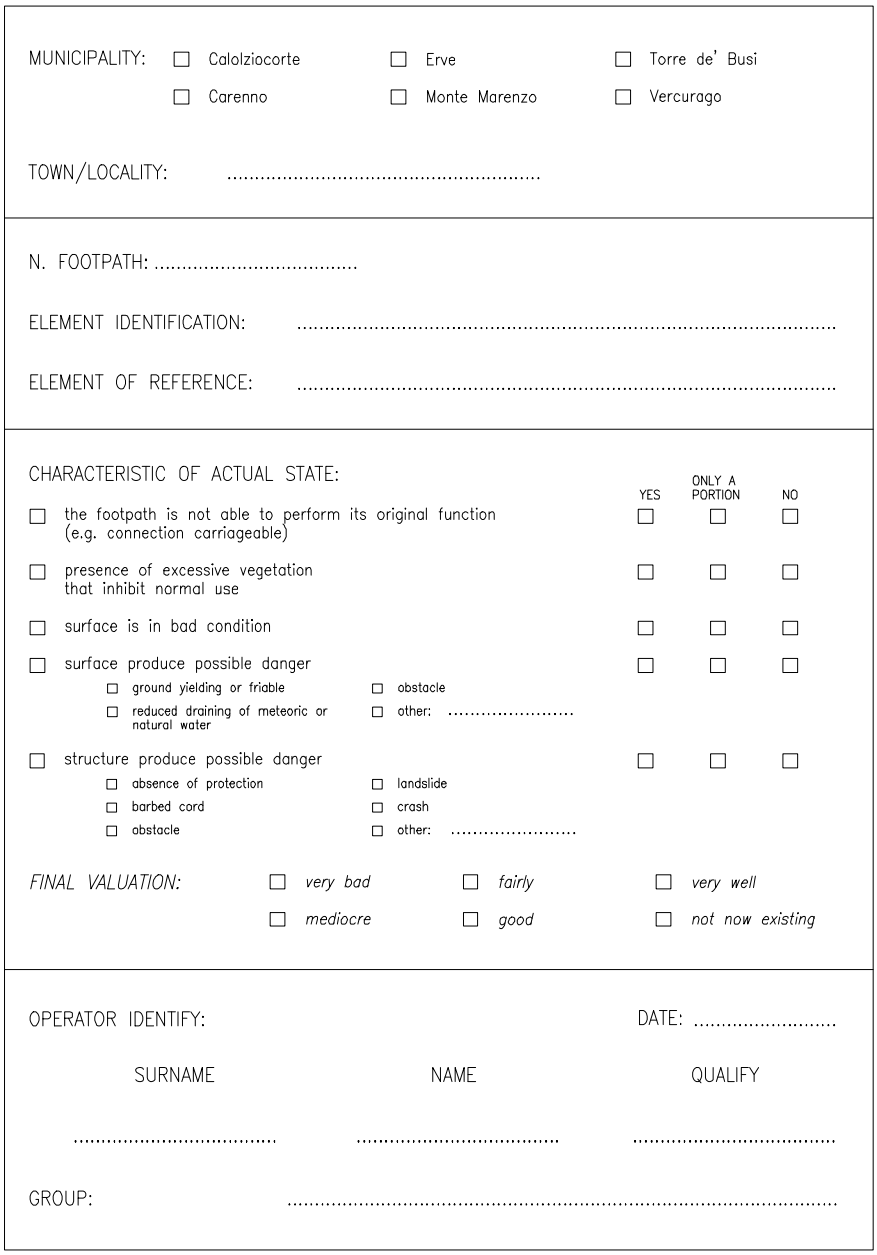


Figure 9: Standard protocol to monitoring the existing state.

7 REALIZATION OF THE DSS

After having set the Decision Support System, we can proceed to realize concretely the support system.

The DSS consists in a series of complex elaborations, structured according to a determinate logical plan, in order to make a system able to support temporal and spatial choices about land use design.

We can synthesise these complex elaborations in:

- maintenance elaboration;

- danger elaboration;
- cost elaboration;
- rescue elaboration.

Each point is subdivided in a series of deepened operations that will be described shortly.

- MAINTENANCE ELABORATION

The maintenance elaboration is so called because based on the effective state of routes and assets correlated to the entire system of footpath. It's mainly based on two elements: condition of route surfaces and condition of route structures.

Entire process delineates graphically general condition of routes and areas that need a maintenance operation, the answer of the system is based on the information contained in database.

The process is not only applied to the system of routes but also to all elements correlate to that system, and contained in the SIT.

The cartographical output consists of two different independent maps, which can constitute, if separated, different view of the territory, or, they can be linked and overlaid in order to generate another general point of view.

These maps consist in system of route, subdivided in different parts with different colours, and each colour is associated to a precise conditions of the areas, as indicated in the following figure:

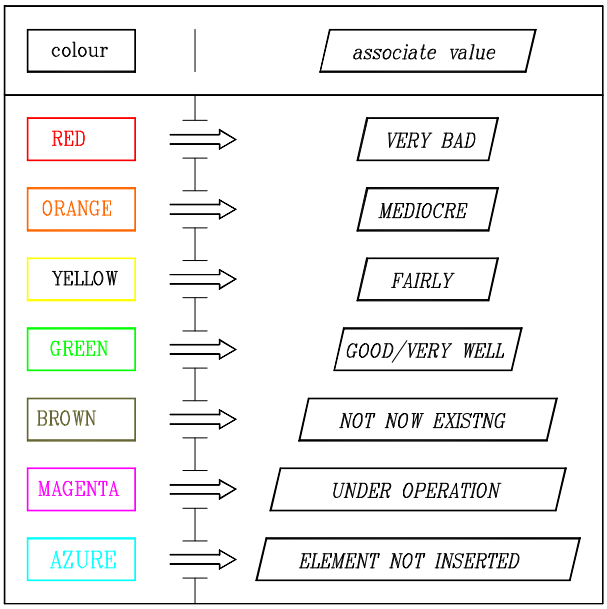


Figure 10: Colour association - condition of route.

In order to reach this result, the system is interrogated through a structured and defined set of queries about the conditions of the system of routes.

This procedure is the results of the Decision Support System and in particular of one of its part called PPS.

The Problem Processing System (PPS), is a set of elaborations that generate answers about the whole decisional process through the systematic manipulation of necessary information contained in database of the public administration.

Databases are liked to the process through a manager of database called “warehouse” (WR); the system searches information that the whole elaboration needs, then the PPS analyses it, and basing on obtained result, the process assigns a determinate parameter to the part of considered route, finally this value is reported on graphic and represented on the map

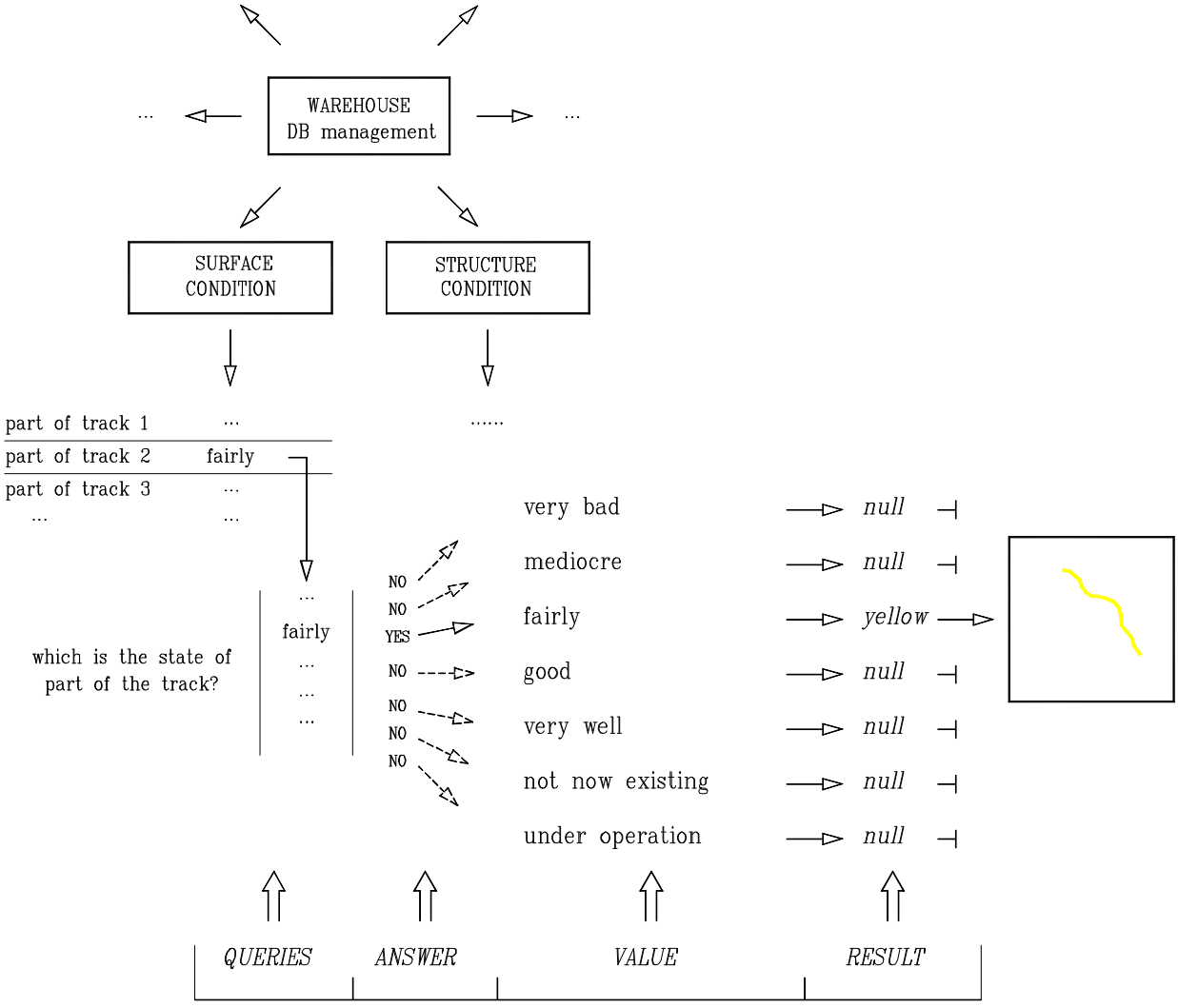


Figure 11: Analysis of operation of the Problem Processing System (PPS) on routes.

The definitive output is a map with the system of routes subdivided in different colours due to the maintenance degree which the element needs.

a – route surface condition

b – route structure condition

c – overlay of route condition

Figure 12: Example of output reported to a tracing part of maintenance elaboration.

- DANGER ELABORATION

The second complex elaboration is defined danger elaboration, because it considers various types of problems that a route can generate.

This area can consider a lot of problems, i.e. presence of barbed wire; vehicle transit and much more; to simplify the process we use only three main categories:

- high;
- medium;
- low.

Through several interrogations, the process associates to the value a determined colour, reports the result on a map, with a procedure similar to maintenance elaboration.

- RESCUE ELABORATION

The third complex elaboration is called rescue elaboration, because it indicates the major or minor difficulty to access the area for rescues, i.e. ambulances or helicopters.

The feature motivation has been associated to the rescue field, to know the motivation of the inserted value, i.e. near to the road, presence of platform to the landing helicopters and much more.

The field in object can contain the following categories:

- difficult;
- medium;
- easy.

This procedure, in order to reach the output maps, follows the head lines written for previous elaborations.

- COST ELABORATION

The last complex elaboration regards cost of an operation in that area, based on hypothetical maintenance works. The main purpose is giving a definition of the cost level to begin a work on the area, in fact there are areas where the cost is higher, and zones where the same operation is less expensive.

The possible values of the field are:

- high;
- medium;
- low.

The system operations for the realization of this elaboration are similar to that ones represented in maintenance elaboration.

- RELATIONS AMONG COMPLEX ELABORATIONS

The elaborations as soon as written can be overlaid in order to generate a general view of the territory.

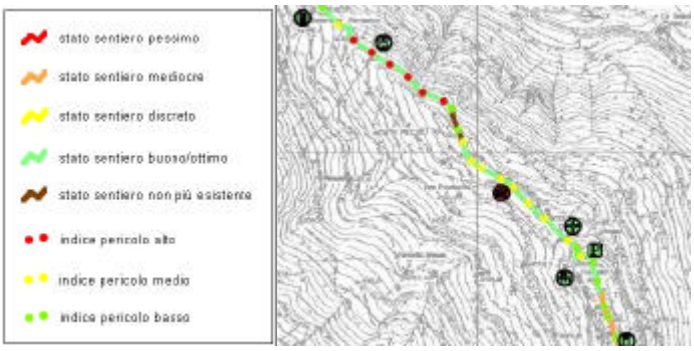


Figure 13: Example of overlay in elaborations.

Confronting each elaboration, overlaying, and considering the budget, the public administration can choose which operations to promote and which to send back, using in the best way the monetary limit.

8 PROJECTUAL AND MANAGERIAL APPLICATIONS

Now we show a reorganize plan and relative extraordinary maintenance of a footpath in San Martino valley.

The Decision Support System supplies as output a series of maps, based on the necessities and preferences of the user; the planner bases his considerations on these maps to determinate which part of the route must be submitted to a maintenance intervention.

Beginning from the map of elaboration maintenance, regarding the overlaying of the surface condition and route structure condition, we can notice that the zones are not in a good conditions.

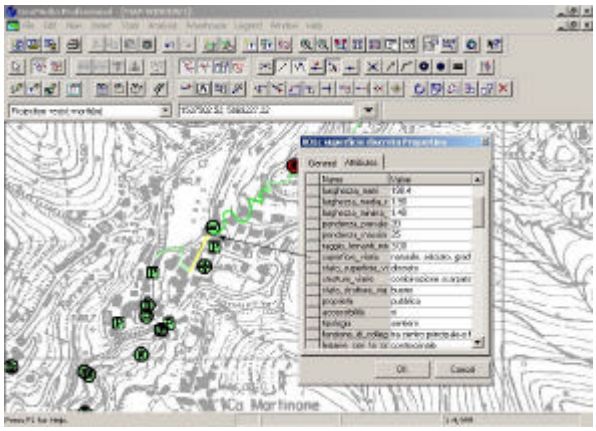


Figure 14: Information captured from GIS.

Dividing this map in two other maps, one related with route surface conditions and the others with route structure conditions, we can understand exactly what is the cause which creates that condition, i.e. it can be due to barbed wire or bad type of pavement.

In these maps are represented also the cultural and historical-artistic assets; in our case they are in good condition except two chapels and a rural building; using the system we can see some images where it's easy understand because they have been catalogued with a very bad value.

Figure 15: Extract of Regional Technical map with indicates two cultural assets catalogued with very bad condition.

Finished the analysis phase of the first map, we look at the output of the second complex elaboration: danger elaboration; in this paper are represented the routes based on potential risk situations that can be created; therefore confronting this map, about operation areas, with the previous map we can indicate other possible operations.

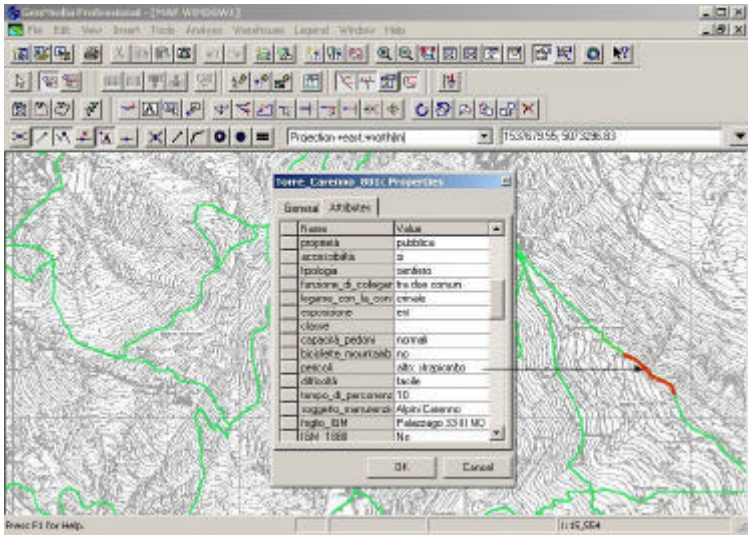


Figure 16: Elaboration danger on a part of the footpath.

With rescue elaboration, the major or minor difficulty of access to the zone, we have a view of which area is easily reachable by means of rescue. We can consider these maps as aggravating of the danger maps.

Consulting these maps of the DSS and all information contained in the SIT, we can identify which operations are to perform or which ones you can postpone to the future.

An example is reported below:

- *plan C* – footpath number 821, locality Piazzolo – intervention length about 120 meters.

  OPERATION ON ROUTE SURFACE – RECOVERY OF THE DEGRADE:

  - cleaning and trimming of the natural surface of footpath.

  OPERATION ON ROUTE STRUCTURE – RECOVERY OF THE DEGRADE:

  - cleaning and trimming of the delimitation and natural scarp.

  OPERATION ON ROUTE STRUCTURE – RESTORATION OF THE EXISTING STRUCTURES:

  - replacement of the wood fence and barbed wire with new wood fence only in lumber material.

  OPERATION ON ROUTE STRUCTURE – NEW STRUCTURES:

  - extension of 20 meters of the wood fence.

  OPERATION ON CULTURAL ASSETS AND RECEPTIVE STRUCTURES – WASHHOUSE:

  - trimming and cleaning of the whole area;
  - consolidation of the natural route surface realising walls of stone;
  - cleaning and restoring of the pipes.

Figure 17: Washhouse - object of operation (plan C).

Through the cost elaboration, we can know the value of the expense and which operations are more expensive with the same work.

There are other important considerations that influence the final choice, i.e. tourism, scenic footpath, flora and fauna and so on, which are contained in Territorial Informative System (SIT).

Although all the plans are important, the public administration must choose which one to perform and which one to send back, because finances available aren't always enough to develop all projects, therefore the DSS can be helped by the Mountain Community to create an order of plans to perform.

After having determined the plans to develop, we proceed at realization of the final maps, always through the DSS.

The planner asks to the system to display the whole route system of San Martino Valley or only a part of that; then he chooses the best cartographic base for the plan, he marks graphically which part of footpath and which cultural assets he wants to attend; then the Decision Support System is projected to supply, in automatic way, the realization of the definitive output maps, setting the presentation and the legend.

The maps are displayed through a personal computer or it's possible to print them.

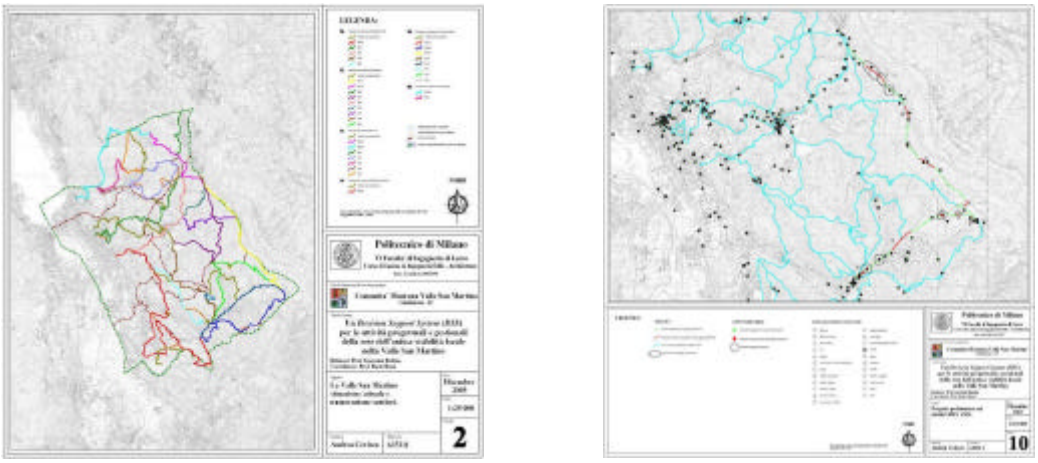


Figure 18: Maps of plan, graphical restitution of the DSS.

- PLANNED CHECKING

Another important application of the Decision Support System, is the planned checking of the San Martino territory, that is to plan the future control of the territory by competent technicians in order to verify the actual state of the elements, being based on the final maps of the DSS.

Therefore, considering the maintenance aspects of the elements, the public administration can organize the controls of the critical point contained in the database,

and decide to verify an element after an extraordinary meteorological event or simply verify the situation in time.

The system can be used in order to support final decision, and supplying a lot of information it considers multiple aspects, some of which are report here:

- effective maintenance state of the footpath and cultural assets;
- operation already done and operation to develop in the future;
- the context where we operate;
- difficulty to access into the area;
- situation of existing danger, from which we deduce what can happen.

All these aspects are important to determinate which zones is to verify periodically, and to determine which operation we have to develop for the conservation of the antique function of the elements; it's better a continue maintenance in time then loosing artistic and cultural assets.

9 CONCLUSIVE OBSERVATIONS AND POSSIBLE FUTURE DEVELOPMENTS

At the end of this work, we can get some important conclusions about the potentialities of this system.

First, it's important to notice the relationship established between SIT-GIS-DSS and the traditional planning process.

The GIS is a tool with greatest capabilities and potentialities, it can be elastic and can be adapted to new requirements of the Mountain Community.

From a planning point of view, we have created, implemented and improved the synergies with the whole planning process.

With this Decision Support System, we have built a structure that links together the information contained in the database of public administration, in order to realize a particular connection among the innumerable parts, which compose the complex Informative System.

An important possible future development is to extend this system to all other parts of the territory, for instance extend to the town, to aid the public administration in the correct manage of all environment.

At the end, we can say that the DSS satisfies multiple requirements of the public administration, and this increases the abilities and the services offered by the Mountain Community to all the users.

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