GIS technologies in the transfer of theknowledge project to the plan project multiple representation of the environmental spaces

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ABSTRACT

An analysis is made of the relation between the conceptualand paradigmatic level of GIS technologies and the new forms of plan, whichmake environment the center of attention. The intention is to study newcriteria for zoning able to give contextual representations of theterritorial, environmental and landscape aspects of the geographical space,and also to study new legislative principles, able to establish integratedrules for the projecting of soil uses, the safeguarding and recovery ofenvironmental systems and the tutelage and boosting of the landscape.
The experimentation of GIS (Geographical Information System)technologies aims at the construction of systems helping to make decisionsfor the control of the environmental and landscape aspects of theterritory.
An analysis is made of the ways in which there are formulated thedescriptions of the various aspects of the environment: the conceptsthrough which knowledge is expressed, the languages used forrepresentations, the cognitive models adopted.
GIS technologies have made it possible to represent in an explicitmanner the paradigms underlying the various models of knowledge.Specifically, the following cognitive models have been developed:
- *ecological* models of nature
- *ecological* models of human settlement
- *ecological* models of inhabitants' mental perceptions

1.PLANNING AND ENVIRONMENTAL SYSTEMS

The framework of territory and town planning has changed a great dealin the last ten years. Very probably it is destined to change further, andin a big way, in the future (Mazza 1997, Mandelbaum et al. 1996, Borri etal. 1997).
In the recent past the environmental emergency has led to theintroduction of new instruments for the control and government of theterritory, serving to take into account, in its transformations,environmental and landscape aspects, environmental and hydro-geological andenvironmental-natural aspects (Gambino 1997, Hirsch and O'Hanlon1995, Newton 1992).
In the years to come, integration with the themes of environment andlandscape will constitute the challenge in the government of the territory,for public administrations, and the dominant theme of research, for townplanning.
The dominant trends regarding the environment and landscape tend toconfigure the planning

instrument more and more as a ìcompatibility planîin relation to existing situations and to value systems which orient onetowards the future, rather than as a ìfunctional ordering planî in relationto previsions of maximization of functions, or optimization of sectorcomponents, which prefigure the future (Fusco Girard and Nijkamp 1997).
The environmental themes force one to look at the town and theterritory with different eyes: attention is demanded by phenomena whichpreviously were ignored or observed from other points of view. It becomesimportant to understand how descriptions of human settlement, formulatedhaving recourse to possible environmental paradigms, intersect with art andthe techniques for the construction of the town plan. It operates bydefining the organization and layout of the spaces in which men'slives and that of their communities are organized, and hence only some of the possible representations of the town and the territory will beconsidered. Of interest are those environmental phenomena that are ofdirect relevance to the definition and description of the space and thatinteract with the lifestyles of men and communities.
Systems that help in decision-making, which control the environmentthrough the town plan, require various conceptual models and variousknowledge bases.
The ìrelationship between cognitive bases and planning choicesî willbe a major focus for study and for the definition of new forms of plan.

2.REPRESENTATIONS OF ENVIRONMENTAL KNOWLEDGE

The foundations of environmental knowledge require analytical basesstructured in such a way as to take into account the multiplicity of thephenomena, the relations and processes that develop in towns and inregions.
The foundations of landscape knowledge require analytical basesformalized in such a way as to represent the territory in terms of meaning,values and quality of urban and territorial forms. Moreover, both requirethat the many disciplinary statutes involved in the representations canhold a dialogue in accordance with interdisciplinary procedures able tolead, without any break, from the construction of knowledge to designsynthesis, which is an element peculiar to the plan.
The multiplicity of the aspects through which there are manifestedthe problems relating to the environment - now privileging the stabilityand physical integrity of soils and waters; now the symptomatic set ofphenomena relating to the forms of the landscape; now the permanence of thecultural, social and anthropological values of the historical identity ofsites and of the cohesion of communities - also motivates the multiplicityof the plans serving to control it. The ramification of the tutelage overthe various dimensions of the environment has required the sampling ofvarious cognitive models, serving to yield various representations of thesame territorial situation.
Three different representations have been produced, resulting fromthe development of three cognitive models, which have structured thethematic information and have processed the information according todifferent levels of synthesis.
The map of the tendency to upheavals and the map of hydro-geologicalrisk highlight the dynamics and stability of soils, and serve to evaluatethe size and state of natural resources, soils and waters; in order toorient policies for their safeguarding, they are related to the indicationsgiven by the basin plan.
The map of the characteristics of the agrarian, historical andcultural landscape takes into account the role of local communities inshaping the landscape, highlights the hidden and deep structures that haveshaped its image, and serves to discover the continuity of human structuresin the rapport that confers cultural identity both on landscape images andon the communities that experience them; in order to orient policies fortheir safeguarding, they are

related to the indications given by thelandscape plan.
The map of the representation of the experiential space is an attemptto represent the livable space, according to the perception that theinhabitants have of it. It shows up the places in which daily life isorganized and the role played by the inhabitants in enriching urban spaceswith meaning, linked to custom and feeling. It is related to the municipaltown plan which takes into account the processes of management andmaintenance of urban spaces and recognizes the inhabitants as activeprotagonists in widespread policies for urban transformation andmaintenance.

3.THE PARADIGMS OF ENVIRONMENTAL KNOWLEDGE

The three representations of the environmental and landscape aspectsof the territory presuppose different paradigmatic definitions of reality.
The forms that configure the situation of areas at risk take on ahomogeneous and uniform distribution in the two-dimensional geometry of themap. Their reciprocal positioning is assigned by the reference coordinatesin relation to a general geographical system, and to them there isattributed a meaning linked to geographical characteristics, alsodistributed in a uniform manner over all the coordinated points: especiallyacclivity, lithology, upheavals, etc. The hierarchy and the valuedifference respond to a system of risk judgment and measurement, which doesnot depend on the system of representation (Besio et al. 1997).
In this case the geographical paradigm was used as a conceptualreference; the logical model and the processing procedures were deducedfrom ecological models of nature, of English and American origin (McHarg1971, Steiner 1991).
The forms which make up the morphology of the landscape aredistributed, in the geometrical space of the map, in accordance with adifferentiated texture of relations, value and meaning. Though referring toa system of general geographical coordinates, they show a distributionwhich is not uniform and homogeneous, because there are areas dense invalue and meaning and areas which, on the contrary, are empty or have alower density of value. The differences, the hierarchies and the valuesystem are implicit in the representation system, which associates with thegeographical space a further formalization of attribution of grammaticaland syntactic significance.
In this case the conceptual reference used was the paradigm of thetheory of meaning, applied to human settlement and the agrarian landscape.The logical model and the processing procedures were deduced fromecological models of human settlement. They were formalized in previouspapers and have been verified in an operative manner in a particularexample of landscape plan. They were inspired by the theoretical hypothesesof the French school of historical structuralism and history of theagrarian landscape, and use the morphological-typological method forreading the territory worked out by Muratori (Besio et al. 1991, 1989,Besio 1989, Muratori 1967).
The forms which configure the models of the perceptive experiencethat the inhabitants have of their living environment are also distributedin a non-homogeneous and differentiated manner in the geometrical space ofthe map. In this case too, differences and dishomogeneities are implicit inthe representation system, which associates with the geographical space afurther structure of meaning. This structure of meaning, unlike theprevious one, develops at multiple levels, which involve the relationshipbetween perception and knowledge on the part of experts and therelationship between perception and knowledge pertaining to common sense.
In this case the conceptual reference used was the paradigm of theecological model of human settlement, referring both to ìcommon senseîperception and to the significance recognized by the expert.Experimentation proved more complex and difficult because in this fieldthere are

not yet sufficient studies and verifications. The logical modeland the processing procedures were deduced from the ìPattern Languageî ofCh. Alexander, from the structural syntactic readings by Hiller and Hansonand from the recent studies by I. Campari and F. Frank on experientialrealistic space, but there was also a revisiting of the mental maps of K.Lynch (Mark and Frank 1992, Hiller and Hanson 1989, Alexander 1977, Lynch1960).

4.FORMA(?)LIZATION

Formalization, necessary to the construction of a GIS, imposed aclear definition of the conceptual references, the theoretical hypothesesand methodological procedures, which are functional to the variousapplications.
Experimentation of GIS technologies required the translation anddevelopment of the paradigms, in accordance with explicit inferences, inthe conceptual models, in the structure of the data banks and inquestioning of the system.
In the development of the work use was made of techniques forstructured representation of knowledge employed in the sector of artificialintelligence (Besio et al. 1989; Besio et al. 1991). These techniques havea double characteristic. On one hand they permit better structuring of theknowledge stored in the database, making it possible to work out complexdescriptions which put together the relevant data, and to organize thesedescriptions in a hierarchic and taxonomic manner. This facilitates theoperations involved in questioning the knowledge base and also facilitatesthe definition of the inferences and processing defined on the data.Moreover, formalization of the representation played an important role inthe endeavor to clarify conceptually the categories employed.
Specifically, use was made of a semantic network system in the KL-ONE(Brachman and Schmolze 1985) tradition of representation language. We quotean example from (Besio et al. 1989).
A first example (Figure 1) reproduces a fragment of the semanticnetwork that describes the concept of *elementary regional system*(ERS), that is to say the smallest portion of territory in which one candetect the project of organized life of a community and which is endowedwith significance for the purposes of reading and interpreting the agrarianlandscape.
r0In Figure 1 the concept of *Portion of Region*(POR) describes a generic portion of territory. A POR is characterized interms of a series of relations linking it to other concepts in theknowledge basis. A POR is characterized by a certain *acclivity*,which is a slope value, by a *dimension*, by a certain *productivity*, and so forth. The *dimension* of a POR is a certain*area*, its *productivity* is a type of *production*. Theserelations can be characterized by restrictions of number, for which thereis specified a lower limit and, if appropriate, an upper limit (the symbol*nil* indicates that the upper limit is not specified).

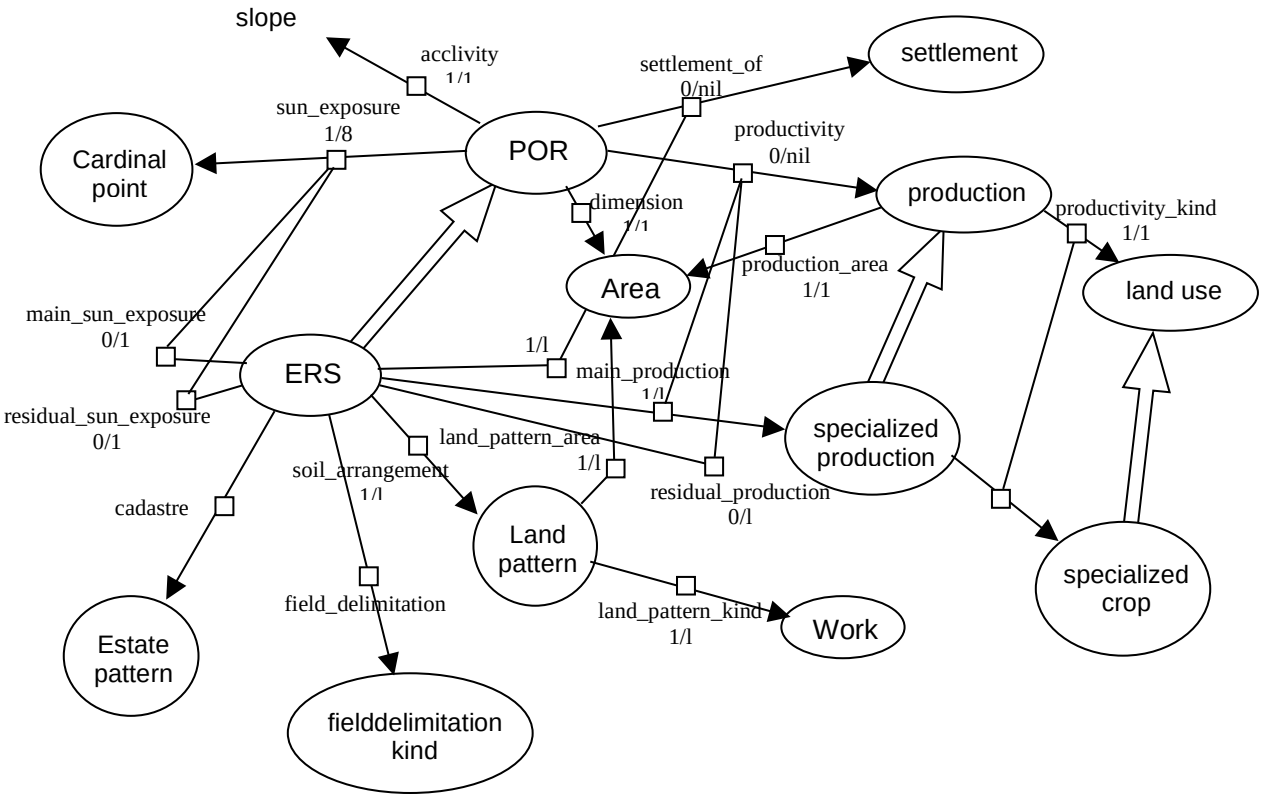

Figure 1: **part of a semantic network describing the concept of *Elementary Regional System* (ERS)**

For example, the area characterizing a POR is exactly one (hence boththe lower and the upper limit coincide with 1). In the case of a genericPOR, the number of settlements present cannot be stated precisely: itvaries from 0 to an unspecified upper limit. Hence the numericalrestriction on the relation *settlement_of* for the concept of POR is0/nil. The *sun exposure* of a portion of territory is characterizedin terms of the cardinal points. Since eight points were examined, ageneric POR can have at most eight values of the *sun_exposure*relation.

The concept of *Elementary Regional System* (ERS) is describedas a particular case (a sub-concept) of POR. As such, the ERS inherits allthe attributes that describe the POR. For example, an ERS is characterizedby the presence of exactly one settlement. Therefore in the specific ERScase, the numerical restriction 1/1 is assigned to the relation *settlement_of* inherited from the POR. As regards the *productivity*relation, in the ERS case there is identified a *main_productivity*and, if appropriate, a *residual productivity*. The inherited *productivity* relation is therefore split into two distinct sub-relations(respectively with number restrictions 1/1 and 0/1). Moreover, the mainproductivity of an ERS must be a *specialized production* (which isrepresented as a sub-concept of the more generic *production*concept). Analogously, for an ERS the *sun_exposure* relation isdistinguished into a *main_sun_exposure* and a *residual_sun_exposure*.

Other relations characterizing the ERS concept are not inherited froma POR, but are introduced locally for an ERS. For example, each ERS ischaracterized by a certain type of *field delimitation*, by a certaintype of *estate pattern*, and by a certain type of *soilarrangement*..

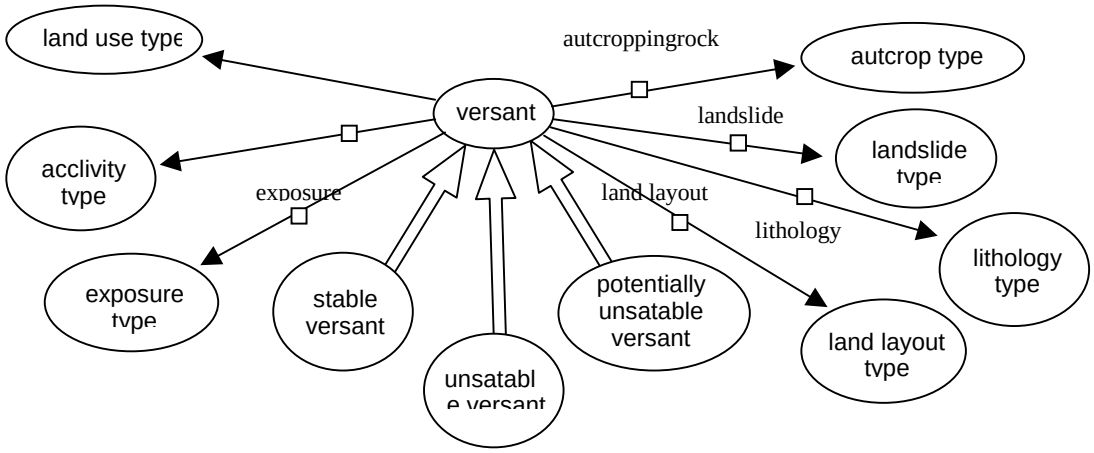

Figure 2: **part of a semantic network for the risk evaluation**

A second example (Figure 2) is taken from a knowledge base which atpresent is still being worked out. It concerns the development of a riskmap, in which risk has been defined as the ratio between the dangerousnessof a landslide and the various categories of urban elements andinfrastructures potentially exposed. In the concept of *versant* isdescribed on the basis of a series of relations with other concepts, whichto some extant are relevant for identifying the degree of stabilityof theversant itself.

Figure 2 shows the relations referring to tendency to landslides,acclivity, exposure, the presence of outcropping rocks, the type of landuse and the type of layout (presence of terracing, etc.). In the completenetwork the concepts involved in the description of the versant are furtherdescribed on the basis of other concepts and relations. These elementscontribute to an evaluation of the risks of instability in a given versant.In this fragment of a network there are only represented three degrees ofstability, described as sub-concepts of versant: *stable versant*,*unstable versant*, *potentially unstable versant*. Thesesub-concepts inherit the structures describing the concept of versant,suitably modified and enriched (the local modifications of the sub-conceptsof versant are not shown in the figure). These descriptions, on the basisof the data referring to the individual instances present in the knowledgebase, will have to contribute to the functioning of the inferentialmechanisms which will make it possible to evaluate the degree of risk inthe specific situations represented.

The encoding of the logical structure of the database was founded onthe representation of the domain of knowledge formulated by means of thesemantic networks with structured heredity. A study was made on the choiceof the scale and extension of the experimentation area, and on the choiceof the most suitable data and their format. The structuring of the databaserequired particular attention to the attribution of relevant meanings tothe different elements in the territory (characterized by components ofform, content and typology) endowed with physical qualities and a form oftheir own. It also required facing problems connected with integrating datacoming from various sources of different natures (digital technical maps,land surveying maps, census sections, demographic data, economic andproduction data).

For the graphic system integration involved:
- for non-digitalized tables, rasterization, cleaning out of thenon-significant parts, geo-referencing, visualization and vectorization.
- for data already in a digital form, verification of thegeographical coordinates and in some cases translation of the graphicformat.
The maps necessary for the integrated analyses were structured in alogical manner into levels of representation; for each level differenttypes, colors and thicknesses of lines were developed.
The logical structure made it possible to define particularprocedures for controlling the quality of the maps, based on theelimination of redundancy in data and duplication of geometrical bodies.Moreover, a comparison was made regarding precision and relativeincongruities-congruities in different sets of themes.
The integration of the maps on natural aspects and those on humanaspects, necessary to the exploration of the experiential space, requiredintegration of geographical objects with alphanumeric data, as well as theconstruction of adequate topological files with stratified information.These files permitted a synthesis through superimposition, with greatdetail, of different sets of themes, which was useful for the determinationof environmental references and for the construction of the map ofsusceptibility to upheaval.
Regarding information retrieval, the definition of the processing ofsynthesis and evaluation required the setting up of an interaction, in thegeographical space of the spatial and morphological configurations ofdifferent sites, between phenomena of differing nature, setting as acondition the interdisciplinary nature of the work.
The project was implemented with Microstation graphics software, MGE(Modular GIS Environment) software for database creation and management,and data retrieval was effected with MGE Analyst software.

5.CONSTRUCTION OF KNOWLEDGE AND CONSTRUCTION OF THE PLAN

Different conceptual and paradigmatic references to space and itsforms correspond to different visions of the world. These visions orientthe construction of knowledge, which in turn, through its transfer into thelanguage of the town plan, i.e. into wefts of zoning and into legislativetrends and criteria, affects visions of the future. In conceptualreferences and in the forms of representation of the various aspects of theterritorial situation, there are also implicit, embryonically,representations of future layouts and interventions and strategies forpossible transformations.
Just as there exist particular correspondences between the levels ofrepresentation of space with various dimensions and the various aspects ofthe territory, the environment and the landscape which are represented init, there are also correspondences between the partitions of space, inaccordance with variously significant forms of environmental aspects, andthe articulation of the territory into the various zones in which, on thebasis of value-oriented judgments, and different behaviors and rules forcontrol of possible transformations are admitted.
The transfer of paradigms from systems for representation ofknowledge to the decisional and institutional systems represented by plansis a problem which has not been very much studied by the town planningdiscipline and considered in professional activity. Yet it is notindifferent to the construction of new planning languages, whosefundamental structure, which at present is indispensable, is still based onzoning and regulations.
It has been clearly shown that a new form of town planning,responding to the requisites of a planning framework integrated withenvironment and landscape aspects, requires depth study not only of thetechnical and operative aspects of the discipline, but above all of itsconceptual

and methodological theoretical levels.
The use of innovative technologies for the construction of knowledgeis a help, instrumental, in that it makes it easy to solve operations whichwould otherwise require complex and stratified processing, but alsoconceptual, in that it requires clarification of the rapport betweenconstruction of knowledge and construction of the plan. GIS technology doesnot provide mere support instruments, which are neutral with respect toaims and objectives. Through a reasoned exploration of the variousrepresentations of knowledge, it also makes it possible for the variousoperational levels of the system (definition of the paradigm, constructionof the data bank, configuration of the system and processing of data) todraw on an epistemological clarification which is wholly internal to townplanning and territorial planning.
There is no need to warn anyone against mistaking the instrument forthe goal, in order to avoid useless and perhaps harmful stressing oftechnology; or against hoping for an impossible saving role with respect tothe many and different problems involved in the plan, in order to avoidinevitable disappointments. However, there can be no doubt that, if theinstrument is suitable and its potentialities are exploited in a pertinentmanner, its utilization permits better focusing of the problems, and henceleads to an easy and effective solution to them.
The stars exist independently of the telescope, but the telescope hasallowed us to see things which otherwise would have been invisible, to knowsomething more about our universe and to understand better how men move andlive in it.

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