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Article

An Ontology of the Strategic Environmental Assessment of City Masterplans

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Abstract: Following a discussion on the semantics of the term "ontology", this paper discusses some key points concerning the ontology of the Strategic Environmental Assessment procedure applied to city Masterplans, using sustainability as a reference point. It also assumes the implementation of Guidelines of the Autonomous Region of Sardinia as an experimental context, with the objective of proposing the SEA ontology as an important contribution to improve SEA's effectiveness.

Keywords: ontology; ontologies; city Masterplans; Strategic Environmental Assessment

1. Introduction

Important conditions for Strategic Environmental Assessment (SEA) to be effective, in the spirit of the European Parliament and Council Directive 2001/42/EC (the SEA Directive), are its cooperative and inclusive attitudes, which are inherently connected to sustainability. Cooperation should involve institutions, planning authorities and agencies involved in environmental assessment procedures. Inclusion implies favoring and catalyzing local community participation in the planning/assessment process.

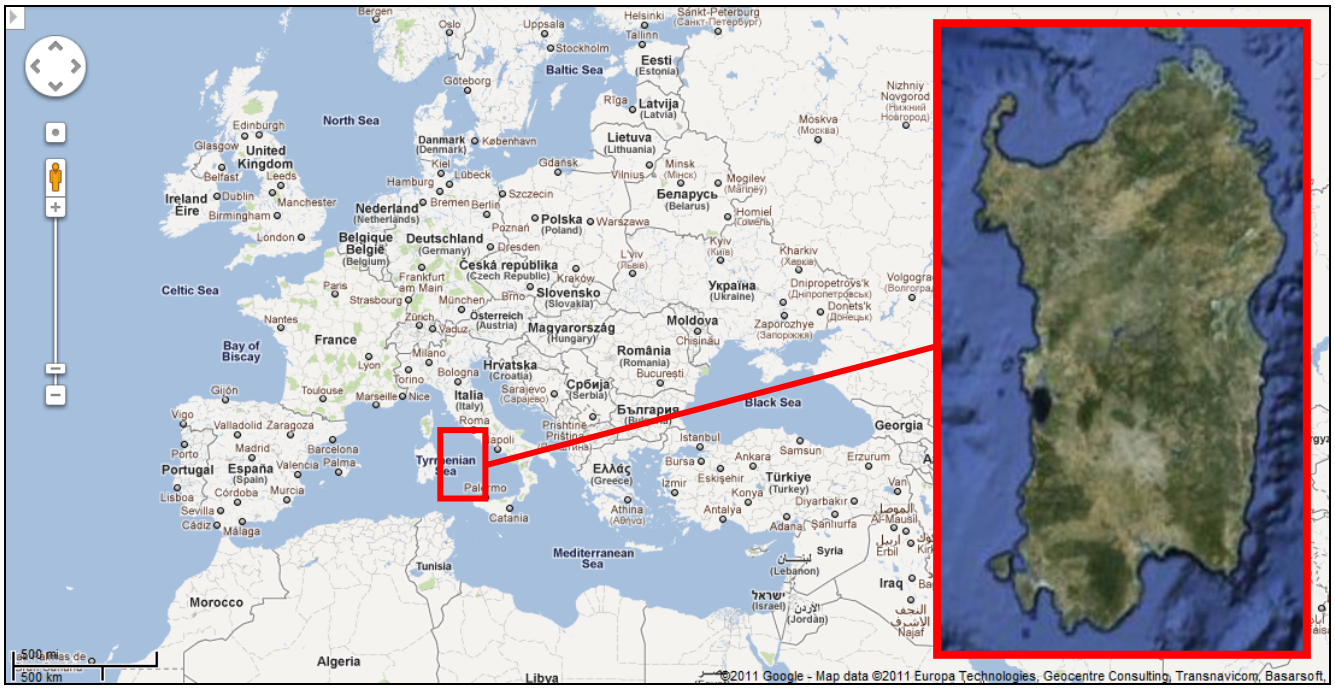
The issue of sustainability is a central reference point of the SEA procedure defined by the SEA Directive, which states that: "The objective of this Directive is to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development,

by ensuring that, in accordance with this Directive, an environmental assessment is carried out of certain plans and programmes which are likely to have significant effects on the environment." (art. 1) So, the final goal of this Directive is to protect the environment by improving the quality of plans and programs through the integration of ruling criteria aimed at defining their objective systems. By doing so, these criteria should implement the paradigm of sustainable development in plans and programs [1,2].

Particular care should be taken in Italy for the implementation of the Directive, based on Italian Law enacted by decree No. 2006/152, regarding the assessment conceptual approach, the general planning/assessment objectives, which have to be inclusive and incremental, and the participation of the key actors of the process, which has to be effective and easy in its preliminary and ongoing steps.

The regional government of Sardinia (an island of about 24,000 km^2 with 1.6 million inhabitants located west of the Italian mainland just south of the French island of Corsica, as Figure 1 shows) issued a Guideline document (GL) [3] that not only formally ensures that an inclusive and incremental SEA process is implemented, but also rigorously defines the steps a SEA proceeding authority, that is a Sardinian city or a province, has to take in order to favor participation of all potentially interested subjects, be they public agencies, profit and non-profit enterprises, social and non-governmental organizations, or citizens, and to speed-up plan approval and its formal establishment, which take place once the pre-implementation SEA process is over. Unfortunately, the application of the GL is still far from being effective.

Figure 1. The location of the island of Sardinia (http://maps.google.com).



This paper discusses some key points concerning the ontology of the SEA procedure applied to city Masterplans, using sustainability as a reference point (third section), after a discussion on the semantics of the term "ontology" (second section). This discussion assumes the implementation process of the GL as an experimental context, with the objective of proposing the SEA ontology as an important contribution in improving SEA effectiveness (third section).

2. The Semantics of the Term "Ontology"

A generally-accepted meaning of the term "ontology" in contemporary theoretical debates of urban and regional planning is "discussion of the substance of an object", that is a discussion of the most important characteristics of its essence, especially in epistemological debates. For instance, Hillier [4,5] points out that, according to some contemporary scholars, "ontology" indicates the paradigm of "relational ontology", that is a discussion of the substance of the relations between agents and structures (capital, social classes, agreed-upon semantics, etc.) which do not possess their own essence, formed only through their being in relation. Moreover, Hillier stresses, with reference to DeLanda [6], that the reference point of planning practice should be the observation and analysis of the relations between the elements which constitute the empirical reality (e.g., agents and structures), whose existence does not depend on the fact that human beings perceive it.

These relations generate emergences, that is unexpected phenomena, for those who are familiar with the single elements but who are not aware of their mutual relations as well: the ontology of agents, structures and relations is a "realistic ontology" of the scientific paradigm of the (planning) disciplinary paradigm, which is based on the empirical analysis of the relation. These emergences have an autonomous existence with respect to agents and structures.

The realistic ontology (the ontology of relations) is an ontology of the reality [4], and a scholar's disciplinary role is to be aware of and to describe this reality, by identifying and analyzing its relational substance.

The "substantial" attribute of the term "ontology" leads to an effective comprehensive view of the contemporary debate concerning ontology and ontologies. In this context, ontology is not referred to, according to the meaning described so far, as one or a set of conditions which define the substance of a concept (reality–agents, structures, relations) as much as the substance of its agreed-upon representation, that is its formal definition. Ontology is the identification of a concept, of a domain—in other words, the cognitive contents that a set of agents identify as the particular characteristics of a domain. So, ontology is not connected to substance, that is the essence of an object, as much as to the agreed-upon available knowledge (scientific, technical, based on traditions and on common sense, *etc*.) concerning an object.

A formal ontology, or, better, formal ontologies, are not connected to essence, but to the essence of representations, or definitions; that is, they propose an agreement on cognitive contents, rather than the substance analysis of an object. According to Smith [7], ontologies are descriptions of domains of objects as closed data models whose nodes define concepts. These concepts are strategically identified and make sense only in the context of the universe they try to model. Moreover, Smith illustrates that, historically, the use of formal ontologies comes from the fact that several disciplines are experiencing a dramatic Tower of Babel syndrome which needs to be addresses in some way. Those who deal with complex systems of data and knowledge have peculiar and often idiosyncratic frameworks for representing information. The semantics used for the same term may vary, or the semantics for different terms could take the same meanings. Formal ontologies could make it easier to deal with this syndrome.

Also according to Guarino [8], as quoted by Pretorius [9], a formal ontology is a projected representation which consists of a specific agreed-upon set of words which describe concepts belonging to a knowledge domain and a set of agreed-upon propositions concerning the meanings of

these words as well. Pretorius agrees with Smith [10] since, in his view, the concept of ontology originated in the field of artificial intelligence [11].

3. Sustainability as One of the Fundamentals for SEA Processes

In the GL, the paradigm of SEA is articulated according to the handbook of the European Commission on environmental assessment of regional development plans [12], which is still a very important reference point, even though a little outdated. Moreover, it is stated that, in order to define the sustainability objectives, the ten sustainability criteria laid down by the European Commission should be taken into account as important reference points [13]. Furthermore, the GL suggests that the city Masterplans should explicitly and specifically state which strategic actions they will implement in order to attain the criteria. This statement should be contained in the SEA environmental report, as it is explained in paragraph 5.3 of the GL. This paragraph suggests that the SEA environmental report of a Sardinian city Masterplan should contain the history of the definition of the plan, and show how the environmental factors were integrated into the decision-making process, with reference to its ruling codes and the international, European Union, national and regional programming acts concerning sustainable development. The environmental report should analyze, describe and assess: (i) the original environmental situation through suitable indicators; (ii) the environmental sustainability objectives which are integrated into the city Masterplans; (iii) the criteria utilized to integrate the environmental components into the city Masterplans with an analysis of their urban contexts; (iv) the likely-significant effects of the Masterplans on their urban contexts; (v) a discussion concerning reasonable alternatives to the decisions taken in order to attain the planning objectives (social, economic, environmental); (vi) the monitoring system.

The GL identifies the handbook criteria as a starting point for defining the sustainability objectives to be included as an important integration within the set of objectives of the Sardinian city Masterplans; however, they are not very clear with regards to the detail of the conceptual and logical process which should drive the Masterplans. In any case, the GL states that sustainability objectives should come from a detailed analysis of the local environmental context which expresses needs and expectations [14]. The implementation into the city Masterplans codes of needs and expectations entailed by the sustainability objectives should substantially improve the potential effectiveness of Masterplans and their quality.

In this framework, the concept of sustainability referred to human settlements entails a very demanding and articulated approach to programming local economic and social development. So, building an ontology concerning "The SEA of city Masterplans" implies studying and projecting how countries and regions of the European Union are interpreting and implementing the SEA Directive. This means analyzing interpretation and implementation processes in order to derive a formal ontology, which, according to SEA Directive, should be based on the representation of sustainability through agreed-upon criteria and objectives.

Three concepts are fundamental for this ontology: the SEA endogeneity with respect to a Masterplan, the SEA as an inclusive and participatory process, the SEA as a social learning process within a Masterplan and on the Masterplan.

According to the SEA Directive, SEA processes should be characterized by continuous interaction and interdependence with the (city Master) plans they are assessing. In other words, a SEA process outside the planning process would not make any sense. The SEA (environmental) authorities should be involved in the process of defining and implementing plans, and they should work side-by-side with the planning authorities. The SEA Directive states that "'Environmental assessment' shall mean the preparation of an environmental report, the carrying out of consultations, the taking into account of the environmental report and the results of the consultations in decision-making and the provision of information on the decision in accordance with Articles 4 to 9" [15]. The concept of endogeneity is not integrated into the Italian Law enacted by decree 2006/152, which implements the SEA Directive into Italian legislation. This law establishes that "The SEA authority and the Planning authority implement the technical development of the SEA process, collect and assess all the available documents, that is observations, objections and suggestions coming from the public […] express their motivated statement within ninety days from the deadlines established by art. 14" [16]. So, in Italian legislation, SEA and planning processes are separated, which could cause a substantial failure of the SEA process. In other words, it is very possible that environmental protection- and sustainability-based priorities coming from the SEA will not be considered as apart of the strategic priorities of a (city Master) plan [17].

From this point of view, SEA is a participatory, cooperative and incremental process, which aims at continuously improving the quality and effectiveness of a (city Master) plan. So, a motivated statement issued by a SEA authority who did not take part in the decision-making process of a plan, whose statement would be entirely analogous to the compatibility statement which concludes the Environmental Impact Assessment process of a project, should not be the desirable end of a SEA process. An adequate SEA process should rather be characterized by the active participation of each public administration sector involved, all of which should share their opinions, project objectives, procedures and policies concerning the future local economic and social development. The SEA endogenous process is cooperative and inclusive *ad intra* in that its stakeholders belong to public administration, but, at the same time, it should entail the implementation of an analogous implementation *ad extra*, that is one which involves the local communities. So, the most important ontological characteristics of SEA are cooperation between SEA and planning public authorities, and participation and inclusion of the private stakeholders in the assessment of plans [18].

The endogenous and participatory/inclusive SEA process should imply continuous feedback on the implementation status of planning policies. In this process, all of the participants should improve their knowledge of the plan, its environmental impacts, and how its policies address the territorial issue at stake. The public and private participants' cooperative attitudes should improve through the SEA as well [19]. Increased social learning, both in qualitative and quantitative terms, is one of the most important outcomes of endogeneity and participation/inclusion.

The three fundamentals of the ontology of SEA processes concerning city Masterplans should entail analysis and interpretation of the environmental and territorial domains of the plans. Analysis and interpretation should effectively represent the domains through concepts and relations, making reference to international, national and local legislative frameworks. In the following section, we tentatively propose an ontology having these features.

4. Experimental Section: An Ontology of the SEA Procedure of City Masterplans

Within the context of spatial planning, ontologies have generally been proposed as a means to share and reuse existing information and data [20], to homogenize data and solve semantic conflicts [21], to support the modeling of spatial datasets [22], and therefore as a possible solution to the issue of making interoperability and integration possible in spite of the proliferation of data and data sets built in the absence of common standards [23]. One of the most challenging and promising field of research concerning the use of ontologies in spatial planning deals with allowing for a better understanding and awareness of programming and planning processes [24,25]. Ontologies, in this context, do not deal with "the specification of what exists and what does not exist, but rather with the creation of a data set that contains concepts related to the domain under inquiry" [25]; in other words, they tackle the problem of describing a given domain of interest by identifying key concepts that define the domain, relations that connect the concepts, and existing constraints, thus making formalization and knowledge sharing within the given domain possible.

There are many definitions of the word "ontology" in the literature regarding the field of artificial intelligence [26]. As Caglioni and Rabino [27] point out, there is no single definition, and conceptual definitions "that regard ontology as a reference system for knowledge" coexist with "others, more operational, which lay the grounds for their actual construction, development and use." One of the most used and most frequently cited definitions is Gruber's [28], for whom an ontology is an "explicit specification of a conceptualization": this conceptualization, or in other words the construction of an abstract and simplified conceptual model of a given object, or phenomenon, or process represented by the ontology, is explicit because each concept, relationship and constraint is explicitly defined. The subsequent definition by Studer *et al.* [29] ("formal, explicit specification of a shared conceptualization"), enriches Gruber's with two additional requirements: first, an ontology should be formal, that is machine-readable; in addition, the conceptual model of the object being represented needs to be agreed by a group of individuals [30], and therefore consensus of members of a given community is necessary.

A significant experience, as far as ontologies for urban planning are concerned, is that of the Towntology project [31], which, among other things, aimed at developing an urban civil engineering ontology and at exploring whether ontologies can improve communication between stakeholders in the field of urban civil engineering. However, the formalization of environmental assessment procedures (either Environmental Impact Assessment or SEA or Appropriate Assessment under the Habitats directive) was not within the scope of the project.

The ontology of the domain "SEA of city Masterplans" was developed according to the phases suggested by guidance documents and methodological reports produced by the Ordnance Survey [32–34], according to which the process whereby an ontology is built can be broken down into a series of steps, the first being the identification of the purpose of the ontology (*i.e.*, the specification of needs and requirements that the ontology should be able to fulfill) and of its scope (*i.e.*, a delimitation of the domain under investigation). These two aspects are crucial for ensuring both that the ontology is correctly formalized and that it is useful, meaning that it contains only those concepts, relationships and constraints that are judged to be relevant, with regard to the possible ways in which the ontology can be used. With reference to the first point (purpose), the ontology here proposed aims to represent the SEA as a process; in particular, it must explain how this process is articulated with reference to the

three foundational concepts discussed above in Section 3 (endogeneity; inclusion and participation; social learning process). With reference to the second point (scope), the domain is here confined to the SEA of city masterplans.

Once purpose and scope have been established, the following step consists of the construction of a glossary ("*knowledge glossary*"), comprising two tables. The first table ("*table of concepts*") contains a list of core and secondary concepts together with their definition in natural language, the indication of the source of the definition, and of possible synonyms. Concepts can be either *core concepts* or *secondary concepts*, depending on whether or not they are included in the domain under investigation, that is, ultimately, on how purpose and scope have been defined in the previous step. Core concepts are deemed necessary to represent the domain; on the contrary, secondary concepts are not part of the domain; however they belong to the glossary because they need to be defined in order to describe core concepts. The second table ("*table of relations*") lists and defines, again in terms of natural language only, relationships between concepts pertaining to the domain.

The definition of concepts and relationships was based on documentary sources only. These consisted of relevant national and regional pieces of legislation concerning both SEA and city masterplans (e.g., the already mentioned Law enacted by decree No. 2006/152; Regional Law No. 1989/45, concerning urban and regional planning in Sardinia; Deliberation of the Regional Government of Sardinia no. 24/23 of 2008, concerning both SEA and Environmental Impact Assessment; GL). The use of such sources was an attempt to ensure that definitions are agreed upon by, and shared among, domain experts. Table 1 illustrates, for instance, a part of the table of concepts. Through a series of checks at internal level of definitions and relations, the two tables were enhanced and modified recursively.

Table 1. Knowledge glossary: table of concepts (an extract only showing some of the core concepts).

Core concept	Definition	Source
City Masterplan	Planning instrument that ensures "a balanced growth of urban settlements, consistent with regional directives and constraints"; in compliance with the provisions of the provincial plan, it regulates possible uses of areas designated for agriculture, industry or tourism developments. It also regulates restoration and renovation of buildings, so as to provide for an adequate supply of services and infrastructures for the local community.	Regional Law 45/1989, art. 4
Environmental Report	Document prepared in compliance with provisions of article 13 of Decree 152/2006. It is a part of the plan, and its preparation accompanies plan preparation and approval. The Environmental Report must identify, describe and evaluate the likely significant effects on the environment and on cultural heritage that might stem from the implementation of a plan, as well as the reasonable alternatives that might be adopted having regard to the plan's objectives and the characteristics of the territory on which the plan, once approved, will be in force.	Decree 152/2006 & amendments, art. 5, and DRG 24/23 of 2008, Annex C, art. 12
Interested Public	People, associations, organizations and groups that are affected, or may be affected, by decisions on environmental matters or that are interested in the procedures that lead to such decisions, including NGOs that promote environmental protection and satisfy legal national requirements, as well as the most representative trade unions.	Decree 152/2006 & amendments, art 5
Municipal Planning Authority	The public administration that prepares a plan subject to the decree; in case the plan is prepared by other than a public administration, the public administration in charge of adopting or approving the plan.	Decree 152/2006 & amendments, art 5

Table 1. *Cont.*

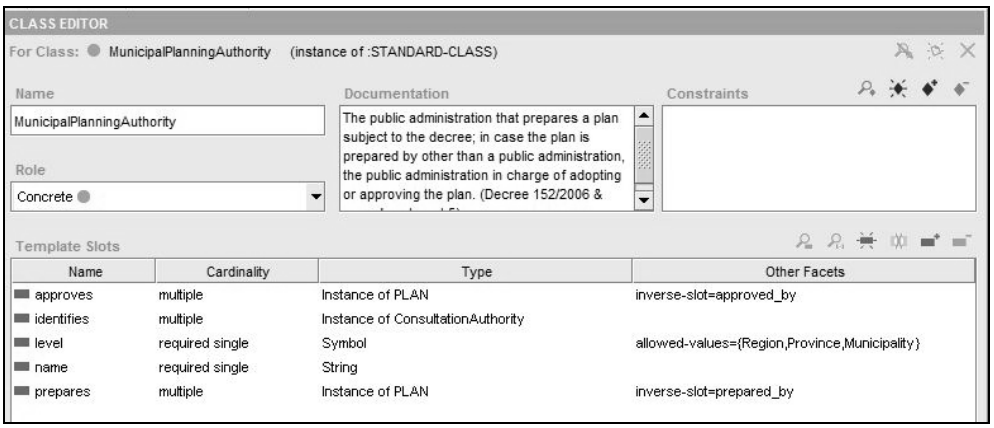
Core concept	Definition	Source
P00_Screening	Assessment carried out in order to establish whether a plan, or a modification of a plan, can produce significant environmental effects and as a consequence is subject to the SEA procedure in compliance with the provision of the national decree, having regard to the level of environmental fragility of the areas concerned by the plan.	Decree 152/2006 & amendments, art 5
P01_Preliminary Activation	Preliminary analysis of the plan's objectives and of their environmental sustainability.	DRG 24/23 of 2008, Annex C, art. 10.1
P02_Scoping	Phase in which the following are decided: - scope and level of detail of information to be included in the environmental report; - forms of participation and consultation.	DRG 24/23 of 2008, Annex C, art. 11.1
P03_ER Preparation	Identification, description and evaluation of the significant impacts on the environment and on cultural heritage that might stem from the implementation of the plan proposal, as well as examination of the reasonable alternatives that might be chosen having regard to the plan's objectives and to the characteristics of the territory concerned by the plan.	DRG 24/23 of 2008, Annex C, art. 12.1
P04_Plan Adoption	Phase in which the city council adopts the plan, in compliance with Regional Law no. 45/1989 on urban planning, together with the environmental report and a non-technical summary, part of the environmental report.	LG, §4.4
P06_Consultation	Phase in which environmental authorities and the public can make their written submissions (observations and objections) on the adopted plan, on the basis of the reading of documents and of compulsory informative meetings to be held after the adoption of the plan	Decree 152/2006 & amendments, art 5
P07_Submissions Examination	The examination of the submissions presented by environmental authorities and by the public. These might or might not lead to modifications of the adopted plan. However, the city council has the obligation to give reason for the rejection of any submission received.	LG, §4.7
P08_Decision	Phase in which the SEA Authority issues the motivated statement that concludes the SEA procedure. The motivated statement is a precondition for the final approval of the plan by the Planning Authority.	LG, §4.7
Public	One person or more people, or associations, or organizations as defined by the law, as well as groups including them.	Decree 152/2006 & amendments, art 5
Screening Decision	Compulsory statement issued by the SEA authority that concludes the screening phase.	Decree 152/2006 & amendments, art 5
Scoping Report	The document that contains the following information: - a description of the plan; - a list of indicators to be used in the environmental analysis; - the definition of a methodology to assess impacts; - indications on how the participation process must be carried out and who must be involved; - indications on how to monitor the implementation of the plan.	Decree 152/2006 & amendments, art 12; LG, §4.2
SEA Authority	The public administration that bears responsibility for adopting the decision that concludes the screening phase and for issuing the motivated statement that ends the SEA procedure.	Decree 152/2006 & amendments, art 5

The knowledge glossary, in spite of its being an explicit and shared (at least, potentially) specification of the entities that constitute the abstract and simplified model of the SEA process developed in the light of the documentary sources examined, is not a formal specification of the domain, up to this point. For the computational aspects, the software program Protégé [35] was used; concepts were arranged in a hierarchical manner, that is they were organized and grouped into classes and subclasses on the basis of the relationship "is a". To state that a given element belongs to a subclass of a class is in fact tantamount to affirming that this element belongs to the class and therefore that it inherits its properties. In this way, key concepts identified in the previous phase were first organized in a taxonomy according to the following classes: "Act", "Document", "Information and

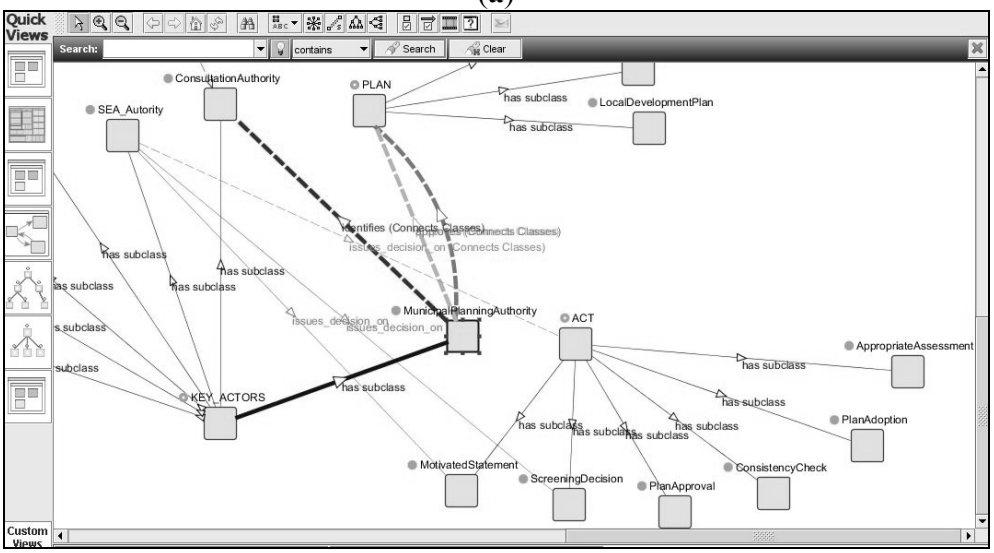
Consultation", "Key Actors", "Plan", "SEA Phase", and then the corresponding definitions were inserted for each class and subclass.

Next, for each class and subclass, appropriate slots were defined and created. Slots can be used either to characterize the elements of a class by means of attributes of different types (for instance, string, integer, enumerated), or to describe the relationships between instances, which are defined as the elements belonging to a given class; in other words, features represent the finest level of granularity and form the basis of the hierarchy. Figure 2(a) illustrates, as an example, the slots assigned to the class "Municipal planning authority", which is a subclass of the class "Key Actors". "Level" and "Name" are two descriptive attributes, both required and both having single cardinality (meaning that only one value for each attribute is allowed); the type of the first is "symbol" (meaning that it can only take predefined values) and that of the second is "string" (meaning that any alphanumeric string is allowed).

Figure 2. (**a**) An example of descriptive and relational slots assigned to the class "Municipal Planning Authority" in Protégé; (**b**) A graphical representation of relations corresponding to these slots.



(**a**)

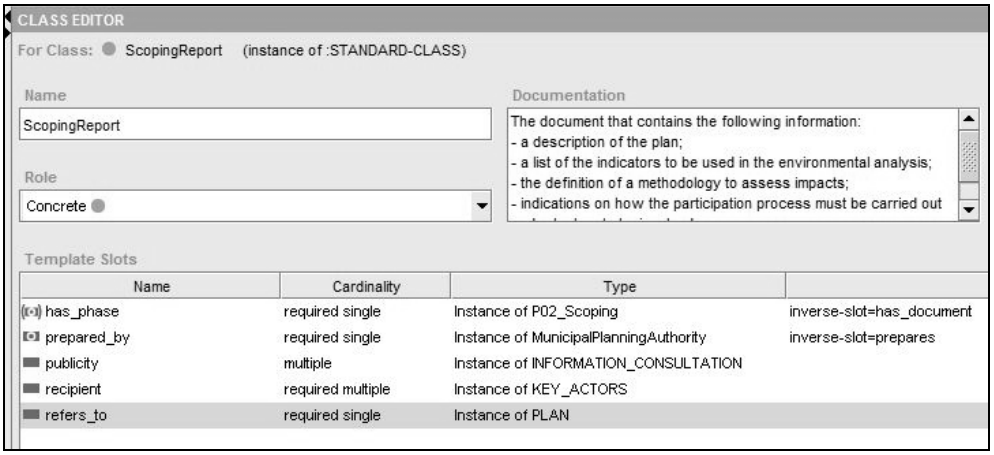


(**b**)

As far as the other three ("Approves", "Prepares", "Identifies") are concerned, they make the relations between the subclass "Municipal planning authority" on the one hand and the classes "Plan" and "Consultation authority" on the other hand explicit, or, more precisely, they make the relations between features belonging to the aforementioned classes explicit. These relations are represented by means of graphs in Figure 2(b). All of the three slots have multiple cardinality (that is, an instance of the class "Municipal planning authority" can prepare and/or approve more than one instance of the class "Plan" and it can identify, together with the authority that bears responsibility for the SEA, more than one feature belonging to the class "Consultation authority"); for two of these instances, inverse relations are defined.

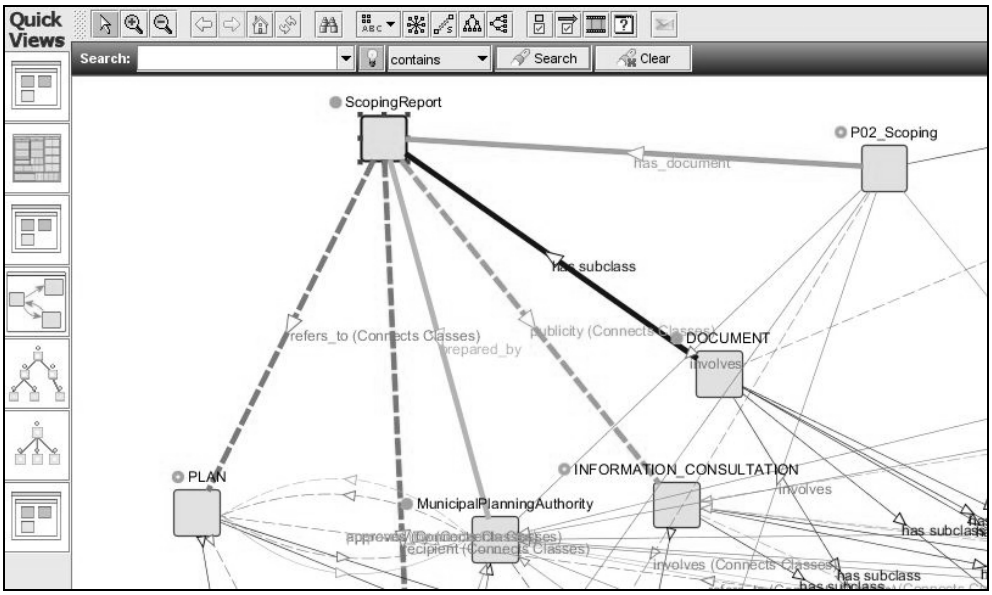
Figure 3(a) shows another example, that of the slots assigned to the class "Scoping report", which is a subclass of the class "Document". Its five slots ("Has phase", "Prepared by", "Publicity", "Recipient", "Refers to") describe the relationships between the subclass "Scoping report" and the classes "P02_Scoping" (subclass of the class "SEA Phase"), "Municipality planning authority", "Information and Consultation", "Key Actors" and "Plan" respectively. These relations are represented by means of graphs in Figure 3(b). The slot "Has phase", having single cardinality, is defined as the inverse of "Has document", which makes explicit the relation between a phase of the SEA process and its corresponding documents, if any. The slot "Refers to" connects a scoping report to the city masterplan it refers to; its cardinality is single because for each plan only one scoping report, a document that aims at establishing both scope and methodology of the SEA process, is prepared and, *vice versa*, each scoping report describes only one plan. The slot "Prepared by", having single cardinality, is defined as the inverse of the slot "Prepares" mentioned in the previous example; its cardinality is single because, in this given domain (that of the SEA of city masterplans) a plan, and consequently its scoping report, can only be prepared by a municipality; things would have been different if, for instance, the domain had included the SEA of other types of plans, prepared and approved by groups of municipalities.

Figure 3. (**a**) An example of descriptive and relational slots assigned to the class "Scoping report" in Protégé; (**b**) A graphical representation of relations corresponding to these slots.



(**a**)

Figure 3. *Cont.*

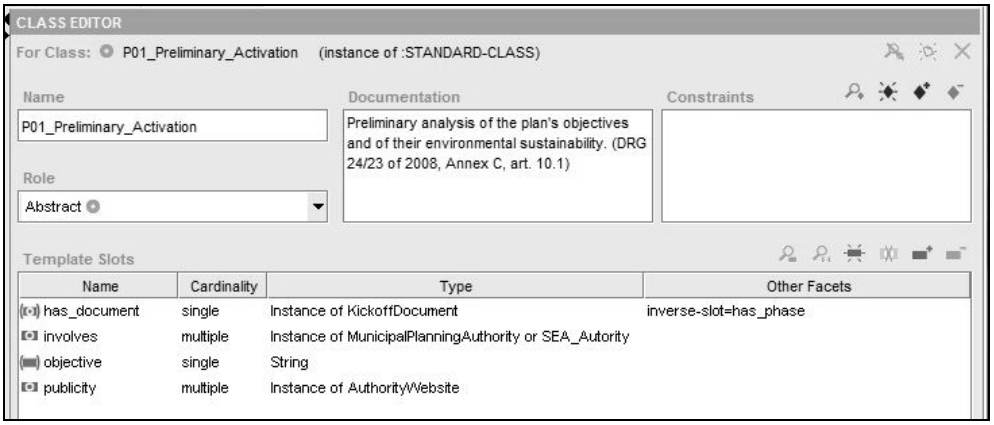


(**b**)

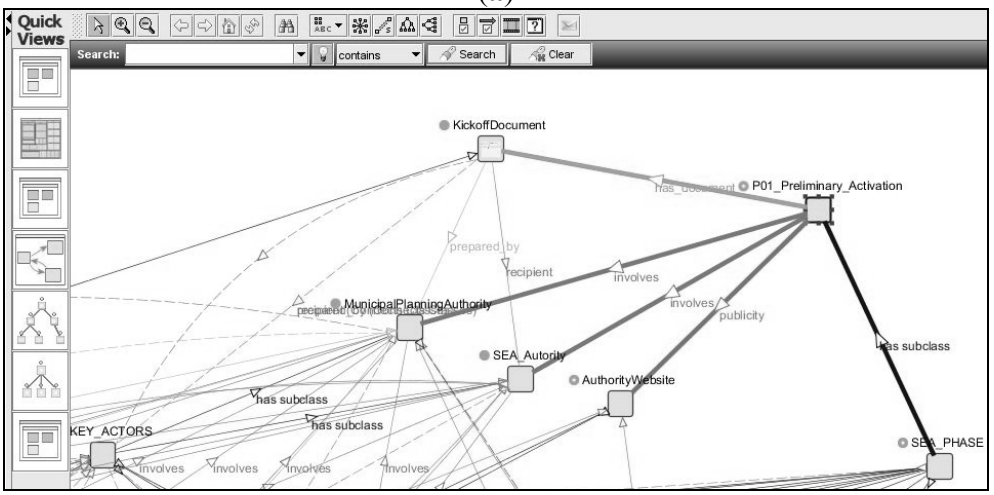
The slot "Publicity" connects the subclass "Scoping report" to the class "Information and Consultation" so as to show in which ways this document must be made available to the wider public. Finally, the slot "Recipient" gives evidence of relations existing between the subclass "Scoping report" and subclasses belonging to the class "Key Actors", since, according to the GL, the scoping report must be sent to a series of authorities and stakeholders, partly identified by laws and regulations, and partly identified in preliminary talks by the municipal authority and by the SEA authority, prior to a compulsory meeting what takes places in the early stages of the plan preparation.

Finally, Figure 4(a) shows a third example of the slots assigned to the class "Preliminary activation", which is a subclass of the class "SEA Phase". In this early phase of the SEA (the second out of a total of thirteen here identified on the basis of the GL), a preliminary analysis of the objectives of the plan and of their environmental sustainability is carried out. A document (here named "Kickoff document") has to be produced by the municipal planning authority and sent to the SEA authority; this document must describe the content of a plan, in terms of its objectives and likely structure, and must contain a list of both public administrations that might be concerned by the plan and consultation authorities to be involved in the SEA process. Therefore, two of the relational slots associated to the subclass give evidence of the relationships between the subclass "Preliminary activation" and the classes "Kickoff document" (slot "Has document"), and "Municipal planning authority" and "SEA authority" (slot "Involves"). These relations, together with a third one represented by the slot "Publicity", are shown by means of graphs in Figure 4(b).

Figure 4. (**a**) An example of descriptive and relational slots assigned to the class "Preliminary activation" in Protégé; (**b**) A graphical representation of relations corresponding to these slots.



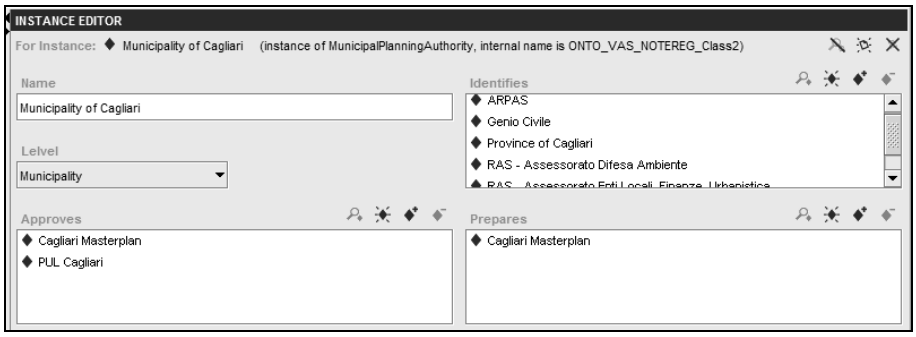
(**a**)



(**b**)

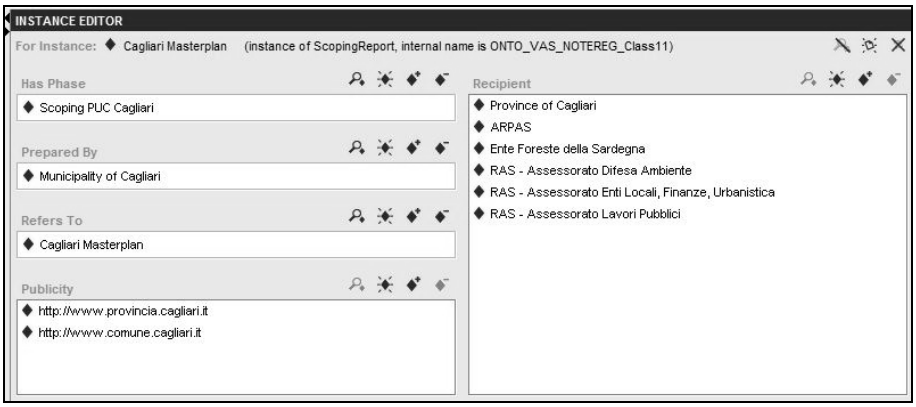
The construction of the ontology continues with the creation of instances and the filling-in of the values of the slots, and this is done by entering these values in appropriate forms that prevent users from including values which are inconsistent with the ontological hierarchy previously defined. Figure 5 shows two examples of this phase.

Figure 5. An example of instance belonging to the class "Planning Authority" (**a**) and one belonging to the class "Scoping Report" (**b**), also showing their slots filled out in Protégé.



(**a**)

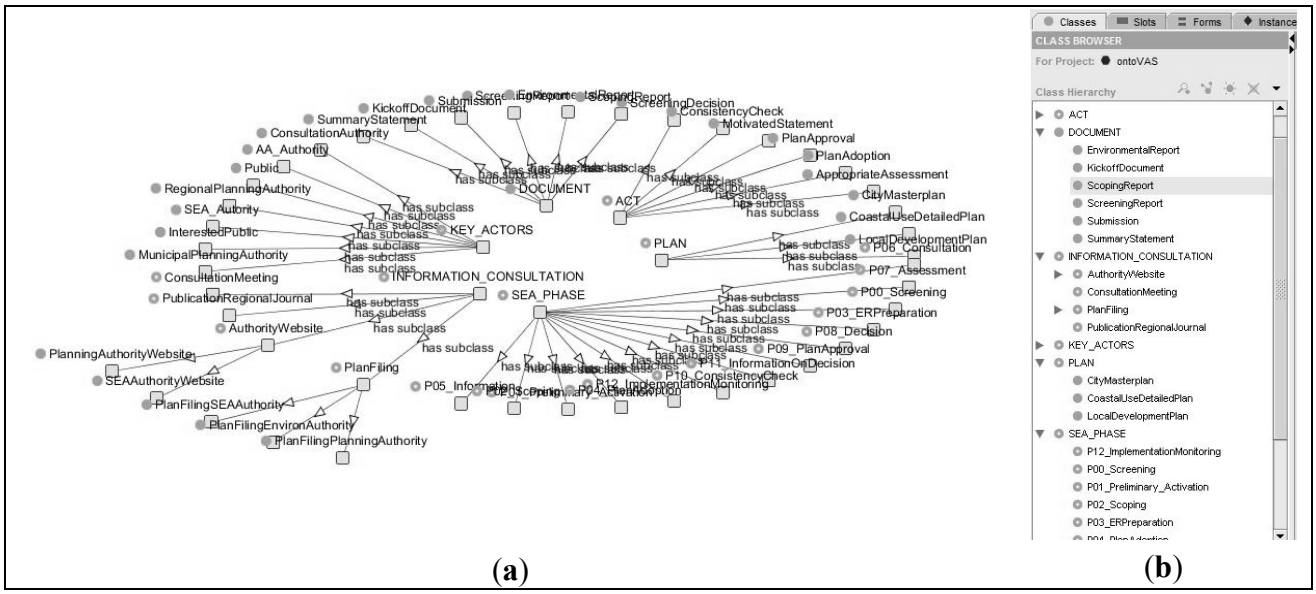
Figure 5. *Cont.*



(**b**)

Once the instances have been created and their slots have been filled in, the ontology is fully and formally defined, even though it can be continually adjusted and integrated; moreover, the ontology can be represented graphically as a graph tree in which classes, subclasses and instances are represented as nodes, and relations as arches (Figure 6). Graphs can be tailored to the user's needs, meaning that the user can choose whether to display all of the ontology, or only a part of it, by selecting the nodes to be represented or filtering the relationships to be shown, which allows for a more effective and more understandable representation and exploration in case of complex ontologies.

Figure 6. Classes and subclasses of the domain in Protégé: (**a**) graph tree (only listing the "is a" type relationships); (**b**) hierarchy (an extract).



(**a**) (**b**)

5. Conclusions

This paper has attempted to build an ontological representation of the SEA procedure of city Masterplans, which can be useful for at least two reasons.

First, this approach provides all the participants involved in the SEA process (be they institutions, organizations or private citizens) with a better understanding of the domain of interest [36], through an

iterative learning process that can continually be refined; this learning process is, in principle, inclusive, because the construction of the glossary can be improved by integrating the definition of concepts, relations, and descriptive attributes, here carried out solely on the basis of documentary sources, in a participative way, by including, for instance, experts in the domains of planning and evaluation, or representatives of the public administrations involved. These might also be involved in the process of defining and identifying relationships between classes and subclasses. Such a collective conceptualization of the domain would also greatly improve the chances of sharing and reusing the ontology in the domain field, and, consequently, it would make the results of this exercise more accessible and understandable to stakeholders and to the wider public. Moreover, such a collective conceptualization of the SEA procedure would foster a collective reasoning about the relationship between government and wider governance processes with reference to the making of a city Masterplan, a planning instrument that deals with shaping places and spaces; in other words, it would tackle one of the two key challenges for planning theory as identified by Healey [37,38].

Second, since the ontology here proposed is a domain ontology, therefore aimed at structuring, representing and communicating knowledge on a specific area of interest irrespective of potential applications, the ontology of the SEA procedure of city Masterplans can be updated, refined and reused in the given domain [28], and it can lay the bases for the development of task-dependent or application-oriented ontologies in the same domain, for instance focusing on administrative and procedural tasks.

A strong point of this paper is that the ontological approach here utilized can be readily exported to the countries where an assessment of plans and programs is required in compliance with the SEA Directive, therefore throughout the European Union. However, the domain ontology here developed is grounded on the normative framework that regulates the SEA procedure in Italy; as a consequence, some adjustments would be necessary so as to reuse this ontology to describe the SEA procedure in Member states other than Italy. A detailed comparison of laws, regulations and procedural aspects (for instance, institutional environments, administrative tiers involved in the process, procedures for the approval of city plans) would be necessary to adapt the ontology to a non-Italian context. Furthermore, the possibility that the ontology here presented might be affected by some issues of semantic precision must be taken into account, as these could limit the exportability of the ontology to other contexts. These issues originate in the fact that the table of concepts here presented was originally built in Italian and translated into English, since the definitions of concepts included in the glossary are based on Italian laws and regulations, technical documents and dictionaries.

References and Notes

1. European Commission, DGXI, Environment, Nuclear Safety and Civil Protection. *A Handbook on Environmental Assessment of Regional Development Plans and EU Structural Funds programmes*; Environmental Resources Management, London, UK, 1998; pp. II.1–II.11. Available online: http://ec.europa.eu/environment/eia/sea-guidelines/handbook-full-text-annexes.pdf (accessed on 6 September 2011).

2. Sustainability criteria are defined by the European Commission in the document quoted as [1] as follows: i. minimize use of non-renewable resources; ii. use renewable resources within limits of capacity for regeneration; iii. Environmentally-sound use and management of hazardous/polluting substances and wastes; iv. conserve and enhance the status of wildlife, habitats and landscapes; v. maintain and improve the quality of soils and water resources; vi. maintain and improve the quality of historic and cultural resources; vii. maintain and improve local environmental quality; viii. protection of the atmosphere, with particular attention to global warming; ix. develop environmental awareness, education and training; x. promote public participation in decisions involving sustainable development.
3. Regione Autonoma della Sardegna [Sardinia Autonomous Region]. Linee Guida per la Valutazione Ambientale Strategica dei Piani Urbanistici Comunali, Allegato alla Delibera della Giunta Regionale della Regione Autonoma della Sardegna n. 44/51, 14 December 2010. Available online: http://www.sardegnaambiente.it/index.php?xsl=1399&s=18&v=9&c=8280&es=4272&na=1&n=10 (accessed on 6 September 2011).
4. Hillier, J. Introduction to Part Two. In *The Ashgate Companion to Planning Theory*; Hillier, J., Healey, P., Eds.; Ashgate Publishing Limited, Farnham, Surrey, UK, 2010; pp. 235–250.
5. According to Hillier [4], p. 240, an important reference related to the meaning of "ontology" in the context of the epistemological debate concerning the disciplinary paradigm of planning theory is the essay by Manuel DeLanda [6] on assemblage theory and social complexity.
6. DeLanda, M. *A New Philosophy of Society: Assemblage Theory and Social Complexity*; Continuum: New York, NY, USA, 2006.
7. Smith, B. Ontology. In *Blackwell Guide to the Philosophy of Computing and Information*; Floridi, L., Ed.; Blackwell, Oxford, UK, 2003; pp. 155–166. Available online: http://ontology.buffalo.edu/smith/articles/ontology_pic.pdf (accessed on 6 September 2011).
8. Guarino, N. Formal Ontology in Information Systems. In *Formal Ontology in Information Systems*, In *Proceedings of FOIS'98*, Trento, Italy, 6–8 June 1998; Guarino, N., Ed.; IOS Press: Amsterdam, The Netherlands, 1998; pp. 3–15.
9. Pretorius, A.J. Ontologies—Introduction and overview; 2004; p. 3. Available online: http://www.starlab.vub.ac.be/teaching/Ontologies_Intr_Overv.pdf (accessed on 6 September 2011).
10. See the Smith's essay quoted in [7], p. 9.
11. See the Pretorius' essay quoted in [9], p. 3: "The concept of *ontology* (written with a lowercase 'o') was first borrowed from the realm of Philosophy by Artificial Intelligence researchers and has since become a matter of interest to computer and information scientists in general."
12. See the European Commission's document quoted in [1].
13. See the Regione Autonoma della Sardegna's document quoted in [3], p. 18.
14. See the European Commission's document quoted in [1].
15. Directive 2001/42/EC, article 2, paragraph 1, letter b. Available online: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2001:197:0030:0037:EN:PDF (accessed on 19 December 2011).
16. Italian Law enacted by decree 2006/152, article 15, paragraph 1. Translation by authors. Available online: http://www.bosettiegatti.com/info/norme/statali/2006_0152.htm (accessed on 19 December 2011).

17. Fidanza, A.; Bertini, C. Lettura critica del "recepimento" della Direttiva 2001/42/CE (VAS) nel D.Lgs. 152/2006, recante "Norme in materia ambientale", 2006. Available online: http://www.inu.it/download_eventi/
lettura_critica.pdf (accessed on 6 September 2011).
18. Sustainable Seattle. *Indicators of Sustainable Community 1998*; Sustainable Seattle: Seattle, WA, USA, 1998
19. Davoudi, S. La partecipazione nella pianificazione per la sostenibilità [Participation in Planning for Sustainability]. *Urbanistica* **2003**, *55*, 119–129.
20. Noy, N.F.; McGuinness, D.L. Ontology development 101: A guide to creating your first ontology, 2007. Available online: http://protege.stanford.edu/publications/ontology_development/ ontology101.pdf (accessed on 16 September 2011).
21. Mizen, H.; Dolbear, C; Hart, G. Ontology ontogeny: understanding how an ontology is created and developed. In *Proceedings of GeoS 2005*, Mexico City, Mexico, 29–30 November 2005. Available online: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.97.5100&rep= rep1&type=pdf (accessed on 16 September 2011).
22. Schuurman, N. Formalization matters: critical GIS and ontology research. *Ann. Assoc. Am. Geogr.* **2006**, *96*, 726–739.
23. Murgante, B.; Scorza, F. Ontology and Spatial Planning. In *Computational Science and Its Applications*: *ICCSA 2011*, 1st ed.; Murgante, B., Gervasi, O., Iglesias, A., Taniar, D., Apduhan, B.O., Eds.; Springer-Verlag: Berlin, Germany, 2011; pp. 255–264.
24. Scorza, F.; Las Casas, G.; Murgante, B. Overcoming Interoperability Weaknesses in E-Government Processes: Organizing and Sharing Knowledge in Regional Development Programs Using Ontologies. In *Organizational, Business, and Technological Aspects of the Knowledge Society, Communications*, 1st ed.; Lytras, M.D., Ordonez De Pablos, P., Ziderman, A., Roulstone, A., Maurer, H., Imber, J.B., Eds.; Springer-Verlag: Berlin, Germany, 2010; pp. 243–253.
25. Las Casas, G.; Scardaccione, G. Rappresentazione Concettuale Della Conoscenza: Ontologia Del Rischio Sismico. [A conceptual representation of knowledge: an ontology of seismic risk]. In *L'Informazione Geografica a Supporto della Pianificazione Territoriale [Geographic Information as a Tool to Support Spatial Planning*]; Murgante, B., Ed.; FrancoAngeli: Milan, Italy, 2008; pp. 279–299.
26. Winter, S. Ontology: Buzzword or paradigm shift in GI Science? *Int. J. Geogr. Inf. Sci.* **2001**, *157*, 587–590.
27. Caglioni, M.; Rabino, G.A. La Costruzione di Un'ontologia Urbana Condivisa e Riutilizzabile [The construction of a shared and reusable urban ontology]. In *Proceedings of the 27th Italian Conference of Regional Science AISRE*, Pisa, Italy, 12–14 October 2006. Available online: http://www.inter-net.it/aisre/minisito_2006/cd_aisre/Paper/Caglioni.pdf (accessed on 16 September 2011).

28. Gruber T.R. Toward principles for the design of ontologies used for knowledge sharing. Technical Report KSL 93–04, Knowledge Systems Laboratory, Stanford University, Stanford, CA, USA, 1993. Available online: http://itee.uq.edu.au/~infs3101/_Readings/OntoEng.pdf (accessed on 16 September 2011).
29. Studer, R.; Benjamins, V.R.; Fensel, D. Knowledge engineering: principles and methods. *Data Knowl. Eng.* **1998**, *25*, 161–197.
30. Agarwal, P. Ontological considerations in GIScience. *Int. J. Geogr. Inf. Sci.* **2005**, *19*, 501–536.
31. Supported by the COST (European Cooperation in the field of Scientific and Technical Research) European instrument, Towntology aimed at promoting the use of ontologies in the domain of Urban Civil Engineering projects. Technical reports and publications are available at http://www.towntology.net (accessed on 16 November 2011).
32. Hart, G.; Dolbear, C.; Goodwin, J.; Kovacs, K. Domain Ontology Development. Technical Report IRI-0005. Ordnance Survey Research Labs, 2007. Available online: http://www.ordnancesurvey.co.uk/oswebsite/partnerships/research/publications/docs/2007/Domain_Ontology_Development_V1.pdf (accessed on 16 January 2011).
33. Hart, G.; Goodwin, J. Modelling Guidelines for Constructing Domain Ontologies. Technical Report IRI-0006. Ordnance Survey Research Labs, 2007. Available online: http://www.ordnancesurvey.co.uk/oswebsite/partnerships/research/publications/docs/2007/Modelling_Guidelines_V1.pdf (accessed on 16 January 2011).
34. Kovacs, K.; Dolbear, C.; Hart, G.; Goodwin, J.; Mizen, H. A Methodology for Building Conceptual Domain Ontologies. Technical Report IRI-0002. Ordnance Survey Research Labs 2006. Available online: http://www.ordnancesurvey.co.uk/oswebsite/partnerships/research/publications/docs/2006/Methodology_for_Building_Conceptual_Domain_Ontologies_V1.pdf (accessed on 16 January 2011).
35. Protégé is a software program developed by the Stanford Center for Biomedical Informatics Research of Stanford University and freely available at: http://protege.stanford.edu/. Version 3.4.7 (frame oriented) was here used.
36. Uschold, M.; Gruninger, M. Ontologies: principles, methods and applications. *Knowledge Eng. Rev.* **1996**, *11*, 93–155.
37. Healey, P. Introduction to part one. In *The Ashgate Research Companion to Planning Theory. Conceptual Challenges for Spatial Planning*; Hillier, J., Healey, P., Eds.; Ashgate Publishing Limited: Farnham, UK, 2010; pp. 37–55.
38. According to Healey, the first challenge (the so-called "analytical challenge") for planning theory "centres on how to conceptualize the relationships between government, wider governance and culture", while the second (the so-called "normative challenge") "centres on disentangling how governance activity informed by 'progressive' dreams about the future […] can be distinguished from that which promotes narrowly-focused, elite-dominated and environmentally-damaging future options."