Chapter 6
Bridging the Gap Between Strategic Environmental Assessment and Planning:
A Geodesign Perspective Revised

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ABSTRACT

Current planning practices in Europe are affected by regulations aiming at environmental protection and risk reduction; however, planners face difficulties in implementing the norms. This chapter discusses the influence of the introduction of strategic environmental assessment and of spatial data infrastructures in the EU. To address these issues, the geodesign approach is proposed, firstly analyzing its relationships with the current planning regulations at the regional level in Italy and then its opportunities for application in practice with regard to the Sardinian case study (Italy); secondly, examples of Planning Support System are proposed and tested with real-world case studies to implement the core phases of the geodesign approach. In addition, the benefits for SEA of developing state-of-the-art workflows in geodesign collaborative workshops are discussed. The chapter concludes suggesting that geodesign may fruitfully address some of the major issues in the current planning and SEA practice, taking full advantage of the newly available resources of SDI.

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INTRODUCTION

Over the last two decades, innovations in environmental protection regulations have started to affect the planning practice in Europe, as their principles were transposed into national and regional legislation frameworks in the Member States.

Firstly, the European Directive 2001/42/EC introduced the Strategic Environmental Assessment (SEA) of plans and programs, including regional, urban and sectorial plans. The SEA is a procedure intended to inform the plan-making process since the early stages of elaboration and before plan adoption, with the aim to guide territorial development according to sustainable principles, including the protection of environmental resources, the social and cultural welfare of the communities, the promotion of savvy decision-making and the participation among the stakeholders and the communities involved in the decision process. Secondly, the European Directive 2007/02/EC, currently under implementation, established the INfrastructure for SPatial InfoRmation in Europe (INSPIRE) in order to enable sharing of territorial information among public authorities at all levels, to better facilitate its public access across Europe. This way, while the SEA Directive brought potential innovation into the plan-making process, the INSPIRE Directive contributed to the digital uptake of the planning media.

Nevertheless, while these Directives can be seen as two drivers of innovation and they are indeed starting to substantially affect the way the plan-making process is carried out, difficulties in properly implementing these principles are still widely found. In operational terms, difficulties are found either in developing transparent and democratic informed decision-making processes and in taking advantage of the new digital sources of information which are growingly made available to support data integration, analysis, design, and impact assessment.

To address these current challenges, the authors argue that the geodesign methodological approach may contribute to address some of the current critical issues and pitfalls of SEA in spatial planning, fostering better integration of the principles of recent regulations, and successfully exploiting the benefits introduced by new technologies and digital data in planning. To this end, after a general discussion of the potential of geodesign methods with regard to current planning regulations and practice, examples of the application of Planning Support System (PSS) integrating a range of methods and tools is presented, giving viable examples on how it is possible to provide planners with novel methods and tools for representing and analysing the territory and to improve informed collaborative processes among stakeholders.

The chapter is organized as follows: the first section illustrates in detail the innovation potential introduced in spatial planning by the SEA and the INSPIRE Directives. The second section first gives a brief description of the geodesign methodological approach based on literature review and subsequently highlights current relationships between the principles of the geodesign approach and the normative principles of planning regulations (with reference to European and Italian laws) as well as to current planning practices (with reference to the Sardinia case study in Italy). In the third section, after a brief definition of Planning Support Systems, an operational demonstration of methods and tools addressing major SEA tasks in local land-use planning is given. The overall aim of the chapter is to investigate to what extent the geodesign approach and PSSs may support planners during the decision-making process, bringing a new systematic and technology-based approach to spatial planning, both in terms of process and tools. Bridging the gap between theory and practice is an urgent issue and testing different viable ways to address it may constitute a valuable knowledge base contributing to bring innovation to present and future planning practice.

INNOVATION IN SPATIAL PLANNING

The SEA Directive

The European Directive 2001/42/EC introduced the Strategic Environmental Assessment as a parallel evaluation process to the preparation of plans and programmes that may have significant impacts on the environment. The main goal of SEA is to ensure that environmental considerations and sustainability principles are taken into account since the early stage of plan-making, to foster informed, responsible and transparent decision-making processes (Fundingsland Tetlow & Hanusch, 2012).

Given that the evaluation process is intertwined with the preparation of the plan since the beginning of the procedure up to the choice of its objectives, the strategies to achieve them, their impacts and finally the monitoring of the expected results, SEA deeply altered (at least in its intents) the traditional way to carry out the planning process. Moreover, it promotes approaches addressing such concepts and principles as transparency, participation and collaboration among decision makers, planners and experts from various disciplines, and the prospective involved stake-holders.

However, in spatial planning practice -unfortunately- SEA has not always led to satisfactory results (Parker, 2007; COWI, 2009; Brown & Therivel, 2000), for there is often a lack of shared vision on how to implement its principles in terms of methods and tools. According to Fisher and Gazzola (2006) the effectiveness of SEA is related to the presence of specific context conditions, including a well-structured regulatory apparatus, a satisfactory inter-institutional cooperation, and a strong attitude towards public participation.

As demonstrated by Fisher (2010), shortfalls in demonstrating how the environmental sustainability issues and the participatory processes **inform the design of the plan alternatives** are frequently found. Moreover, considerable deficiencies often persist during the generation of plan alternatives (Fundingsland Tetlow & Hanusch, *ibidem*), which are specifically required by the Directive, and during the post-decisional phase, in which the plan initiatives are implemented (Gachechiladze-Bozhesku & Fischer, 2012). As a matter of fact, the implementation of plan actions should be repeatedly monitored in order to ensure proper achievement of the proposed strategies, but this step is often underestimated due to lack of specific regulatory requirements and of a clear awareness of the benefits that it could bring about (Gachechiladze- Bozhesku & Fischer, *ibidem*).

Another inherent characteristic of SEA, useful to ensure the democratic nature and transparency of the process, is public participation, required in the form of consultations of environmental authorities, stakeholders and citizens, during the elaboration of the plan and of the Environmental Report (ER). Indeed, the territorial knowledge to support decision-making should be not only correct and relevant, but also acceptable to stakeholders, and for this reason it is important that they are called to contribute to its construction (Runhaar, 2009). Currently in planning practices, on the one hand, we assist to a significant increase in cooperation between public authorities, on the other hand, this collaboration is not always followed by an equivalent progress in public consultation that should also involve citizens in the process (Rega and Bonifazi, 2014), due to lack of specific guidelines to better address participatory practices and a lack of public administration willingness (Rega and Baldizzone, 2015).

Moreover, in order to orient the planning process results towards "good governance", the environmental assessment should be deeply consolidated internally (Zoppi, 2012), but such an integration is often difficult because of the many public and private stakeholders involved and because of management complexity that makes the process cumbersome and non-transparent. As a consequence, a strong misalignment between SEA and the plan process is frequent (Zoppi, *ibidem*), with a consequent reduction of SEA effectiveness.

Although many National and Regional Authorities in Europe issued guidelines for a more successful implementation of SEA principles (Partidario, 2012; De Montis *et al*, 2014a), some operative steps of SEA still need more detailed definition in order to address such issues as the adoption of more systematic approaches for the identification of alternative future development scenarios, the identification of methodologies to guide collaboration and participation and the documentation of the reasons which lead to the selection of the preferable scenario (Gonzalez et al, 2015). As will be discussed in this chapter, geodesign offers reliable methods and tools to address the issues above, including informed and transparent decision-making, collaborative design alternative creation and assessment, negotiation to achieve consensus on final decisions.

The INSPIRE Directive

Over the last two decades or so, advances in Information and Communication Technologies enabled broader accessibility to digital spatial data (or geographic information) (Aalders and Moellering, 2001) and Spatial Data Infrastructures (SDI) have flourished worldwide.

The European Directive 2007/02/EC aims at supporting informed and responsible decision-making in domains such as spatial planning, environmental protection and economic development, through the creation of an Infrastructure for Spatial InfoRmation in Europe (INSPIRE) for sharing spatial data among public and private bodies, and with the broader public (Craglia and Annoni, 2007). According to the INSPIRE interoperability principles, public authorities in the Member States should collect and give open online access to 34 spatial data themes, including a variety of territorial themes of relevance to planning. Digital data and metadata are created according to common specifications, in order to facilitate the diffusion and seamless integration of geographic information in transboundary contexts.

The key components for INSPIRE implementation are: (i) metadata, for cataloguing data, (ii) spatial data, spatial data services and technologies, (iii) policies, protocols and agreements on sharing and access, (iv) people (i.e. data providers, service providers and users), (v) procedures and standards (Steiniger and Hunter, 2012). Access to data and services is supported by geoportals, geoweb-technologies able to give free public data access to potential users (Maguire and Longley, 2005).

The INSPIRE Directive contributed to a great extent in promoting the diffusion of SDIs in Europe (Campagna and Craglia, 2012), leading to opportunities and benefits for planners, environmental impact assessment analysts, and local administrations primarily at the local and regional level (Craglia and Campagna, 2009). Indeed, improvement of the quality and quantity of available information may positively affect the analysis and the comprehension of urban and environmental phenomena, offering unprecedented opportunities to enhance informed and responsible decision-making. In Italy, as in many other European Countries, several Regions developed their own Regional SDI and some Italian regional planning laws required their use in planning. The Lombardy Regional Territorial Government Law n. 12/2005, for example, recognized the role of such infrastructures as a reference platform supporting spatial planning processes. In Sardinia the Regional SDI is made up of two interacting elements: the Information System for supporting data management, and the Spatial Data Infrastructure (Vandenbroucke, 2011). It currently collects and gives access to more than 500 spatial data layers, including the geographic, historical, urban and environmental themes. Their accessibility is granted by interoperability Open Geospatial Consortium (OGC) services (i.e. download, Web Map Services and Web Feature Services).

Despite the diffusion of SDIs, their value for spatial planning is still limited due to the widespread lack of skills by professionals in applying advanced spatial analysis techniques. As such, in many contexts, spatial data are used at best to produce thematic maps and the planning documents. The advanced use of Geographic Information Systems (GIS) to inform design and support impact assessment is unfortunately still very limited in practice.

GEODESIGN: NEW OPPORTUNITIES FOR THE PLANNING PRACTICE

Geodesign can be defined as the act of design in the geographic space (Artz *et al*.,2010) and represents a new methodological approach to decision-making. It applies system-thinking and it is supported by spatial information systems and science. Such an approach involves the combination of the analysis of the territorial context with the design of planning proposals and their real-time impact simulation (Flaxman 2010; Artz *et al*., 2013), using a synergistic iterative approach which integrates not only environmental issues, but also economic and social concerns (Dangermond, 2010). The performance of alternative scenarios can be visualised not only in the geographic space in form of maps, but also through charts, graphs and reports (Ervin, 2011), facilitating knowledge building and communication. Such techniques support the collaborative creation and assessment of spatial development alternatives and the design of improvement measures iteratively when necessary. Geodesign studies are normally carried out by multidisciplinary teams composed by planners and geographic information systems technologists, experts in natural and social sciences, and the local communities, with the purpose of achieving a holistic view of the different problems which may arise during a planning process, in a mutual learning process. Geodesign, therefore, acts as a design approach informed by sustainable development principles: it involves substantive objectives, such as environmental protection and improvement of quality of life of affected communities; procedural objectives, including the democratic nature of the process and its transparency; and instrumental objectives, such as exploiting the power of digital information and technologies to support informed decision-making.

Steinitz (2012) proposed a methodological framework (a.k.a. the Geodesign Framework, GDF) structured in six models and three iterations, in order to guide the practical implementation of the geodesign approach into regional and urban planning and design studies.

The first three models of the Steinitz' framework describe the current state of the territorial system. In their digital implementation, after an accurate analysis of the study area based on a selected set of relevant spatial data layers (Representation Model), the Process Model investigates the future development scenario of the territorial system without the implementation of any planning action (i.e. *do-nothing*). Afterwards, the ongoing dynamics are considered, in order to evaluate risks of and opportunities for change (Evaluation Model). The evaluation model may integrates technical criteria (e.g. environmental constraint) and political objectives (e.g. development in a given system), influencing the change model in an explicit, transparent and trackable way. The assessment phase is followed by the intervention phase in which, starting from the identification of possible alternative plans for the future (Change Model) and their environmental, economic and social impacts (Impact Model), it is possible to choose a shared development alternative as a result of an assessment of their coherence with the broader set of objectives expressed by the decision makers (Decision Model). This is normally done through negotiation, enabling to reach consensus in the face of multiple - often conflicting- objectives. A complete geodesign study should consist of three iterations: during the first one, which can be considered a scoping phase, models are built from the first to the last in order to identify the purpose of the study; in the second iteration, they are detailed in reverse order with the aim to define how to carry out the study in terms of methods and tools, which can be considered as the metaplanning phase (Campagna, 2014a; 2016). Finally, during the third iteration, models are implemented from the first to the sixth again to complete the study.

In operational terms, the GDF entails a rationale which is coherent with the spatial planning process as it is shaped by the SEA Directive, since it guides the study area analysis to inform the design from the early stage of the strategic decision-making process and keeps up with it in a non-linear way, enriching it through iterations (Campagna *et al.*, 2016). Furthermore, this coherence can be also observed comparing the tight relationships among the contents of the Environmental Report, as listed on the Directive's Annex I, and the structure and outputs of the GDF models (Campagna, 2014b). The key assumption is that the geodesign approach can contribute from an operational point of view to deal with many of the current issues and pitfalls encountered in urban and regional planning practices thus contributing to improve SEA.

In the light of the above premises, the GDF seems capable of introducing a new systematic approach to the spatial planning/SEA process, both in terms of workflows and tools.

In order to explore the similarities and differences between the geodesign approach and current planning practice, two analyses were conducted:

- A comparative analysis between geodesign principles and spatial planning laws (case study: Italy)
- A comparative analysis between geodesign methods and tools and planning practices (case study: Sardinia)

These are described in the next sections.

The GDF Principles in Spatial Planning Laws

While the geodesign proposition as an integrated framework is relatively new, many of its key concepts can be traced back in the planning and landscape architecture tradition. Hence, a number of them can be found in existing planning regulations, though often not in an integrated way. In this section a review of spatial planning laws from three Italian regions (Lombardy, Tuscany and Sardinia), that were considered innovative at the time of their adoption is presented, in order to check to what extent similarities between their content and the GDF key concepts can be found.

The regional regulations analysed include:

- Lombardy Regional Territorial Government Law n. 12/2005
- Tuscany Regional Territorial Government Law n. 1/2005
- Sardinian Regional Spatial Planning Law n. 45/1989 and Sardinian Regional Guidelines for SEA of Local Land-Use Plan (LLUP)

The comparative analysis shows that the Representation Model is one of the GDF models whose concepts and contents are more developed in the body of laws. This is not surprising since for the elaboration of urban plans it is commonly required the definition of the study area boundaries and the collection and analysis of spatial data, with the aim of creating a complete local knowledge base. All the spatial planning laws under analysis specify somehow the territorial analysis contents, including the description of geological and hydrogeological characteristics, the selection of natural and vulnerable sites and the description of historical settlements and mobility infrastructures. In addition, Tuscany and Lombardy laws also establish the creation of a Regional SDI as a common platform to be used for collecting and sharing spatial data among all the stakeholders involved in the planning processes. By contrast, the Sardinian regional law does not refer to any specific data management technology, since the establishment of the Sardinian Regional SDI came later the Regional Law, which dates back to 1989. The latter also requires the identification and analysis of other local legislations affecting the territorial context under analysis, and a coherence analysis between their objectives and the objective of the new plan. However, what was not clearly required is the relation between the Representation Model contents and its connection to the other models as expressed in the GDF and its iterations.

In line with the SEA Directive requirements, in the normative body under exam, the Impact Model is specifically required for the assessment of the potential positive or negative effects resulting from alternative plan designs and the identification of mitigation measures, if needed, in order to guarantee the protection of the territorial and environmental resources. However, the regulations do not refer to methods and tools for the assessment and comparison of impacts. The only exception was found in the Sardinian Regional Guidelines for SEA of Local Land-Use Plans, which suggest the use of tools such as impact matrices and overlay mapping. Still, no requirements on the use of advanced spatial analysis methods and tools was found, demonstrating a low awareness of planning professionals of the latest advances in the field. This is not surprising, given that in the Sardinian context, teaching of GIS methods in the academic planning curricula started only in the middle-2005, and a similar situation is found all over Italy; hence senior professionals who developed the guidelines may not be aware of the latest advances.

The identification of the main vulnerabilities and vocations of the territory or, in other words, the sensitivity of each area to hazard and its suitability for given uses, which can be considered an essential part of the Evaluation Model in the GDF, is only partially treated in planning regulations. Reference was found to the necessity to identify those areas which need to be changed or preserved, and to several functional suitabilities with regard to such objectives as environmental requalification, landscape management or ecological preservation. In addition, in this case only the Sardinian Regional Guidelines suggest a methodology to carry out this study, through the SWOT analysis method, with the aim to identify the strengths, weaknesses, opportunities and risks linked to the characteristics of the analysed territory.

It is not easy to find clear links to specific steps of the Process Model either, possibly because the laws do not provide clear guidance on the methodology to be adopted for the preparation of the plan. The only exceptions are generic references to the need to analyse the likely evolution of the environment before plan implementation, through the analysis of the territorial transformation dynamics. More specifically, the Sardinian Regional Spatial Planning Law proposes the analysis of population projections to estimate the housing demand, as a mandatory step for local land-use plan design, but this is clearly not enough to set change targets for all the systems

The Change Model and the Decision Model are certainly the models whose content is least treated within the body of legislation under analysis. Indeed, with the exception of a few references to the need to design a number of possible alternative scenarios during the preparation of the plan, there are not specified methods neither for their design nor to how to make a choice among them in the light of the objectives specified by decision makers. This can be considered one of the possible reasons why the elaboration of planning alternatives is often lacking in practice, as highlighted both by studies in literature and, as a detailed complement, in the second part of this study.

GD in Planning Practices

In this section, the results of the analysis of selected case studies of Sardinian Local Land-Use Plans and Environmental Reports are presented. The analysis aims at identifying which geodesign-like methods and tools, if any, are currently implemented in the planning practice in Sardinia. In this Italian region, Local Land-Use Plans of coastal municipalities have to be in compliance with the Regional Landscape Plan and the Regional Hydrological Risk Assessment Plan. At the same time they are subject to SEA, according to standard procedures. Despite the process of adaptation of the Local Land-Use Plans to the Regional Landscape Plan is a mandatory step for municipalities, only a few municipalities have completed it to date (less than 10% in 2021) since the Regional Landscape Plan adoption in 2006 (De Montis *et al.*, 2014b).

The analysis revealed that in all the case studies analysed in 2017 during the knowledge base construction, which aims to represent the environmental, economic and urban systems state in the municipality (i.e. Representation Model), the territorial context is represented through a set of cartographic representations often built using Geographic Information Systems, combing digital datasets retrieved from the Sardinian Regional SDI by local authorities. Moreover, a set of eleven environmental standard analysis sheets are always given in order to describe environmental components (e.g. air quality, flora and fauna, mobility, energy) through a set of indicators, as required by the Sardinian Guidelines. In the plan-SEA document, the local normative framework is also analysed by coherence matrices showing the consistency of the plan main objectives with the objectives of other overlapping plans.

The analysis of the territorial dynamics before the implementation of the plan (i.e. Process Model) is mainly carried out through predictive models based on the extrapolation of historical data and trends. In practice, in the case studies under exam the most common analysis is a forecast model of the socio-demographic dynamics, which enables the assessment of future housing demand within the municipal boundaries. Some case studies also integrate the quantitative population forecasting with spatial analyses describing processes geographically, in form of thematic maps or reports, depicting phenomena like soil erosion and traffic flows, or a specific hazard occurrence (e.g. landslide risk and potential instability of slopes), as required by the Regional Hydrological Risk Assessment Plan. In spite of all this, the Process Models cannot be considered much developed because not all the main system dynamics within the territory are always analysed systematically.

The assessment of the current territorial conditions (i.e. Evaluation Model) is often carried out through a SWOT analysis, which allows identifying possible Strengths, Weaknesses, Opportunities and Threats of the municipal area in form of textual tables or reports. Seldom, this analysis is supported by maps representing land suitability for selected individual land-uses (e.g. farming or breeding).

Despite the design of alternative development scenarios (i.e. Change Model) represents a key step for a robust SEA process, as required by the European Directive and the Sardinian Regional Guidelines, and as suggested by the technical literature (Partidário, 2012), the formulation of future alternative possible land use scenarios is mostly omitted. Only in a few case studies among those analysed, two plan alternatives are given, including the do-nothing alternative and the final plan. This can be considered a major methodological shortcoming in a SEA process implementation, which generates difficulties in the understanding of how the decision-making process is informed on the basis of the context analysis results.

Usually, also the next two models of the GDF are only partially implemented. Indeed, the aim of the Impact Model is to identify and evaluate the environmental impacts resulting from alternative plan choices, in order to identify the preferred one during the decision phase (i.e. Decision Model). While in all case studies impact assessment analyses are found as required by law, they only address the unique plan alternative, in order to identify its possible negative effects which need to be mitigated. Therefore, the comparison of the environmental impacts of different alternatives is always missing. The results of the impact analysis are usually reported in the form of impact matrices, showing on x-axis the plan actions and on y-axis the environmental components (e.g. air, water, soil). Checklists and indicators showing the expected change of some indicators values as a result of plan choices are also used (e.g. increase of air pollution or energy consumption). Only in few cases are these considerations represented in the geographic space through the overlap of the planned land uses and specific sensitive areas (e.g. protected areas). No reference to the use of advanced spatial analysis for impact assessment was found in any of the case studies analysed.

To summarize, this analysis identified several elements which may recall a geodesign methodological approach. However, not all the environmental analyses, as well as the representation of their results, are modelled in the geographic space as suggested by the geodesign approach. In addition, often analyses and evaluations are implemented in a comprehensive manner, lacking to address the complexity of territorial systems.

If the first phase of our study highlights several existing elements of coherence as well as shortcomings between the GDF models and the main normative principles of selected planning regulations from a theoretical perspective, the second phase identifies the methods and tools relating to a geodesign approach already in use in current planning practices. Such an analysis enabled to identify the potential for geodesign application to improve the practices, but also the current difficulties hindering it. On these premises, it is possible to try to fill the gap with a more advanced application of geodesign principles, methods and tools. The following section presents applied examples in this direction, thanks to the development and application of (geodesign) Planning Support Systems.

PLANNING SUPPORT SYSTEMS IN GEODESIGN PRACTICE

While Planning Support Systems have been proposed since the late 1980s to enable novel models of digital planning, their diffusion up until now has been rather limited in practice considering their potential.

Spatial planning encompasses a range of complex procedures in the attempt to manage territorial system dynamics according to development strategies (Couclelis, 2005). In addition, as Te Brömmelstroet and Schrijnen (2010) argued, the intrinsic complexity of planning processes is affected at the urban and regional level both by the increasing number of actors involved in the process and by their contrasting planning goals that evolve across different spatial scales. In such a context, advances of Information technologies (IT) and computer-aided planning, such as Geographic Information Systems, may help to generate innovative solutions for dealing with this complexity (Te Brömmelstroet *et al., ibidem*). However, despite a certain degree of diffusion of GIS and PSS among planners and practitioners, their efficacy in practice is still limited (Klosterman, 1999; Vonk *et al.*, 2008).

The idea of leveraging planning procedures with technological innovations is not new. In 1989 Harris (1989) gave an early definition of the concept of Planning Support Systems as an integrated system for supporting the planning tasks, coupling a range of digital models and computer-based methods. More operatively PSS were originally conceived as “a user-friendly microcomputer-based planning system, which integrates GIS, sketch tools and spatial models” (Harris, *ibidem*), aiming at dealing with the complexity of planning procedures, so helping to filling the gap in the integration of geo-technologies in planning practices (Geertman and Stillwell, 2004).

A PSS generally gives access to a range of geo-tools through a user friendly interface, in order to support the representation and management of spatial data (e.g. visualization tools), its analysis, to run simulation and forecasts, to design plan alternatives and to assess their impacts on the environment. Many PSS give the possibility to compare alternative scenarios in order to improve the collaboration among experts from different disciplines and the negotiation procedures among stakeholders, in order to produce consensus on design solutions in accordance with the complex system of planning goals. In addition, many PSS also offer reporting tools to present the results of the plan-making phases, supporting the transparent sharing of information about the process and its outputs.

Despite the potential of many existing PSS, their successful integration into planning practices seems to be far from realised (Geertman and Stillwell, *ibidem*; Vonk *et al.*, 2005). Pitfalls in PSS use are related both to the frequently poor flexibility of the PSS addressing different planning processes (Campagna *et al.*, 2006) and their high degree of complexity (Brömmelstroet, 2013).

These problems represent a barrier for the integration of PSS into practices, producing a cause-effect loop that generates a lack of knowledge in the planners community regarding their potential, with a consequent additional underuse of PSS in practice (Vonk, 2006). In an attempt to fill the gap between the planners need for technological support and the available innovations, in the last decades research on PSS produced a range of applications. The most successful examples are software suites such as CommunityViz (Placeways™), What If? (What if? ™) and INDEX (Criterion Planners™).

Among them, the CommunityViz architecture encloses a range of user-friendly dynamic tools to support the implementation of Land Suitability Analysis (LSA), sketch planning, real-time impact assessment through dynamic dashboards, and the comparison of different scenarios with automatic production of reports. These tools were tested by the authors in a workshop aimed at measuring their usability in a planning context that traditionally has a poor level of digital uptake, such as that described in the next section.

GEODESIGN AND PLANNING SUPPORT SYSTEMS: OPERATIONALIZING GEODESIGN TWIGS

A planning process from a geodesign perspective may be seen as an integrated study aimed at reaching consensus on how to improve a territorial system through changes. Although it is grounded on local values and decision models unique in their complexity and locality, a range of methods and tools can be identified which can find broad application in the development of the six models of Steinitz' framework.

In this section, the authors present a practical example on how they integrate a selection of methods in a PSS, aiming at implementing the geodesign methodological approach in a case study of Local Land-Use Planning in Gonnesa (Italy). The main goal of the study was to investigate, through a workshop, how such a PSS could support planners digital-wise during the decision-making process. The following paragraphs describe the technology in action with reference to the six geodesign framework models. Afterwards the results of the technology testing are discussed.

The Representation Model

As mentioned above, the purpose of the Representation model is to represent and visualise the study area from the perspective of the people of the place as this is encoded in the decision model aiming at facilitating them to develop a deeper understanding of the territorial dynamics. Several means can be used for this purpose: from traditional paper maps, which depict static territorial phenomena in a specific moment, to spatio-temporal GIS databases, which enable the interactive visualization of territorial dynamics. Techniques for representing the territory are continuously evolving (Kerski, 2013); nowadays, web-mapping tools allow merging GIS capabilities with user-friendly web interfaces, improving the efficiency of geographic information sharing within collaborative planning processes. This approach to data representation is an intrinsic characteristic of the web-based PSS developed in the Gonnesa case study for communicating and analysing spatial data during the Representation and Process Models development. The web-PSS was developed using ESRI technology (i.e. Story Map and the Web-App builder). It enables to describe and analyse the territorial context through the support of maps and interactive tools.

This web-PSS (Figure 1) can be considered as a local geoportal that creates a wide range of thematic maps combining a variety of spatial datasets retrieved from the regional SDI or from the local municipality. Each thematic map can be complemented by relevant documents and can be progressively enriched with new data, providing increasingly accurate and complete information. The Web-PSS represents the complexity of the territory in a user-friendly way and allows to perform queries or simple spatial analysis operations through automatic pop-up windows. During the workshop, the thematic maps were made available on the internet site of the Gonnesa Municipality, and used by the workshop participants as well as by other interested citizens.

The web-PSS allows managing the spatial information from different sources on a single platform, facilitating its readability by the interested citizens.

Figure 1. User-friendly representation of geospatial data during the plan-making process

While the adopted technologies are not new, their integrated use represents a viable example to give the Representation Model broader access to the involved parties and the broader public.

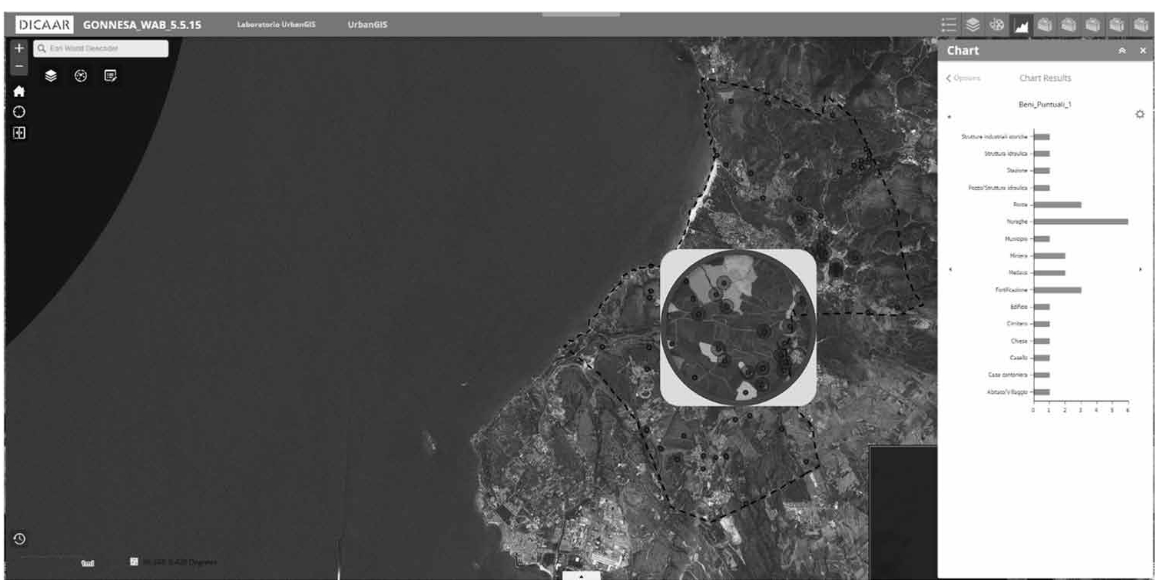
The Process Model

The Process Model aims at improving the comprehension of environmental and urban processes, investigating territorial dynamics through a range of methods and analyses, such as simple overlay or geoprocessing.

To this end, analytical functions were integrated in the Web-PSS, enabling users to combine different environmental (e.g. protected areas, natural landscape, hydrogeological hazards) and urban data (e.g. land-uses, roads network, historical goods) and to perform queries and spatial analyses on specific issues of interest (e.g. the number of historic sites in a given area) or to compare interactively different data themes. Besides offering geoprocessing functionalities, the Web-PSS displays spatial indicators dynamically calculated (Figure 2). The users can also turn on/off the layers and combine and analyse all or part of them in an easy way, with the aim of producing maps which represent individual phenomena or a combination of them. The interpretation of these phenomena helps participants to improve their awareness of the urban and environmental characteristics of the territory and formulate appropriate and informed strategies during the Change Model.

Indeed, the Web-PSS proved to reduce the difficulty of spatial data representation and sharing and made information available in a more systematic manner, as declared by the participants in the post-workshop survey.

Figure 2. The web-PSS supporting spatial indicator calculation



The Evaluation Model

The aim of the Evaluation Model is to assign a value to the current dynamics in order to recognise strengths and weaknesses of territorial resources and, subsequently, possible opportunities related to the economic, social and/or environmental change. The construction of the Evaluation Model entails the use of a wide range of geo-tools nested in a PSS.

To this end, a customized desktop PSS based on the CommunityViz software enables to build a tool for interactive Land Suitability Analysis (LSA), which was used to dynamically identify the areas suitable for given land uses, in accordance with a chosen set of criteria. More specifically, the LSA operates through two categories of parameters: constraints and factors. A constraint is a Boolean spatial criterion which represents a specific urban/environmental phenomenon that can be considered or not in the analysis (e.g. hydrogeological hazard areas, protected areas), while a factor is a spatial criterion that may assume different weights in the evaluation process according to its relevance (e.g. proximity to main roads, or the slope). When in the PSS a constraint is switched on/off or the weight of a parameter is changed through sliders, it produces a real time response on the evaluation maps and the suitability rate of the different locations for change. In the workshop, this interactive evaluation process fed a discussion about the significance of each parameter affecting the planning goal, promoting a constructive exchange of views among stakeholders with different priorities.

The results of the analysis are depicted in a map in grayscale, where the darker colours represent the most suitable areas and the lighter colours the least suitable one. Such an analysis often requires a large number of parameters and for this reason a GIS-based LSA helps planners to deal with the intrinsic complexity of spatial phenomena in a simpler way (Malczewski, 2004).

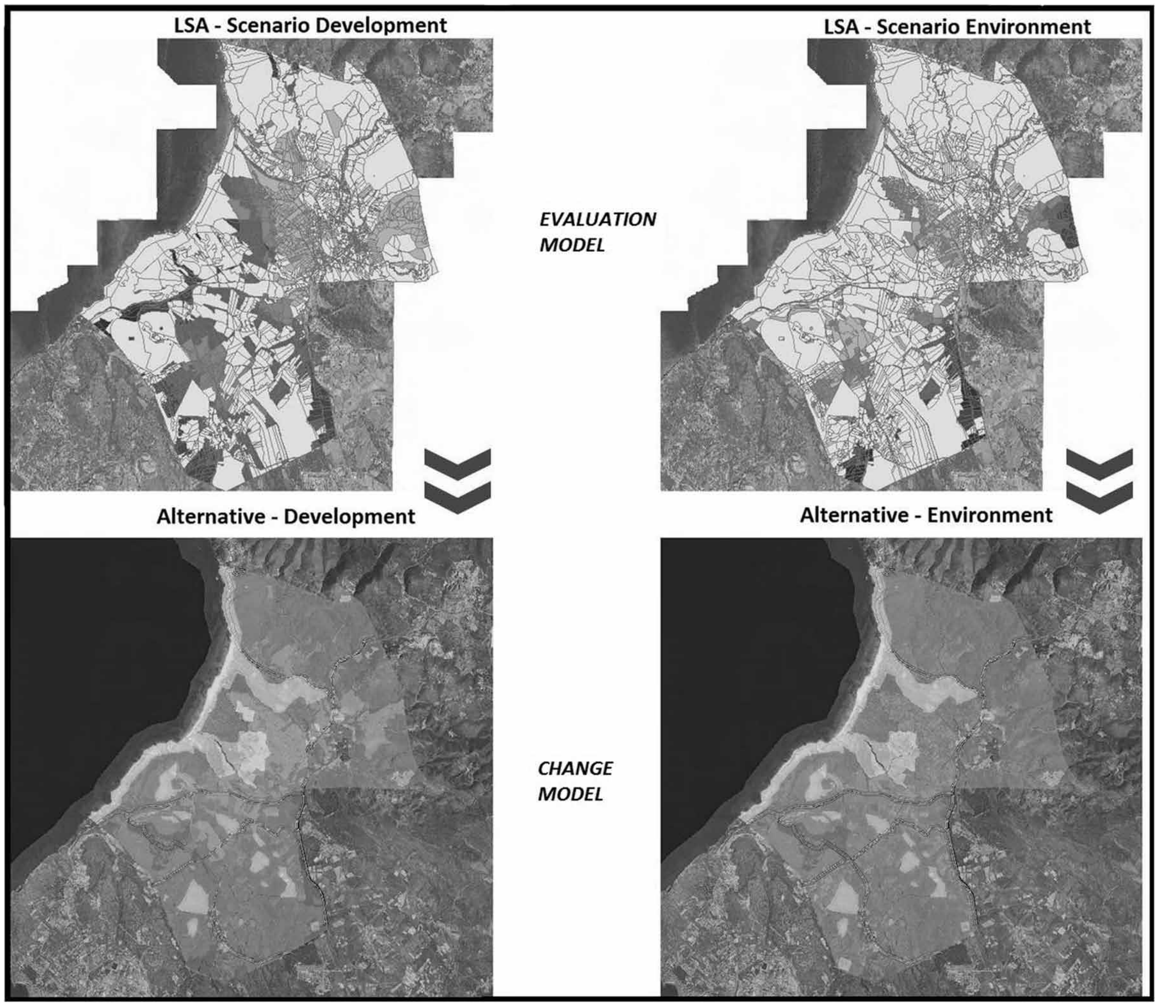
The output of these discussions is a set of evaluation maps (Figure 3) which, representing the most suitable areas for specific land uses, represents the input for the design activities and inform decision-making by collaborative discussion.

The Change Model

In order to investigate how the territorial context may be changed, the PSS uses a sketch planning tool, for altering the study area and visualising these changes in the geographic space in real time. This way, it simplifies the evaluation of their consequences (Heppenstall *at al.*, 2001) for supporting the decision-making process (Harris, 2001).

Indeed, the sketch planning tool gives the users the possibility to interactively sketch on a screen, using a digital pen, a set of planning proposals for a specific planning purpose, related both to their own conceptual ideas of future territorial developments (Al-Kodmany, 2002) and to the information coming from the analysis and evaluation of the territorial context. Despite sketch planning is considered an easy-to-use geo-tool, the successful integration into planning practices is influenced by different issues (Al-Kodmany, *ibidem*) such as its tendency to centralize the design activities around a single person in contrast to collaborative processes principles (Ligtenberg *et al*, 201). For this reason, this tool needs to be supported by innovative methods and instruments. In a planning process each designed alternative may represent the proposal of a different stakeholder (or a group of them) with different system of values and interests. This representation method gives the stakeholders the opportunity to compare and edit their own proposal and finally discuss for the most suitable solution to reach the overall agreed planning goals.

Figure 3. The evaluation maps produced through the LSA feeds the sketch planning tool

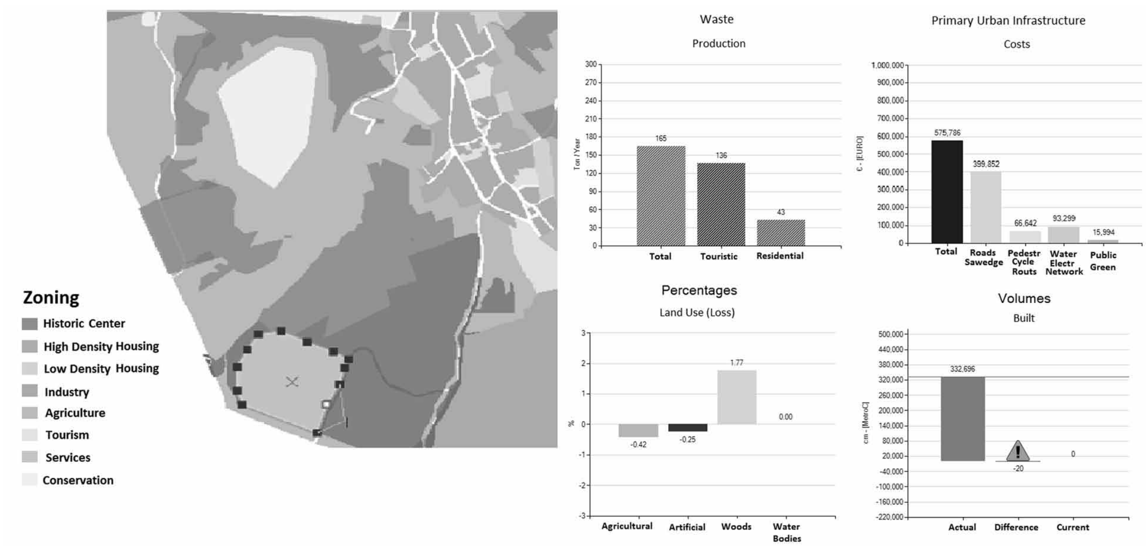


The Impact Model

The Impact Model is used to evaluate the possible impacts of the designed scenarios on the environment and, within the PSS, it operates through dynamic spatial indicators organised on a digital dashboard. The strengthened role of indicators for communicating complex information in an easy way is well-known in the scientific literature (Hammond et al, 1995; Smeets and Wetering, 1999; Niemeijer and de Groot, 2008). The spatial indicators may represent spatial or non-spatial data and may be static or dynamic values related to strategic domains, such as environment, economy or energy. Planners can also change a specific scenario in an effort to improve the performance of a planning solution. In the Local Land-Use Plan case study, in the hypothesis of locating new tourist areas, the indicators represented the impact on natural or anthropic systems (e.g. loss of natural landscapes, environmental resource consumption, costs to support new urbanization services) and their value changed in real-time on the basis of the sketched planning solution. Furthermore, the indicators are linked together in a network integrated in the PSS so that, if a design alterative is edited, the spatial indicators linked with that specific design change. If the planner reduces the size of a touristic area, the number of inhabitants and their consumptions change automatically, as well as the economic costs and the loss of natural values (Figure 4). This process is based on the concept of causal chain, according to which, each operation feeds back the others in a cycle, linking the components in a framework.

During the test workshop the impact model was able to assess the design choices in real time, contributing to the generation of alternatives in accordance with both the planning goals and the sustainable environmental resource consumption.

Figure 4. Real time sketch planning and impact assessment



The Decision Model

In order to facilitate the final decision, the PSS supported the comparison of both the maps of design alternatives and their impact indicators. Scenarios could be compared with the aim of evaluating the influence of different alternatives on the environment. Given that a scenario may positively affect certain systems and may have negative effects on others, the comparison tool showed the stakeholders the impacts of their design choices fostering collaboration. Planners, during the negotiation phase, could edit scenarios in order to generate a final decision which achieve the planning goal with regard to sustainable resource consumption. Furthermore, the final decision can be accompanied by the production of reports, which include maps, documents and indicators, which can be used to enhance the transparency of the decision-making process.

The PSS described above was tested in a planning study conducted in the municipality of Gonnesa (Sardinia), during an experimental workshop carried out by the authors, with the purpose of investigating how it may support planners in a decision-making process. The case study concerned the process of adaptation of the Gonnesa Local Land-Use Plan to the Sardinian Regional Landscape Plan. The goal of the workshop, organised in collaboration with the local administration through a set of preliminary meetings and interviews, was to identify the most suitable area to assign to new tourism development.

A range of participants such as planners, local administrators, researchers and other professionals, was selected to contribute to the workshop activities, which were based on the experiential learning cycle of Kolb and Fry (1974). They were asked to analyse the territorial characteristics through the web-PSS (i.e. Representation and Process models) and, in the context of the Evaluation Model phase, to discuss about criteria and weights that could be dynamically changed through sliders, producing a real time feedback as suitability maps. The output of this discussion was a set of two evaluation maps corresponding to two different development scenarios: the "environmental protection oriented map" which gives the highest priority to the locations not compromising natural protected areas, and the "development-oriented map" which gives the highest priority to proximity to roads and services. The two evaluation maps represented the input for the design activities carried out during the next workshop phase, in which users were called to sketch a set of planning proposals on an interactive screen by a digital pen (i.e. Change Model). Thereafter, the impact of every different scenario on the environment (i.e. Impact Model) was assessed interactively with the digital dynamic dashboard through a range of spatial indicators changing real-time on the basis of the sketched planning solutions.

The workshop users were finally asked to discuss the reasons for their design choices, comparing the impacts of each solution on the environment. This procedure generated a collaborative process, in which the users provided their own contributions according to their own expertise and their role in the decision-making process. After the discussion phase, a negotiation among the users allowed them to edit their design solutions and eventually reach a shared final scenario fitting the needs of the local authority to develop the tourism sector while taking into consideration sustainable environmental resource consumption (i.e. Decision Model).

The workshop represented an endeavour to fill the gap between research and planning practices, with the aim of integrating innovations in Local Land-Use Planning. It contributed to investigate how the PSS architecture enabled, on the one hand, to support planners for dealing with the range of planning tasks related to SEA and Planning and, on the other hand, to demonstrate a possible viable way for integrating geodesign workflows in planning process, as synthetized in Table 1.

These results show possible ways to improve single planning tasks within the plan-making-SEA process. It is worth noting that other tools can be used to implement the workflow described above. Notably, the ESRI ArcGis GeoPlanner web-based PSS enables the interactive development of evaluation maps, sketch-design, and dynamic impact indicators dashboard creation.

In the next section, the geodesign workshop with Geodesignhub is presented to demonstrate how the dynamic workflows can successfully enable, by the use of digital data and technology, to contribute to develop design alternatives expressing different sets of values, to assess their performance iteratively, and to support negotiations towards consensus while monitoring the process unfolding. All these analyses can be considered essential requirements of the SEA, and are currently poorly addressed in the planning practice.

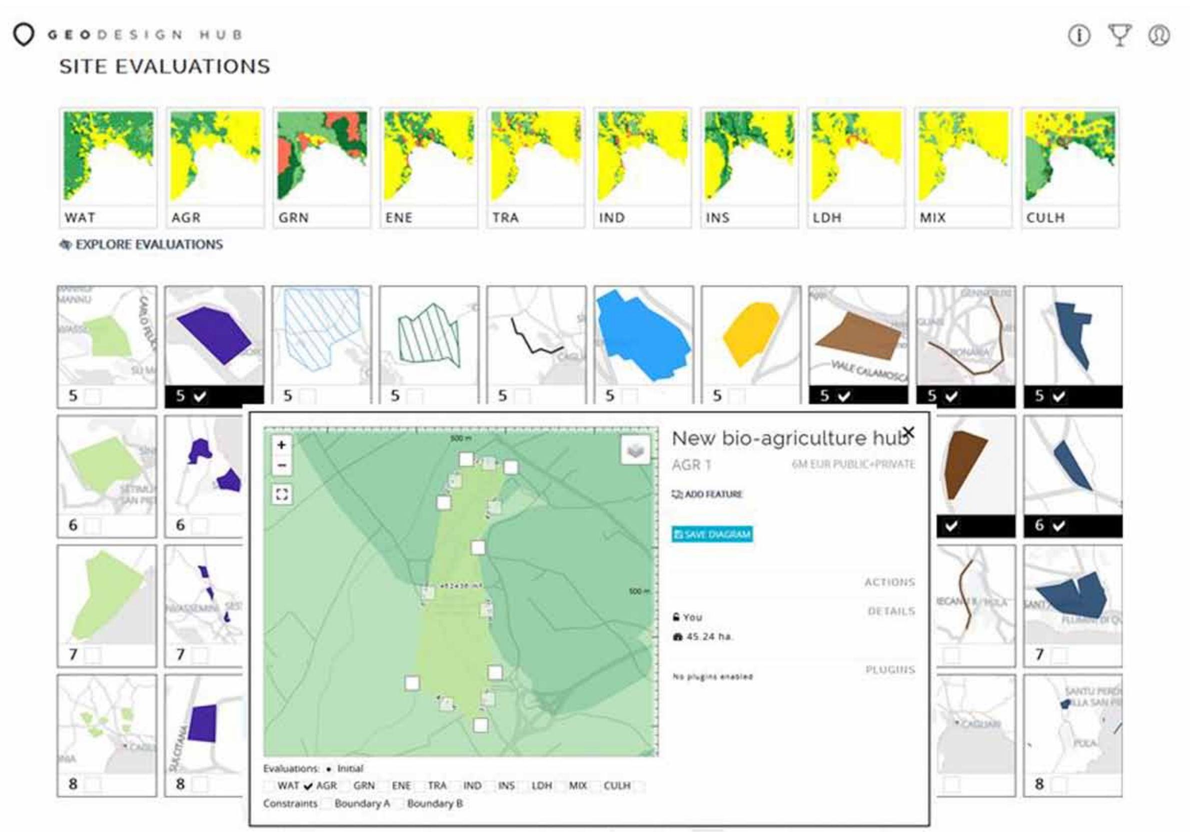
Table 1. Relationships between Environmental Report contents (ex Annex I of Directive 2001/42/EC), the geodesign framework models and the PSS features

Environmental Report	Geodesign Framework	PSS features
(b) the relevant aspects of the current state of the environment […]; (c) the environmental characteristics of areas likely to be significantly affected; (e) the environmental protection objectives, established at international, Community or Member State level, which are relevant to the plan or programme […];	Representation Model	web-based PSS: web-mapping tools, merging GIS capabilities with easy-to-use Web-interfaces, for representing the complexity of the territory.
(b) the relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme; d) any existing environmental problems which are relevant to the plan or programme including, in particular, those relating to any areas of a particular environmental importance, such as areas designated pursuant to Directives 79/409/EEC and 92/43/EEC;	Process Model	web-based PSS: web-analysis tools for interactively combining and comparing different data themes and for performing queries and spatial analyses on specific issues of interest.
(f) the likely significant effects on the environment, including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors;	Evaluation Model	Desktop PSS: Land Suitability Analysis for dynamically identifying the areas suitable for given land uses, in accordance with a chosen set of criteria.
(e) the environmental protection objectives, established at international, Community or Member State level, which are relevant to the plan or programme and the way those objectives and any environmental considerations have been taken into account during its preparation; (g) the measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme;	Change Model	Desktop PSS: real time sketch planning tool for altering the study area and visualising the alternative designs in the geographic space.
(f) the likely significant effects on the environment, including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors;	Impact Model	Desktop PSS: spatial impact indicators on a digital dashboard for evaluating the possible impacts of the designed alternatives on the environment.
(h) an outline of the reasons for selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information;	Decision Model	Desktop PSS: scenario comparison tool for assessing the influence of different alternatives on the environment in order to support a final decision.

GEODESIGN WORKSHOPS

Several recent studies which addressed more specifically the relationships between the Evaluation, Change, Impact, and Decision Models (Rivero *et al*, 2015; Nyerges *et al, 2016;* Campagna et al, 2016, Pettit et al, 2019)were recently developed relying on the novel Geodesignhub PSS (www.geodesignhub.com). Geodesignhub is a web-based PSS which was originally developed (Ballal, 2015) to implement the Steinitz framework for geodesign (Steinitz, 2012). It supports collaborative design by taking as input evaluation maps externally developed with GIS software, which are used as informative base to crowd-source projects and policies as geographic diagrams by a potentially unlimited number of workshop participants (Fig. 5). Using the system evaluation maps allows to inform locational choices for design in order to avoid negative impacts and select best locations for projects and policies.

Figure 5. Projects and policies crowdsourcing with geodesignhub



Individual project and policies diagrams are shared among participants and then available for selection by teams with diverse interests and objectives to compose complex integrated design, or *syntheses*. Syntheses are assessed for further impacts dynamically in real-time, so that the impact model can support their iterative improvement. The syntheses of the different teams represent alternatives design proposals, which can be compared with the support of performance and impact indicators, and mediated toward consensus through negotiation. In fact, Geodesignhub offers a set of reliable tools to support negotiation. Furthermore, Geodesignhub was built with interoperability standard technology, so that external models can be linked via API.

Geodesign workshops with Geodesignhub are particularly effective in supporting collaborative strategic planning for they allow collaboration among a wide number of stake-holders in a reasonably short time (i.e. normally a workshop last between 12 and 15 hours). Furthermore, the Geodesignhub interface is user-friendly, enabling the seamless participation of participants with little or no technical background and skills. Regular post-workshop satisfaction surveys run by the authors in several research, teaching, and planning practice case studies confirmed a high level of satisfaction by workshop participants.

- The major advantages of using geodesign workshops in the SEA-planning process can be summarized as follows:Planning alternatives are generated on the base of explicit and transparent evaluation, impact, and decision models;

- Final decisions are made through informed negotiation towards consensus;
- Planning alternatives are iteratively improved with the support of the impact model;
- A high number of stakeholders can take part to the design, enriching the consultation with the possibility for them to directly contribute to the final design;
- Design results are immediately available for further processing and reporting, improving design evolution traceability and transparency.

Last, but not least, the latest experiences by the authors in coordinating geodesign workshops with Geodesignhub in real world planning process at the time of COVID-19 pandemic, proved workshops can be effectively run fully digital (i.e. using Geodesignhub in combination with a virtual conferencing platform such as Zoom) simplifying organization and logistic and facilitating wider participation.

CONCLUSION

Notwithstanding the introduction of Strategic Environmental Assessment and the growing availability of Spatial Data Infrastructure in Europe, contemporary planning practice often shows difficulties in up-taking their innovation potential. The geodesign approach may offer the missing methods and tools needed to address some of the most critical parts of the planning process which often determine the failure of a correct SEA application.

The analyses of current practices in Sardinia and in Italy shows that the adoption of the digital media as a base for plan-making is still very limited. A similar situation may be expected in many other regions in Europe looking at existing literature. In the best cases, spatial data and GIS are used to create maps, and very seldom advanced spatial analyses techniques are used to support environmental savvy informed design and decision-making in SEA-based planning. Likewise, very seldom digital communication technology are used to support collaboration and participation.

However, as it happened in the past in other periods, we are now living a wave of progress due to rapid advances in Information Communication Technology, and this may represent an opportunity to bring innovation in spatial planning and design further. While geodesign techniques can in principle be applied without computer support, the use of digital data and technology can bring new dynamics in the analysis, the design, the impact assessment, and the decision-making steps of planning processes. Currently, unlike in the past, this opportunity appear more mature and should not be missed. The growing interest by academia in the use of new technology in planning research, and in the education of the future (digital native) planners, will possibly, eventually, enable to cope with many challenges which were abandoned at time in the past, such as the use of advanced operational models, visualization tools, and planning support systems towards more sustainable planning as auspicated in Agenda 21.

With this chapter, the authors aim at giving a contribution in explaining the relationships among normative, methodology, and technology frameworks and the planning process in practice. The proposed case studies, if may show only a possible way to bridge the existing gap, may also contribute to demonstrate the feasibility of the geodesign approach and its potential to address some of the most critical SEA pitfall in planning.

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