Chapter 5 Spatial Planning and Geodesign

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1 Geodesign: Short History, Fast Diffusion

While the term 'geodesign' was occasionally used earlier by some scholars with fairly different meanings, its current concept is due to the scientific debate originating in a series of meetings held in California in the early 2000s. A first workshop on 'Landscape Change', funded by the National Science Foundation and by the Environmental Systems Research Institute (Esri), was held in 2001 in Santa Barbara, California, when a group of scholars in Landscape Architecture and Planning, and in GIScience (http://www.ncgia.ucsb.edu/landscape/landscape.htm) started a new debate on how to bridge the gap between the design professions and GIScience (Goodchild, 2010; Wilson, 2015). Later in 2008, a second workshop on 'Spatial Concepts in GIS and Design' was held, again in Santa Barbara (http://www.ncgia.ucsb.edu/projects/scdg/), by the same core group of specialists interested in investigating to what extent the fundamental spatial concepts that lie behind geographical information systems (GIS) were relevant in design.

Since the first meetings, where leading scholars from landscape, urban and regional planning and GIScience met together with Esri, the major player of the GIS industry, the term has been occasionally used as a marketing buzzword in the GIS business world. Nevertheless, the work of the original group of scholars attracted the attention of a constantly growing and active community of researchers, educators and professionals in spatial planning. In the last decade, every year regular summits and conferences on geodesign were held in the USA (www.geodesignsummit.com) and Europe (http://www.digital-la.de) and occasionally in Asia and Latin America, bringing together GIS and design experts and practitioners from academia, government agencies and non-governmental organisations (NGOs), as well as the private sector, with numbers usually exceeding 100 participants or more from across a wide range of disciplines. In addition, the term geodesign started to appear in the thematic tracks of major international planning conferences and events, such as the annual meeting of the Association of European Schools of planning (Silva and Campagna, 2016) demonstrating the rapid diffusion of the approach. Beside the growing interest by researchers and practitioners, geodesign quickly became the major subject of new academic curricula in the USA (Foster, 2013) and to a lesser degree to date, in Europe (Campagna, 2017).

Geodesign literature is also fast-growing, with 118 papers indexed in Scopus since 2014, and an actual positive trend. Most notably, in 2016, a special issue on geodesign was published by the *Landscape and Urban Planning* journal (Steiner and Shearer, 2016), documenting some of the most actual research issues and advances in the domain. The book publishing world also features several titles, among which *"A Framework for Geodesign: Changing Geography by Design*" by Carl Steinitz (2012) – originally published by Esri Press and currently translated in Japanese, Spanish, Portuguese and Italian – represents a major methodology reference for the approach. In 2017, the term geodesign was included in the International "*Encyclopedia of Geography: People, the Earth, Environment and Technology"* thanks to the contribution by Fisher (2017).

Several definitions of geodesign have been given. Among the earliest and more popular ones, Michael Flaxman at the Geodesign Summit 2010 defined geodesign as *"a design and planning method which tightly couples the creation of design proposals with impact simulations informed by geographic contexts".* More broadly, geodesign can be defined as a novel approach to spatial planning and design which includes project conceptualization, analysis, simulation, design of alternatives, evaluation and impact assessment, decision making, negotiation, stakeholder participation and collaboration (among other stages) within an integrated process.

Geodesign applies system thinking aimed at ensuring, as in environmental planning, the sustainability of territorial development processes at all scales. Its main novelty lies in offering both (i) methods, and (ii) enabling technologies, for making the relationships between knowledge building, design and decision making explicit, organized and transparent. As such, in principle, geodesign has the potential to contribute to address many of the current pitfalls of contemporary planning practice, but at the same time raises questions on its effective applicability in solving current complex sustainable development challenges. As an open and flexible planning and design approach, grounded in the extensive use of information technology, and thanks to its growing popularity, geodesign has the potential to become a new umbrella term to cover many if not most of the issues relating to the use of information communication technologies (ICTs) in planning.

From the planning support system (PSS) research perspective, on the one hand, geodesign may offer the underlying methodology often missing in existing fragmented workflows and tools; while on the other hand, its attempt to handle the complexity of the whole design process may pose new challenges to PSS design and implementation. So far, a mixed approach, where GIS, spatial models and visualization tools would be coupled into integrated PSS, enabling the implementation of complex workflows within the planning process, seems to be the most appropriate, thanks also to current advances in geospatial technology interoperability. In this sense, geodesign contributes a reliable framework for organizing and coordinating the planning processes by meta-planning; that is the design of the planning process (Campagna, 2016). This approach may contribute to guide the seamless integration of ICT tools supporting the interrelated process activities and tasks in more effective PSS accordingly.

With this premise, the core of the Steinitz's framework is used in the next sections to review the main families of digital tools required to support the different parts of a geodesign study, while the last section discusses to what extent so far it has been demonstrated to be effective in terms of implications for day-to-day planning practice, in what sense it may provide added value to current practices, and under what circumstances.

2 Geodesign: Methods and Technologies

Spatial planning scholars have long been using diagrams and workflows to model planning processes as series of interrelated activities or tasks, with different levels of detail, from the overall high-level process description by macro activities, to the detailed geoprocessing workflows definition to implement geospatial analyses and models. Carl Steinitz, in his 2012 book, included the use of diagrams with several chapters to give a comprehensive and general methodology framework to support the organization of a geodesign study, or, likewise, of planning and design processes.

Such a kind of framework describing the core of the process in terms of activities, actors, products, sequences and their relationships may offer not only a meta-planning tool to design new processes (Campagna, 2016), but also a grid through which to analyze existing processes, or some of their specific aspects. In this sense, elsewhere the author has used the Steinitz' geodesign framework to analyze the completeness of content of Italian regional ditto regulations (Campagna and Di Cesare, 2016) and of local land-use plans (Campagna *et al.,* 2018) with regards to the Strategic Environmental Assessment principles and guidelines (Directive 2001/42/EU). In the remainder of this chapter, the framework is used as a grid to review the current opportunities for the application of PSS and tools in spatial planning according to a geodesign approach.

In order to find relevant elements to devise families of technologies and tools to build PSS, we can refer at the evolution of PSS definitions, starting from the high-level concepts of the earlier definitions, and then refinements with those which take on board the most recent results of PSS research and the consequent evolution of scholarly PSS.

In general terms, a PSS was originally conceived as an architecture for coupling a range of computer-based methods and models into an integrated system for supporting the planning functions (Harris, 1989). This is a first main definition that distinguishes PSS from general purpose GIS or spatial decision support systems (SDSS) which may be of use in some very specific and detailed technical planning task (Geertman and Stillwell, 2004). Indeed, PSS should aid planners in planning activities seen as part of complex analysis, design and decision-making processes (Campagna, 2016), rather than only on specific data-processing workflows. In 1999, Klosterman's definition of PSS highlights three main technology components of a PSS: GIS; operational models; and (geovisualization tools. These indeed would enable the support of (geo)computation and visualization of spatial (and aspatial) and temporal data in many recurring tasks in spatial planning and design workflows.

If we look at the geodesign framework though, in terms of data and information requirements for its application to real-world studies, another important dimension is still somewhat missing: that is community's preferences and values. This is where spatial multi-criteria analysis (SMCA) methods and tools come into play as a necessary way to carry on analyses. Last but not least, Geertman and Stillwell (2009, p.3) define a PSS as *"a combination of planning-related theory, data, information, knowledge, methods and instruments that take the form of an integrated framework with a shared graphical user interface"*. The acknowledgement of theories (and methods) and interfaces adds to PSS further technology requirements concerning workflows modelling (and management) and system interfaces. The latter should be also seen in relation to the main type of activities planners do; they are related to three main planning languages – verbal, graphical and numerical; to the main categories of actions such as analysis and design, collaboration, communication, decision, negotiation; and to the main categories of actors such as professionals and experts, decision makers, stakeholders, and in some cases, citizens and members of the local community.

On the basis of these premises, a brief overview of the relationships between geodesign and technology is given below: the geodesign framework represents the method, which supports the definition of processes and workflows, where GIS, models, SMCA and interfaces are considered as the main technology categories which can be coupled within integrated PSS. In general terms, GIS can be regarded as general-purpose systems, comprising tools for handling geo-referenced data, applicable for a wide diversity of technical tasks and for solving spatial problems (Geertman and Stillwell, 2004). Thus, GIS can be considered relevant and effective when spatial data management – calculation and visualization – is the main task at hand. Models come into play, when time is a dimension of concern, such as in simulation and forecasting. SMCA is required when dealing with preferences and values (in space and time). Interfaces are the means of connection of technology components and the users.

In addition, it should be noted that community preferences and values are usually not recorded in official spatial datasets. However, current advances in web and mobile spatially-enabled technologies may help to address this limitation, and social media platforms may help to generate data with space and time references useful for earning insights about community preferences, values and behaviours, as often happens in (social) volunteered geography. Thus, emerging social media technologies can become useful tools to be integrated in PSS.

According to Steinitz (2012) a geodesign study should include the iterative development of six models, namely the representation, process and evaluation models in the process assessment phase of knowledge building, and the change, impact, decision models in the intervention phase, when design alternatives are generated, assessed against possible impacts, and a final decision is made (A and B in Figure 1). The workflow should include three iterations: the study scoping; the detailed definition of the process (meta-planning); and the implementation of the planning study.

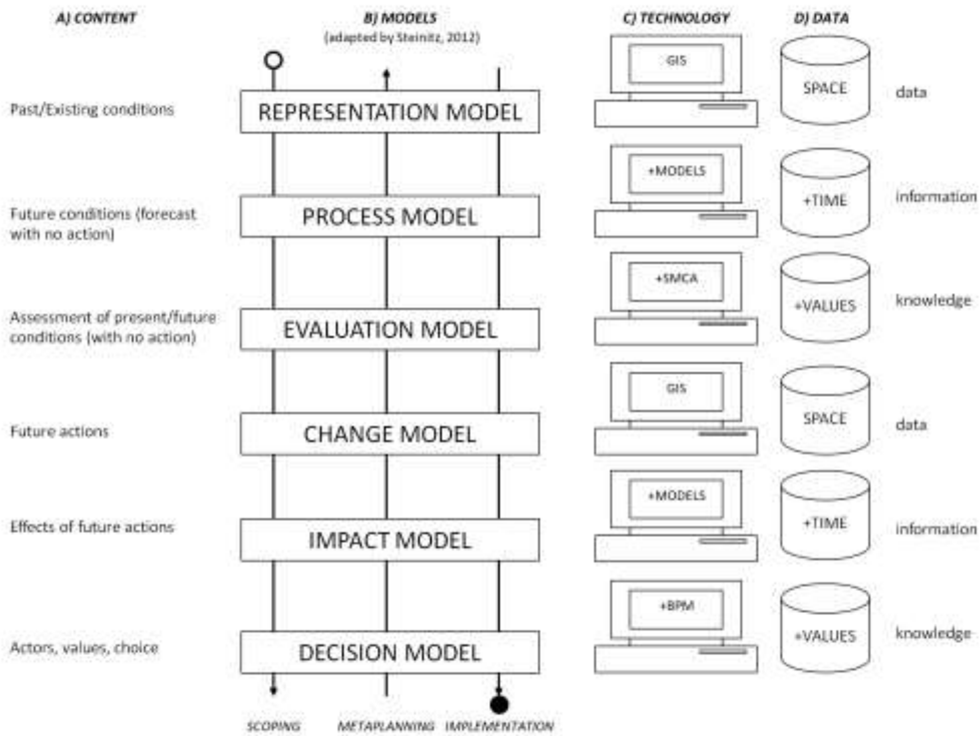

Figure 1 Relationships between the geodesign framework (A, B) (Steinitz, 2012), technology (C) and (D) data

In the representation model (RM), a relevant description of past and current conditions of the study area is assembled. While in general the transition from analogue to digital media for a planning document is far from being completed, the use of digital spatial data in RMs can nowadays be considered common practice in many developed countries, thanks to the diffusion of GIS and of spatial data infrastructures. The latter, breaking the siloes of formerly isolated spatial data sources, make comprehensive datasets of the most used spatial data themes interoperable and easily accessible to planning professionals (Procaccini and Pineschi, 2013). Since the RM, which can be often considered well developed in planning documents, *de facto* concerns specific moments in the past or the present, the spatial dimension of data is mostly relevant, and basic GIS map and geoprocessing functions are usually sufficient to produce quality cartographic results. Occasionally, additional geovisualization tools may be required to overcome the limits of GIS graphic rendering. Beside traditional technical cartographic representations tools, the output of the RM is nowadays increasingly published for broader diffusion to the wider public thanks to the widespread diffusion of user-friendly interactive geo-browsers and spatially-enabled web apps.

Things change when it comes to the construction of the process model (PM), which isusually far less developed and diffused in real-world professional practice. The aim of the PM is to learn insights into how the past and current situations of the territorial systems in the study area are evolving or likely to evolve in the future. In this case, to describe territorial dynamics, the spatial dimension should be analyzed in relation to the temporal dimension through forecasting or simulation models. In order to address the complexity of territorial dynamics, agent-based modelling (ABM) toolkits are nowadays available for integration with major commercial and open-source GIS platforms, representing a flexible solution if compared to complex operational models. They still may require skills to be implemented which are not as common among professional planners as basic GIS functions, including programming.

The evaluation model (EM) represents a third step in knowledge building. Thanks to the output of the representations and insights derived from the RM and the PM, within the EM evaluation maps are created representing where each territorial system of interest (e.g., housing, transport, agriculture, industry, commerce, cultural heritage or others) would support or require conservation versus transformation. In this case, different criteria and their relative importance are specific to the local community living, and in charge of governing territorial development in the study area. Hence, in the EM, local community values represent the variable of main interest to be represented in space (and time).

While this kind of data can be in general handled in a purely technical working environment applying a rational planning approach, when community values come into play more participatory and communicative approaches to planning are often required, and collaborative decision-making methods and tools may be needed. The mediation among often conflicting values and preferences should then be facilitated by interactive platforms accessible to an enlarged arena of users. Among existing PSS, the popular *CommunityViz* offers agile modelling tools to create interactive land suitability models and dynamic dashboards populated by performance and impact indicators; the latter being of great support also for the creation of the impact model (IM), when coupled with sketch planning interfaces. Still, being a desktop application working on top of Esri ArcGIS, the interface requires the support of technical personnel to be used, and unless underlying models are rather simple, computing time may result in a limitation to being of use in interactive multi-actor collaborative or participatory meetings outside technical offices and research labs.

The more recent web-based Esri *Geoplanner* offers similar tools which make the link between the EM, the change model (CM), and the IM seamless, with a simplified and more user-friendly interface and fast computing performance in a multi-user web environment, though at the cost of limitations in the impact modelling capabilities. Still, web-based spatially-enabled technologies may offer opportunities not only to directly support collaboration and communication, but also for collecting passively useful social media geographic information (SMGI) for building the EM, as demonstrated by Di Cesare *et al.* (2018).

While the assessment phase with its three models allows knowledge creation and making sense of the zero-alternative under a do-nothing scenario, the intervention phase entails the creation of development alternatives with the CM, the assessment of their impacts with the IM, and the decision on the final plan with the decision model (DM). The DM should include the definition of the actors participating in the process and their roles. To this end Business Process Management (BPM) techniques (C in Figure 1) can be used for planning and documentation (Campagna, 2016).

Under the complexity of current development challenges and decisional spatial governance contexts, the intervention phase is increasingly requiring the collaboration of multiple actors, including professional experts, designers, decision makers and other stakeholders, and the broader public in some cases. Under such conditions, traditional desktop professional PSS often result in being of less effective use, especially in the early stages of the planning process where the main spatial development strategies are defined. In this case, the possibility of having a multi-user PSS where actors can interact and collaborate to develop alternatives based on their preferences, dynamically assess their main impacts, and negotiate towards a final strategic plan, was a major challenges until few years ago. This challenge was successfully addressed by the novel *Geodesignhub* PSS, which supports the implementation workflow of the intervention phase where the CM, IM and DM are implemented. Being an open platform, it is interoperable and it can be seamlessly linked to external GIS databases, models and geovisualization tools via application programming interfaces (APIs). It should be noted that, as in the assessment phase, the dimensions of interest of the CM, IM and DM are space, time and values respectively (D in Figure). What changes in between the assessment and the intervention phase is that the former apply to the current conditions in the study area, while the latter applies to the change alternatives created in the CM.

3 Geodesign workshops with Geodesignhub

Geodesignhub is a web-based PSS developed by Hrishikesh Ballal as an outcome of his doctoral research at University College London (Ballal, 2015) which now is currently available as a full-fledged PSS (www.geodesignhub.com). It can be used to tailor the intervention phase of the Steinitz' framework (Steinitz, 2012) to a variety of planning contexts. The platform, which takes as data input GIS layers of the EM of the territorial systems of interest in a geodesign study (e.g., housing, transport, green or blue infrastructures, commerce, industry, cultural heritage, or the others as deemed relevant in the study area), enables the collaboration of a number of actors (usually up to 30 but cases with more participants are reported) through individual accounts. *Geodesignhub* is commonly used to support intensive (e.g., two day) planning workshops, where participants – who may be experts, decision makers, stakeholders or even citizens – interact along the geodesign workflow through a user-friendly (up to the level of being easily used by laymen) interface.

The core workflow of *Geodesignhub* usually includes three main phases: (i) in the first phase, the participants, who may have an expert or political role, thanks to a personal web log-in account, access the system where they draw diagrams representing individual projects or policies through a geobrowser; a matrix of shared projects and policies proposal arranged by system is created (Figure 2); (ii) in the second phase, participants representing different decision makers or stakeholders select projects and policies from the shared repository of diagrams according to their preferences, so composing integrated plan alternatives or syntheses; the interface offers real-time dashboard and dynamic impact maps for their assessment (Figure 3); (iii) afterwards in the last phase, a negotiation process among different groups starts; it is supported by specific tools available in the system (Figure 4) which aid negotiation among coalition or macro-teams. This way, through negotiation, new alternatives are generated mediating possible conflicts among the original single-group alternatives, and eventually a final design or plan is agreed upon based on consensus.

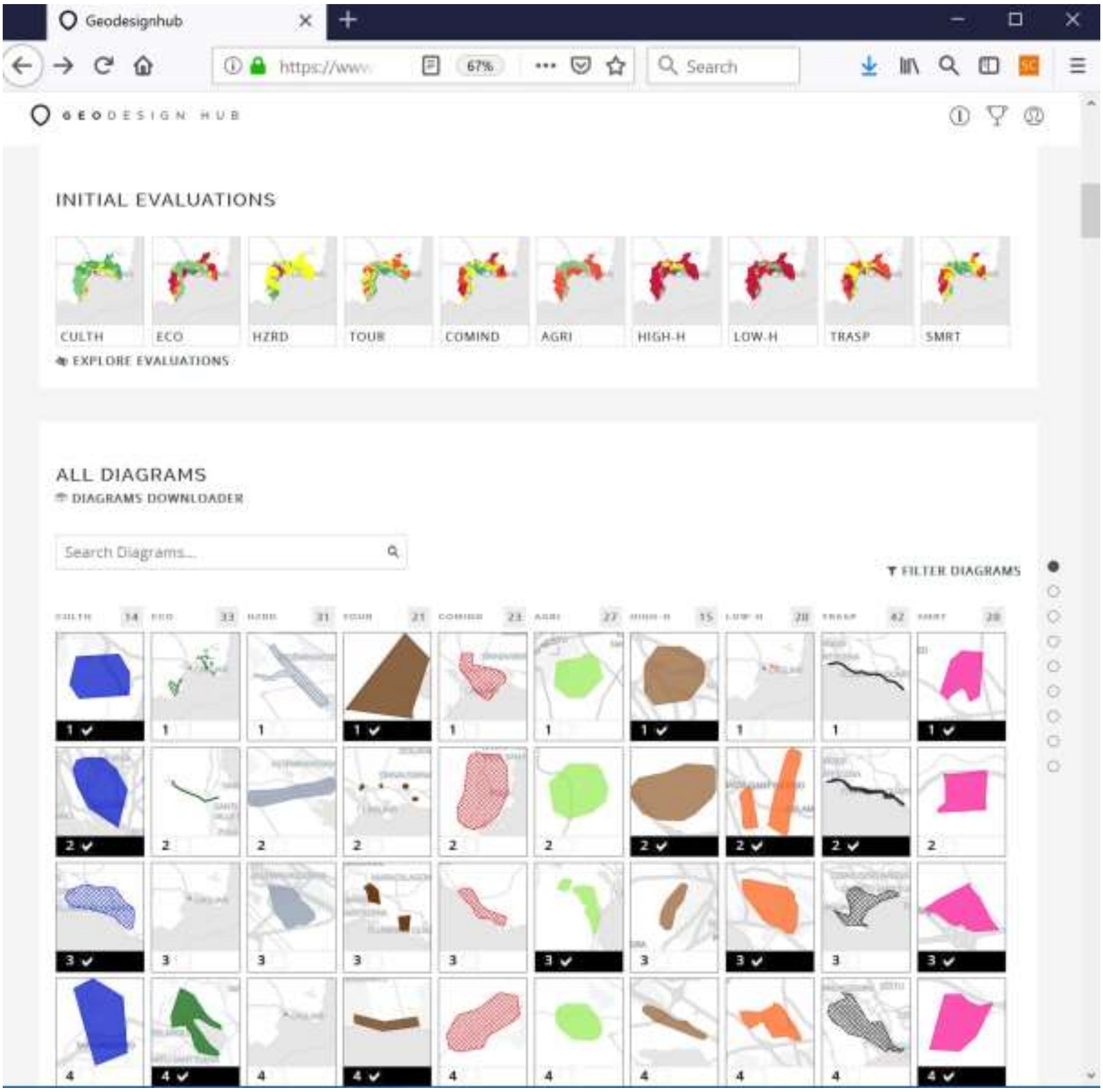

Figure 2 Collection of project and policy diagrams in *Geodesignhub* (from the Cagliari Metropolitan Area geodesign study, 2018): selected diagrams (highlighted in black) were chosen by a team of stakeholders to compose an integrated planning alternative or synthesis

In Figure 2, each tile represents an interactive object , which can be explored by one-click activating a geobrowser in a pop-up window. In the "initial evaluations" section of the webpage (top in Figure 2), the initial evaluation maps are presented. In the lower part of Figure 2, project and policy diagrams are organized and colour-coded by territorial system. Diagrams are usually created by individual workshop participants by sketching in the user-friendly pop-up geobrowser and shared with all the others in a common repository of individual design actions visualized in a tabular grid and arranged by systems (i.e., columns). However, diagrams can be also created using existing project files by uploading, or generated dynamically by external models (e.g., allocation, rule-based or others), connected via the *Geodesignhub* API. Thanks to the fact that the system is fully open and the API can be used to couple *Geodesignhub* to external systems and tools, in the original Cagliari geodesign workshops, design alternatives were exported dynamically via the API and loaded in *CommunityViz* to run off-line more sophisticated impact models than those available within *Geodesignhub*. Once the matrix of diagrams is completed, in the second phase of the workshop, teams of stakeholders can select the diagrams which contribute to achieve their objectives creating integrated spatial planning alternativechemes, or syntheses. The system allows their direct comparison as shown in Figure 3 where impact indicators are shown thanks to a real-time dash-board. In the last phase of the workshop, group of teams who proposed compatible syntheses negotiate in order to achieve consensus on a common alternative development scenario, thanks to negotiated design tools, shown in Figure 4.

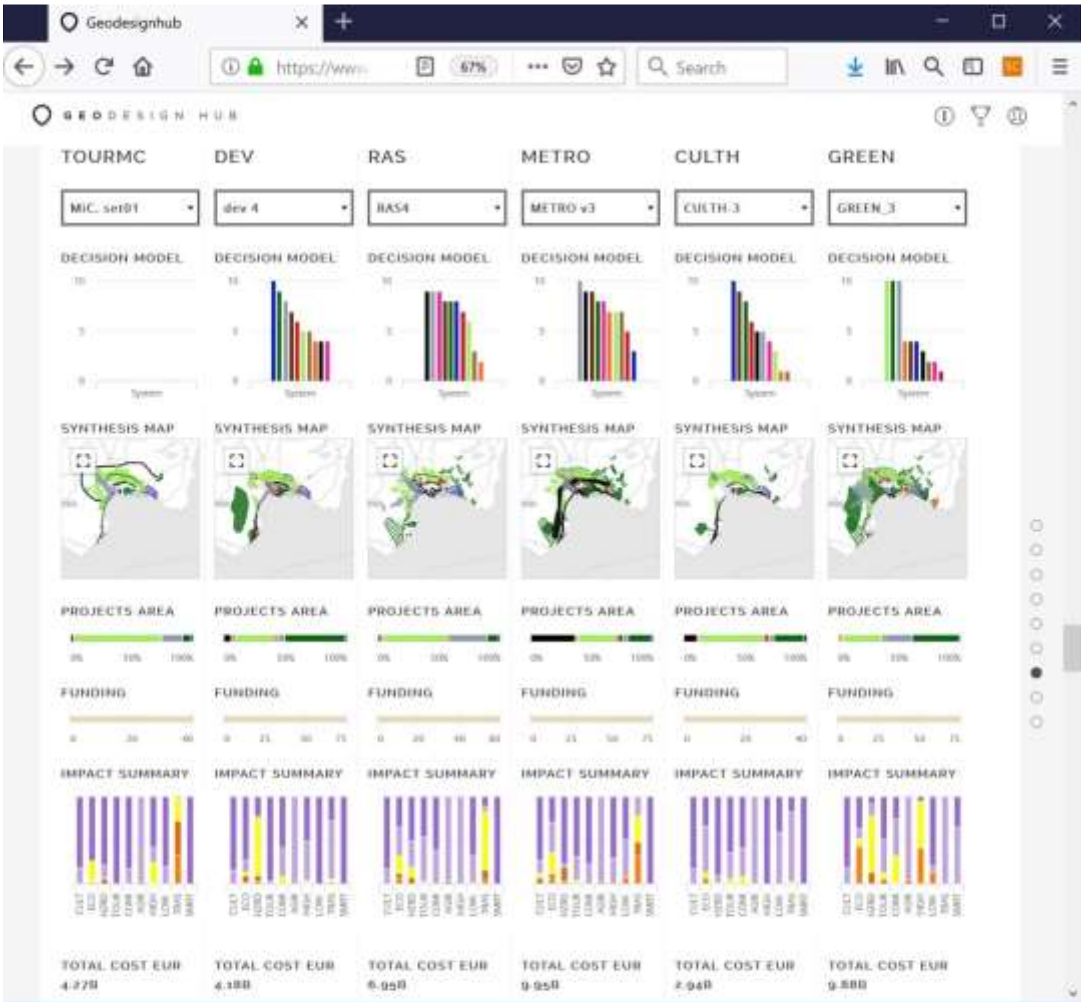

Figure 3 Comparison of planning alternatives or syntheses, created by teams of stakeholders representatives (i.e., the GREEns, the TOURist enterprises, the CITIzens, the PULA municipality, the REGiOnal Government, and the local DEVelopers), with the performance and impact assessment real-time dashboard (from the Cagliari Metropolitan Area geodesign study, 2018)

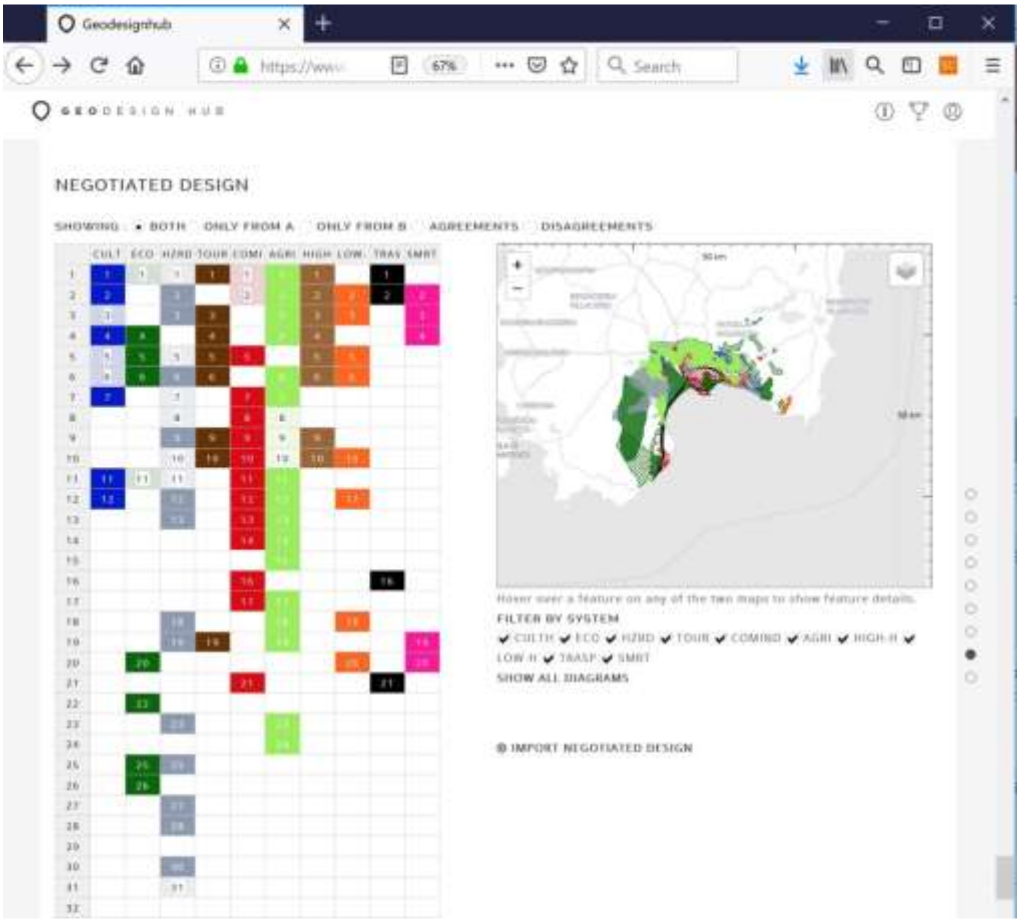

Figure 4 Example of negotiation support tool in *Geodesignhub*: the tool allows exploring agreement and conflict among two syntheses so providing interactively useful information to support the discussion among different teams of stakeholders

4 Discussion

The *Geodesignhub* PSS was used in a number of training, research and real-world geodesign workshops worldwide, carried out in different planning contexts and at different scales. The first Cagliari Metropolitan City case study held in 2016 enabled the geodesign team to create, in a very short time – approximately two months for data preparation by the coordination team of experts, and two days of full-time intensive workshop – an agreed final plan based on consensus through negotiation. Around 30 designers, researchers, public officers and professionals played the roles of stakeholders grouped in six teams with different sets of preferences and values, which eventually agreed on a final masterplan design for the area.

The workshop was very successful for the participants had no previous ideas about possible development scenarios for such a large and complex geographic area composed of 17 municipalities which were traditionally experienced in making plans only within their municipal boundaries. That is to say, this was the first time in the region that a design study was carried out in a context where the local community was not used to thinking about plans at the metropolitan geographic scale – introduced in the Italian planning system only recently – and therefore had no previous ideas about possible integrated sustainable development scenarios for the region. All the participants reported appreciation for the *Geodesignhub* platform which was considered very user-friendly also by those unfamiliar with GIS or PSS, and for the underlying design workflow which was considered innovative and effective.

Among other successful geodesign workshops involving real-world institutional decision makers and stakeholders, in Sydney, Australia, a geodesign workshop with *Geodesignhub* was used to foster collaboration among the metropolitan public agencies, municipalities, industry and academia in envisioning the future of the southern suburbs of the metropolitan area. As reported by Steinitz (2017, p.67), the majority of participants agreed in a post-workshop questionnaire survey that the geodesign workshop was successful overall in eliminating the barriers among stakeholders and in obtaining satisfactory design results based on consensus. Data from unpublished interviews and questionnaire surveys, occasionally collected by the author after the conclusion of several workshops held in Italy and Brazil, confirm the general positive appreciation of the participants both in the innovative collaborative planning (geodesign) workflow and in the *Geodesignhub* PSS functionalities, user-friendliness and overall user experience.

In the Georgia geodesign workshop in 2015 (Rivero *et al.,* 2015), *Geodesignhub* supported the horizontal collaboration of the Georgia coastal counties representatives who negotiated a coherent regional planning scenario addressing climate change. The workshop was repeated a second time (Rivero *et al.,* 2017) with broadened scope, demonstrating the interest of the local authorities for the approach. In a case study of Mulranny, Ireland (Steinitz, 2018), a participatory planning approach was successfully adopted by which the inputs for *Geodesignhub* were hand-drawn by representatives of the local community in a small village representing their local knowledge and then digitized to support the collaborative design, demonstrating the possibility to use *Geodesignhub* as a public participation PSS. Likewise, Mourao Moura and colleagues (de Oliveira Monteiro *et al.,* 2018) successfully used *Geodesignhub* to involve for the first time the local disadvantaged community in Maria Teresa, an illegal settlement in Belo Horizonte, Brazil, in the requalification planning process promoted by the local authorities.

5 Conclusions

The complexity of current planning challenges, relating to unprecedented pressure of human actions on territorial systems and to multi-actor institutional and decisional contexts, calls for innovative approaches to planning and design. In Europe, strategic environmental assessment (SEA) was introduced in 2001 (Directive 2001/42/EU) to address sustainable development challenges by bringing innovation into spatial planning. However, planning practices still lack the means to make full use of SEA principles and requirements, such as grounding the plan making and decision making on *ex ante* explicit environmental considerations and involving pro-actively all the concerned institutional actors and stakeholders.

Oftentimes, SEA coupling to the spatial planning process missed expected outcomes resulting in a costly bureaucratic process. Geodesign methods and enabling technologies can contribute to address some of the most serious current SEA pitfalls such as meaningful alternative planning scenario generation, dynamic impact assessment and collaborative informed decision making. While the Steinitz framework, if correctly applied, can ensure meaningful, complete and transparent production of the content required for the SEA's environmental report (Directive 2001/42/EC art-5 and annex 1), such PSS as *Geodesignhub* enable the participation of all relevant stakeholders in what is possibly the most important and least understood part of the planning process; that is putting knowledge into action through design and decision making (Campagna and Di Cesare, 2016; Campagna *et al.,* 2018).

While other geospatial information technologies can be coupled to support the enactment of planning and design workflows according to the geodesign framework, *Geodesignhub* can be considered unique in supporting a fast, collaborative and informed design based on negotiation. This is of particular value especially in those processes where strategic plans are to be designed in a short time in the face of conflicting interests, such as in strategic planning or emergency response. While the default set-up of the system and its use in intensive workshop is often used for territorial or local strategic or master-planning rather than for detailed operational plan making, this apparent limitation may be overcome thanks to its interoperability which allows coupling with external models and tools. In other words, the geodesign workshop with *Geodesignhub* is of particular value in collaboratively defining environmentally-savvy, high-level spatial strategies based on consensus and conflict resolution with a system approach. Thereafer, the workshop data can be easily shared and taken as input in more technical systems (i.e., GIS) by professionals for the executive or higher-scale plan making.

In any case, reaching consensus on a master planning scheme through negotiation seems to be a crucial stage of the process, and one of the factors determining the length and success of the planning endeavour. Without that, the process may easily become lengthy, not transparent, costly, ineffective and unaccepted by the affected community. In addition, focusing on long-range problems and strategic issues and facilitating group interaction and discussion among the different type of planning actors can be considered a distinctive scope of PSS, whereas GIS and SDSS can be used to solve more technical design part by planning professionals (Geertman and Stillwell, 2004). Anyway, as soon as a strategic scenario is agreed upon by entitled decision makers, making it operational through iterative increases in scale is feasible using more traditional professional GIS tools and/or other SDSS and PPS, as shown by Moreno Marimbaldo *et al.* (2018) with their geodesign PSS for linear infrastructure planning and design.

The geodesign approach is earning fast-growing popularity and, as discussed in this chapter, it has the potential to address some of the current pitfalls in spatial planning and SEA, as well as in PSS application, for it may represent the missing glue between methodology, processes and technology integration. The novel *Geodesignhub* PSS is an example which contributes to demonstrating this hypothesis, showing the innovation potential which may be achieved by integrating state-of-the-art technologies on the base of the geodesign framework, and this possibly paves the way towards a new generation of technology integration approaches for planning support.

Acknowledgements

The author is in debt to and wishes to thank very much Carl Steinitz, Hrishi Ballal and Tess Canfield for sharing their invaluable experience in geodesign and in using the *Geodesignhub* PPS during several years of collaboration. Carl Steinitz conducted the Cagliari geodesign workshop, which was coordinated by the author, with the support of the Sardinia Autonomous Regional Government of Sardinia under the Visiting Scientists Program 2015 at the University of Cagliari. The content of this chapter is based on the research carried out by the author, who is entirely responsible for any possible inaccuracies and the views expressed.

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