Advances in spatial information: new opportunities for spatial planning

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Abstract

This paper concerns the use of data sources in spatial planning, design, and decision making, focusing in particular on recent advances user-generated contents and enabling technologies. After a review of recent development digital data sources nowadays available to planners to support their technical activities within the plan-making process, it is argued volunteered geographic information and technology can expand the planner toolbox, enabling the seamless support to tasks that would have been cumbersome to be implemented in practice until a decade ago. A geodesign case study is described in detail in order to demonstrate these assumptions in the face of a complex design process at the metropolitan city scale.

Keywords

Geodesign, Big data, AGI, VGI; SMGI

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Introduction

In many developed Countries, the last two decades faced the widespread diffusion of digital data sources, including spatial data. Along this process the planning toolbox have been enriched by the adoption of Geographic Information Systems (GIS). The process of digital uptake in its earlier stages involved mostly Authoritative Geographic Information (AGI), that is spatial data produced by or for public authorities in order to undertake their institutional responsibilities such as spatial planning, policy-making, and governance (Longley et Al, 2010). In many European countries, including Italy, and regions the process accelerated in the late 1990s, and culminated in the first decade of the new millennium with the shift from the cartographic CAD format to GIS databases. In 2007, the adoption of the INSPIRE Directive 02/2007/EC unleashed the spatial data access to the wider public through the creation of geoportals (Campagna and Craglia, 2012). Nowadays in many European as well as in many Italian regions, Spatial Data Infrastructures (SDI) maintained by Regional and local authorities offer hundreds of large scale spatial datasets (Vandenbroucke, 2007). Hence, the territorial physical representation which constitutes the starting point of any spatial planning and design endeavour is enriched and facilitated up to an unprecedented fashion. Territorial and environmental information systems offer spatial data quantity and quality which would have been above any expectation of planning practitioners only a decade earlier. In addition, many regions, in Europe as well as in Italy, started to adapt their spatial planning regulatory frameworks to current developments, in order to take advantage of the new opportunities offered by the spatial data revolution: it is the case, to mention only one example, of the Lombardy Spatial Government Law n° 12/2005 which established the regional information system as shared platform to support spatial planning and governance. However, advances in digital spatial information sources are far from being limited to that. In 2007, Goodchild (2007) published the first popular paper describing the blooming phenomenon of the digitally enabled citizens' observation, which fosters the diffusion of volunteered neo-geography as a popular issue in the research agenda of academics in many fields worldwide. In October 2016, the successful completion of two EU COST actions on citizens' observation and Volunteered Geographic Information (VGI), which produced two volumes on the subject (Capineri et al., 2016; Foody et al., 2017) was celebrated at the Royal Geographic Society in London, attracting the participation of many scientists from Europe and the United States. VGI, that is, geo-referenced User-Generated Content (geo-UGC), produced by volunteers thanks to web 2.0 spatially enabled technologies, proved to be a reliable information not only to produce real-time updated measures of geographic objects and phenomena, such as in the case of the popular Openstreetmap.org initiative, but also to record citizens' perceptions, preferences and behaviours in a fashion which pervasively characterise social media (Campagna, 2016). The implications for the innovation in knowledge building and public participation in spatial planning are huge and still poorly understood, as the first scientists are at an early stage of the exploration of this potential. Nonetheless, the number of endeavours towards this direction is growing both in the research and in the practice.

The opportunities fostered by this scenario, however, require developing new methodologies and tools to put this potential for innovation in knowledge building into action. In the last decade or so, geodesign (Goodchild, 2010), a novel methodological approach originally formalized by Carl Steinitz (2012) has been increasingly supported by academia (Foster, 2013) and the geospatial industry (Miller, 2012) earning growing popularity. Geodesign can be defined as "a set of techniques and enabling technologies for planning built and natural environments in an integrated process, including project conceptualization, analysis, design specification, stakeholder participation and collaboration, design creation, simulation, and evaluation (among other stages)" (Flaxman in Wheeler, 2010). As such, it may represent the key innovation to achieve the above objective. In the light of the above premises, the following section briefly describe the geodesign approach with reference to the core of the Steinitz framework (2012), which is the methodology foundation of the study presented in the fourth section. Before reporting on the case study, in section 3, the potential of the use of VGI, with a particular focus on Social Media Geographic Information (SMGI), is discussed from a technical perspective with regards to its usage in spatial planning and design.

Geodesign

The geodesign methodology, following the integrated approach proposed by Steinitz, provides an operational framework for developing sustainable and collaborative spatial planning processes. The Geodesign Framework (GDF) integrates public engagement strategies, geo-information technologies, environmental concerns and dimensions since the early stages of complex decision workflows in urban and regional planning. Thus, it may contribute solving many of the problems in current planning practices and environmental impact assessment (Campagna and Di Cesare, 2014). The methodology has evolved and

matured over the last decades and has been tested in several case studies in different territorial contexts, at various scales and involving multiple groups of actors (among them Rivero et al., 2015; Nyerges et al., 2016; Campagna et al., 2016).
The GDF is structured in six models. Each model has a specific function starting with the representation and analysis of the context, of its internal dynamics and the expression of expert and community values. The first three models are developed in the so called assessment phase (Steinitz, 2012), which represents the knowledge building effort to support the design of alternatives. The models of the assessment phase are subject to the simulation and evaluation of their impacts which is intended to inform the actors driving them towards a final decision. This second part of the process is the so-called intervention phase (Steinitz, ibidem). More specifically, the knowledge building phase is structured in three models: the representation model examines existing conditions in a particular geographic context, or study area, while the process model simulates changing conditions under no changes (or "zero alternative"), and the evaluation model assesses those conditions in the face of expressed community values. At this stage, in the change model possible alternative ways of improving the existing territorial conditions are developed and evaluated against their possible impacts (i.e. impact model). Eventually, in the decision model a change alternative is selected for implementation.
Despite the modelling approach of geodesign follows the above-mentioned structure, for each geodesign study the framework need to be shaped on the basis of context characteristics, actors involved, data availability and tools selected. The contribution of experts and of the representatives of the community can be flexibly adapted to comply with the local institutional and socio-cultural settings. This implies the use of data and information, as well

as of techniques and tools that should be applied to fit local conditions. Hence, when pluralism matters, having the possibility to encode the community experiential knowledge, perspectives, preferences and values in the planning knowledge base becomes a necessity. In order to explore current possibilities in this regard, in the next section a brief of the research experiences by the authors in using social media data for planning is reported. Later in the fourth section, an application to a thorough geodesign study is described in detail.

Volunteered geographic data sources

The world of volunteered geography boomed since a decade or so, opening new ways in the spatial data production models with the diffusion of geo-referenced user-generated contents. The widespread diffusion of low cost location sensors, enabled millions of web users to act as citizens sensors. After a decade of advances in technologies and techniques, volunteered spatial data sources, following novel quality assurance models, are starting to compete with traditional AGI, which thanks to a sort of wisdom of the crowd effect, offer quality up-to-date topographic representations around the globe, even in those regions where official dataset are lacking. However, besides offering an open surrogate of AGI sources at no cost, volunteered geography can be considered revolutionary for another non-secondary aspect: if properly used, VGI can offer insights on community perspectives, preferences, values, and social behaviours in space and time. This is particularly the case of a special kind of VGI, that is Social Media Geographic Information.

SMGI can be defined as the collection of space-time referenced multimedia content (i.e. text, images, audio, and video) produced by citizens using location aware smart devices. SMGI can be active, when the users consciously contribute data within a crowdsourcing exercise, or passive, when they upload geo-referenced content in their everyday use of social networking platforms (e.g. Twitter.com, Instagram.com, etc). In both cases, however, interested analysts can access data within the limit of the access policies of social media platforms, and use them for analyses.

The structure of SMGI is novel and peculiar in that it differs from traditional spatial data: the latter feature spatial and thematic components about geographical objects (i.e. location and geometry, and characteristics) while the former has, in addition to space and thematic attributes, more components with particular semantic value. In fact, each record of a SMGI dataset contains information on the time of publication, the user who created and published it, and in some cases users' preferences (i.e. n° like/dislike). In addition, each record may have multimedia thematic attributes (i.e. short/long texts, images, videos, sounds). This complex structure requires a new approach to analyses, which can offer powerful insight in understanding users' behaviours, preferences, perspective, and values as argued by Campagna (2016).

Hence, altogether SMGI may find suitable use both in the assessment phase of a geodesign study (i.e. knowledge building) and in the intervention phase (i.e. decision-making). The case study in the next section offers practical examples of these assumptions.

Geo-UGC opportunities in (geo) design processes: The Cagliari case study

The first Cagliari geodesign workshop

The case study reported in this section was developed in 2016 within the international research activities of the UrbanGIS Lab (http://people.unica.it/urbangis/) at the Civil and Environmental Engineering and Architecture Department (DICAAR) of the University of Cagliari (UniCA), Italy. The main underlying purpose of this study was twofold. Firstly, it aimed to apply the geodesign methodological approach to a master-planning process to develop collaborative and sustainable future design for the Cagliari metropolitan city as recently established by Sardinian Regional Law n. 2/2016. Secondly, it attempted to test the application of public participation procedures in spatial planning exploiting the opportunities offered by novel information resources (i.e. AGI and VGI), and advanced web-based collaborative technologies. On the one hand, the use of VGI and SMGI in different models of the GDF is potentially advantageous in supporting a more pluralist understanding of places, by earning new insights from experiential knowledge and users' preferences. In fact, data for the study were collected from both social networking platforms and the regional SDI, combining multimedia contents with authoritative layers. On the other hand, collaboration technologies enabled to handle the in-built complexity of the intervention phase of the GDF involving thirty-two participants in designing change alternatives collaboratively, and in negotiating a final design shaping future development.

The local workshop coordinator assisted by a team of 10 experts, worked 3 months part-time to implement the assessment phase of the geodesign study. The multi-source data collection, processing and analysis were implemented in accordance with the scope of the problem, and using the methods and tools defined in the early iterations of the framework during preliminary meetings.

The study area of the Cagliari metropolitan city includes 17 municipalities. The new form of local government is still taking its first steps in Italy, given that it had been introduced and enforced at a national level only recently by Law 7 April 2014 n.56, and transposed by the Sardinia Autonomous Region into the regional legislation in 2016 (Regional Law 4 February 2016 n.2). The choice of the study area stems from the challenges of coordinating the design of a wide area including a large number of municipalities, each of which traditionally used to plan only within their own boundaries. This workshop was the first full digitally-supported collaborative wide area inter-municipal planning exercise ever done in the region. In addition, the area features a complex combination of environmental and socio-economic territorial dynamics, making it a challenging case.

Despite the 17 municipalities may have different problems and interests, they gravitate around Cagliari, the main municipality, and share with it intertwined economic, social and environmental dynamics. In the study area, industry features one of the main Sardinian pole in Macchiareddu, between Cagliari, Assemini and Capoterra. Agriculture characterizes most of the remaining municipalities, whereas Cagliari, as a regional capital, is the main services pole. In addition, in the last two decades Cagliari gained a reputation of tourist destination, attracting growing numbers of visitors from across the world thanks to the presence of the biggest inter-modal hub in Sardinia, and its recent inclusion in low-cost air routes and among the Mediterranean cruise destinations. Cagliari also offers high-value natural and cultural resources that together with high-quality food products and gastronomy availability in the wider study area, makes the capital very attractive to tourists. Moreover, the ICT sector has become a significant industrial reality in the Cagliari area, which is nowadays recognized as one of the main national innovation pole in Italy in terms of fertile ground for start-ups.

In line with the traditional vocation of the territory and with the aim to boost the new economy sectors, the local team defined three main objectives for the Cagliari metro area future scenario: i) "tourism development" extending the season and diversifying the supply of tourism products and related services; ii) "agrifood" driving spatial policies toward more sustainable agriculture and attracting new tourism influxes in the countryside with its wide range of food excellence; iii) "Cagliarifornia" fostering the local ICT industry development to help increasing high level of specialization employment opportunities. The expert-driven scenario was projected over a 20-year time horizon, when the total population is expected to grow slightly up to nearly 470,000 people by 2036 (i.e. growth rate +0.1). The projection was based on the 2011 and earlier Censuses and considered, in addition, the positive impact generated by the chosen "pro-development" scenario.

Other than defining the main local development trajectories, the geodesign study coordination team planned in advance how public participation intervenes within the different models, the tools to be used for implementing each study step, the spatial systems dynamics describing the current state of the area and data collection methods and sources. This way, the geodesign framework was customized to the specific case study.

Firstly, the representation, process and evaluation models were built in a GIS environment supplementing AGI with UGC to describe ongoing territorial dynamics and to identify users' interests and needs. The scientific and societal knowledge encoded in the evaluation model was then used as input data in the collaborative web-based platform Geodesignhub in order to support the intervention phase (i.e. change, impact and decision models). Accordingly, after the knowledge building process was completed, an intensive two-day workshop was organized to allow members of the local community to actively collaborate proposing changes (i.e. project, policies, and integrated combinations of them) and assessing their impacts through the user-friendly interface of the software.

The assessment phase

By definition, geodesign adopts system thinking. Since the very early stages of the study, the close collaboration between the local experts in the geodesign team with the coordinators led to the selection of the ten systems in order to represent the area and its demand in the light of the current normative and planning framework. They included three systems relating to vulnerability and risk of the study area, revealing areas of high historical-cultural or natural value potentially threatened by natural or man-made hazards: cultural heritage (CULTH), ecology (ECO), and hydro-geological hazard (HYDRO). Likewise, seven systems were chosen to highlight the most suitable and attractive areas for services, infrastructures and other land-uses relevant to the underlying development scenario: tourism (TOUR), agrifood (AGRI), transport (TRASP), low density housing (LOW-H), high density housing (HIGH-H), commerce and industry (COMIND), and smart services (SMRT) .

The primary source of digital spatial data on the Cagliari metro area was the regional SDI of Sardinia. The geoportal services for search and download were especially useful for collecting information regarding geographic objects and facts and, thus, for representing territorial dynamics (Di

Cesare et al., 2018). One example is the vulnerability system CULTH describing the spatial distribution of cultural and historical areas within the metro area to be included in future preservation strategies. In order to construct the respective representation model, a series of potentially relevant datasets available in the regional SDI were selected and downloaded, including those representing historic town centres, cultural assets and industrial archaeological sites related to the production processes of historical relevance. Nevertheless, information on people perception of places is traditionally missing in official information. Hence the representation, process and evaluation models are an opportunity for effective use of geo-UGC, in particular when it is needed to grasp subjective phenomena, such as perception of the local community (Di Cesare et al., 2018). An example demonstrating this assumption, we used SMGI to describe, among others, the system TOUR, which depicts the spatial distribution of tourists' preferences regarding existing tourism lodging services and natural and non-natural resources. The first three models regarding the TOUR system were created using digital spatial data from various sources to explore the geography of the place through both planned tourist areas (i.e. AGI, with data from the regional SDI) and spatial and temporal patterns of tourists, investigating preferences (i.e. SMGI, with data from Booking.com and TripAdvisor.com) and the main areas of interest within the metro area (i.e SMGI, with data from Panoramio.com). As expected, SMGI provided insights on the area spatial dynamics, which would have not been available through traditional data sources only. The application of SMGI Analytics (Campagna, 2016) on the TOUR system was developed according to three main stages: data extraction and collection from social networking platforms for the creation of the representation model, kernel density analysis for the creation of the process model;

spatial distribution of users' preference detection and integration with AGI through a land suitability analysis for the creation of the evaluation model. The result of this process is an evaluation map identifying locations of interest the for future tourism development strategies within the metro area (Di Cesare et Al., 2018). The TOUR evaluation map was then classified in five suitability levels according to a predefined color code: from very high attractiveness areas for tourism development strategies (dark green) to very low attractiveness, due either to the lack of tourism facilities or of users' interest (dark red). Likewise, all the ten evaluation maps were created by teams of experts through risk or land suitability analyses (depending on the system) in a desktop GIS environment and classified accordingly aiming at identifying, for each system of the study area, its inherent territorial vocation in terms either of vulnerability or of suitability for change (Figure 1). The color-code is different for the three vulnerability maps, as is the case for the system CULTH: red areas indicated those characterized by a very high vulnerability, where only actions aimed at preserving these sites can be permitted, and the dark green areas are the least vulnerable ones, which do not present any restriction in use. The different interpretation of the common classification is the reason why the systems were grouped in two categories (i.e. conservation vs action): it was functional to the fact that the evaluation map classification and representation (i.e. red, yellow, green) was the same for all the system, w it should be read differently in the two cases: while in the case of suitability for development red means "stop" and green "act", in the case of risk red means stop for actions in other systems but go for action to preserve resources or address risk issues. This classification turned out to create confusion among the participants, and it was changed to a different classification of the evaluation maps

in the other workshops following the original one to avoid any possible confusion.
Each evaluation map was created applying well-established spatial multi-criteria overlay techniques in GIS. The novelty here is that among the criterion maps used to map the final suitability several were produced using SMGI representing the spatial distribution of citizens' preferences and values which are not usually available in AGI datasets.

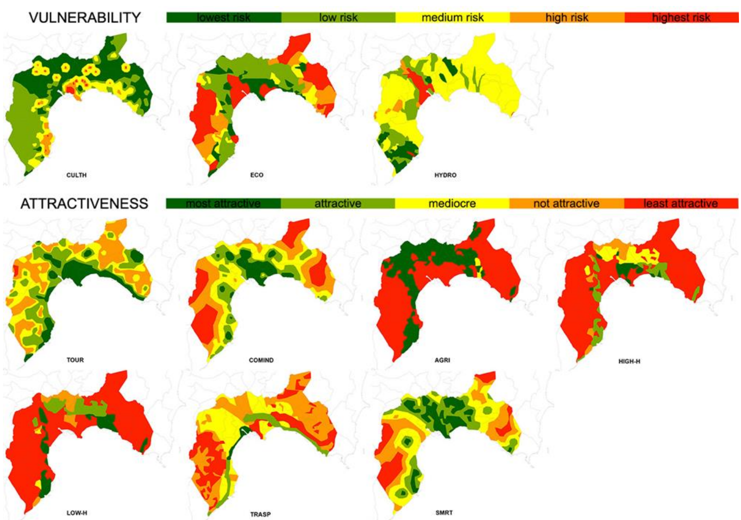

Figure 1 - The ten evaluation maps classified in five level of attractiveness/vulnerability

In addition, the local team assigned to each system a quantitative target in hectares to be achieved within the plan implementation and examined the relationships between the ten relevant variables. A sustainable and multi-system approach was adopted, wherein a territorial sub-system can

change over time and, as a consequence, directly or indirectly impact the others in the process (Nyerges et al., 2016). Interconnections among systems were encoded in a series of impact score-matrixes, in which the experts classified, on a scale from +2 (positive) to -2 (negative), the qualitative impact of a project in a system on the other systems (cross-systems impact model). In this case the values of impacts were based on expert judgment using a simplified Delphi method; in principles, the matrix could have been reviewed combining the technical knowledge with the results of a crowdsourcing project.
In order to further demonstrate the second assumption of this paper, that is that UGC can be gathered to enrich with community knowledge and preferences the design process, the following paragraph shows, in detail, how a web-based collaborative platform featuring social networking functions was used to involve a large number of users in creating planning proposals until a final agreed plan was achieved by negotiation. In other words, the next paragraph shows how it is possible to involve up to a potentially unlimited number of users in the intervention phase of a geodesign study.

The intervention phase

While in the previous paragraph it was shown as geo-UGC, extracted from social networking platform, were used as information resources in the assessment phase for the construction of the representation, process, and evaluation models, below we report the main steps of the geodesign workshop workflow, in which thirty-two participants have been directly involved into an actual design crowdsourcing project. They were asked to create informed and volunteered content about design and choice exploiting the functionalities of the Geodesignhub online platform. It should be noted that the number of participants involved could have been higher, and in some circumstances unlimited.

The "Geodesign Workshop on Future Scenarios for the Cagliari Metropolitan Area" took place in May 2016 at DICAAR, UniCA. The heterogeneous group of participants, consisting of researchers and students from several universities, public administration representatives (Autonomous Region of Sardinia) and local professionals (engineers, architects, agronomists) was engaged in an intensive two-day planning studio from 9am to 5pm each. The workshop was opened by the conductors, who introduced the main concepts of the geodesign approach, the study area with its characteristics, and the Geodesignhub platform. In the first stage of the workshop, on the basis of individual professional skills and expertise, the participants were divided in ten groups, each of which was asked to propose design options (i.e. projects and policies) in the form of diagrams (i.e. georeferenced lines and polygons as in the example in Figure 2) to change the ongoing territorial processes, each with regard to the territorial system of their expertise among the ten.

The design activities were supported by the user-friendly sketching tool of Geodesignhub, which facilitated the involvement of participants of various backgrounds and skills who were not necessarily familiar with professional GIS tools. Indeed, the team members managed to quickly familiarize with its user-friendly interface and the design of projects and policies (Figure 2) based on territorial knowledge embedded in the evaluation maps, which were previously uploaded to the platform by the coordination team.

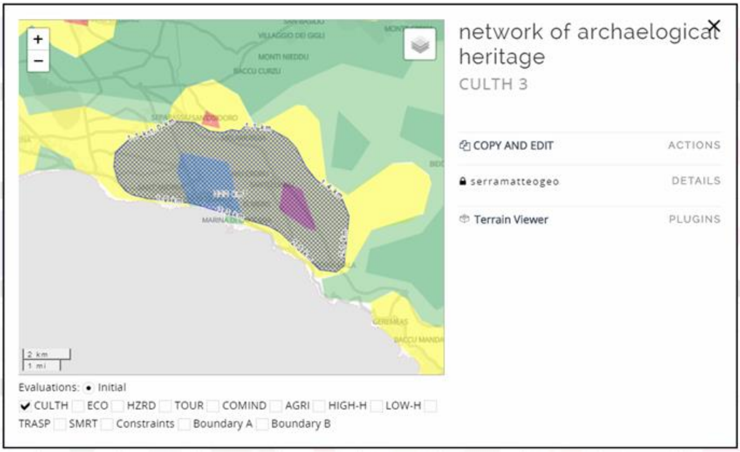

Figure 2 - The hatched polygon represents an example of policy to improve the vulnerability system CULTH. The base map is the color-coded evaluation map of the system which is used to inform the design. In the first phase of the workshop, participants were asked to produce the diagrams.

In the above phase, a significant number of around 200 design options were created and collected into a grid with ten columns, one for each system, the coordination team re-organized the participants into six multidisciplinary teams, each playing the role a local stakeholder group, for the following phases of the workshop: Metropolitan government (METRO), Regional government (RAS), Green NGO (GREEN), Cultural Heritage Conservation (CULTH), Developers (DEV), Tourism Entrepreneurs (TOUR). Their different viewpoints were made explicit by the groups which were required to rank on 1-to-10 scale the relative importance of each system. According to these priorities, each group was asked in the second phase to select and combine diagrams together to achieve complex integrated design alternatives, or *syntheses*, which best reflected their priorities with regard to future changes. The diagrams were shared and used by all groups, regardless of who created them; they could be selected from those available or new could create from scratch anytime according to the stakeholders need. At the end of the first day, the participants took advantage of the platform functionalities to assess and compare the six alternatives thanks to the interactive impact model dashboard (Figure 3). Performance indicators of the six synthesis were displayed as stacked bar charts and maps showing the positive and negative impacts on the study area (Figure 3a). The map on top-left of Figure 3a was created in the second phase of the workshop by one of the stake-holders group selecting individual project and policy diagrams generated in the first phase of the workshop. Hence, it represent an integrated development scenario as coherent combination of actions, which are color-coded by system for improved readability. The map on top-right of Figure 3a shows an example of impact map: the map is generated by the system considering the overlay area of each diagram in the synthesis with the evaluation maps of all the systems and by multiplying the area for synthetic qualitative scores previously defined representing the positive or negative effects of an action in one system on all the other systems depending on the location. This is an approximation which anyway makes sense of the overall impacts. Given the system interoperability functions, design data can be exported and ingested in a professional GIS for more detailed analysis, but this option would be lengthy and given the speed of the workshop workflow, which is intended to obtain strategic planning schemes in a very short time to resolve conflicts among stakeholders, the real-time qualitative assessment turned out to be effective for the purpose. Histograms measuring the percentage of achieved change targets of each of the six syntheses (Figure 3b), and values representing development costs of the six design alternatives were calculated and displayed by the system (Figure 3c).

The real time interactive impact dashboard enabled the participants to quickly and easily review their proposals for impact mitigation and to find differences and affinities between the designs of the groups. After the third round of syntheses refinement, the six team leaders presented their proposals in order to enable each group to assess possible alliances and partnerships based on potential consensus. Two coalitions originated from the application of a sociogram matrix, in which each team assigned a value from -2 (disagreement) to +2 (complete agreement) to the other groups according to the similarities and compatibility of their designs. A strong connection emerged between TOUR, CULTH and RAS, whereas a second less robust alliance was formed between GREEN and METRO. While the two coalitions started their negotiation phase, the Developers groups, which obtained negative assessments from all the others teams, decided to initiate a dialog with the strongest affinity group succeeding in finding consensus on a common shared design with them. At this point, given the similarities between the two alternatives, and using the negotiation support tools of Geodesignhub to graphically highlight the agreement and the conflicts, a final agreement on the future development of the Cagliari metro area was negotiated by all the participants as a result of a collaborative design effort.

Given the high number of participants which collaboratively contribute to the design, the final synthesis created with Geodesignhub can be considered as a conceptual plan originating from crowdsourcing, which feature some SMGI characteristics in terms of data model. In fact, the structure of a diagrams differs from traditional geographic information, for it combines the spatial component with the time dimension (i.e. time sequence, project implementation timing), user information (i.e. authorship, preferences), and in some cases multimedia contents (i.e. photo, video, title, tag), on top of the thematic attributes of usual kind (i.e.

project type, relevant territorial system). The data can be exported, directly in GIS format files or using the Geodesignhub API, and the different types of dimensions can be used to analyse the overall design process offering new insights on the relationships between knowledge building, design and decision-making, and on the influence of the different actors on the final design.

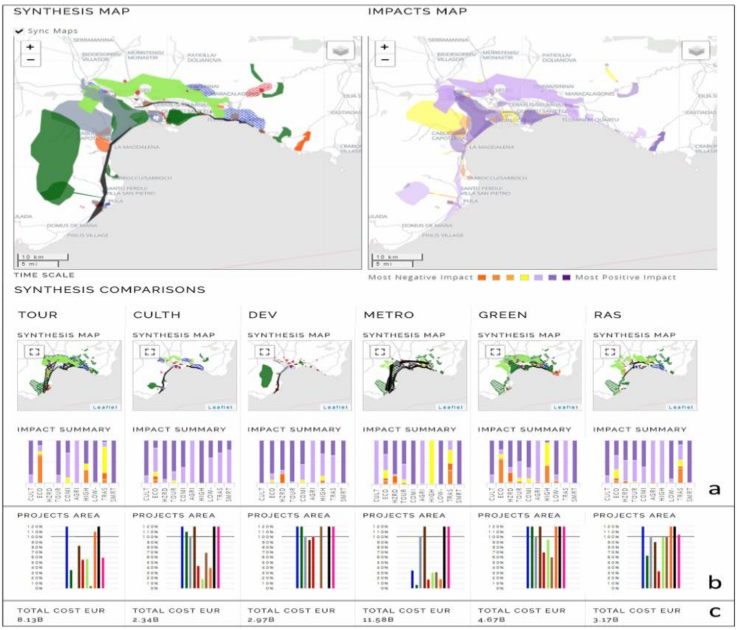

Figure 3 - Syntheses assessment and comparisons tools in Geodesignhub

In addition, at the end of the workshop, the coordination team selected a total number of thirty-two diagrams (on average three per system) among those contained in the final design and generated a voting link using a dedicated tool of Geodesignhub. The link gives access to an online platform where a user-friendly map-based interface enables the users

to express their preferences using a like/dislike functionality to assess the projects or policies previously created by the workshop participants. A potentially unlimited number of people could, therefore, express their views with regard to final synthesis.
In summary, while SMGI can be used in the assessment phase to generate input for the Geodesignhub platform, the software itself also integrates, beside design support features, several functions to produce further SMGI with relevance for design and decision-making in the intervention phase, as reported in table 1.

Table 1 – Social media network functionalities and main generic features of Geodesighub

Social Media network features	Other Features
Geo-referenced multimedia content creation	Updated Evaluation maps
Add videos to diagrams	Import diagram from an external file/model
Add photos to diagrams	Cash flow analysis
Add tags to diagrams	Diagram buffer
Add comments to diagrams	Copy and edit a diagram
Voting link	Design timeline
Geodesignhub API	Design budget and costs
	Design impact calculation
	Negotiation tools
	Globe 3D
	Design Analytics

Conclusion

This paper discusses the opportunities offered by the new sources of spatial information for and in spatial planning. After presenting an overview of recent advances in digital spatial data sources, focusing in particular on SMGI, a detailed geodesign case study demonstrates how the integrated use of both authoritative and volunteered geographic information resources may enrich not only the way knowledge is built to support design, evaluation and decision-making, but also how the process itself generates further information which can be used for better understanding of the process itself.

In the case of the construction of the evaluation model of the TOUR system, available official data would not have been sufficient for describing the current dynamics and express community values. The integration of SMGI (i.e. booking.com, tripadvisor.com, and panoramio.com data) in the analytical workflow, enabled to suggest most suitable areas for tourism development taking into account the preferences of current tourists (booking.com and tripadvisor.com) and the perspective of the local community (panoramio.com) on locational choices. Regarding the application of the geodesign framework, the use of the Geodesignhub PSS proven feasible involving the broader community in the bottom-up generation of design alternatives and in the creation of consensus through negotiation, creating new knowledge, mutual-learning, awareness and as a result a proactive attitude towards collaboration.

Still possible biases and subjectivity in the creation of the evaluation models can be found, but the geodesign approach demonstrated to help to earn a clearer understanding and awareness on the relationships between knowledge building, design, and decision-making, and to make them transparent within the complexity of current planning challenges.

On the base of these results, it is possible to expect that the use of digital geographic information according to a geodesign approach may contribute to better operationalise those principles of Strategic Environmental Assessment involving transparency, pluralism, democracy, and responsibility which often face difficulties to be implemented in the practice, at least if we look at the problem from a technical procedural perspective. Current results suggest it may represent a new interesting direction of research and experimentation. Then, those difficulties may possibly remain mostly a matter of political will.

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