CONCEPTUALIZING A WEBGIS-BASED DECISION SUPPORT SYSTEM INTEGRATING ONLINE COMMUNITY INTERACTIONS FOR URBAN AND LANDSCAPE REGIONAL PLANNING

Track N° 12 Online communities as a new form of digital collective action in a digital society

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Abstract

This paper explores the potential of using Online Communities for innovating decision making for urban and regional planning. Regional planning for urban development is generally implemented by gathering, processing and disseminating geospatial data related to land use and risk areas. Decision and policy making are developed by zoning scenario-based dynamics of human pressures and needs versus resources availabilities. These general principles are enforced into GIS based Decision Support Systems that synthetize optimal cost-benefit scenarios of resource allocations while managing and mitigating natural and human-driven hazards from large to local scales. Starting from the data collection from different authoritative geospatial databases, this work firstly illustrates a data homogenisation procedure aimed at building a knowledge base of the elements that characterize landscape under legal protection. Then, it conceptualizes a WebGIS-DSS aimed at involving OCs, whose contribution offers innovative scenarios in planning activities by using social networks and personal mobile devices.

Keywords: webGIS, Open Data, Big Data, DSS, Regional Planning, Online Communities.

1 Foreword

Safe and sustainable urban and landscape protection and development are generally achieved, at the regional governing scale, by identifying and zoning the areas characterized by homogeneous resources and risk conditions. Those conditions generalize the complexity and diversity of the human-nature-society mutual interdependencies into homogeneous areal units pertaining to natural and anthropogenic processes and features of the same kind. This general principle applies to any regional urban and landscape planning project from natural hazard management and planning (Directive 2007/60/EC on the assessment and management of flood risk; Misiak et al., 2014) to cultural and natural landscape protection (Marcucci, 2000; Von Haaren, 2002; Fusco Girard and De Toro, 2007; Jeong et al., 2013; Gisotti, 2017; Franco et al., 2018) to any zoning project aiming to manage and protect green or blue (Directive 92/43/CEE “Habitat”; Graymore et al. 2009; Caspersen et al., 2010; De Groot at al., 2010; Carver et al., 2012), archaeological or historical (Schummler et al., 2014; Di Napoli et al. 2019), socio-economic or industrial entities (Gorsevski et al., 2012; Rikalovic et al., 2014; Gavrilidis et al., 2016).

Decision and policy making are nowadays technically implemented, by means of Geographic Information Systems (GIS) that support and interface Decision Support Systems (DSS) used by managers to simulate scenarios and the impact of potential management actions. GIS-DSS are implemented to gather, process and visualize the entire and diverse set of geospatial information on the physical and human-linked dynamics and features (Carver, 1991; Jiang and Eastman, 2001; Joerin et al., 2001; Malczewki, 2004; Malczewki, 2006; Chen, 2010; Chen, 2014; Mele and Poli, 2017; Parry et al., 2018). As a result, bounding conditions are applied to govern and regulate any social and economic transformations in protected areas.

Notable examples are the flood hazard and risk management plans (Directive 2007/60/EC on the assessment and management of flood risk), the landscape protection plans, archeological zoning maps (European Landscape Convention, 2000; Italian Cultural Heritage and Landscape Code, 2004; Piano Territoriale Paesaggistico Regionale del Lazio, 2007) or the municipal urban regulatory models (PRG Roma, 2008). While the human-nature resource versus risk ecosystem shall be analysed holistically by inter-linking the diverse dynamics and landscape features into one unique framework, the various zoning and regulatory data models are produced and disseminated by means of web-based interfaces for the GIS-DSSs that use heterogeneous geospatial data and rigid interfaces. In other words, the different regional urban and landscape management plans “do not talk to each other” reflecting the inefficiencies and rigidity of the government-driven decision and policy making (Spasiano and Nardi, 2019).

Nonetheless, open geospatial data are nowadays largely available, supporting a novel paradigm of open and integrated government where different regional planning data models and DSSs can work in sinergy for efficient urban and land protection as well as for transparent and effective communication and interaction with the regional and local communities. In this regard, it is also clear that nowadays remote sensing and portable device hardware technologies, further empowered by soft tools like social media applications, are paving the way for novel ways of interfacing and interacting (Campagna et al., 2012; Albuquerque et al., 2015; Assumpçao et al., 2018). As a result, in less than two decades, we are moving from static cartography applications and offline management, to real-time observation and decision systems, integrating satellite, drone and web-cam monitoring systems, with decision-makers and final users (i.e. citizens) that are no longer only receiving inputs and mono-direction information, but participate and engage in the regional management process as both “human sensors” and dynamic actionable information producers (Lisjak et al., 2017; Assumpçao et al., 2018).

This work proposes a novel geospatial data model aiming to gather and process the heterogeneous information pertaining to different regional planning databases to produce a unique and homogeneous data framework. This data framework firstly fulfills the need to make citizens understand the basic structures of urban and regional planning, in which they interact, net of the complexity of available data. Additionally, supporting the vision that bottom-up approaches shall characterize the future settings of urban and landscape decision and policy making, this conceptual contribution reflects on the potential integration of online communities into a webGIS-DSS in planning processes and dynamics by surveying activities in order to:

- increasing knowledge and awareness of landscapes, urban environment and their resources;
- building concerted and shared urban planning scenarios;
- giving feedback in adopted actions.

Several studies investigated the potential of involvement of Online Communities (OC) in territorial decision-making supporting by surveying methods: the quantity and the variety of social media contents can be particularly useful in analyzing human behavior in urban and natural spaces (Elwood et al., 2012; Frias-Martinez, et al., 2012; Peng and Huang, 2017; Rzeszewski and Beluch, 2017); in identifying conflicts arising from different interests and visions (Karimi and Brown, 2017); in the awareness and evaluation of ecosystem, recreational and tourism services (Caspersen and Olafsson, 2010; Koppen et al., 2014; Richards and Friess, 2015; Guerrero et al., 2016; Canedoli et al., 2017; Heikinheimo et al., 2017); in land use and landscape analysis and in the assessment of natural and cultural resources (Aretano et al., 2013; Loconte et al., 2014; Van Zanten et al., 2016; Martì et al., 2017; Sun and Yun, 2017; Zolkafli et al., 2017); in the prevention and identification of natural hazards (Albuquerque et al., 2015; Zhang et al., 2019). Different implications, therefore, that converge in research topic of Citizen Science, as a discipline aimed at involving citizens in support of decision and policy making (insert citation).

This manuscript is organized as follows: this introductory section is followed by Section 2 describing the data and methods implemented for this work. The conceptualization of regional planning webGIS-DSS model is introduced and explained in detail in Section 3. Section 4 presents sample results of the selected data and information modelling framework applied to a regional case study pertaining to Lazio region, in central Italy, representing the city of Rome domain. A final discussion section is then provided synthesizing the ongoing work and expected outcomes of this investigation, also sharing the pros and pitfalls of this research.

2 Data and methods

The proposed DSS is based on the implementation of a GIS data model gathering, homogenizing and visualizing thematic layers describing regional urban and landscape entities. The purpose of this procedure is to identify the basic elements of urban and regional structures within four categories of cartographic layers, as illustrated in table 2. These thematic categories, then, allow a rapid visualization and querying of geospatial data, even for non-expert users, by dynamic and intuitive dashboard. These preliminary steps were necessary to overcome the technical and structural differences that often distinguish geospatial data of various origin. Additionally, social network databases are queried to extract relevant information regarding geotagged posts of interest for the presented modelling approach, as human behavior, human-environment interactions and users' feedbacks. The webGIS-DSS is implemented into the ESRI GIS system, by using the ArcGIS PRO for data processing and adopting the ArcGIS Online platform for programming the webGIS. The main data and methods, adopted for this work, are hereafter described in more detail.

2.1 Geospatial layers and data homogenization

The geospatial layer modelling and processing for data homogenization is based on the implementation of the following steps:

1) Gathering and verification of vector layers representing zoning data as obtained from open data of available landscape and urban plans;
2) Attribute table filtering for identifying unique table fields to produce homogenized feature names (Table 1).
3) Definition of general categories for developing final *merge* processing of geospatial data for obtaining homogeneous geospatial layers.

Step 3) supports the production of well-identified thematic layers (Table 2 and 3) in order to produce a consistent and homogeneous representation of the resources and risk characterizing the zoning model. For homogenization here we refer to geospatial layers characterized by consistent spatial scale, resolution and attributes.

Field	Description
FID	Feature ID
Filename	Source layer filename
layer	User-driven identification of layer specification
NAME	Reference spatial domain (regional, municipal, …)

Table 1. Vector data model for polygonal entities.

Layer	Category
Water – rivers and lakes Water – Seas and coastal	Water
Archeology Public interest areas	Cultural and natural heritage
Forests and green zones Verde – Forests and shrubs	Green protected areas

Table 2. Geospatial simplified and homogeneous data model for urban and landscape planning: Vector data model for polygonal entities

Layer	Category
Landscape/panoramic hotspots	Landmarks and hotspots
Archeological spots Historical buildings	Historical entities
Springs and source water Geo-sites	Hydrologic and geomorphic entities

Table 3. Geospatial simplified and homogeneous data model for urban and landscape planning: Vector data model for point entities.

2.2 GIS interface: dashboard and infographics

The ESRI Arcgis platform (Law and Collins 2018; Law and Collins, 2019; Price, 2019) is used to perform of the data processing and visualization using the different applications provided by the GIS operating environment. In particular, Arcgis PRO is used as data processing client, while Arcgis Online is used for data visualization, sharing and for the development of the final user interface.

In particular, Arcgis Online is used for producing dashboard and infographics that support interactive visualization and query of the geospatial layers. Aim of the GIS interface is to support the use, understanding and analysis of the data by non-expert users by means of a user-friendly interface. Basic operations of filtering and query are provided (i.e. filter or visualize data and associated information of the attribute table by municipality; use of standard zoom, pan and other dynamic visualization tools with generalized plots using pie charts, histograms and tables to read and process attribute data of single or combined geospatial layers).

2.3 Online community data gathering and geo-visualization

Regional plans – related to urban and landscape uses, activities and to territorial development and protection in general – involve a significant variety of actors and users. Actors are those who take decision and have government control over the interventions and transformations of the landscape that may, or may not occur. Actors are expert and public entity managers that play the decision and policy making roles. Urban and non-urban ecosystem are, then, characterized by the general public. Citizens characterize this category, generally non experts, that – acting also as private entity managers or team members – are impacted, and must respect, the bounding conditions and regulations transferred by regional management entities by means of regional planning models.

There is, thus, a very dynamic and heterogeneous community of managers, stakeholder and users that is already hierarchically structured and linked to the regional and urban management process. This community, that have been organized offline in the last century, is nowadays already interacting online. This interaction is structured within the geospatial data visualization and sharing environment while categorizing the users of the GIS. The GIS environment included different categories and level of access to the geospatial data, from the data producers and regulatory managers that have administrative rights and access to the platform to the final users, the general public and citizens, that have only visualization and query rights.

Nevertheless, citizens, to date, may play a much more important role while accessing and visualizing data. Citizens, thanks to low cost data and information sensor and transmission technologies (mainly using portable devices), act as “human sensors” and process data in multiple directions. It is, in fact, not only a final destination as geospatial data reader, but the citizen can observe, reproduce, picture and comment the urban environment and send data to the urban planning managers.

In this research work, we theorize a conceptual working model to implement this interaction. Social networks are selected and used to query georeferenced information produced by users to evaluate the interaction of citizens with the urban and landscape homogeneous areal units produced by the GIS. As a result, geotagged and geographically positioned posts, namely User Generated Content (UGC) gathered by most widespread social media (i.e. Twitter, Instagram, Flickr and YouTube) to understand and interpret, by using appropriate filtering on data content with hashtags, the ground level visualization of territorial entities that have been bounded by regional zoning plans for regulatory activities. In this way, a cross-check and validation of the regional plan can be performed by integrating user generated data, extracted using available social network Application Programming Interface (API) to query the big data by selecting appropriate keywords and hashtags to geolocate and visualize the history of relevant images and videos pertaining to the features and processes of interest.

2.4 WebGIS-DSS online community integration workflow

ArcGIS Online provides and easy to develop and use GIS interface published in the ESRI cloud as webGIS. A webGIS is a GIS data visualization and simplified operating environment that is accessible by means of a web browser to publish, by means of a GIS server hosting data by a public IP, and provide internet users with some GIS functionalities to navigate, understand, visualize and query the spatial and numerical attribute of thematic layers.

The dashboard is an interface for illustrating the value of data by means of dynamic thematic maps with related attribute tables and plots. For our specific case, as illustrated in Figure 1, the proposed dashboard we mean a data visualization interface that integrate data from regional planning with geotagged user-contents. This platform allows a dynamic data visualization and query, for fostering knowledge and citizens' engagement with bottom-up approaches. User-generated contents (UGC) can help decision makers and urban planner in their activities by pointing out points of interest, heritage at risk, common behaviours related to ecosystem services or for recreational purpose or land use changes. A set of additional information that can shed light on specific aspects of landscape and urban spaces, according to a bottom-up approach that places local communities at the centre of decision-making processes. In this sense, the operational dashboards represent a suitable tool for relating authoritative data – produced in the context of landscape government and protection – with information provided by users. These latter data sources can underline the place perception and give useful feedbacks about the effects of planning decisions.

Decision Support Systems (DSS) is a data and information system developed to support organizations in processing and interpreting information to performed decision making. DSS are commonly used for regional planning and often implemented using GIS environments. DSS can be intended as tools based on the optimization of multi-criteria analytical models and the integration of different parameters (Carver, 1991; Joerin and Musy, 2001; Chen et al., 2009; Manos et al., 2009). In this sense, the OC can provide additional information in order to support strategic decisions on the landscape planning and land use management. Among the techniques adopted for this purpose it can be noted spatial patterns creation, resulted by the spatial elaboration of social media information (Campagna et al., 2012; Kahila Tani et al., 2015). These patterns are, then, compared with economic, environmental and social factors that together define territorial profiles for regional planning actions and interventions (Frias-Martinez et al., 2012; Zhang et al., 2019). DSS perform the function of creating alternative scenarios based on the typology and quantity of adopted parameters. The applications fields of these tools are different. They range from the industrial site selection suitability (Gorsevski et al., 2012; Rikalovic et al., 2014) or agricultural (Manos et al., 2009), residential (Gavrilidis et al., 2016; Gopal et al., 2016; Parry et al., 2018), tourism (Carver et al., 2012; Heikinheimo et al., 2017) or nature protection destination land use (Convertino et al., 2013). The role of the OC can be decisive in understanding territorial dynamics.

In this work, we conceptualize the integration of online communities into a webGIS-DSS for regional urban and landscape ecosystem management purposes, starting from the implementation of an operational dashboard for visualising and querying open geospatial data. The workflow of this integration is depicted in Figure 1. Moreover, the OC-based DSS integrates modules for the collection and processing of OC contents to support decision making. In particular, we show the results of tests related to two potential OC applications:

- On a voluntary basis; users release information through appropriate online surveying platforms, i.e. Public Participatory GIS (PPGIS) or through surveys promoted on social media (Guerrero et al., 2016; Heikinheimo et al., 2017);
- Passively via platforms developed by experts who acquire social media content via Application Programming Interface (API) from Twitter, Instagram and so on (Frias-Martinez et al., 2012; Hawelka et al., 2014; Martì et al., 2017; Rzeszewski and Baluch, 2017).

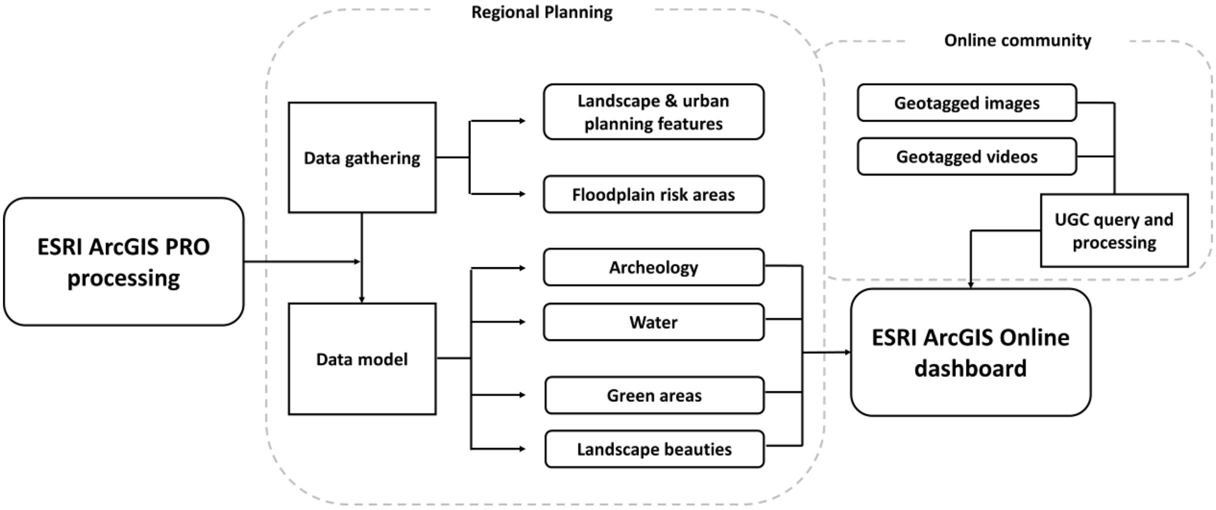


Figure 1. Flow chart depicting the processing integration model of online communities into a Regional Planning webGIS-DSS.

3 The city of Rome (Lazio) case study

Data model tested in Spasiano and Nardi (2019) is here used for testing OC integration for conceptualizing a novel DSS regional planning. Homogeneous database includes the data and model results illustrated in Section 2, with specific regard to typical areas that characterize the Lazio Landscape Regional Plan.

The regional administrative unit, Lazio Region, including the city of Rome, in central Italy, is selected as case study for testing the proposed procedure. This region covers an area of approximately 17,000 km2 hosting almost 6 millions of people. Half of the people and most of the urban transformation are linked to the city of Rome area that is located towards the coastal area of the Tyrrhenian sea. The Lazio Region is characterized by diverse morphology with low relief and large alluvial plains along the Tiber river and its tributaries. This area hosts a wide variety of natural and cultural heritage features as well as green and blue spaces.

In this sections the different steps and components of the conceptual model for integrating online community interactions with the regional planning model are visualized by showing GIS layouts, extracted from the GIS, as well as the dashboard, infographics linked to the webGIS-DSS. A sample visualization of UGC from the general public is also provided to depict the implementation of the online community data integration model for the study domain.

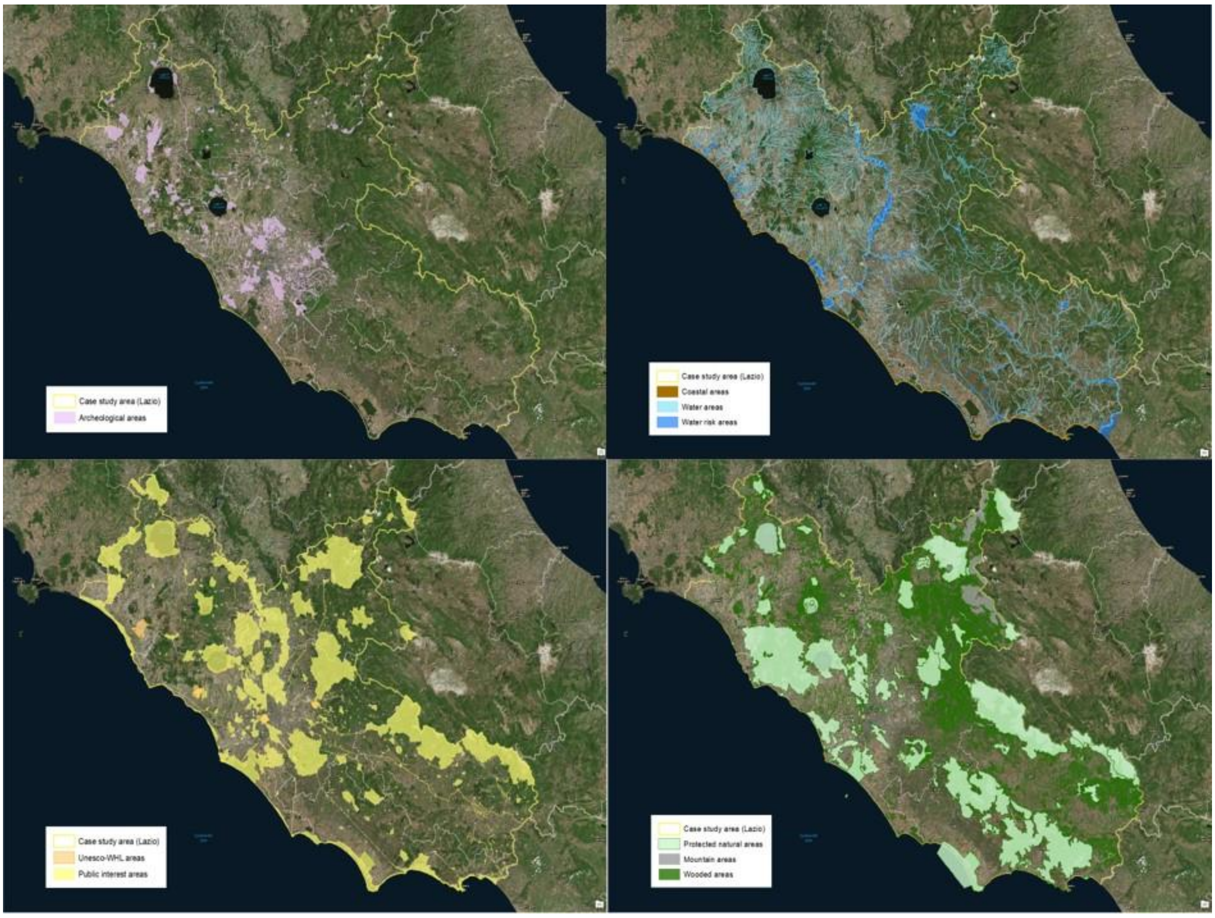


Figure 2. The four main categories of data are visualized in this geospatial maps. The archeological zoning (upper left), the coastal and water ares (upper right), the areas of public interest and cultural heritage (lower left) and the green speces (lower right) are represented and color coded using single values.

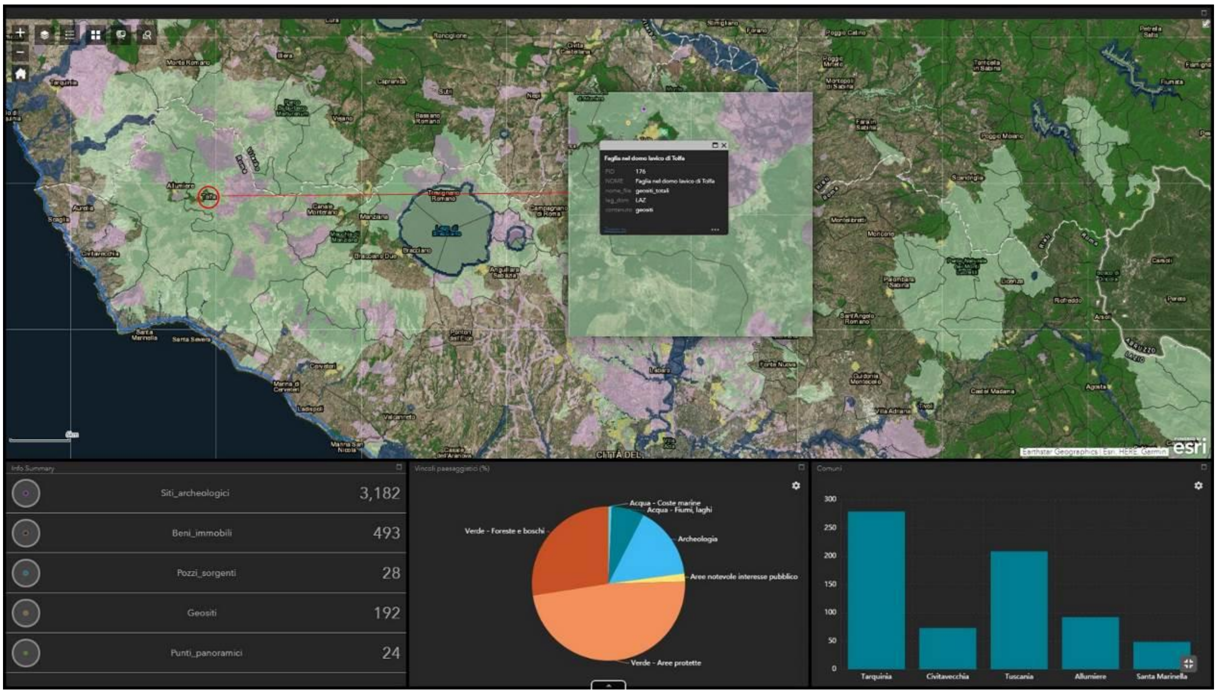


Figure 3. The webGIS-DSS is visualized with the dynamic data visualization interface built in Arcgis Online and associated infographics (lower panels).

The operational dashboard, here illustrated, provides the decision makers with a basic knowledge of the set of protected resources and flood risks areas, that characterize urban landscape. The OC engagement marks the evolutionary transition from operational dashboard to DSS tool. The knowledge function of analysis model thus extends to the shared and concerted urban planning scenarios and actions, using data integration and survey for awareness methods.

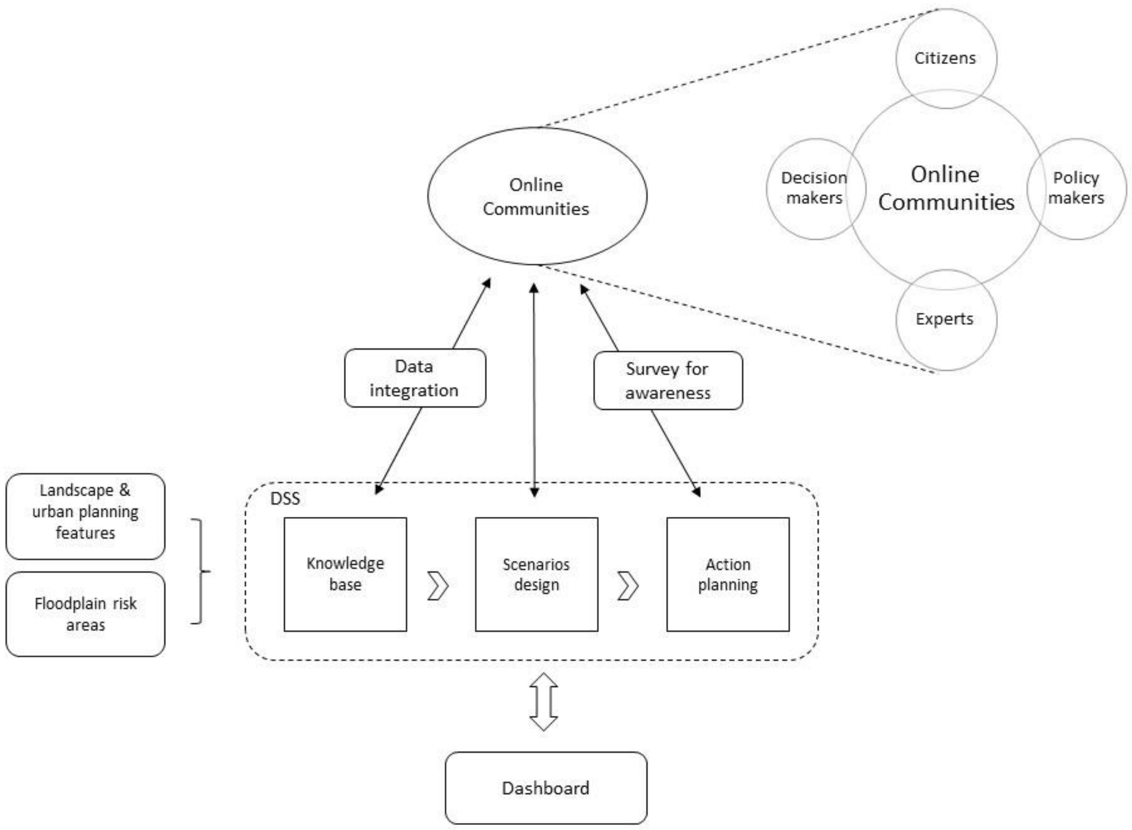


Figure 4. Flow chart depicting the main actions of DSS model and describing users' typologies.

The purpose of the DSS is to connect different types of users (citizen, decision makers, experts) by providing them with the same cartographic survey tools within a sharing and exchange data platform. The sharing and the integration of data within the DSS is aimed at responding to the need to bring together the needs of residents with the environmental, landscape and morphological characteristic of urban spaces.

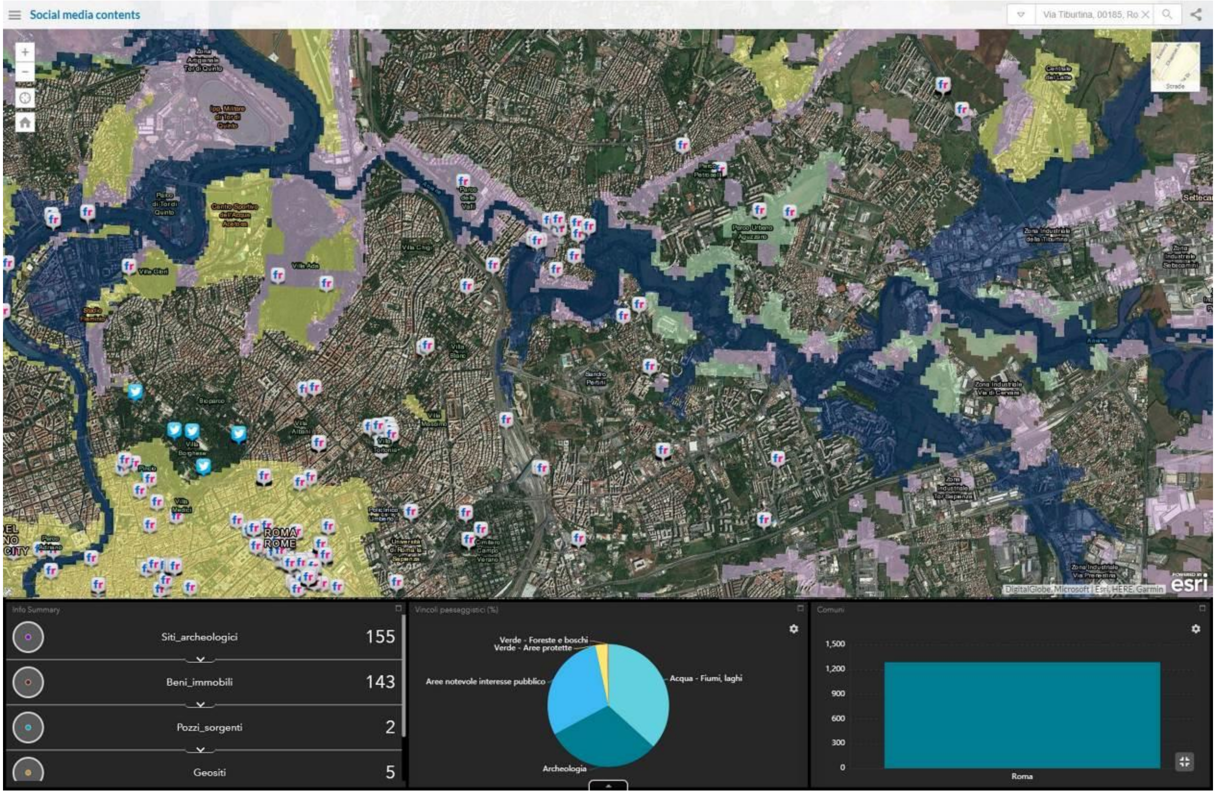


Figure 5. WebGIS representing information gathered from UGC derived using social network. The system is able to dynamically visualize and query UGC using filtering methods by location or by keyword.

A sample test in urban part of the ancient Via Appia (south-east area of Rome) allows to better clarify the theoretical concept so far exposed. This area falls within different types of constraints areas (archaeological, environmental, landscape interest) despite the presence of artificial and urbanized surfaces that indicate a coexistence between contrasting land uses (as illustrated in Figure X, comparing information layer with the satellite image).

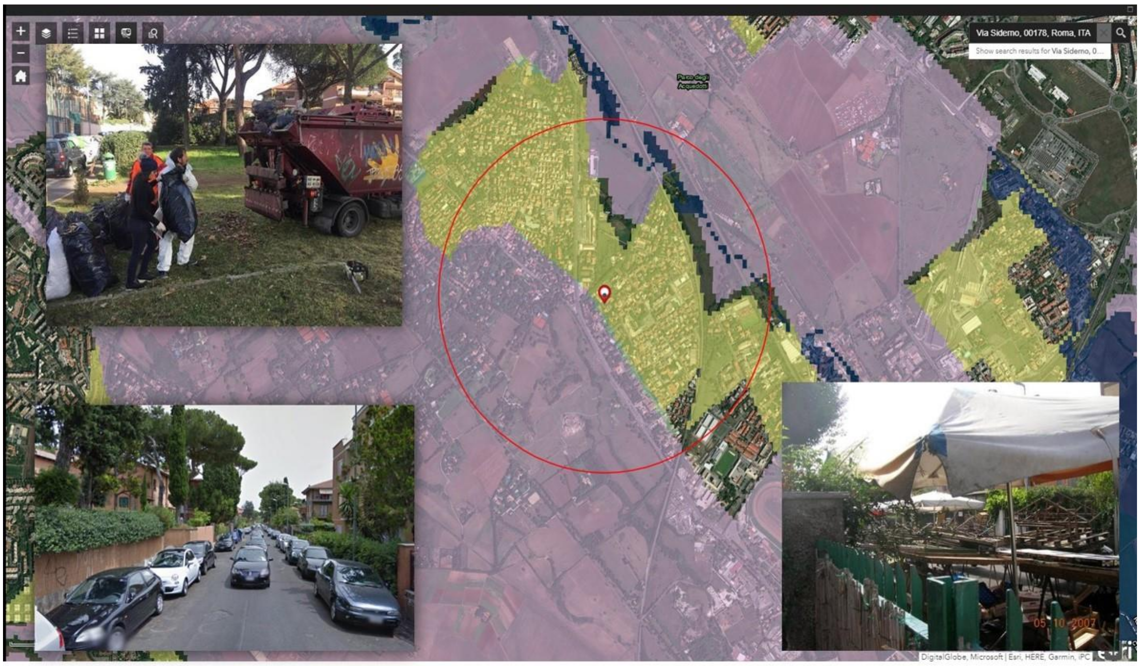
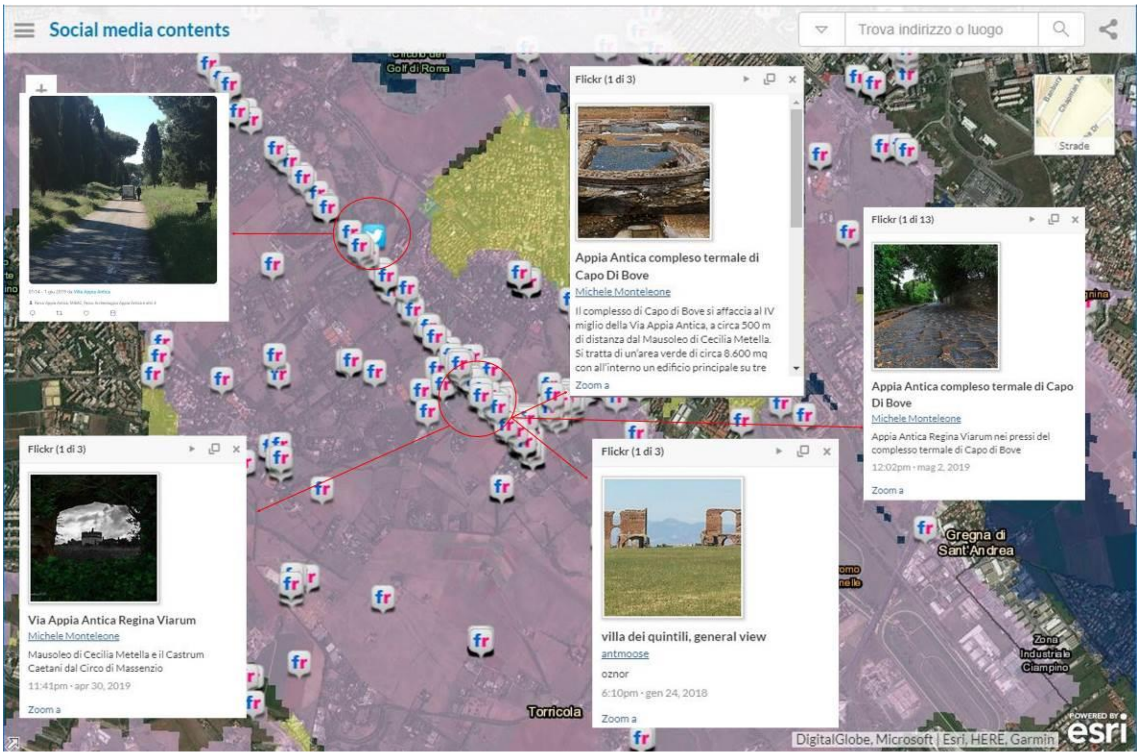


Figure 6. Sample screen of Via Appia zone case-study.

Citizens' report – through the use of social media and online data collection platforms – can be so useful to guide and support urban planning activities towards a mediation between the needs expressed by citizens and the need to protect landscape structures.



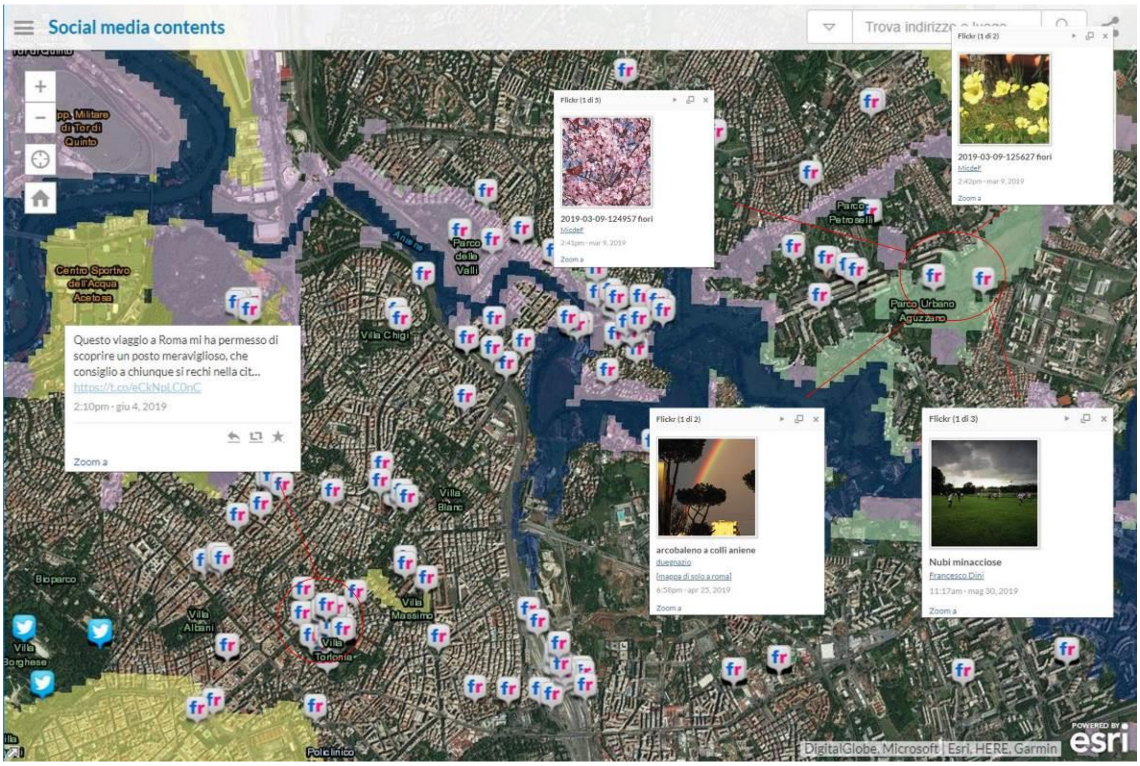


Figure 7. *A sample application of the UGC query and visualization depicting the information (images and videos) provided by users within the regional planning zoned areas. The upper sample area represents the Appia Antica area while the lower sample area is the Aniene river highly urbanized ecosystem*

4 Discussion

WebGIS-DSS are effective and widely used tools for regional planning of urban and landscape ecosystems. Geospatial and open data are increasingly available from multiple sources to identify and quantify the processes and features of interest for the different zoning models that support decision and policy making to protect the natural and cultural heritage while safely support socio-economic development under pressing needs and challenging natural hazards.

It is common and current practice to develop GIS environment to process and visualize geospatial data and disseminate actionable information to stakeholder and users of regional planning decision and policy models. The general public, in current operational framework, is able to access data in only one-direction that is as information receiver.

Nevertheless, novel technologies are transforming citizens in “human sensors” able to smartly gather, process and re-direct information in multiple manners and directions. Citizens are producing a wealth of information at the urban and landscape level by and big data are already available providing the human experience by means of UGC of what the general public sees and experiences at the local scales.

This conceptual work explores the value of the online community engagement as data provided with the aim of capturing the human experience within the regional zoning models. Major outcomes of this research may be summarized as follows:

- GIS processing tools allow to homogenize the diverse and heterogeneous open geo data that characterize the different regional planning models supporting integrated and holist urban and landscape management;
- Homogenized geospatial data can be analysed and queried linking the quantitative and qualitative information associated to processes and features of the natural and anthropic dynamics (i.e. resources and risks) occurring at regional scale;
- Informed decision and policy making is developed by means of webGIS-DSS to share information and decisions to the expert and general public;
- webGIS-DSS can, nowadays, be implemented with an open iterative loop that does not end with the final user of the information distribution system, like a reader, but iterates receiving and integrating the user-driven information and also the experiences from the local communities;
- the integration of online communities into webGIS-DSS may pay the way for a novel generation of DSS for regional planning where the human sensing capabilities may enhance and empower the decision and policy making by:
    - validating the regional planning zoning model by identifying what citizens visualize, do and think within the bounding models of the regional plans (see for example the different landscape properties of Figure 6 where the same archaeological domain is, in reality, characterized by very different actual landscape properties);
    - interact with citizens to support a more sustainable, informed and engaged society (see dashboard features of Figure 4 and 5 and also sample UGC of Figure 6 showing very different human behaviour and feelings).

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