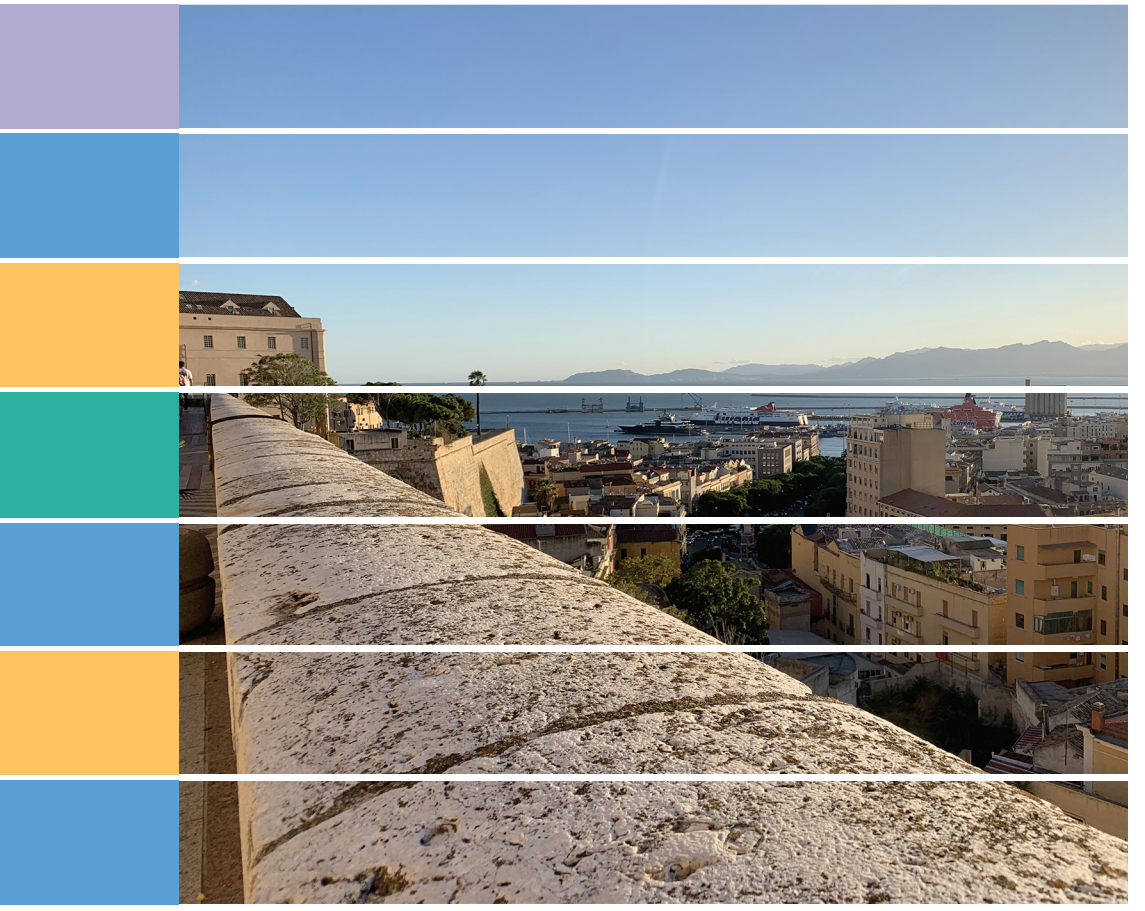
Carmela Gargiulo Corrado Zoppi
Editors

Planning, Nature and Ecosystem Services



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Smart City, Urban Planning for a Sustainable Future

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Carmela Gargiulo Corrado Zoppi

Editors

Planning, Nature and Ecosystem Services

INPUT aCAdemy 2019

Conference proceedings

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This book collects the papers presented at INPUT aCAdemy 2019, a special edition of the INPUT Conference hosted by the Department of Civil and Environmental Engineering, and Architecture (DICAAR) of the University of Cagliari.

INPUT aCAdemy Conference will focus on contemporary planning issues with particular attention to ecosystem services, green and blue infrastructure and governance and management of Natura 2000 sites and coastal marine areas.

INPUT aCAdemy 2019 is organized within the GIREPAM Project (Integrated Management of Ecological Networks through Parks and Marine Areas), co-funded by the European Regional Development Fund (ERDF) in relation to the 2014-2020 Interreg Italy – France (Maritime) Programme.

INPUT aCAdemy 2019 is supported by Società Italiana degli Urbanisti (SIU, the Italian Society of Spatial Planners), Istituto Nazionale di Urbanistica (INU, the Italian National Institute of Urban Planning), UrbIng Ricerca Scientifica (the Association of Spatial Planning Scholars of the Italian Schools of Engineering) and Ordine degli Ingegneri di Cagliari (OIC, Professional Association of Engineers of Cagliari).

This book is the most recent scientific contribution of the "Smart City, Urban Planning for a Sustainable Future" Book Series, dedicated to the collection of research e-books, published by FedOAPress - Federico II Open Access University Press. The volume contains the scientific contributions presented at the INPUT aCAdemy 2019 Conference. In detail, this publication, including 92 papers grouped in 11 sessions, for a total of 1056 pages, has been edited by some members of the Editorial Staff of "TeMA Journal", here listed in alphabetical order:

- Rosaria Battarra;
- Gerardo Carpentieri;
- Federica Gaglione;
- Carmen Guida;
- Rosa Morosini;
- Floriana Zucaro.

The most heartfelt thanks go to these young and more experienced colleagues for the hard work done in these months. A final word of thanks goes to Professor Roberto Delle Donne, Director of the CAB - Center for Libraries "Roberto Pettorino" of the University of Naples Federico II, for his active availability and the constant support also shown in this last publication.

Rocco Papa
Editor of the Smart City, Urban Planning for a Sustainable Future" Book Series
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INTRODUCTION

This e-book contains the Proceedings of the INPUT aCAdemy 2019 Conference held at the University of Cagliari on 24-26 June 2019, titled "Planning, nature and ecosystem services."
Input aCAdemy follows the tenth INPUT Conference, held in September 2018 at Tuscia University, in Viterbo and, in some way, it breaks the biennial tradition of the INPUT Conferences. The reason for the frequency increase of the INPUT Conferences is that the Department of Civil and Environmental Engineering and Architecture of the University of Cagliari is involved in a project funded by the Programme INTERREG Marittimo–Italia France–Maritime 2014–2020, Axis 2.
In the context of the project, entitled "GIREPAM–Integrated Management of Ecological Networks through Parks and Marine Areas", the Department and the Office for Nature Protection and forest policies of the Regional Autonomous Administration of Sardinia are studying and defining an experimental methodology to integrate conservation measures concerning Natura 2000 Sites into marine protected areas regulations. The methodology is implemented to build the new regulations of two marine protected areas of Sardinia, namely the Island of Asinara and of the Island of Tavolara and Cape Coda Cavallo.
Since GIREPAM allocates a considerable amount of funds to the organization of an international conference on protection of nature and natural resources, ecosystem services and their relationship with spatial planning processes and practices, green infrastructure, and integrated management of protected areas and Natura 2000 Sites, and these funds must be spent by December 2019, the research group at the Department proposed to the INPUT Community, during the 2018 Viterbo Conference, a 2019 INPUT Conference focussing on these themes. The INPUT Community responded enthusiastically and, that being so, the research group has made every effort to make the event come true.
The Conference develops through plenary sessions and parallel tracks. The scope of the plenary sessions is to propose distinguished points of view concerning research and implied planning ideas and policies on important and significant issues which feature the ongoing scientific and technical debate on nature and natural resources.
The questions proposed and discussed in the Conference are three central topics which are characterized by several studies available in contemporary literature, and by vibrant debates as well, both from the theoretical and technical points of view. These questions are presented and discussed in the three plenary sessions which are the starting points of the three days of the Conference. Each plenary session is organized as follows: first, a speaker, a distinguished scholar, proposes the findings of his theoretical and/or applied research work and derived implications for spatial policy; secondly, a discussant, a distinguished

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scholar as well, critically analyzes the positions expressed in the first place and identifies open or unresolved questions and outstanding issues; thirdly, the public enters the discussion, through questions, observations, critical positions. Finally, the speaker replies to the discussant's and to the public's statements.

The first plenary session is on "Valuing ecosystem services in money: A necessary evil for protecting biodiversity?"; the speaker is Erik Gomez-Baggethun (Faculty of Landscape and Society, Norwegian University of Life Sciences); the discussant is Andrea Arcidiacono (Department of Architecture and Urban Studies, Polytechnic University of Milan).

The second plenary session concerns "Managing urban ecosystems for goods and services"; the speaker is Kevin Gaston (Environment and Sustainability Institute, University of Exeter); the discussant is Bernardino Romano (Department of Civil, Building-Architecture and Environmental Engineering, University of L'Aquila).

The third plenary session is related to "Mapping and modeling ecosystem services: A cascade ES modeling approach applied to the Flemish Natura 2000 Network"; the speaker is Jan Staes (Department of Biology, University of Antwerp); the discussant is Beniamino Murgante (School of Engineering, University of Basilicata at Potenza).

The topics presented in the plenary sessions are the background of the discussions which characterize the parallel tracks. These tracks are featured by studies which consider protection of nature and natural resources, ecosystem services and their relationship with spatial planning processes and practices, as regards the following topics:

1. Ecosystem services and spatial planning;
2. Integrated management of marine protected areas and Natura 2000 sites;
3. Rural development and conservation of nature and natural resources;
4. Geodesign, planning and urban regeneration;
5. Green and blue infrastructure;
6. Smart city planning;
7. Water resources planning, ecosystem services and nature-based solutions in spatial planning;
8. Conservation and valorisation of architectural and cultural heritage;
9. Accessibility, mobility and spatial planning;
10. Tourism and sustainability in the Sulcis area;
11. Ecological networks and landscape planning.

The closing plenary session of the Conference proposes a roundtable discussion on "Planning Nature 2000 Network and protected areas: The integration of conservation measures into regulations." The roundtable will involve panelists from several institutions who participate in the GIREPAM Project.

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THE INTERNATIONAL GEODESIGN COLLABORATION

THE CAGLIARI CASE STUDY

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ABSTRACT

This paper presents a two-scales geodesign study of the Metropolitan City of Cagliari developed according the International Geodesign Collaboration (IGC) guidelines and standards. As such, the study aims at contributing to the broader IGC research questions concerning how the geodesign approach to spatial planning can help addressing the most urgent complex challenges of sustainable development. After an introduction on the main key-features of the IGC initiative, the case study is presented in terms of the design approach and workflow. The paper concludes with a discussion on what lesson can be learnt from applying the geodesign approach with regard to planning education and practice.

KEYWORDS

Geodesign; International Geodesign Collaboration; Collaborative Decision Process, Systems Thinking

1 INTRODUCTION

Geodesign is a novel approach to spatial planning and design aiming at addressing current challenges of spatial development. Geodesign methods relie on extensive use of spatial information technologies to support collaborative, iterative, and dynamic design and spatial decision-making. Thanks to the use of state-of-the-art GIS technologies and Planning Support Systems, geodesign workflows proved to be successful in framing processes facilitating fast awareness-rising and achievement of consensus among participants in the strategic phases of spatial planning (Steinitz, 2017). In addition, geodesign can support all the design phases from project inception to the detailed design of implementation plans and projects (Moreno Marimbaldo et al., 2018). As a part of an international initiative aimed at fostering geodesign research worldwide, this paper reports on a geodesign study undertaken on the Metropolitan City of Cagliari (MCC) according to the International Geodesign Collaboration (IGC) guidelines. The IGC is an international geodesign research initiative started in 2018 aiming at building and facilitating the sharing of knowledge on the possible ways to address major sustainability challenges of current time. The means envisaged to achieve this ambitious objective are standardization and sharing. Accordingly, almost one hundred partners, mostly from academia, from all over the world joined the IGC, and along 2018 the partners completed 56 studies of local planning and design at various scales. The results were presented at the first IGC meeting held in February 2019 in Redlands, CA, and hosted by ESRI.

The IGC standards for the geodesign studies include:

- modular size for the study areas at various scales (i.e. double multiples of 0.5 km);
- a set of Global Assumptions, which identify major current global dynamics (e.g. global population growth, climate changes, sea-level rise, etc.[1]) to be studied in their local influence in the selected study areas;
- a standard number of 9 Systems to be analyzed, including blue, green, grey, energy and transport infrastructures, low-density and mixed high-density housing, institutional and industry-and-commerce land uses, plus a system to be chosen locally (for the MCC study History and Cultural Heritage was chosen);
- a set of Technology Innovations to be considered for each system: innovations include the latest or forthcoming technologies which can introduce technical improvements in design with regard to each system (e.g. autonomous vehicles or hyper-loops in

[1] for a full list of GA see https://www.envizz1.com/global-systems-research.

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transport, photovoltaic road pavements in energy production, or green building and 3D printing in housing);

- a common format for reporting the results of the study, in order to facilitate comparison among the studies.

There is broad consensus in the geodesign community of researchers and practitioners to refer to the geodesign framework proposed by Steinitz (Steinitz, 2012) as a flexible though robust methodology approach for organizing geodesign studies. The Steinitz framework for geodesign entails the iterative development of six models, the first three of which (i.e. representation, process, and evaluation model) concern the creation of the knowledge base for design and decision-making, while the last three (i.e. change, impact, and decision model) include the creation of design alternatives, the assessment of their impacts, and the creation of a final design based on consensus. While the representation and the process models entail the description of current territorial systems dynamics and their likely evolution without any action, the evaluation model is intended to express an assessment of the current and future conditions in the study area. The product of the evaluation model is a series of maps representing less or more favorable settings for action for the territorial systems taken into account to inform the design, on the base of which change alternatives should be developed (i.e. the change model). The Steinitz framework for geodesign was applied by the authors to develop the study of future scenarios for Metropolitan City of Cagliari according to the IGC guidelines and standards as described in the remainder of this paper.

2 CASE STUDY: FUTURE SCENARIOS FOR THE METROPOLITAN CITY OF CAGLIARI

The recently established (2016) Metropolitan City of Cagliari comprehends seventeen municipalities of South Sardinia (Italy), including Cagliari, the regional capital. The population is approximately 430k inhabitants, in an area of 1,248 km². The area is surrounded by mountains to the East and on the West, by the Gulf of Cagliari to the South, and by the agricultural Campidano plain to the North. In 2018, the MCC started the works for its first planning initiative, the Territorial Strategic Plan, which is going to set the development framework for future physical planning. However, to date, no inter-municipal planning endeavor has ever been carried on in the region. Hence, developing a new strategic plan for the area represents a challenge and an opportunity for innovation, both in technical, political and socio-cultural terms for the local community. This study represents a first attempt to propose a working framework for reasoning on possible future development scenarios, in line with the IGC assumptions and perspectives, on territorial technology innovation.In the last

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decades, the MCC faced overall stable trends in population growth, affected mainly by a limited movement of population from the inner small towns of Sardinia and very limited immigration flows; meanwhile the Municipality of Cagliari lost approximately 30% inhabitants in favor of neighboring municipalities within a 15-20 km radius, due possibly to market dynamics related to real estate prices. As a major challenge for future coherent and balanced development, the MCC needs to balance spatial development patterns in terms of infrastructures and services, as well as ensuring environmental and economic sustainability. In order to explore possible scenarios for the MCC future sustainable development, two workshops (WS) applying the guidelines of the IGC were organized as design studio exercise at the Department of Civil and Environmental Engineering and Architecture of the University of Cagliari. The WS were conducted in October 2018 using the Geodesignhub planning support system (Ballal, 2015), after the set of evaluation maps was created in August 2018 as a preparatory phase of the study by the authors, using ESRI ArcGIS. The first WS was held within the Spatial Planning Course of the Civil Engineering MSc program, concerned a study area of 80x80 Km including the whole MCC (Fig. 1), and involved 58 students. The second WS was held within the Geodesign course of the Architecture BSc program, concerned a nested area of 20x20 Km (Fig. 1), and involved 76 students. Running two WS in sequence allowed to experiment the change of scale in the design as the architecture students had to comply with the design earlier developed by the engineering students. A number of underlying local assumptions were considered to inform the study.

Fig. 1. Case Study areas: a) the first study concerned the whole MCC area (80x80 km); the second-high scale study, concerned the South-East area (20x20 km)

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A population growth of 25k and 50k inhabitants was assumed as baseline scenario in order to set quantitative targets for the ten systems, where possible. In addition, a number of objectives were adopted to inform the creation of the evaluation and change models with regard to each system, as described below:

- water Infrastructure (WATER): reduce hydrological risk and limit pollution of resources.
- agriculture (AGRI): protect prime soils, promote bio products and foster innovation in production to address desertification processes, climate change, and possible future shortage of water.
- green infrastructure (GREEN): enhance connectivity and expand protection to natural or semi-natural areas.
- energy: increase green production through technology innovation, promote local production.
- transport infrastructure: improve accessibility to most populated areas and the level of service of current road infrastructure. Improve the light-rail network. Foster active travelling in recreation, leisure and cultural heritage accessibility.
- industry and commerce (INDUSTRY): promote technology innovation in production and balance spatial distribution within the MCC to reduce workers commuting.
- residential lower density (LDH): accommodate demography growth limiting fragmentation and sprawl;
- residential with commerce and services (MIX): accommodate demography growth with densification and enhance accessibility to commerce and services.
- institutional (INST): promote locational accessibility and balanced spatial distribution.
- cultural heritage (CULTH): preserve historic centers and protect archaeological sites while enhancing fruition.

Following the Steinitz framework, ten evaluation maps – one for each system - were created following standard legend and color code (Fig. 2) to facilitate their understanding and usage by the participants. The color code use the "traffic lights" metaphor were red means "stop" (i.e. the system is working well and no action is needed), yellow means "alert" (i.e. it is not advisable to take any action due to constraints or hindering factors), and different shade of green means growing levels of suitability for actions within each system (the darker the green, the more suitable).

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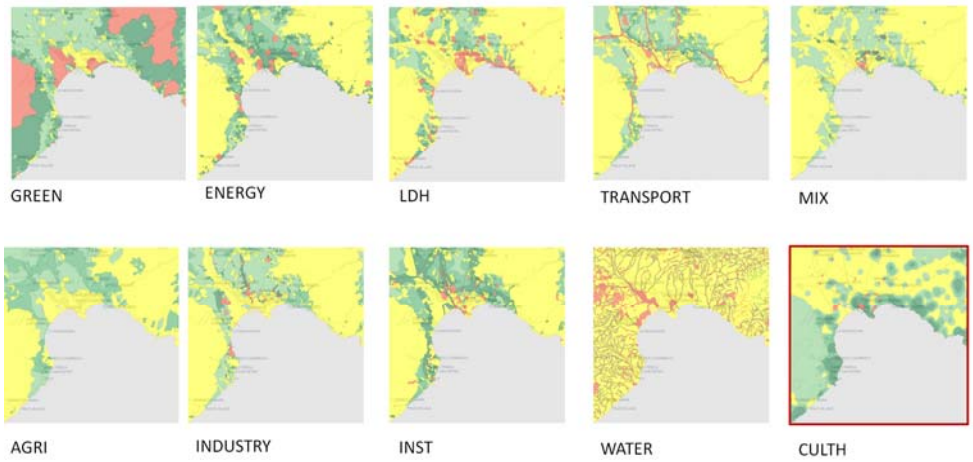

Fig. 2. Set of evaluation maps (i.e. one for each system)

3 GEODESIGN WORKSHOP SETTINGS

Two geodesign workshops were organized, one for each case study area. Each workshop was scheduled in five 3-hour sessions (Fig. 3), according to the following steps: 1) design of project and policies (i.e. diagrams); 2-4) iterative design of integrated syntheses (i.e. scenarios), 5) negotiation. The workshops were supported by the Geodesign hub planning support system (www.geodesignhub.com). Geodesign hub is a web-based collaborative geodesign platform where each participant joins a virtual planning studio workspace offering interactive design and decision-making tools needed to carry-on the workshop workflow.

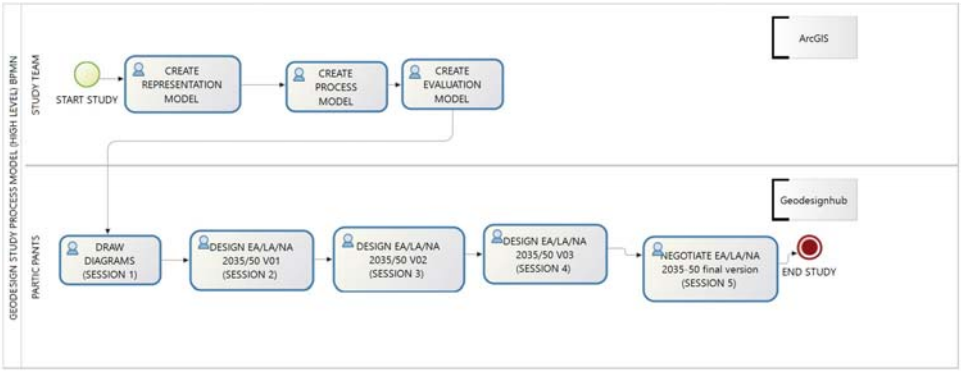

Fig. 3 Geodesign workshop process model

In the first phase (i.e. step 1) participants played the role of experts in one system (e.g. transport planners or engineers, housing experts, etc.) whose duty was to produce three diagrams each: diagrams had to represent projects implementable respectively with

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technologies available at the three time horizons chosen for the study by IGC (i.e. 2020, 2035, and 2050).

The rationale behind this step was to get the participant familiar with possible technologies able to bring innovation to projects in their system. All the diagrams were saved and shared in Geodesignhub in a matrix organized by system (column) and color-coded accordingly (Fig. 4, right). It should be noted that Geodesignhub takes, as input layers for its geographic interface, the evaluation maps developed prior to the WS, which can be used as mash-up overlay to support locational choices during the design of a diagram (Fig. 4, left).

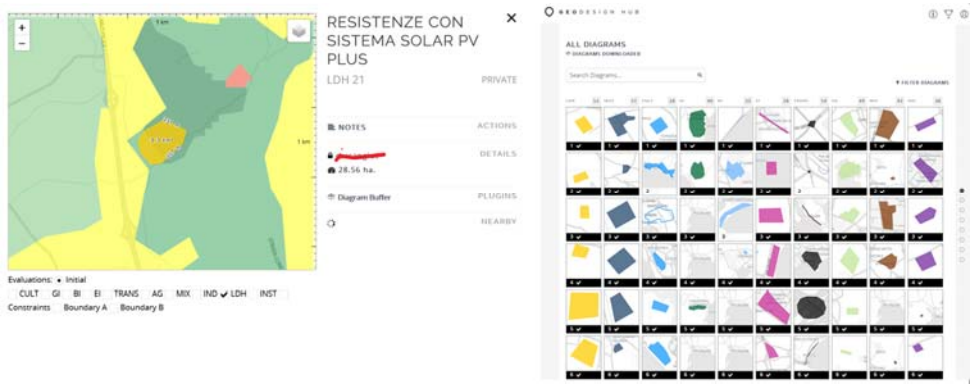

Fig. 4 (Left) Diagram creation in Geodesignhub; (right) the shared diagrams matrix

In the second phase (i.e. steps 2-4) participants developed their integrated design, or syntheses, under different assumptions and requirements which were set-up to explore possible development scenario alternatives depending on time horizons (i.e. 2020, 2035, and 2050), rate of technology innovation, and likely growth dynamics (Tab. 1).

TEAM	DEVELOPMENT SCENARIO	TIME HORIZON	TECHNOLOGY INNOVATION	POPULATION FORECAST
EA35	Early Adopter	2035	Available 2035	+ 25K Inhabitants (as-is)
EA50	Early Adopter	2050	Available 2035-2050	+ 50K Inhabitants + 10-15% (high growth)
LA35	Late Adopter	2035	None	+ 25K Inhabitants + 10-15% (high growth)
LA50	Late Adopter	2050	Available 2035-2050	+ 50K Inhabitants + 10-15% (high growth)
NA35	Non-Adopter	2035	None	+ 25K Inhabitants (as-is)
NA50	Non-Adopter	2050	None	+ 50K Inhabitants (as-is)

Tab. 1 The six scenario-driven change teams

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The teams developed their syntheses, along three dedicated sessions, moving iteratively between the change and the impact model - or in other words between design and impact assessment - thanks to the built-in impact model in Geodesignhub.

At the end of the fourth session, the teams presented their syntheses to each other. In the final session (i.e. step 5), a negotiation was held between the couples of teams having the same technology rate of adoption and different time horizons (i.e. EA35 and EA 50; LA35 and LA50; NA35 and NA50). Three final designs resulted from the negotiation process: EA3550, with the higher level of innovation up-take; LA3550, with an intermediate level of technology innovation; and NA3550 with little or no technology innovation. Fig. 5 and 6 depict the three results of the 80x80km and 20x20km studies respectively. Tab. 2 reports a summary of most used technology innovations[2].

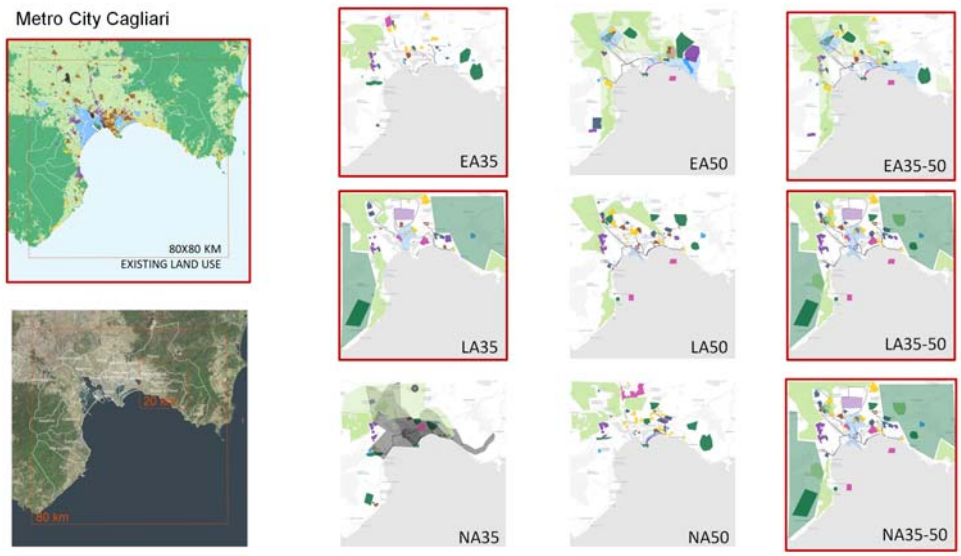

Fig. 5 Geodesign workshop results in the 80x80 km study area

3.1 SCENARIOS IN THE 80X80 KM AREA

The Early Adopter (EA) team started locating green Energy Infrastructures (i.e. eolic and photovoltaic) in the South-North axis to compound existing commercial-industrial land-uses. The transport network was extended with light rail to enhance connectivity between the Eastern settlements to the centre and the South East Coast.

[2] for a full list of IGC technology innovations see https://www.envizz1.com/global-systems-research

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SYSTEM	TECHNOLOGY INNOVATIONS
Water	Wat 2035 5 waterseer, wat 2035/2050 2 water retention
Agri	Agr 2035/2050 1 organic agriculture, agr 2035/2050 5 agroturismo, agr 2035/2050 12 rooftop gardening, agr 2035/2050 15 drones in agriculture
Green	Grn 2035/2050 5 integration of vegetation into building design, grn 2035/2050 6 genetically modified trees and engineered trees, grn 2035 12 green roofs
Energy	Ene 2035 3 olar roads, ene 2050 12 small wind power on power pylons, ene 2035 4 tidal power
Transport	Tra 2035 7 electric autonomous vehicles (eav), tra 2035 13 redefining biking with bikeshares and e-bikes, tra 2035/2050 5 hyperloop transport, tra 2035 16/17 transportation network with sustainable energy infrastructure
Ind/com	Ind/com 2035 8, renewable energy sources, ind/com 2035 2 industrial robotics, ind/com 2035 3d printers and cnc devices
Res	Res 2035 1 building integrated solar pv plus storage, res 2050 6 3d printed buildings and materials
Mix	Mix 2035 11 mart city as smart systems, mix 2035 12 innovation districts
Culth	Hist/cult1 virtual reality, hist2 smart apps location based services

Tab. 2 Technology innovations

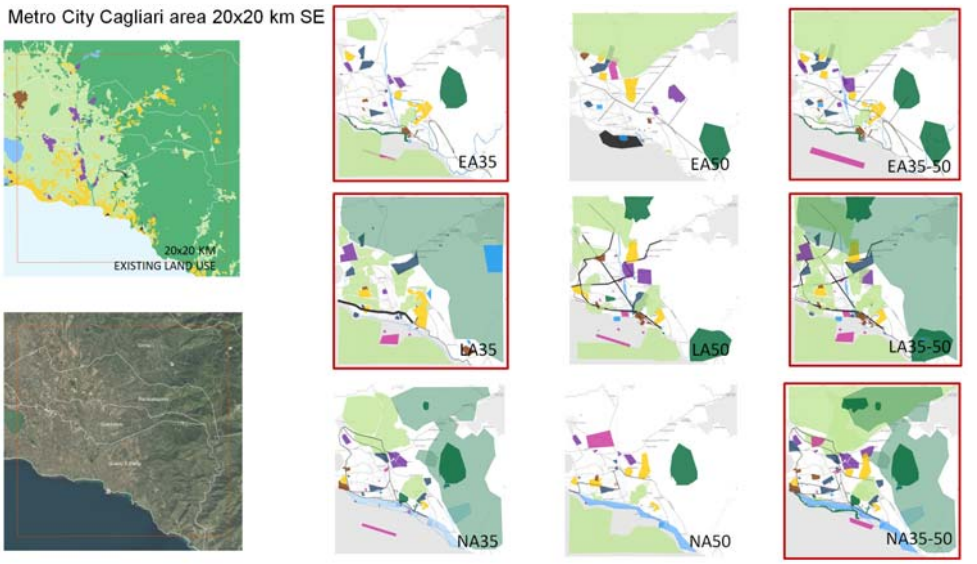

Fig. 6 Geodesign workshop results in the 20x20 km study area

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The Eastern and Western edges were preserved to consolidate existing green infrastructure, while further industrial development was maintained nearby the existing plants. New areas for mixed uses and low-density residential areas were located in the central areas with decreasing intensity of use from the center to the outer edges.
The development for the 2050 was planned to accommodate further demographic growth aiming at reaching the given target for all the systems.
As results the 2050 design included a central more developed area surrounded by a green belt. Innovations were considered used in particular to address water (i.e. WAT 2035 5), energy (e.g. ENE 2035/2050 and ENE 2035 3) and transport (i.e. TRA 2035/2050 5) issues.
The Late Adopter (LA) team started the design considering the Blue Infrastructures and Mixed use together with Transport infrastructures to address current issues in the central area of the Metropolitan City. Accessibility and connectivity were considered important as well as water supply and hydrological risk reduction.
The Eastern and Western areas were preserved mainly as green areas for agriculture and forest uses. The central development was thought as a network of higher density single or multifunctional poles. The development for the 2050 was planned to accommodate further demographic growth aiming at reaching the given target for all the systems. Similarly, to EA2050 the LA2050 design included a central more developed area surrounded by a green belt, though with a different use patterns. Innovations were considered in particular to re-think industry development (i.e. IND/COM 2035 2) transport infrastructure (e.g. TRA 2035 7 and TRA 2035 17) and green energy production (i.e. ENE 2035 3). The Non-Adopter (NA) team started the design considering the improvement of the Transport and the Blue Infrastructures of primary importance as well as preservation and management of the rich Cultural Heritage resources in the area.
Renewable energy and Green Infrastructures were also considered of major importance. Change patterns reinforce connectivity along the coast aiming at supporting tourism development. Residential development was distributed in the North-Eastern and Eastern part of the more developed areas, and more space for green infrastructure and agriculture was preserved in the West/North-Western and South-Eastern areas respectively. Mixed uses were preferred to Lower Density Housing in order to contain urban sprawl and soil consumption. While no substantial technology innovation was considered by the Non-Adopters, technology changes included the promotion of sustainably building and transport (i.e. promotion of car and bike sharing), as well recovery of traditional agricultures relying on currently existing innovation.

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Scenarios in the 20x20 km area

The Early Adopter (EA) team developed the first design focusing mainly on coastal and marine areas, also developing a submarine infrastructure for energy production and a big submarine crop, responding to the need to increase food production despite water scarcity. They also provided for a flora coastline protection green infrastructure and a cycle network along the whole coastline, connecting the archaeological sites of the area, which represent an important asset for tourism. The restoration of the natural waterways project and the rainwater reuse project was located in the inland and north-west territory, where the main residential areas are concentrated, together with industrial plants and services.

In the scenario planned for 2050, agriculture was developed in a large northern area, where the team located an underground crop. In the Eastern part of territory, they planned two green parks. They also increased the areas for institutions, low density housing and services in the western part of the study area and, as a consequence, increased the accessibility through a complex transport system, including vehicle accessible roads, cycle networks and an infrastructure for fast magnetic levitation trains.

The Late Adopter (LA) team mainly focused on: preservation of natural resources, through a green infrastructure policy involving an extended north-east part of the study area, and food production, through the localization of a great number of organic farms and a submarine crop in the sea. They also planned for taking advantage of renewable energy sources, through the creation of a tidal power station.

The low-density residential areas were located in a big central area, while the main services and industries further north. For the transport system, the team defined sustainable mobility infrastructures concentrated mainly along the coast, where fast trains and cycle networks were planned.

In the 2050 scenario they confirmed the initial asset of the study area and planned for further sustainable transport infrastructures, connecting also the coastal zone with the inland ones. Also, an increase in renewable energy production system was foreseen, which will meet the needs of the new residential areas and industries, together with two important blue infrastructures intended to reduce flood risk.

The Non Adopter (NA) team started localizing three macro areas: a very extended buffer running from north-east to south-east which includes green infrastructure policies and projects, a large area dedicated to agriculture land-uses in the north-west, and eventually a central zone with mixed and residential big areas, mostly located in the coastal part, and scattered institutional and industry projects. Lastly, in order to connect the macro-areas, they designed two main routes.

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In the evolved scenario, the three macro areas were confirmed with some minor changes. The agricultural area were extended to the east part, while in the central area an increased number of projects were localized, including: low density housing areas in the inland places, new institutional projects (i.e. the hospital and the university campus), and green energy infrastructures. Moreover, along the coastal areas, an extended blue infrastructure was planned in order to canalize the rainwater, to react efficiently against to climate change-related extreme events (i.e. extreme storms and heavy rainfall) and protect the built-up areas.

4 DISCUSSION AND CONCLUSIONS

The geodesign study presented in this paper is the first example of the application of the IGC guidelines to the Metropolitan City of Cagliari. The main objectives of the study were to earn early insights on how the study area reacts to the pressure of the global dynamics which affect the planet and generate the current challenges to be addressed in planning and design for sustainable development, and on how technology innovation in infrastructure and land-uses may affect future sustainable development scenarios. While the results of the intensive workshops alone may be far to offer final solutions for future planning in the study areas, if considered together to, and in comparison with, the results of all the other studies undertaken under the umbrella of the International Geodesign Collaboration, they may offer a rich knowledge resource for geodesign research. In this sense, all the materials produced in the first year of the IGC project are open-access and can be used by the partners and by other researchers as knowledge base for further systematic and comparative investigations, which will be developed within the future IGC activities.

In addition, the two workshops proved to offer a number of benefits to the participants, including the coordination team and the workshop participants. They represented a visioning exercise with regard to possible future sustainable development scenarios for the study areas. The workshop preparation and implementation supported all the participants in earning a better understanding of the territorial dynamics and to design collaboratively by applying systems thinking. This may be considered as much of a value especially where traditional planning systems are structured by sectors (e.g. regional planning, local land-use planning, transport planning, energy planning). Geodesign approach seems, in fact, to be particularly valuable especially in early stages of strategic planning, when the planning actors face new complex problems and need to build their understanding of inter-related territorial dynamics. From the teaching perspective, the workshops were very well-received by the participants, which were students with little or no previous knowledge of both spatial planning and design, and on using spatial information technologies. The learning curve observed by the instructors during the sequence of the five WS sessions was surprisingly efficient, and the overall results

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were eventually difficult to achieve otherwise in such short time (i.e. 15 hours). The participants, which were students in civil and environmental engineering and architecture, also learned a new approach to design which was based on proactive collaborative team-work. This is peculiar of the geodesign approach, according to which no single planner or designer may be able anymore, due to the current the increased complexity of territorial systems, to design alone.

From this, as well from previous experiences of the authors (Campagna et al., 2016) and from other similar experiences reported in literature (Nyerges et al., 2016; Steinitz, 2017; Rivero et al., 2017; Zschaber de Araújo et al., 2018), in running geodesign studies and workshops it seems reasonable to expect that similar benefits can be achieved in the planning practice. In particular, in such cases as in the Metropolitan City of Cagliari, where planning actors were traditionally used to plan at the municipal level whereas the institution of the new metropolitan city requires a shift in perspective for planning at the wide area scale, the collaborative geodesign workshop with Geodesignhub can represent a novel reliable approach to foster collaboration, systems thinking and awareness rising, consensus building and negotiation.

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