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Geodesign iterations: relevance for planning research, education, and practice.

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Abstract. The geodesign methodology (Steinitz, 2012) proposes iterations as a way to develop a study from early scoping stages aimed at understanding how the study should be framed, to metaplanning, aiming at defining how the study should be implemented, to the final real-world implementation.
Iterations may be part of the same study, or alternatively, it is argued here, they may be implemented in different study instances on the same study area. The latter approach may indeed have benefits with relevance for planning research, education, and practice.
With reference with the Metropolitan City of Cagliari (Italy) study area, the author reports on several geodesign study instances on the same area, arguing each instance may indeed be considered as an iteration at the macro level, describing how between 2016 and 2021 several study instances helped first to scope which issues, opportunities, and challenges needed to be addressed in the study area, then to serve as a case study in academic planning courses, and eventually in setting the ground for a real-world strategic planning process involving local authorities.

Keywords: Geodesign, Metaplanning, Strategic Planning, Co-design

1 Introduction

In the last two decades geodesign research and practice has attracted growing international interest in the community of scholars and practitioners in spatial planning and design, and related disciplines. Indeed the geodesign methodology approach has deep roots in the tradition of landscape planning and may offer a substantial contribution to current sustainability challenges.

Looking at one of the most recent definition of geodesign found in literature, it can be defined as a planning and design method that unites science and design in a process to make planning decisions in collaboration among design professionals, experts in geographic sciences and in geographic information technology, and the people of the place (Debnath et al, 2022 after Steinitz, 2012). Geodesign applies system thinking to understand the territorial systems study area, and uses negotiation to support consensus building in collaborative decisions (Carlsson, 2017).

The current interest for geodesign is documented by a growing body of literature (i.e. journal special issues, papers, books) most notably in the last decade. At the time of writing (i.e. April 2022), a simple query using "geodesign" as a single keyword on Scopus return 262 documents: excluding the first three oldest references in the query results, which referred to geodesign with a different meaning than the one intended here, since 2010 publications on geodesign flourished. As a benchmark of the growth in academic popularity on geodesign, the same query in Scopus back in 2018 and 2021 returned 91 and 197 papers respectively. Likewise, the same query in Google Scholar, which mines by a larger corpus of documents than the collection of papers in indexed journals in Scopus, returned 2,220 documents in 2018, 3,640 in 2021, and eventually 4,230 at the time of writing (i.e. April 2022).

In the geodesign body of literature, the book *A framework for geodesign: changing geography by design* by Carl Steinitz (2012) can be considered a milestone as the richest methodology references for developing geodesign studies. The International Geodesign Collaboration (IGC) a worldwide network of more than 470 members, in more than 240 organizations, in 61 countries (https://www.igc-geodesign.org/) since 2018 has extensively tested the application of the Steinitz's framework and common geodesign standards demonstrating its relevance and potential in addressing current most urgent sustainability challenges (Fisher et al, 2020).

With reference to the above context, the next session reports in synthesis the core elements of the Steinitz' framework, focusing on the role of iterations. While the geodesign framework focuses on iterations within individual studies, the concept of macro-iterations involving multiple instances of studies in the same study area is the focus here. Hence, in the remainder of this paper, several instances of the Metropolitan City of Cagliari case study are documented in synthesis as a base for analyzing the potential benefits of macro-iterations with relevance to spatial planning research, education, and practice.

2 The Steinitz's framework: six models, three iterations

This section provides a summary description based on the authors experience of the application of the Steinitz's framework aiming at highlighting its core elements, the six models and, in particular, the importance of the study iterations.

The Representation Model (RM) describes the territorial dynamics in the study area, from the past until the present (i.e. the time of the study). The RM consists of data. From an application perspective, it should be noted that the data format from the past to current time has evolved from the analogue to the digital formats. Time frequency of data surveys has changed accordingly: while with regards to the past it is expectable to find analogue maps referring to sporadic time references, current digital geographic data detected trough remote-sensing and in-situ sensors enable to monitor territorial dynamics close to real-time, providing spatial big data. It should be noted though, that in developing a geodesign study, one should aim at gathering not the most but the least data necessary to answer the study relevant questions. If this is true, understanding how to describe the study area is not a straightforward single step, but

it requires several iterations through the six models in order to find what is the least set of data needed to solve the complex design problem at hand.

The Process Model (PM) uses input from the representation model to foresee how the territorial system might evolve in the future under the hypothesis of no design/changes (i.e. *do-nothing* alternative in planning). While the representation model consists of spatial data at given times, the process model is more dynamic, in the sense simulation and forecasting are indeed dynamic in essence: thus, the space-time dimension of data become more relevant in foreseeing the evolution of territorial dynamics, so creating meaningful information.

The Evaluation Model (EM) assigns values to the expected territorial system evolution. It answers to such questions as "do we like expected future"? If answer is yes, no design change is needed; otherwise designing possible changes is required. The EM links knowledge building to design and decision-making: as such is a fundamental step in the workflow. It informs what and where changes are needed, possibly making decision more transparent and evidence-based. In this sense it may give an important contribution in informing and shaping the design. In the EM, beside the temporal dimension, values are attached to spatial data proving context for decisions (i.e. knowledge).

The Change Model (CM) consists of design proposals for the future: possible changes are collected and assembled in complex syntheses. Changes are described by spatial data presenting projects and policies.

The Impact Model (IM) aims at understanding the consequences of proposed changes assembled in alternative syntheses in the territorial systems. As in the case of the PM the time dimension becomes relevant. The consequences of possible changes, which are represented by spatial data (e.g. project or policies in space) are considered in their geographic context and described in terms of territorial dynamics, that is in their evolution along time. This is also a foresight endeavor based on forecasting and simulation, where time again becomes very relevant.

The Decision Model (DM) involve choosing, based on the information provided by the IM, and by providing values of entitled decision-makers, the preferable set of changes, or synthesis. Selecting who is entitled to make final decisions is part of the process, and it depends on the local context as well as on the purpose and scale of the study, and influences the format of the output of the other models.

According to Steinitz (2012) in addition, a geodesign study should involve three iterations across the six models. In the first iteration, the study's *scoping*, models are developed from the first to the sixth in order to understand what the main questions to be answered actually are. First data are collected, territorial dynamics of main relevance are detected, possible changes are devised and assessed, possible outcomes are framed and their impacts investigated, before it is possible to define the context for decision-making. Once it is clear who should be the actors involved at each stage, the second iteration starts. This time the models are revised in reverse order, from the sixth to the first one. In fact, in the second iteration, it is the decision-making context which provides requirements to each model: e.g. the IM should provide meaningful information to the decision-makers, so its content and format should be suitable to the purpose, and it descends from the DM. In turn, depending on what information the IM

will need as input, the CM data should be shaped accordingly, and so on, until the RM is refined to be suitable as initial input of the process for the following iteration, which is eventually the *implementation* of the process. It should be noted that it is along the second iteration that actors, tasks, workflow, data, formats, supporting technologies are defined, according to a *meta-planning* approach (Campagna, 2016).
While the three iterations (i.e. scoping, meta-planning, and implementation) may be formalized individually in the methodology framework, in reality they are not strictly linear, and along a study unlimited number of cycles and back-loop can be followed until the objective of the study is reached, that is, a future scenario is defined, on which consensus among involved parties is reached. In this sense, what defines the boundaries of a study are then its purpose and objectives.
A study can be indeed developed in different contexts such as research, education, or practice. If several studies are conducted on the same study area with different purposes (i.e. research, education, or practice) each with its specific objectives, each instance on the study should learn from the previous one and at the same time evolve from it, as the new study develop new additional knowledge and possibly generate new perspectives. In academia, it is not uncommon to use case studies from the real-world within planning and design studio classes, for generating knowledge and ideas informing subsequent real-world planning plan-making. In this sense each study instance can be considered as a *macro-iteration* with the final aim of building knowledge for eventually making-decisions which will be implemented in the real world. Each macro-iteration is therefore expected to enrich the understanding of current complex challenges. This assumption was tested along several macro-iterations in the Metropolitan City of Cagliari case study between 2016 and 2021. Eventually, while the results of each macro-iteration were different in terms of design, it is argued each macro-iteration provided new knowledge useful both to improve the process and in its results, or, in other words, to improve geodesign as a verb and as a noun.
It should be also noted that geodesign studies are usually fast, but at the same time very complex, with respect to both the process and its results. Thus, considering several study instances, or macro-iteration, on the same study area may indeed substantially contribute to better learn the geodesign methodology and its application technicalities, and it is therefore recommended to those who are approaching geodesign for the first time.
In the following section, several iterations of the Metropolitan City of Cagliari case study are described, each with its specific purposes, context, settings, and results, before a critical comparison on the overall experience is given in the remainder of the paper.

3 Case studies

The case studies presented in this section contribute several macro-iterations of the geodesign study of the Metropolitan City of Cagliari (Italy). The main macro-iterations taken into consideration for this critical review are three, and were developed in 2016, 2018, and 2021 respectively. The scope of each macro-iteration was

different in the three cases: research, education, and practice respectively. The structure of each macro-iteration was however substantially similar. Each case study included a knowledge building phase in which the representation, process and evaluation models were built producing the input for a subsequent intensive geodesign workshop implemented with the support of the web-based Planning Support System (PSS) Geodesignhub (http://www.geodesignhub.com). While the first two workshops were developed in presence, the last one was developed fully online with the support of the Zoom (http://zoom.us/) online meeting platform, due to COVID19 pandemic social interaction restrictions which was ongoing at the time of implementation. While the knowledge building phase usually last for a few months, the intensive workshop phase usually last between 16 (as in 2016) and 12 (as in 2021) hours, distributed either in two subsequent days (as in 2016) or in shorter three-hour section within two weeks (as in 2021). Implications of different scheduling are discussed in the next section, where the case studies are compared.
The main characteristics of each workshop are documented in the next paragraphs before a comparative critical review of similarities and differences among the cases is given.

In each case, the knowledge construction phase was fully digitally supported relaying on digital spatial data and on desktop Geographic Information System (GIS) technology, and included the following main steps:

- Data acquisition: in all the cases data from the Italian national census (ISTAT) and from the geoportal of the Regional Government of Sardinia were used, whereas in the 2021 case study additional Volunteered Geographic Information (Capineri et al *eds*, 2016; Zook and Breen, 2017) data sources such as Openstreetmap.org and Flickr.com were also used to include spatial data themes otherwise not available in the regional geoportal.
- Selection of the ten systems of interest: in 2016 the ten systems were chosen looking at the study area by local researchers; in 2018 the IGC standard system were adopted; while in 2021 the system were derived with reference to an existing strategic development agenda (Table 1);
- Development of the representation, process, and evaluation models, culminating in the production of an evaluation map for each system;
- Definition of change targets for each system (i.e. total area required for changes in the system);
- Definition of a cross-systems impact model;
- Selection of the workshop participants, arrangement of the design teams, and workflow scheduling.

3.1 Case study 1 (2016)

The first geodesign study on the future scenarios of the Metropolitan City of Cagliari was held at the University of Cagliari in 2016. This was the first ever case study on the recently established (2016) Metropolitan City of Cagliari in its current boundaries, which include seventeen municipalities. As such, there were not previous planning and design studies for the future development of the study area, and the work-

shop represented the first chance to reflect on its future scenarios for sustainable development. The study area is a complex territorial system including settlements, hosting a population of 431,538 inhabitants in July 2017, mountains (to the East and to the West) with natural or semi-natural landscapes, industrial areas, wetlands, and agricultural land-uses. The area is rich in natural and cultural landscape resources and in the last decades attracted a growing tourism demand.

Table 1. Selected systems in the case studies (recurrent systems in bold).

	2016	2018 (IGC standard)	2021
1	**Ecology**	**Green Infrastructures**	**Green Infrastructures**
2	Hazard	Water Infrastructures	Water Infrastructures
3	**Agriculture**	**Agriculture**	**Agriculture**
4	**Transport**	**Transport**	**Transport**
5	**Commerce/Industry**	**Commerce/Industry**	**Commerce/Industry**
6	High density **housing**	Mixed **housing**	Energy
7	Low density **housing**	Low density **housing**	**Housing**
8	Tourism	Institutional	Tourism
9	**Cultural heritage**	**Cultural heritage**	**Cultural heritage**
10	Smart services	Energy	Smart Hub

Given the size, and the territorial systems complexity, the first study was aimed at earning first insights about possible future sustainable development scenarios. Hence, the first study was exploratory in nature and it was developed from a research perspective. A total of thirty-two participants were selected by the study coordinator to form a multi-disciplinary team, including local experts, PhD and graduate students, and local stakeholders from the public and the private sectors. After the knowledge building phase was carried-on along three months by the coordination team, an intensive workshop lasting a total of 16 hours within two days was held in early May 2016. Six design teams with different roles and with different objectives initially individually developed their own design syntheses, which were than compared and negotiated among teams coalitions until consensus was reached on a final future development scenario.

The relevance of this first geodesign study on the Metropolitan City of Cagliari area is that it was the first comprehensive planning and design study at its scale in the area. In fact, the traditional planning system in Sardinia includes regional landscape planning and local land-use planning, as well as a number of sector plans undertaken at the regional or at the local scale. The metropolitan planning scale was therefore a novelty which required a change in perspective. Given the research perspective of the study, moreover, a neutral scientific approach was adopted which enabled understanding the functioning and possible planning of the territorial system without having a substantial political bias. As such, this first case study represented a solid base to further studying the area for the following years for the educational and eventually real practice experiences described in the next paragraph. In addition, the final negoti-

ated design (Fig. 1) was exported in a desktop PSS (i.e. CommunityViz) for testing interoperability and more a complex impact model. Further details on this study can be found in (Campagna et al, 2016).

3.2 Case study 2 (2018) /IGC

In 2018, the International Geodesign Collaboration was first established. Since then, the members of the IGC, which were mainly scholars as well as educators, defined common standards to develop comparable geodesign studies around the world, this way fostering geodesign research and education. IGC standards, which were agreed as first step in the collaboration, included common formats for spatial extent, systems and colors, global assumptions and system technology innovations, as well as development scenarios and time stages (https://www.igc-geodesign.org/global-systems-research).

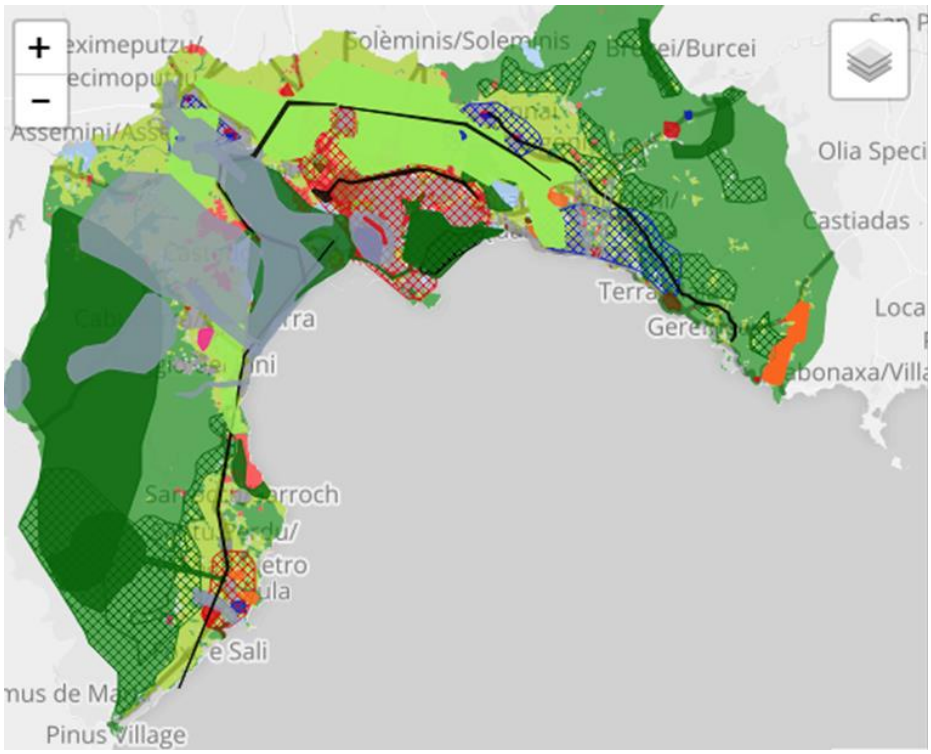

Fig. 1. Final negotiated scenario for the Metropolitan City of Cagliari 2016 study in Geodesignhub (Source: Author).

The IGC standards were adopted in the second study on the Metropolitan City of Cagliari which was developed within two studio classes at the Faculty of Engineering and Architecture of the University of Cagliari. The first class, including 56 civil engineering graduate students worked on the whole study area (i.e. a 80x80 km square)

while the second class, including 76 undergraduate students in architecture, worked on a nested frame 20x20 km at a larger scale. The smaller scale study started in advance and informed the larger scale study aiming at exploring multiscale design coordination. The design teams working to build the IGC development scenarios, unlike the previous case study where design teams play different stakeholders roles, were framed using two future time horizons (i.e. 2035 and 2050) and a different approach regarding technology innovation adoption (i.e. early adopters, late-adopters – after 2035- and non-adopters). The final negotiated scenarios are shown in figure 2.

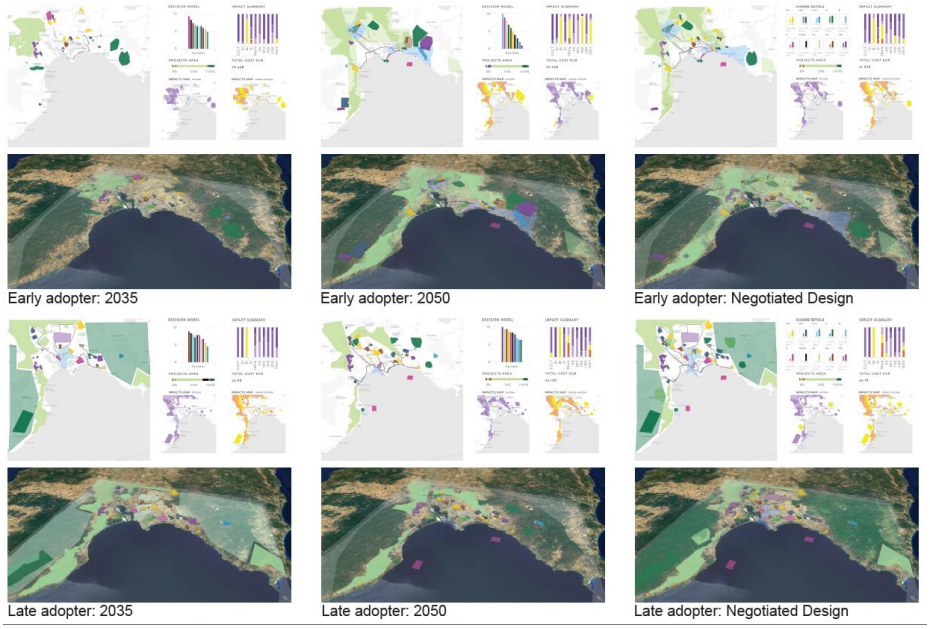

Fig. 2. Final agreed scenario of the Metropolitan City of Cagliari 2018 IGC study (Source: Author).

3.3 Case study 3 (2021) /IGC

The third macro-iteration of the study was developed in Aril 2021 within the making of the Strategic Plan of the Metropolitan City of Cagliari, which was eventually adopted in July 2021. Aim of the study was to involve the 17 municipalities of the Metropolitan City in defining a spatially explicit future development scenario. In this case, all the framework models were rebuilt from scratch with the support of system expert; still the experience earned in of the previous iteration for framing the representation, process, and evaluation models was fundamental.

The workshop was implemented fully online in 4 three-hour sessions along two weeks, with the possibility for the participant to work remotely on the workflow tasks out of the plenary sessions, with or without the support of the coordination team which offered office-hour online slots. The final negotiated scenario was agreed in 12 plenary hours and priorities were agreed for projects and policies (Fig. 3) and the

content was included in the final Strategic Plan of the Metropolitan City of Cagliari documents adopted a few months later. This workshop offered the Municipalities a substantial opportunity to have their voice heard by the higher level of government, i.e. the Metropolitan Council, which eventually adopted the plan. In addition, the collaborative design format of the geodesign workshop offered the participants an unprecedented learning experience while evolving from a local to a metropolitan wide planning and design perspective.

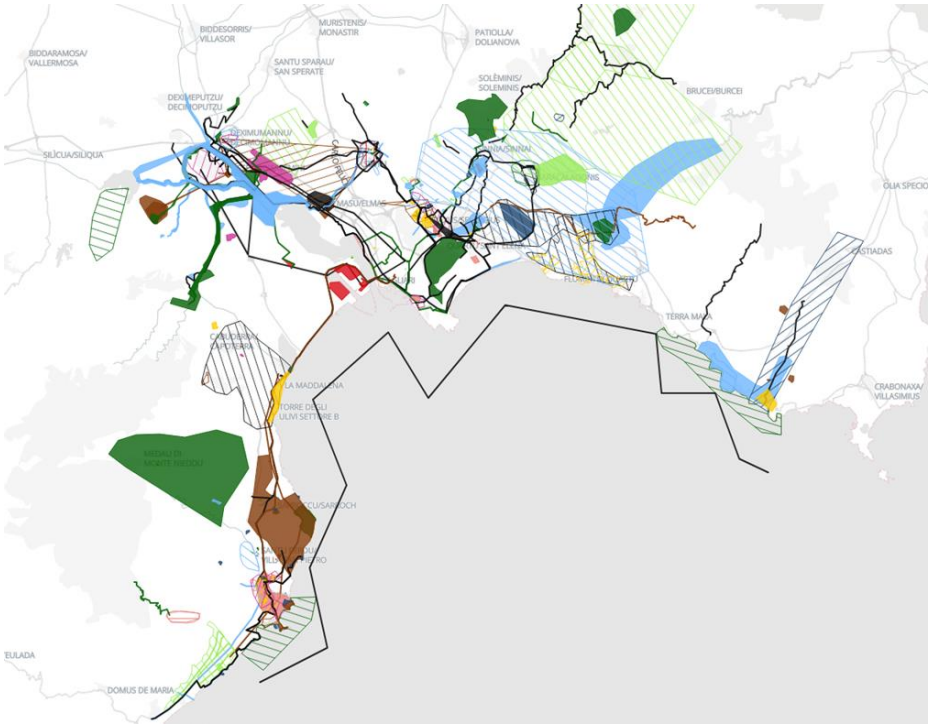

Fig. 3. Final agreed scenario of the Metropolitan City of Cagliari 2021 study (Source: Author).

3.4 Other case studies (2017-2022)

In addition to the three main case studies presented in the previous paragraphs, the Metropolitan City of Cagliari studies were used several times each for one-day intensive workshop tutorials aimed at teaching interested educators on geodesign methods, workflows and tools. Notably, since 2020 the in-presence workshop format was adapted to online only settings due to ongoing pandemic social interactions restrictions and occasional lock-down periods. In a few years, thanks to these initiatives hundreds educators and practitioners got familiar with the geodesign methodology, techniques and tools, and many of them successfully developed their own case studies afterwards.

4 Comparative analysis of the case-studies

Geodesign is a robust methodology which proved to be effective in addressing current complex challenges of sustainable development. The critical review of several macro-iterations of a geodesign study on the same study area may offer a great deal of experience which we believe is worth sharing, with the aim of helping interest scholars and practitioner to approach this complex methodology especially at early stages. In this section, critical reflections on the different stages of a geodesign study are given.

4.1 Comparison of the knowledge building phase

Looking back at the knowledge building phase in the three macro-iterations, two main lessons can be learned:

- The knowledge building phase starts from data. No matter how much data are available in existing regional and local Spatial Data Infrastructure, which depending on the study area and scale may be more or less developed, the macro-iterations on this case study demonstrate that official data sources are usually not enough to represent fully represent relevant territorial dynamics: most of the time, volunteered geographic information sources are needed to fill existing limits in official data sources.
- Beside the representation and the process model, building sound evaluation models may be a challenge in conceptual and technical terms. A detailed account on how to build an evaluation model is given by Campagna et Al. 2020.

4.2 Comparison of the intervention phase

The intervention phase (i.e. iterations on the change, impact and decision models), that is the one implemented with the geodesign workshop format within the geodesign study, evolved in the three macro-iterations. Due to the occurrence of COVID19 pandemic and the introduction in the last few years of lock-down and social distancing measures worldwide, the geodesign workshops, implemented in-person (i.e. same place, same time) in early experiences (e.g. 2016 and 2018 macro-iterations of the Metropolitan City of Cagliari) moved online. Both in-presence and on-line formats proved to work equally well in providing robust results in term of design as well as learning experience for the participants. Nevertheless, the in-person workshop format may better support critical discussion among the participants, at the cost, though, of higher organization and logistic efforts. The latter may be sometimes relevant in eventually choosing which format to apply.

The 2016 macro-iteration was carried on in single intensive workshops during 16 hours along two days. In the 2018 workshop, in order to comply with ordinary teaching schedules, a combination of five 3-hours sessions totaling 15 hours were arranged. Breaking the intensive workshop into shorter session proven effective as it gave participants more time to reflect on the evolution of their work. Based on this experience, and also considering time availability of public authorities decision-makers and tech-

nical staff a multi-sessions format was chosen also for the 2021 workshop. The choice was successful for it allowed representatives from municipalities more time to develop their design proposal in between sessions. Eventually in the 2021 workshop the final design with priorities was completed in four main plenary sessions, 3-hours each, plus a final session for the review of the results.

4.3 Comparison of the final design

The main advantages in the geodesign approach are substantially two: i) developing spatially explicit and transparent alternative design syntheses informed by the geographic context; and ii) reaching consensus among the participants. These are two substantial benefits which may help to comply with the principles introduced in planning by Strategic Environmental Assessment, and eventually by sustainability of development principles such as democratic, evidence-based, transparent, responsible decision-making in spatial planning aiming at preserving natural resources, while improving the socio-economic system dynamics. Geodesign studies including intensive collaborative workshops such as those described in this research proved to be particularly effective and successful in strategic planning, where reaching in a very short time consensus of future development scenarios is of bigger importance than design precision. Indeed, when there is agreement on a future development scenario among all the actors of the affected community, a road map is given for the framing of consequent physical planning, for which broad collaboration in the implementation is somehow ensured. In Europe, this approach may be particularly useful for public authorities as it provide a solid base in applying for development funds such as the recent European Green Deal.

4.4 Comparison of the outcomes of the macro-iterations

The three main macro-iterations of the Metropolitan City of Cagliari geodesign study provided tangible benefits for geodesign research, education, and real-world planning practice. Each macro-iteration actually provided useful insight for research with regards to geodesign as a *verb* (i.e. the process) and geodesign as a *noun* (i.e. the design outcomes. Each macro-iterations in fact contributes new knowledge on the complex territorial system in the study area, as well as new alternatives for future development, enriching each time the understanding of the participants, including the coordination team, and inspiring new design perspective and new understanding of complex territorial sustainable development challenges.

With regards to education, in broad sense and for the reasons above, a geodesign study macro-iteration is always a rich learning experience. In this sense, it contributes to educating a community to handle its future. When it comes to university education, the 2018 IGC macro-iteration had several tangle benefits as well: considering the participating students in civil engineering and architecture had little or no previous experience in planning, they learned in a short time and with a fast learning curve how to apply system-thinking in land-use and infrastructure (e.g. green, blue,

transport, energy, etc.) planning. They also learned to work with fully digital techniques and tools with ease.

When it comes from real world planning and design practice, participants from the public authorities, from the private sector and from NGOs learned to collaborate with each other with a new media, breaking consolidated power relationships which in traditional planning process often hinder the possibility of win-win situation and often end up in a zero sum game, when someone win and the other loose.

Post-workshop questionnaire surveys as well as informal feed-back from participants to the macro-iteration of the Metropolitan City of Cagliari case study, the detailed description of which is out of the scope of this paper, as well from other geodesign studies, substantially confirm these assumptions.

Last, but not least, archiving a repository of fully-digital geodesign workshops along several macro-iteration open the way to the application of geodesign process analytics techniques, as proposed by Cocco et Al. (2019).

5 Conclusions

This paper aims at proposing critical insights on the role of iterations in the geodesign framework. Beside the iterations proposed by Steinitz in its framework (2012), this paper analyses macro-iterations (i.e. several studies instances on the same study areas) developed by the author in research, education, and real-world planning practice in half-decade.

It is argued macro-iterations are useful one after the other to enrich knowledge on the sustainability challenges in the study area with two major benefits: i) grasping the complexity of the territorial system so improving the final design; ii) earning experience on how to conduct the process. It is also argued that conducting preliminary studies within research and education settings may be necessary before conducting real-world planning processes, where stakes are high in deliberation.

Critically reflecting in terms of iterations, besides learning on how to build the six framework's models, may help to systematically analyses how complex planning and design processes may be improved in term of process itself and of their results. Planning several macro-iterations may be particularly useful as a strategy for those researcher and practitioners who wish to apply the geodesign framework for the first time to grasp the complexity of its application, and eventually develop the necessary experience to apply geodesign in the real-world practice.

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