Lessons and questions for geodesign arising from the International Geodesign Collaboration
Geodesign South America 2019

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Abstract
The world faces challenges that ignore national and regional boundaries and cannot be solved by single individuals, nations or sciences. Design to accommodate population growth and rising global temperature requires multi-disciplinary approaches and collaboration among all stakeholders. Geodesign is a collaborative approach integrating multiple disciplines and using geographical information systems (GIS)-based analytic and design tools to help explore alternative future scenarios. During 2108-19, ninety-one universities world-wide participated in the first International Geodesign Collaboration. Through the adoption of common analytical and reporting frameworks, the projects enable us to compare outcomes and consider what lessons have been learned, where we might make changes to facilitate greater mutual learning, and which areas remain elusive because of governance or technical differences between nations and regions. This paper reports initial findings from the first year of the collaboration.

Introduction
The world is facing undeniable change. Not only is land use change, the domain of geodesign, at the root of both negative and positive environmental change, but it both impacts and is impacted by global patterns. Nearly 15 million hectares of United States farmland, 2.2% of the total, is now foreign-owned, by Dutch, Canadian, Chinese and German owners, among others (Hettiger 2019). Fifty-two million hectares, 14% of Australia's farmland is foreign-owned (Barbour 2016). Individual air pollution events like sandstorms and Chinese New Year fireworks can be traced in North American air quality (Ngo, Zhong & Bao 2018) monitored since 1979 by the United Nations Economic Commission for Europe via the Convention on Long-Range Transboundary Air Pollution (Bergesen et al., 2018). Global tourism accounts for more than 10% of global GDP and 10% of total global employment (WTTC 2018). Imagining and addressing the implications of such global patterns are often described as "wicked problems", an expression coined by Horst Rittel (Rittel & Webber 1973; Buchanan, 1992) to describe problems too complex, and engaging too many realms of knowledge, to be easily solved by small teams. However, this is the nature of problems addressed by designers and planners on a daily basis, and geodesign is a systematic, scale-less approach with promise to find solutions (Orland 2016).

The intent of the International Geodesign Collaboration (IGC) has been to enable those using the geodesign framework (Steinitz 2012) as a design and planning approach to learn from each other and use those lessons to improve how we design for a globe that is rapidly changing and increasingly stressed. The premise of the core leadership of IGC, Carl Steinitz, Brian Orland and Thomas Fisher, in initiating the organization in February 2018, was that to address the most complicated issues facing the world, the geodesign community needed to be able to compare its products. To achieve that end, a set of guidelines was proposed, including requirements as to the scales and project configurations to be used, the environmental systems to be considered, the key scenarios and time-steps to be addressed, and a common framework for reporting. Esri, the international provider of GIS products and services, committed to hosting a meeting of the collaboration to share projects, in February 2019, prior to the Geodesign Summit, an annual meeting also hosted by Esri.

Figure 1: Participant (blue) and project (red) locations. Webmap: http://arcg.is/1mjH0P0

The IGC core team used a wide array of professional networks to invite participants to join. Ninety-one universities joined the collaboration, representing thirty-six countries; projects were located in thirty-nine countries (Figure 1). A meeting was held in California at which fifty-six participants displayed posters of their work (https://www.envizz1.com/igc-2019-completed-projects). Thirty-seven participants from 14 countries presented their work at the meeting (https://www.envizz1.com/igc-2019-conference-presentations). A book, *The International Geodesign Collaboration: Changing Geography by Design*, will be published by Esri Press in February 2020, featuring fifty-one of these projects together with analysis and reflections by leading thinkers and writers in the area of geodesign (Steinitz, Orland and Fisher 2020).

This paper examines the projects, their locations and extents; their contents and emphases; and their participants and outcomes, to identify lessons that can be gathered from the collection, and questions that should be addressed by future geodesign projects.

Anatomy of an IGC project

<u>Project boundaries, shapes and sizes:</u> No geodesign work area is square; however, establishing square bounds achieves two ends: first, it enables simplified comparison of projects, whether using quantitative measures or visual comparison alone; second, it compels the consideration of project context. Both of these issues impact a third and fourth; that evaluation of land capabilities and impacts should not be considered narrowly in terms of the immediate effects of a project but should always be considered in terms of the incremental changes achieved by the project. For example, in evaluating the capabilities or suitabilities of a project area it may be valuable to see that particular values extend beyond the immediate planned development, to reveal additional opportunities and to avoid unnecessary redundancy. Impacts, similarly, must be put in context to understand if the designed benefits are proportional to the investment made, and meaningful rather than trivial in the broader scope of potential changes in the area (Figure 2a). Figure 2b shows the size distribution among IGC 2018-19 projects.

Figure 2: (a) Project areas, 1, 2, 5, …. 160km x 160km (b) Project size distribution

<u>Geodesign systems and common color palette</u>: A designer's primary method of analysis is visual. IGC colors were chosen to identify evolving land use patterns across time and alternative design scenarios as well as to enable project-to-project comparisons. Figure 3a indicates the color selections for the primary required systems; Figure 3b shows an example of their use to illustrate the observation that project emphases on different geodesign systems might vary with distance from the equator. The study of color legends and their use as analytical tools is widely covered in the cartography literature (e.g., Brewer 2015). The most challenging decision by the IGC core was to limit the representational schema to facilitate comparison while accepting that for many projects that limitation would be onerous. Our choice for IGC 2018-19 was as illustrated here, requiring teams to adopt nine common systems and allowing one free choice – for several projects that free choice was used for cultural and historical land use protections.

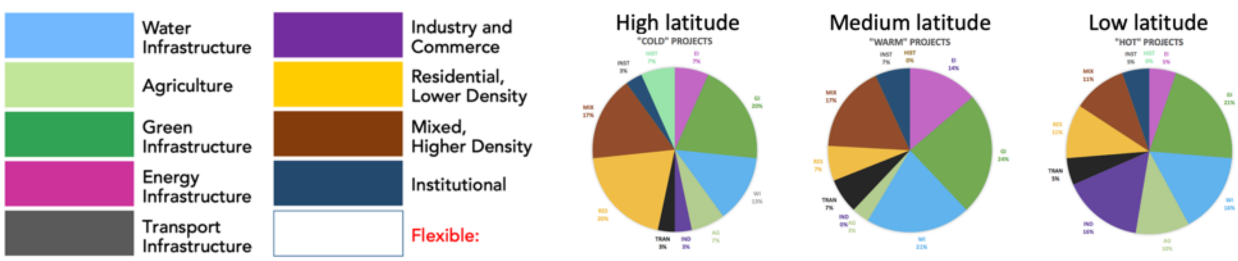

Figure 3: (a) Nine required systems (b) Varying system use, grouped by latitudes

<u>Global assumptions and a library of geodesign innovations:</u> Major international agencies and national governments recognize a range of global challenges to be faced, from population increase to poverty alleviation to pollution control. From IGC participants and other experts we convened a panel to consider and identify twelve issues of global scope that would shape geodesign responses to challenges at national, regional and local scale. IGC participants refer to the global assumptions to identify project requirements (Figure 4). Innovation to address these challenges can occur in each of the systems identified in Figure 3. For each of the nine required systems a panel of experts was asked to compile lists of design, planning and technological innovations that may contribute to developing geodesign solutions; 187 were identified, spread across the nine required systems (Figure 5).

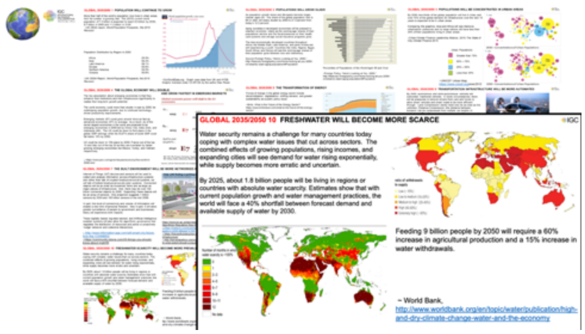

Figure 4: Twelve global change assumptions

Figure 5: Library of 187 design innovations

Common scenarios and timeframes: Project-to-project comparison is only possible when they share common strategies and are reported at common timeframes. The three defining change strategies for IGC are the early-adopter, where innovations are implemented immediately, and the changes tracked through time. The late-adopter scenario delays adoption of innovations, in most circumstances resulting in less overall change. The non-adopter scenario is often called "business-as-usual" and accepts that change will occur but not necessarily shaped by implementing any design or technology innovations. IGC specified the common reporting times of 2035 and 2050 (Figure 6).

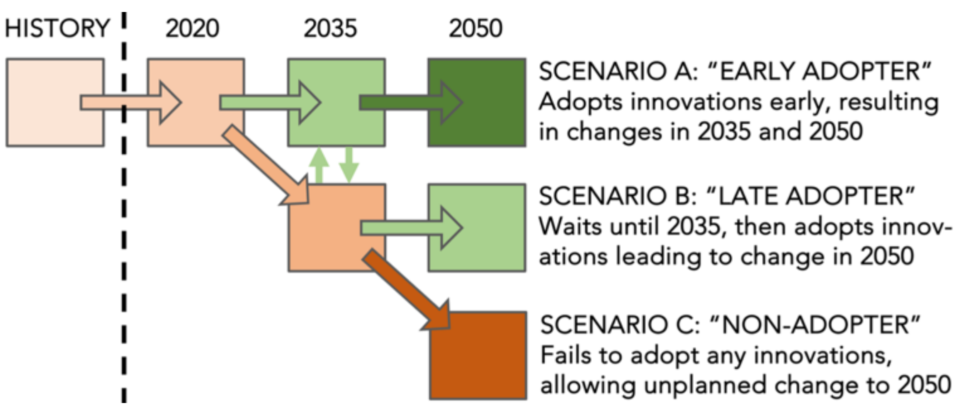

Figure 6: Three design scenarios, three time-steps. Projects were assumed to start in 2020

Common reporting formats: The final component of IGC was the establishment of common reporting formats. The scenario diagram (Figure 6) forms the central organizing element for both publication in book form (Figure 7a) and as posters (Figure 7b).

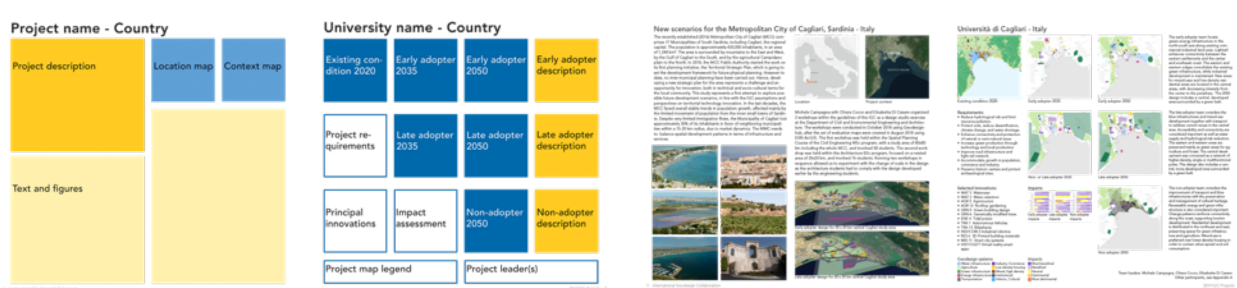

Figure 7a: Content layout for book publication

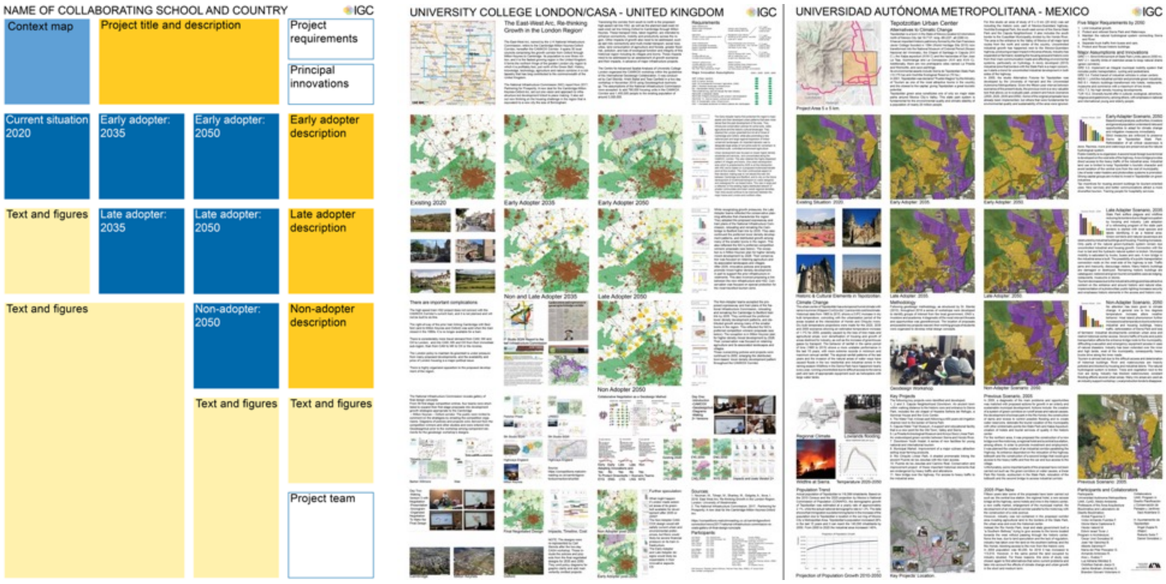

Figure 7b: Content layout for poster presentation

Results

Project participation was widely spread, in the locations of IGC members, of participant institutions, and of projects (Figure 8). Asia, Europe and North America each have strong representation, reflecting traditional strengths in GIS-related education, although it is notable that despite smaller numbers of GIS-trained design professionals, both Africa and South America have consistent representation of both participants and completed projects Figure 8.

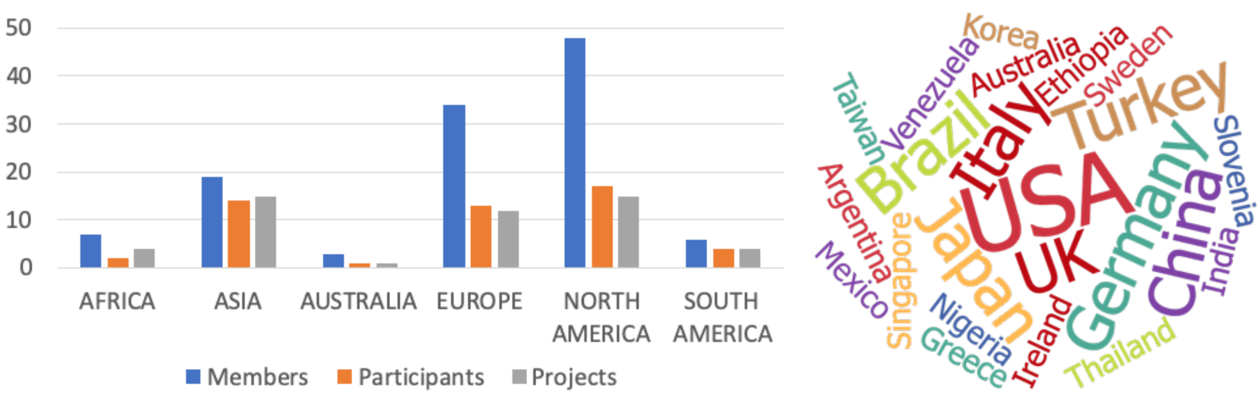

Figure 8: Collaborating schools (a) by continent and (b) wordcloud: frequency per country.

Reading the project titles is inspiring for the range of topics investigated by IGC participants. Table 1 includes a sample of those, Figure 9a illustrates the variety and frequency of words used. Urban issues and challenges are predominant in the titles. Participants were also asked to identify their project types as Urban, Suburban, Rural or Wildland. Forty-four of fifty-one self-identified as urban in focus, evenly distributed across all project scales. Twenty-nine indicated suburban, twenty-two as rural and just three as wildland. Fifteen projects self-identified with only type of focus, all of those urban. Projects addressing two or three types accounted for thirty-five of the total, with just one project, from Penn State University, addressing all four (Figure 9b).

Table 1: Selected project titles

South-east of Buenos Aires: planning for adaptation and mitigation
Green infrastructure plan for Jaguare Creek in Sao Paulo
Pampulha, future urban landscape for a UNESCO cultural heritage area
Urban plan for the Candelaria-Plaza Venezuela Zone, Caracas
The CAMKOX corridor: re-thinking London's growth
New scenarios for the Metropolitan City of Cagliari, Sardinia
Agriculture and energy: alternative futures for Grinnell, Iowa
Shimonagaya in Yokohama, green design for a declining population
Environmental and social resilience by design, in Houston, Texas
Integrated infrastructure for Seriti Town
Geodesign for the historic city of Xi'an
Urban valleys as ecological corridors in cities, Imrahor Valley

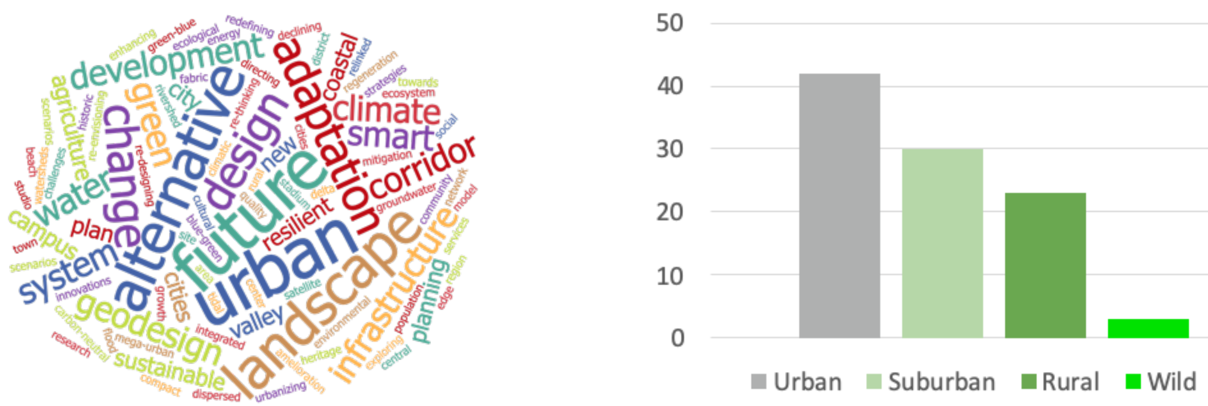

Figure 9: Project topics (a) common words in project titles (b) urban-wildland content focus.

Discussion

An Esri Press book, *The International Geodesign Collaboration: Changing Geography by Design* (Steinitz, Orland and Fisher 2020) contains detailed analysis of project outcomes. I will address four issues here, each central to the Geodesign framework described by Steinitz (2012): systems thinking, data-based decision-making, and public participation.

<u>Systems thinking</u> emerged in the 1970s as an approach for solving the multiple concurrent challenges of complex problems (Meadows 2008). It proposed that we think of the world for which we design as a series of overlapping systems, such as water infrastructure, agricultural and transportation systems, each of which has its own logic and operations and each one interacting with the others operating at the same location. The overlay mapping commonly used by planners and designers, and more recently manifest as geographic information systems (GIS) is an explicit example. The systems dictated by IGC were those shown in Figure 3a. While they were not used consistently or universally by all participants, they were used by the majority. The Leibniz University Hannover project addressing the Lahn River Valley took a systems-oriented approach to evaluate food production, climate regulation, habitat provision, and recreation provision under status quo, early adopter, late

adopter and non-adopter scenarios (Figures 10a, 10b). In all systems, the results indicate that early adoption of design innovations leads to benefits in all systems.

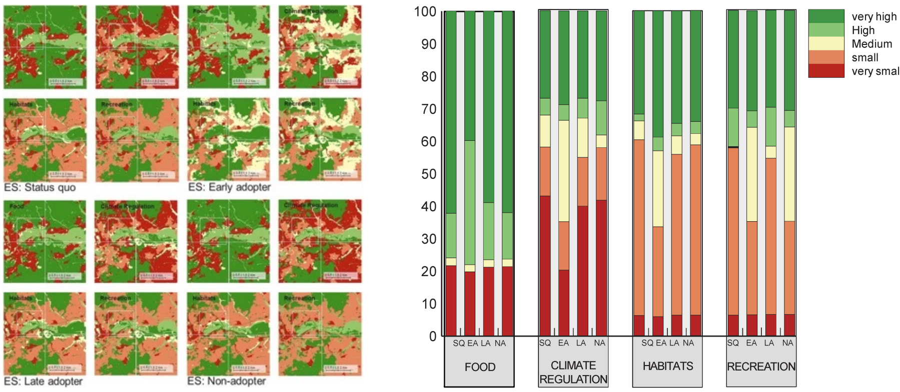

Figure 10: Lahn River systems analysis (a) scenario outcomes (b) impact evaluations.

Data-based decision making via change models and impact assessments is central to operation of the geodesign framework. The Paso Robles region study by CalPoly San Luis Obispo (Figure 11) has used metrics for water sources, groundwater inflow, and water use to indicate resource allocation, and performance indicators for quality-of-life, natural environment, and sustainability to evaluate scenario outcomes.

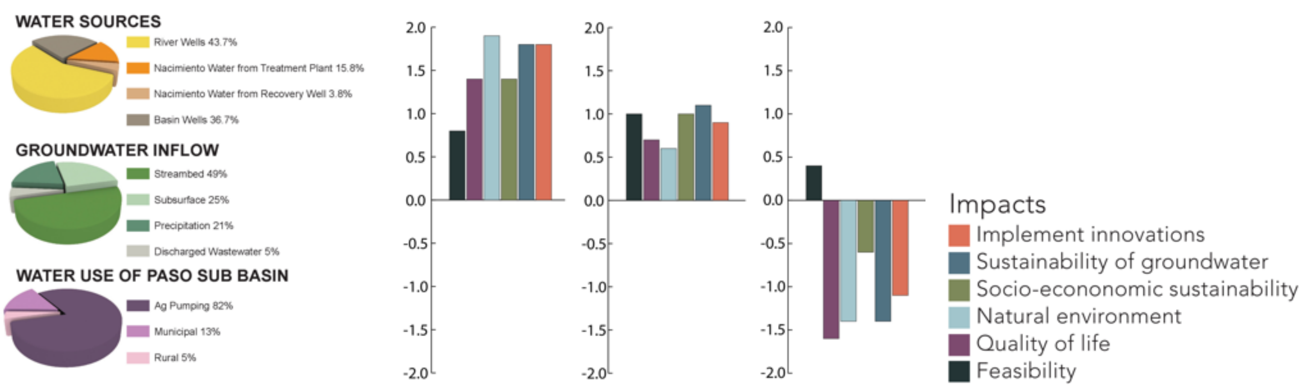

Figure 11: Paso Robles (a) resource allocation (b) impact evaluations.

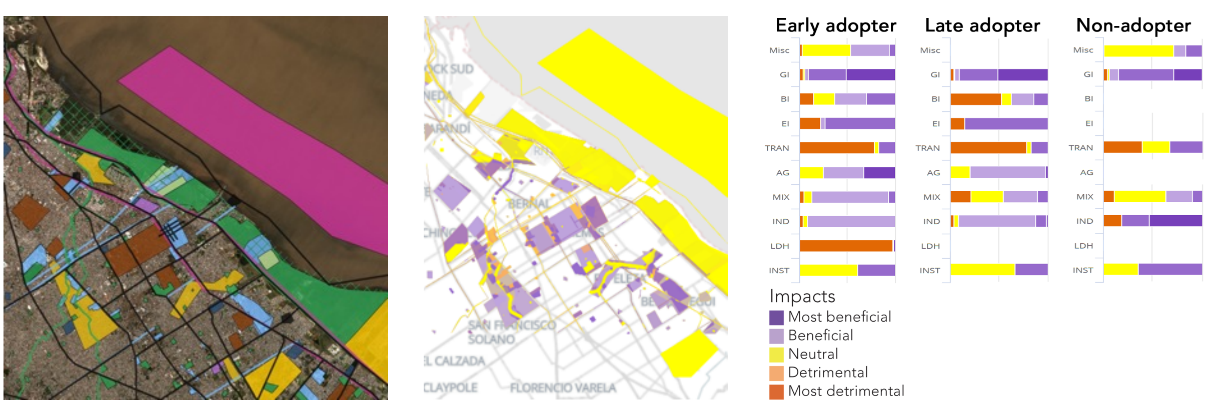

Figure 12: South East of Buenos Aires (a) Early adopter design (b) impact map and evaluations.

Impact evaluations are the principal means of assessing project outcomes. In one IGC project addressing flooding issues in an area South-East of Buenos Aires, faculty and students of the University of Buenos Aires used the impact evaluation tools in Geodesignhub design and analysis software to assess the impacts of the three alternative scenarios dictated by IGC. Early adopter plans show activity in all systems and the most beneficial outcomes, the non-adopter outcomes show activity in fewer areas, especially blue and energy infrastructure, agriculture and low-density housing.

Figure 13: CAMKOX corridor north of London (a) Early adopter design (b) impact map and evaluations.

Public participation is a significant goal of the geodesign framework, presenting processes in readily understandable forms and allowing rapid and interactive testing of ideas are key strategies to that end. Some projects, notably those of University College London, Ritsumeikan University, CalPoly San Luis Obispo, and the University of Basilicata were able to engage broad constituencies of project participants drawing on local and regional expertise. As well as the cognitive aspects of accessibility to public participation, another important facet is the ability to engage large numbers of people. Some of the IGC projects were undertaken by small groups of experts whereas others involved significantly large numbers. The University of Cagliari completed studies at two scales, 20x20km and 80x80km and engaged more than one hundred citizens and students in their processes (Figure 14).

Figure 14: Students and citizens of Cagliari completed designs at two scales (a) 80 x 80km (b) 20 x 20km.

Conclusions and future directions

The first iteration of the International Geodesign Collaboration was, by necessity, an experiment. The core group leading the initiative did not know what to expect in terms of the numbers of people wishing to join the project, the limitations of timing, resources or the fit with existing teaching responsibilities. The guidelines developed for IGC were thoughtfully developed but for this first iteration were untested by use in the public setting or classroom. Nevertheless, the project attracted broad and enthusiastic participation culminating in an energetic gathering in Redlands, California, in February 2019 to share the outcomes of eighty or ninety somewhat simultaneous projects. Several observations emerged. First, the superficial comparability of the common display format masks the enormous variety of design goals and approaches within the fifty-five projects displayed in Redlands. That, however, may be the heart of the learning opportunity IGC presents. Usually our ability to discern the richness of designs is obscured by there being no common ground and thus no starting point for comparisons. In the IGC case we can array three projects at similar scales (Figure 15) and see not only the designer's intentions but see design shaped by, left-to-right, the tight spatial constraints of European settlement patterns, the expansive and large-scale planning required for a new airport in Australia, and the granular development dictated by a relatively homogeneous rural landscape with strong land-use traditions.

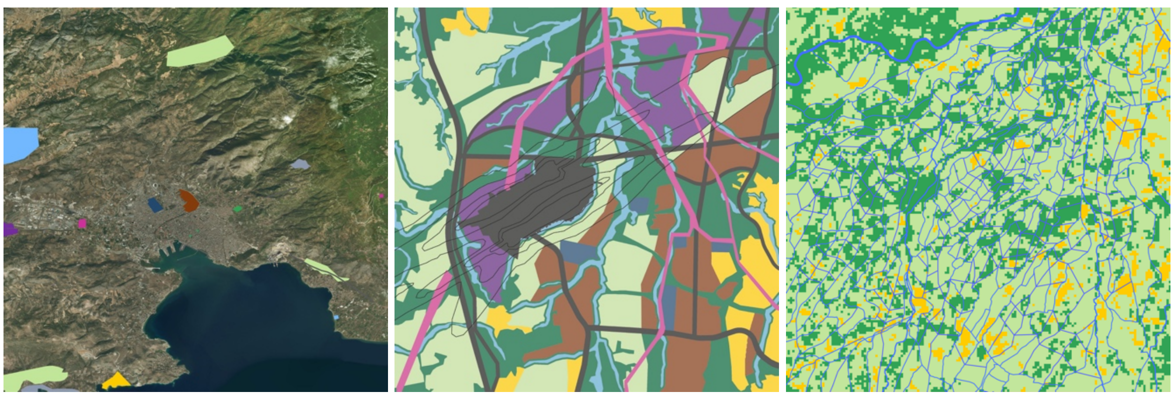

Figure 15: Projects 20 x 20 km (a) Thessaly, Greece (b) Sydney, Australia (c) Chiang Mai, Thailand

Three high-latitude urban-regional projects display similar goals in consolidating cores and creating green-belt conservation zones to achieve efficiency and resulting reductions in greenhouse gas production and improved water management (Figure 16).

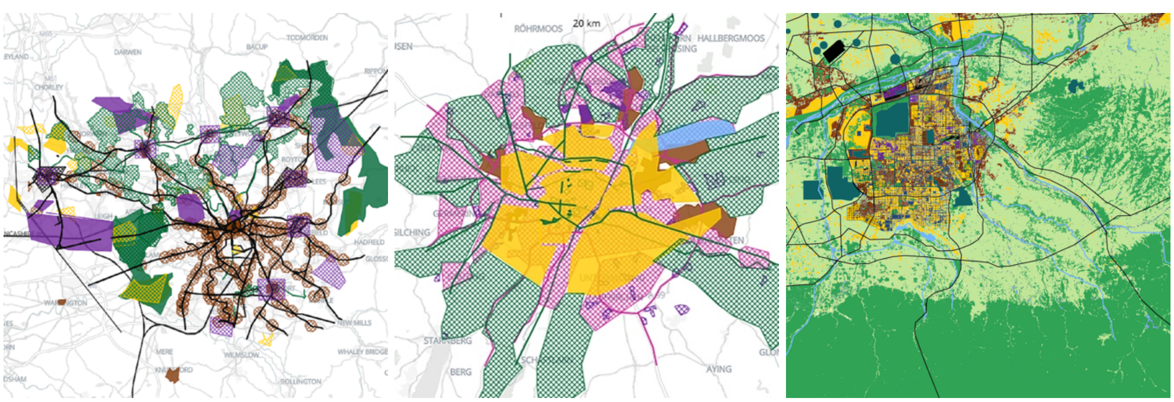

Figure 16: "high-latitude" projects (a) Manchester, UK (b) Munich, Germany (c) Xi'an, China

Three dense urban projects, each 5km x 5km demonstrate common strategies of reinforcing transportation corridors for commercial and mixed development while identifying and protecting green urban corridors for stormwater management, habitat preservation and for passive recreation to relieve the human pressures of urban living (Figure 17).

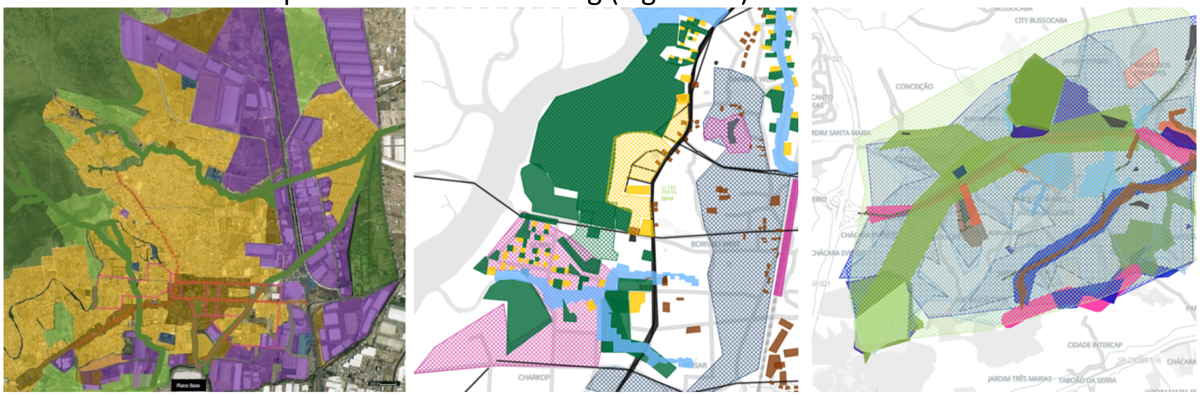

Figure 17: dense urban projects (a) Mexico City (b) Mumbai, India (c) São Paulo, Brazil

There is clearly much opportunity for continuing and refining such comparisons. However, one weakness of the first-round of IGC was the lack of any metrics or descriptors that could summarize the achievements of designs and allow comparison. The value of such metrics sits at the project level, in tracking and articulating how designs evolve over time – from 2020 to 2035 to 2050, did the situation improve or decline? Between the early adopters of innovations, through the late adopters to the non-adopters, did the innovations results in improvements? Would it have been valuable to wait and evaluate the innovations further and be a late adopter?

In seeking such an evaluation framework, the IGC core concluded that to truly address the global sustainability goals that drove the initiation of IGC, projects must report their outcomes and impacts in an appropriate framework, although we realized there is no easy way to achieve that. As a step toward this goal, we have requested that all IGC projects indicate how well their design scenario outcomes would address the global sustainability goals of the United Nations Development Program, Sustainable Development Goals (SDGs) (Figure 18).

GOAL 1: No Poverty
GOAL 2: Zero Hunger
GOAL 3: Good Health and Well-being
GOAL 4: Quality Education
GOAL 5: Gender Equality
GOAL 6: Clean Water and Sanitation
GOAL 7: Affordable and Clean Energy
GOAL 8: Decent Work and Economic Growth
GOAL 9: Industry, Innovation and Infrastructure
GOAL 10: Reduced Inequality
GOAL 11: Sustainable Cities and Communities
GOAL 12: Responsible Consumption and Production
GOAL 13: Climate Action
GOAL 14: Life Below Water
GOAL 15: Life on Land
GOAL 16: Peace and Justice Strong Institutions
GOAL 17: Partnerships to achieve the Goal

Figure 18: Seventeen Sustainable Development Goals, seven directly affected by biophysical design and planning (green tabs), five indirectly affected (orange tabs).

The land use/land cover decisions made during geodesign operations shape how global biophysical resources can address the SDGs, regardless of project type or scale. In the case of those marked with green in Figure 18, the connection is direct; to address hunger there must be enough land and water for agriculture. For those marked orange, the connection is indirect but still vital; to address health there must be clean air, parks for recreation, land for growing food, etc.

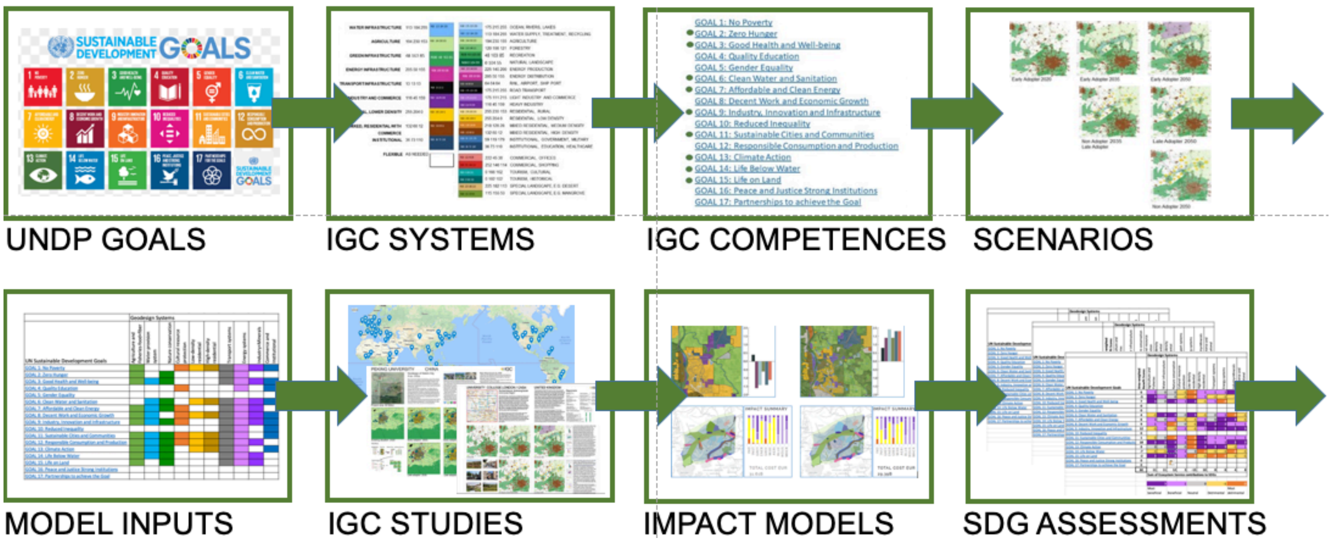

Figure 19: A workflow for IGC projects

IGC has developed a workflow incorporating our thinking on achieving summary assessments of SDGs (Figure 19). These assessments require single summary judgements to be made for each of the resource systems (second box in Figure 19) against each of the twelve SDG goals that have design consequences. We acknowledge that impacts may have a range of values across the affected areas, they may be influenced by the spatial pattern of changes, and they may be influenced by conditions outside the square study area. Regardless of these complications, summary judgments will need to be made, to enable comparisons of our case studies, to inform and feed back into the design process. Full details of the workflow and guidance for making assessments is on the IGC webpage, https://www.envizz1.com/project-workflow.

IGC has proceeded into a second year, with over eighty active participants and forty registered projects. The lessons of the first iteration, summarized briefly here are more fully developed in a forthcoming Esri Press book, *The International Geodesign Collaboration: Geography by Design* (Steinitz, Orland and Fisher 2020) Building on those lessons, and on our continued improvement of processes and supporting guidance the IGC will act as a framework for coordinating our different efforts so that we can understand the impacts we are making on critical global systems, compare between our individual projects to ensure that our projects bring about the high levels of environmental improvement to which we all aspire.

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