Evaluating Practical Implementation of Geodesign and its Impacts on Resilience

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Abstract: Using systems thinking, geodesign offers a promising mixture of design process and strategic analysis for building more resilient landscapes. Although the scholarship and literature on geodesign is increasing rapidly (C.-L. WU & CHIANG 2018), there is little evidence of an empirical evaluation of the geodesign approach in practice. Do geodesign processes encourage more resilient outcomes? Using content analysis and multivariate regression, we evaluate 35 geodesign projects from the 2019 International Geodesign Collaboration to determine the connections between geodesign processes and resilience. The projects were submitted by academics from over 50 different places across the world as part of landscape or urban design studios. We find that most of the submitted projects include a comprehensive and explicit set of design objectives and a wide range of diverse strategies. Most projects, however, fail to address process relationships, raising concerns that this deficiency might reduce the diversity and dynamics of design outcomes. Our evaluation also found that projects with more robust and comprehensive design strategies scored higher in our resilience measures. The findings offer insights for designers, practitioners, and policymakers to better utilize the geodesign approach.

Keywords: Geodesign, evaluation, International Geodesign Collaboration (IGC), systems thinking, resilience

1 Introduction

Over the past century, the growing reality of global climate change has led to various impacts on human and environment systems (MCCARTY et al. 2001). As a result, many local communities are facing disastrous and irreversible system feedbacks and their associated externalities (ADGER et al., 2005, GU et al., 2018). To cope with this heightened uncertainty and unpredictability, increasing attention has been given to the concept of resilience – replacing sustainability as a dominant goal and/or design and development approach (DAVOUDI et al. 2012). At the same time, design processes connected to geodesign have gained a lot of attention in a variety of literature as an approach to address these “wicked” problems that are ambiguous, complicated (with multiple interconnected systems), and highly uncertain (BRIAN ORLAND et al. 2016). According to EIKELBOOM & JANSSEN (2017), the geodesign process provides a dynamic mechanism for spatial analysis, stakeholder participation, and feedback necessary for resilient designs. Numerous, practical geodesign implementation projects have been conducted by a variety of professional and academic organizations, yet only a few studies just started evaluating the implementation of the geodesign process (COCCO et al., 2019, 2020). Moreover, there are few empirical studies evaluating the impacts of these applications on resilience outcomes. This engenders questions about its implementation and efficacy. Two fundamental questions are addressed in this study: 1) how are the geodesign processes implemented in different design projects? 2) do geodesign practices really improve resilience in landscape design?

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2 Methodology

We use content analysis to assess how geodesign projects align with criteria suggested in the STEINITZ (2012) geodesign framework and in the literature on resilience evaluation methods (BERKE & LYLES 2013, HAASNOOT et al. 2013, SHARIFI 2016). We evaluated 35 geodesign projects from the 2019 International Geodesign Collaboration (IGC) (B. ORLAND & STEINITZ 2019). The projects were submitted by academics from over 50 different places across the world as part of landscape or urban design studios.

Content analysis (BELL et al. 2018) is used to make replicable inferences on each project by interpreting and coding textual and graphic material provided by each team. The approach uses more detailed indicators to analyze the content of designs and identify specific areas of intent. A survey on team attributes and the process undertook by each team was also issued. We evaluated 35 responses to the survey and tied each to its corresponding design. For each project and survey, multiple variables are created for statistical analysis.

2.1 Content Analysis of the Implementation of Geodesign Process

We use the six principles from the Steinitz geodesign framework to code and score each project: 1) data representation, 2) process relationship, 3) goals and priorities, 4) design strategies, 5) impact assessment, and 6) implementation and monitoring. Since most IGC projects are conceptual designs without actually being implemented or monitored, implementation and monitoring is not evaluated. We tried to identify specific strengths and weaknesses of each design by evaluating the presence or absence of specific criteria (Table 1). This helped us identify similarities, differences, and trends across designs.

Table 1: Principles of the implementation of geodesign process

	Principle	Principle description	Principle components
A	Data representation	Empirical fact base that later helps to identify and prioritize goals to inform design strategies	Data resources; inventory and analysis of existing conditions
B	Process relationship	Recognition of significant processes and their relationships	Recognizing physical, ecological, human geographical processes; and their relationships
C	Goals & priorities	Identification and prioritization of expected future conditions that address current problems and reflect public values	Design vision, goals, and objectives
D	Design strategies	Specification of different design guides to accomplish goals and overcome uncertainties	Identifying different types of strategies; Specifying how they relate to certain goals and impact assessments; Costs, benefits, and co-benefits of strategies
E	Impact assessment	Assessing the influences of proposed changes	Identifying metrics and processes of impact assessments
F	Implementation & monitoring	Commitments and guidance to translate design strategies into action and track progress toward goals	Timelines for actions; assigning responsibilities to specific organizations; identifying funding sources for implementation and monitoring; identifying implementation and monitoring progress; acknowledging potential updates

Assessing the presence or absence of specific criteria associated with each design (as key words in text or content in diagrams) allows the conversion of texts and graphics to a quantitative measurement of design quality, which eases comparisons between designs, enables identification of trends across designs, and permits statistical analyses. Each indicator is coded on a 0 or 1 binary scale. Items within each of indicators receive a score of 0 if they are not mentioned in the designs. Items scored as 1 indicate they are identified as the description of the indicator. A worked example of how one project is coded and evaluated is shown in Figure 1.

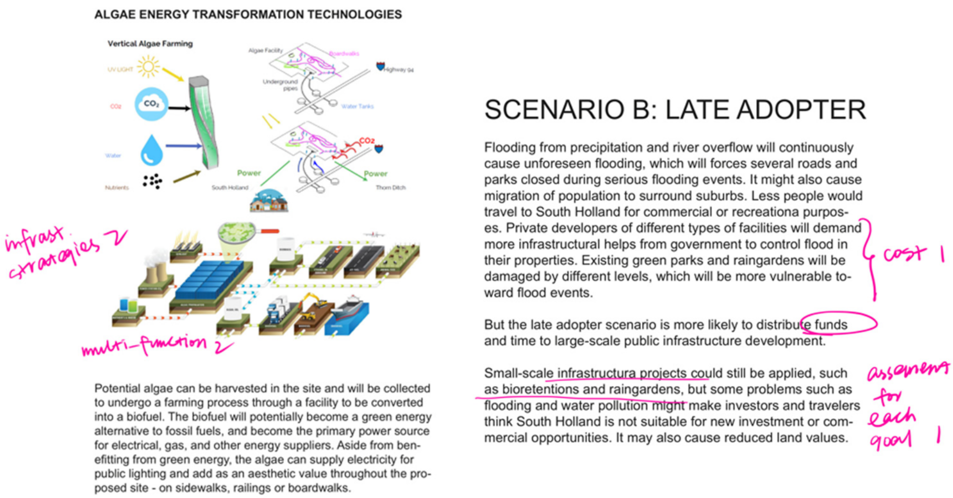

Fig. 1: An example of how one project is coded

2.2 Multivariate Regression to Evaluate the Associations between Implementation of the Geodesign Process and Resilience

From the literature, we find six resilience criteria to evaluate our sampled projects (AHERN 2011, HAASNOOT et al. 2013). They include diversity, dynamics, connectivity, uncertainty, redundancy, and multifunctionality. From the theory of resilience, we identify five key principles of resilience – diversity, dynamics, connectivity, multifunctionality, and redundancy (AHERN 2011, MEEROW et al. 2016, SHARIFI 2016). These five principles are increasingly considered as significant principles for the resilience framework, especially for landscape design and planning (DEAL & GU 2018, J. WU, 2014). Besides these five commonly used principles, multiple scholars have demonstrated the importance of addressing uncertainty in achieving resilience (BERKE & LYLES 2013, CHAKRABORTY et al. 2011, HAASNOOT et al. 2013). Scholars claim that the resilient efforts should go beyond the conventional paradigm of "predicting and planning" and embrace new methods that allow us to identify, evaluate, and address uncertainty (MUNARETTO et al. 2014). Thus, total six principles are used in this study to evaluate the resilience of design, including diversity, dynamics, connectivity, multifunctionality, redundancy, and uncertainty (Table 2).

Table 2: Resilience evaluation principles and indicators

Principle	Indicator	Description
1 - diversity	diversity	describe whether the design project thoroughly addresses multiple dimensions or sectors of resiliency in text
	diversity detailed	visualize how they do multi-dimension analysis by diagrams
2 - dynamics	dynamics	describe that the project addresses changes across different temporal scales
	dynamics detailed	visualize how they address temporal dynamics
3 - connectivity	connectivity	describe that the project addresses cross-scale spatial relationships
	connectivity detailed	visualize how they address cross-scale spatial relationships by diagrams
4 - uncertainty	uncertainty	acknowledge that uncertainties are involved in future projection in text
	uncertainty detailed	describe sources of uncertainties and visualize how they address future uncertainties by diagrams
5- redundancy	redundancy	describe the co-benefits of implementing certain several strategies in text
	redundancy detailed	visualize how different strategies have the co-benefits by diagrams
6 - multi-functionality	multi-functionality	describe multiple functions of implementing one certain strategy in text
	multi-functionality detailed	visualize the multi-functions of implementing a certain strategy by diagrams

Similar to the content analysis of the application of geodesign process, we evaluate the resilience of projects' design outcomes by assessing the presence or absence of specific indicator of resilience associated with each design (as key words in text or content in diagrams), which allows the conversion of texts and graphics to a quantitative measurement of design quality. Each indicator is coded on a 0 or 1 binary scale. For each resilience principle, there are two indicators, e. g. diversity and diversity detailed. Items within each of indicators receive a score of 0 if they are not mentioned in the designs. Items scored as 1 indicate they are identified as the description of the indicator. The possible resilience scores that a project can get is 0-12. We use Pearson correlations to analyze the relationships between the application of geodesign process and each resilience principle, as well as overall resilience of design outcomes. Our main hypothesis is that projects that score highly in terms of (geodesign) process will also do well in resilience scores.

3 Results

We generate a set of principles and indicators for evaluating the practical process of geodesign projects by integrating the well-established geodesign framework (STEINITZ 2012). The principles of resilience are generated based on resilience literature (AHERN 2011, MEEROW et al. 2016). For purposes of this paper, only results of the preliminary study are presented in following subsections. In another forthcoming paper we will look closely at how principles and indicators of the geodesign process, resilience, and another measuring item – team attributes – are interrelated.

3.1 Content Analysis Results of the Application of Geodesign Process

We found that the average IGC geodesign project scored 24 out of 52 (46 % of all possible points). The highest-scoring design was 36 (69 % of all possible points). The lowest-scoring design was 15 (29 % of all possible points). 15 out of 35 projects (less than half) scored above 26 (50 % of all possible points), which suggests that most projects assessed did not completely follow the geodesign framework or that the scoring criteria was too fine for the nature of the projects submitted.

Among the five process principles used for our scoring criteria projects scored highest on principle C, "Goals & Priorities", with an average score of 4 out of 7 (57 %). 22 out of 35 projects score equal to or higher than 4, evidencing that most projects evaluated included a comprehensive and explicit set of design objectives. This process is important in the decision-oriented geodesign framework, as it reflects the expected conditions of future landscape needs. Principle D, "Design Strategy" also received generally high scores (averaging 8/15 – 51 %). 20 out of 35 projects score equal to or higher than 8, which suggest that a wide variety of robust strategies were included and coded contributing to high scores in this process.

The design projects scored lowest on the principle B – Process Relationships – with an average score of 2/8 – 28 %. The principle of process relationship is developed from the process models within framework, which tends to answer the question of how the landscape operates. Failing to address process relationships may result in the neglect of the inherent hierarchies and dynamic changes of landscape that help identify intervention scales and system interconnections (HAYEK et al. 2016). A poor process score might also be reflected in a poor impact assessment (Principle E) score as process models leads naturally in to the formation of evaluation methods and criteria for analysing the impacts of design scenarios.

3.2 Multivariate Regression to Evaluate the Associations between Implementation of the Geodesign Process and Resilience

Pearson correlations were conducted with the six principles of resilience as the dependent variables (Table 3). The preliminary result of the relationship between geodesign process and diversity of design outcomes are shown in this paper. More detail could be found in another forthcoming paper. Three of the five geodesign processes – process relationship, design strategy, and impact assessment – were significantly and positively correlated with the diversity of resilient design outcomes. According to AHERN (2011), diversity in resilience theory indicates "the diversity of species within functional groups that have different responses to disturbance and stress (e. g., temperature, pollution, disease)". The regression results showed that the more comprehensive teams analysed process relationship, created design strategies, and assessed strategies' impacts, the more diverse the design outcomes were. As impact assessment process (p value < 0.01) showed a significant positive relationship with the diversity of design outcomes, and most of the teams scored highest on assessment results, one explanation may be that the sampled projects which showed more results of the impact assessment could have more diverse responses to disturbance and stress, thus increase overall resilience. The process relationship (p value < 0.05) of the geodesign process also showed a significant positive relationship with the diversity of design outcomes. As most of the teams scored highest on ecological processes, it seems that ecological processes may be more important than physical infrastructural and human geographical processes in terms of providing more diverse responses to disturbance and stress. The reason for this could be that with more robust analysis of the relationship between different ecological groups, the ecosystem services offered by any ecological group are more likely to keep functioning and adapted to different conditions (AHERN 2011). Moreover, the design strategy process (p value < 0.05) was also positively correlated with diversity. Because most of the teams scored highest on alternative strategies and land use strategies, one explanation may be that the projects with more than one type of design strategies besides land use strategies could have more diverse responses to disturbance and stress.

Table 3: Correlation between each geodesign process and each resilience criteria

Geodesign process	Diversity	Dynamics	Connectivity	Uncertainty	Redundancy	Multifunctionality	Overall resilience
Data representation	0.177	-0.163	0.192*	0.127	0.229*	0.327†	0.324†
Process relationship	0.355†	0.22*	0.049	0.057	0.139	-0.055	0.225*
Goal & priority	-0.201	-0.067	0.184*	0.181	0.083	0.27	0.168
Design strategy	0.321†	-0.009	0.202*	0.377‡	0.55‡	0.601‡	0.682‡
Impact assessment	0.391‡	-0.14	0.294†	0.062	0.217*	0.209*	0.376

* Significance < 0.10. †Significance < 0.05. ‡Significance < 0.01.

Regarding overall resilience, multiple regressions were conducted to identify the geodesign processes that significantly affect overall resilience of design outcomes. Of the five geodesign process principles (Table 1), the principle of design strategy, encompassing fifteen criteria, accounted for the most variation in overall resilience score ($R^2 = 0.465$, $p < 0.01$). This principle accounted for almost half (46.5 %) variation in the total process scores. Two other principles were found significantly correlated with our overall resilience score: process relationship ($b = 0.213$, $t = 2.14$, $p = 0.041 < 0.05$) and impact assessment ($b = 0.205$, $t = 0.103$, $p = 0.057$) (Table 4). These three principles of geodesign process – process relationship, design strategy, and impact assessment – show a positive influence on our resilience variables.

Table 4: Results of regression analysis on geodesign process principles and resilience

	Overall Resilience					
	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	-0.083	0.123	-0.675	0.505	-0.335	0.169
Data Representation	0.153	0.135	1.128	0.269	-0.124	0.43
Process Relationship	0.213	0.1	2.14	0.041	0.009	0.417
Goal & Priority	0.031	0.16	0.197	0.845	-0.296	0.359
Design Strategy	0.619	0.16	3.869	0.001	0.291	0.947
Impact Assessment	0.205	0.103	1.985	0.057	-0.007	0.417

4 Discussion

Because of the recent emergence of the geodesign approach and the greatly contextualized character of the geodesign projects from different places of the world, there is no established framework or precedent for evaluating geodesign practices and their impacts on resilience. This is reflected in the great variation in geodesign process scores of our sample. Despite this, the sampled projects share common strengths and weaknesses that affect resilience of design outcomes.

To answer the first question in the introduction (how are the geodesign processes implemented in different design projects), the results show that most of the submitted projects include a comprehensive and explicit set of 'design objectives' and a wide range of 'diverse strategies. Most projects, however, fail to address 'process relationships', raising concerns that lacking process relationships might reduce 'diversity' and 'dynamics' of design outcomes. For the second question (do geodesign practices really improve resilience in landscape design), the answer is yes. The results show 0 that the regression model using the principle of 'design strategy' to predict overall resilience gets the highest R2 value. It indicates that the 'design strategy' principle reflects the most effects of the geodesign process on overall resilience in design outcomes. The projects with more robust and comprehensive design strategies were of higher resilience. Also, as expected, the results show that all the principles of geodesign process have significant positive effects on certain attributes of resilience. However, some geodesign process principles may not be predictive for all resilience attributes. For example, the principle of impact assessment is not related to 'uncertainty' and 'overall resilience'. One of the reasons could be that impact assessment reinforces the conventional design method of "predicting and planning" rather than identifying, evaluating, and addressing uncertainty (MUNARETTO et al. 2014). Another reason could be the limitation of the small sample size. It is also important to note that the content analysis of geodesign posters requires significant authors' interpretation and may subject to authors' bias. 1

5 Conclusions

In this paper, we used content analysis to review the implementation of the geodesign process and used multivariate regression to evaluate the relationships between geodesign process principles and resilience of design outcomes. Content analysis isn't new to planning evaluation. The method has been used in planning fields to analyze plans from various domain, including sustainable planning and climate change adaptation planning. In landscape architecture, however, few researchers have used this method to evaluate the practical implementation of the geodesign approach. We believe that geodesign practice should be evaluated and explored more broadly in order to accomplish more resilient results. Owing to the subjective character and highly contextualized nature of landscape architecture, there are few established precedents, methods or frameworks for evaluating the quality of landscape designs from an evidence-based, quantitative perspective. This study fills this gap by providing a series of principles and indicators for assessing the implementation of the geodesign approach and its efficacy in achieving resilience. This helps landscape designers better operationalize the geodesign processes with the hope that this will lead to higher-quality design outcomes. We hope that these findings lead to more resilience and the translation of designs into on-the-ground actions.

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