Teaching Coastal Resilience Using Geodesign: A Study of Virginia Beach

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Abstract: This study examines using Geodesign as a framework for generating resilient plans and policies for coastal resilience. Particularly, Geodesignhub (Geodesignhub.com) is used to evaluate scenarios for adapting to sea level rise in the City of Virginia Beach, United States. Currently, this city facing a sea level rise with frequent storm surges, does not have a comprehensive resilient plan against sea level rise. As such, Geodesignhub was used to generate and evaluate scenarios to produce such a plan. In addition, Geodesignhub is used to teach coastal resilience to landscape architecture students. Students prepared the datasets and participated in Geodesign workshops as interest groups. Overall, Geodesignhub was effective in generating scenarios as well as teaching complex resilience issues.

Keywords: Geodesign, coastal resilience, Virginia Beach, educational technology

1 Introduction

Like many coastal cities in the world, the City of Virginia Beach, United States, faces a challenge of global climate change and resulting sea level rises. As most of the city is flat with very little topographic variations, it is especially susceptible to sea level rises and storm surges. The city, spanning 803 km^2, has an elevation of 26.8 m at its highest point above mean sea level. The average elevation is 3.65 m above mean sea level. Even with a modest sea level rise, storm surges frequently threaten the city. According to a 2008 Virginia Hurricane Evacuation Study, most of the city would be inundated by a Category 4 storm surge (see Figure 1). During the recent storm Matthew, Wilmington, NC, not too far from Virginia Beach, was reported to have more than 2.4 m of storm surge (WEATHER.COM 2016). In this situation, storm and sewage drainage will not work as gravity cannot take the waters to lower ground. Homes will not be able to maintain gardens, as salt water will kill the vegetation during the frequent storm surges. Consequentially, the three major economic generators of the city (i. e., tourism, agriculture, and military) are also under serious threat.

However, the city's current Floodplain Ordinance requires only that finished floors be at least two feet above the 100-year flood elevation, which is not enough (CITY OF VIRGINIA BEACH 2017). The city's Comprehensive Plan discusses sea level rises but does not actually present plans.

One of the reasons that the threat of sea level rise is dealt in a lasses-faire manner is perhaps due to the fact that there is not a systematic information and analytic tool that includes not only the storm surge levels, but also other factors; these other factors would constitute impacts on housing, transportation, commerce, history and culture, etc. The second reason might be that there is no easy vehicle to collaborate among parties with different interests and knowledge.

This study argues that in order to generate resilient plans and policies, 1) there has to be a system that is easily accessible and understandable, and 2) there should be a collaboration over time (i. e., years and decades) between various parties to resolve their differences and

Journal of Digital Landscape Architecture, 2-2017, pp. 279-286. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-629-1, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537629029.

contribute their knowledge to other parties; Geodesign can help achieve both. Geodesign framework helps decision makers systematically understand complex problems such as the impacts of climate change faced by the city and facilitates such collaborative work.

This paper documents a studio project that used Geodesign for a resilient city design. A total of twelve students and one teaching assistant participated in the studio course that is offered to senior level and graduate students.

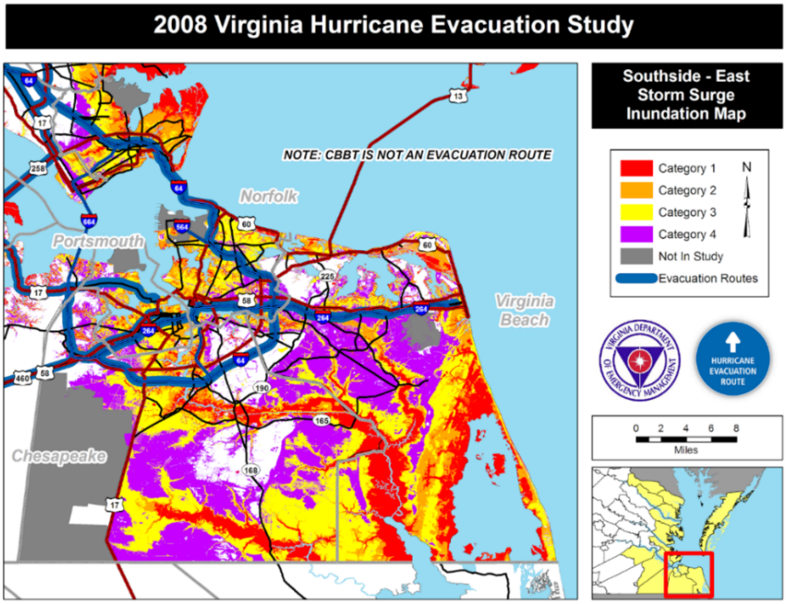

Fig. 1: Virginia Hurricane Evacuation Study estimates that most of the city will be inundated by a Category 4 storm surge (VIRGINIA DEPARTMENT OF EMERGENCY MANAGEMENT 2016)

2 Geodesign Methods

Geodesign is based on and shaped by a set of questions and methods necessary to solve large, complicated, and significant design problems. These design problems are often at geographic scale ranging from a neighborhood to a city, landscape region or river basin (STEINITZ 2012).

Geodesign is a design and planning method that tightly couples the creation of design proposals with impact simulations informed by the geographic contexts (FLAXMAN 2010).

Considering its ability to solve large and complicated problems at a city scale, Geodesign becomes a useful tool for the resilience issues that the city faces. Its ability to quickly assess the impact based on design and policy decisions is essential in helping to shape the city's resilience. In addition, it has the capability to help groups collaborate to reach a consensus on design and policy decisions are tremendously beneficial. FLAXMAN's continued research on Florida's Everglades is a working demonstration of Geodesign in a similarly situated environment (FLAXMAN & VARGAS-MORENO 2012, MIT EVERGLADES PROJECT WEBSITE

2016). As such, the personal discussions with STEINITZ and his Georgia project helped form the project idea (SMITH 2016).

Based on STEINITZ's framework of Geodesign, HRISHI BALLAL at University College London developed an online tool, named Geodesignhub (geodesignhub.com). This studio utilizes the online tool. The tool best realizes STEINITZ's framework. Its additional benefit is that any changes proposed online calculates its impacts, such as environmental, budgetary, etc.

BALLAL advised throughout the project by helping with data preparation and later by leading workshops through Skype communication from the United Kingdom.

The following represents the steps taken for Geodesign

Phase 1: Geodesign System Building

1. Identify 10 major systems to evaluate: i. e., ecology, tourism, military, etc.
2. Conduct analyses/evaluations
3. Upload evaluations to the server

Phase 2: Workshops

4. Propose plans and policies during workshops
5. Synthesize the plans and policies
6. Evaluate impacts of the plans and policies
7. Negotiate plans and policies among parties with various interests, such as government, conservationists, and developers, etc.

3 Study Area and Challenge

The City of Virginia Beach is located around the center of the East coast of the United States and at the South Eastern tip of the State of Virginia. Its total area is 803 km^2 (310 mi^2), of which 670 km^2 (258.7 mi^2) are land and 133 km^2 (51.3 mi^2) are water. 132 km^2 (32,700 acres) of the city are currently under cultivation. The city's present population is approximately 437,994 and is expected to grow to 530,000 by 2040 (ENVISION 2040 2011).

The city's biggest challenge, as described in the introduction, is sea level rise in the coming decades (Figure 2). However, as shown in Figure 1, the more imminent problem is storm surge as it is already impacting the city. In 2003, Hurricane Isabel recorded 2.3 m of storm surge (WIKIPEDIA 2016). Combined with sea level rises, future storm surges could reach over 3m, which is a significant threat to the city with an average elevation of 3.7 m.

Particularly, one of the three main economic generators, agriculture, exists below the *greenline*, an urban-growth boundary. Figure 2 shows the majority of *greenline* is under 1.8m of sea level rise. Sea water from storm surge will affect agriculture well before sea level reaches the agricultural area. Tourism, another of the three economic generators, can also be affected by the changing beach morphology. Military bases are also affected by sea level rise and storm surge as their elevation is below 2.5 m.

In addition, the local ecosystem is left vulnerable by sea level rise. For example, the ecosystem of Back Bay National Wildlife Refuge with its sea turtles, barred owls, red foxes, and marsh rabbits will be impacted by the changing shorelines.

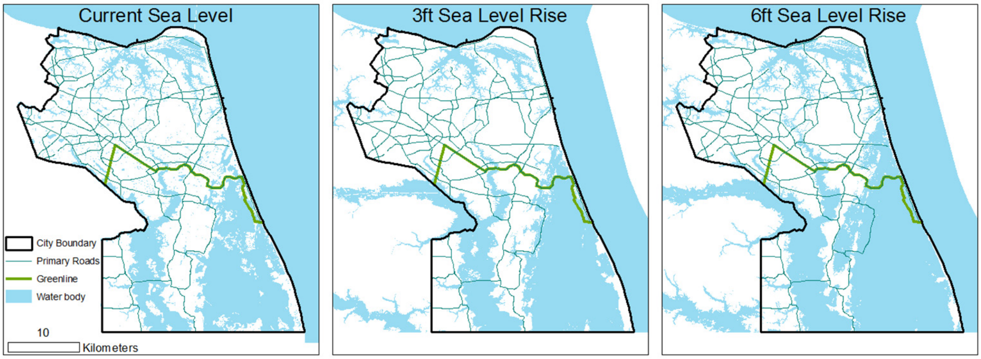

Fig. 2: Impact of sea level rises of the City of Virginia Beach. The impact is more severe below the green line (thicker line in the middle) affecting its agriculture business more seriously. The figure shows 0.9 m and 1.8 m sea level rise.

4 Phase 1. Geodesign System Building

One of the first tasks of Geodesign is to identify ten evaluation systems that are important for the city and creating evaluation maps in collaboration with others who worked on similar projects. The following ten areas are identified: 1. Climate, 2. Ecology, 3. Ground water, 4. Surface water, 5. History/Culture, 6. Tourism, 7. Housing, 8. Commercial/Industrial resources, 9. Military, and 10. Transportation.

Students in the regional studio prepared the evaluation maps using the following criteria.

Existing (red): "Red represents where the system is "existing" already and in a healthy state, meaning that it is feasible to remain…a constraint in terms of information but not a total constraint."

Not appropriate (yellow): "Yellow represents lowest priority for change, "not appropriate" or not capable of supporting the system, meaning do not put it there; e. g. too wet or steep or…unless you provide change to the basic area conditions; e. g. fill in the ocean for new land, regrade the mountain, etc. All of which are very risky projects. This is also a constraint in terms of information."

Capable (light green): "Light green represents low but higher priority, "capable," meaning that you can place it here if you also provide the technology and market to make it feasible; e. g. water and sewers, access roads for mechanical harvesting, etc., and the market comes."

Suitable (green): "Green represents higher priority, "suitable," meaning that the area is capable of supporting the project and it already has the appropriate technologies to support the activity taking place; e. g. septic tank soil or sewers, access roads for mechanical harvesting, etc. But there may not yet be a market for the change."

Feasible (dark green): "Dark green represents the highest priority for change, "feasible", meaning that it is suitable and there is a demand or market to provide the new land use change; e. g. that someone wants to buy the product or new house (and at a profit) or that the government wants to protect and improve a historical landscape."

The necessary GIS layers were provided by the city. For each system, multiple GIS layers were processed using the following ArcGIS functions: Union, Dissolve, Simplify, Eliminate, Smooth. The resulting maps are shown in Figure 3 below.

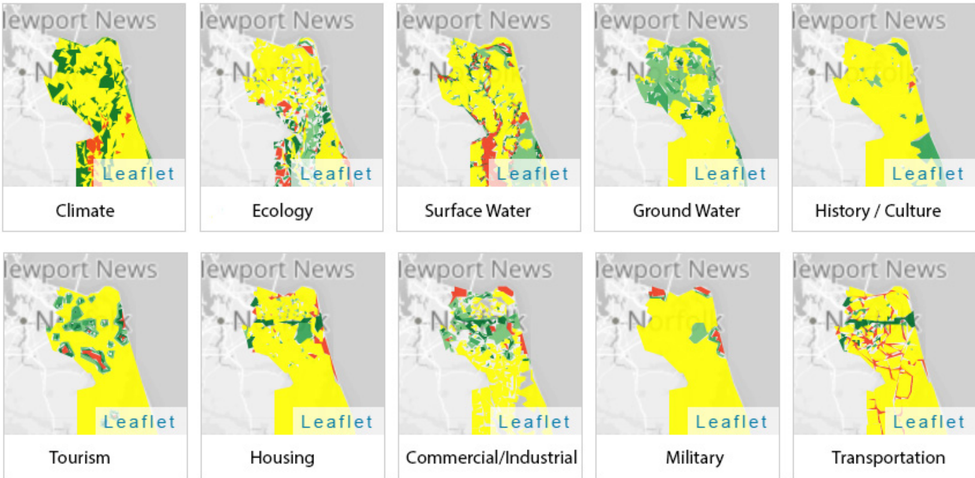

Fig. 3: Ten evaluation systems for Virginia Beach

5 Phase 2. Workshop

Once the ten evaluation systems are prepared, they are then uploaded to the Geodesign Hub server along with other supporting layers, such as 0.9 m sea level rise, major roads, and Back Bay National Wildlife Refuge GIS layers.

Once the data is uploaded, the system is ready for workshops where the participants can create their own resilience plans. The created plans and ideas can then be negotiated within the system between parties. Since the system is on an online server, the workshop participants can work from remote locations.

The workshop participants were students: 7 senior landscape architecture students, 4 graduate exchanges students from Tongji University, Shanghai, China, 1 master's student, and a teaching assistant who is a PhD student. They were grouped into 4 interest groups representing 1) developers, 2) conservationists, 3) government, and 4) elderly people as the city estimates that by 2040, 20 % of population is expected to be over 65.

Proposing Changes

The next task is to work with the ten evaluation maps to assess the current conditions, then propose and draw the changes online. The participants work as experts on the evaluation topics such as ecology, climate and housing, to come up with the design and draw it online. For each map, the participants were asked to propose as many as ten changes. Some did more and others did less (Figure 4).

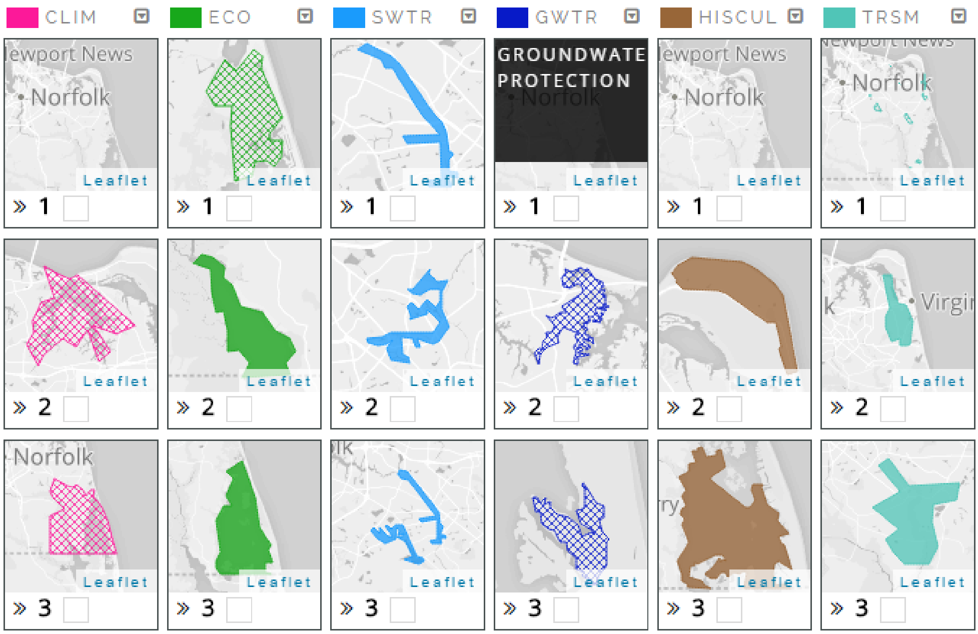

Fig. 4: Examples of change proposals for ten evaluation systems. Solid polygons are for physical change proposals and hashed polygons are for policy changes.

Synthesis and Impact Models

The next task in the workshop is to make synthesis maps. Thirteen participants were divided into interest groups of three and four, representing environmentalists, developers, government representatives, and senior citizens. Each group then synthesized the change proposals above that best represented their interests by choosing the proposals they liked. As proposals are added or dropped, the amount of changes, the impacts on each of the ten systems, the cross system impacts, and the estimated costs are calculated in real time. Thus, participants can adjust their plans quickly after considering their respective impacts.

Comparative Assessment

Utilizing the real-time impact tools, the interest groups were then able to each come up with plans that best represent their interests. Resulting impacts and budgets are calculated in the figure.

Negotiated Design

The final phase of the workshop is negotiating and coming up with the negotiated design(s) (Figure 5). The tool allows teams to negotiate. By picking and choosing, teams can collaborate to come up with a negotiated design.

6 Discussions and Conclusion

In this study, a Geodesign framework, Geodesignhub, was examined for its potential as a tool to create resilient plans and policies for the City of Virginia Beach. This study also examined to see if Geodesignhub could be utilized to teach resilience to students.

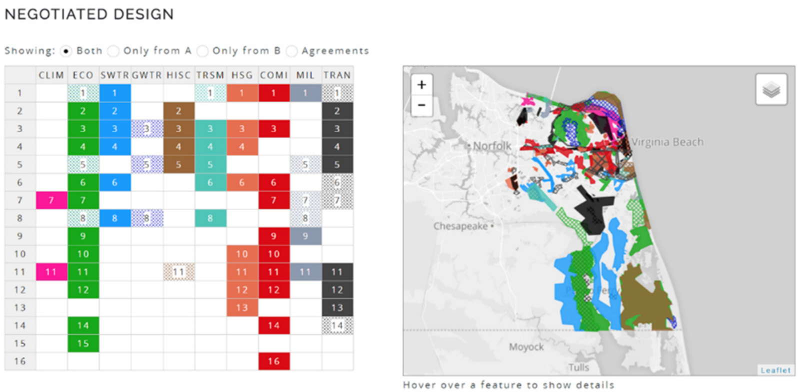

Fig. 5: Negotiated Design

This study built an online system using a Geodesign framework that can be used to create resilient plans. Workshops using the framework was an integral part of creating resilient plans and policies. The workshops were organized to engage thirteen student participants. Since the participants also built the ten systems and had good understanding of the environment, they were able to generate a consensus-based resilient plan collaboratively. They were able to meet the program requirements, such as accommodating the population displaced by sea level rise by densifying higher grounds including Oceana Naval Air Station assuming it will close as a base.

Although landscape architecture students are not necessarily the most suitable interest groups for a Geodesignhub study, the study demonstrated that Geodesignhub could be used as a teaching tool. Unlike many other prior studies where the workshop participants did not develop the ten evaluation systems, student participants understood the ten systems better because they themselves prepared it. By understanding the systems that was relatable to them, the students were able to represent the interest groups. This study illustrated the incredible potential of Geodesign as a teaching tool as students will learn more by preparing the evaluation systems themselves.

While the final resilience plan created by students is not refined enough to be useful, the Geodesign framework provides a foundation for further modifications and improvements. Hence, the value of having the workshops with students before the future workshops with professionals is useful in locating where the potential problems might arise.

Since the system was built, tested, and has been improved through an on-campus workshop, it is now ready to be brought to the City of Virginia Beach for workshops with city planners, Army Corp of Engineers, Chesapeake Bay Foundation, professional designers and planners, and developers, etc. The project is documented in a report. Overall, the book along with this study will be distributed to the city's administration. In addition, a Geodesign workshop will be organized with the help of landscape architects and planners working in the city, including a landscape architecture student who worked as an intern for a firm in Virginia Beach. Funding is being sought for the future workshops from the same funding source for this study, Global Forum on Urban and Regional Resilience.

Hopefully, this study will become a foundation for encouraging earnest discussions among populations of the city about sea level rise and its impacts. By doing so, the city is one step closer in planning to making it more resilient.

Acknowledgement

This study was possible thanks to funding provided by the Global Forum on Urban and Regional Resilience (GFURR).

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