Simulation-Based Learning Environments to Teach Complexity: The Missing Link in Teaching Sustainable Public Management

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Abstract

While public-sector management problems are steeped in positivistic and socially constructed complexity, public management education in the management of complexity lags behind that of business schools, particularly in the application of simulation and simulation-based learning. This paper describes our development of a Simulation Based Learning Environment that includes a coupled case study and SD simulation surrounding flood protection, a domain where stewardship decisions regarding public infrastructure and investment have direct and indirect effects on businesses and the public. The Pointe Claire case and CoastalProtectSIM simulation provide a platform for policy experimentation under conditions of exogenous uncertainty (weather and climate change) as well as endogenous effects generated by structure. We discuss the model in some detail, and present teaching materials developed to date to support the use of our work in public administration curricula. While learning and outcome evaluations are not complete, we believe that he effectiveness of this approach will be demonstrated.

Overview

There is a new challenge facing public management education—to teach public managers to handle a broad range of novel situations characterized by complexity when dealing with an emerging class of problems that we dub “sustainable” public management problems. This paper first gives a quick overview of the current state of public management education, poses a preliminary multi-dimensional concept of complexity that encompasses both positivist and social constructionist view of complexity, and proposes a broad design for simulation-based learning environments (SBLEs) to teach in this complex domain. We next present an example of one such SBLE—the Pointe Claire Coastal Protection Case, a case focusing on the decisions of a Regional Coastal Planning Commission on the Mississippi Coast faced with the dual threat of current storm damage from hurricanes such as those already hitting the coast (e.g., Katrina) as well as the future probable threats of enhanced damage due to global warming. Finally, the paper discusses how this SBLE was implemented in a first class on modeling methods in the Rockefeller College's core MPA program and presents some preliminary results from instructor attempts to evaluate the instructional technology as well as student learning in this complex domain. The paper concludes with reflections on future research needed in this area.

Part I: Traditional Public Management Education and Complexity

This section reviews the current state of public management education and briefly discusses complexity in decision making, suggesting a simple but comprehensive taxonomy of complexity in public policy decisions.

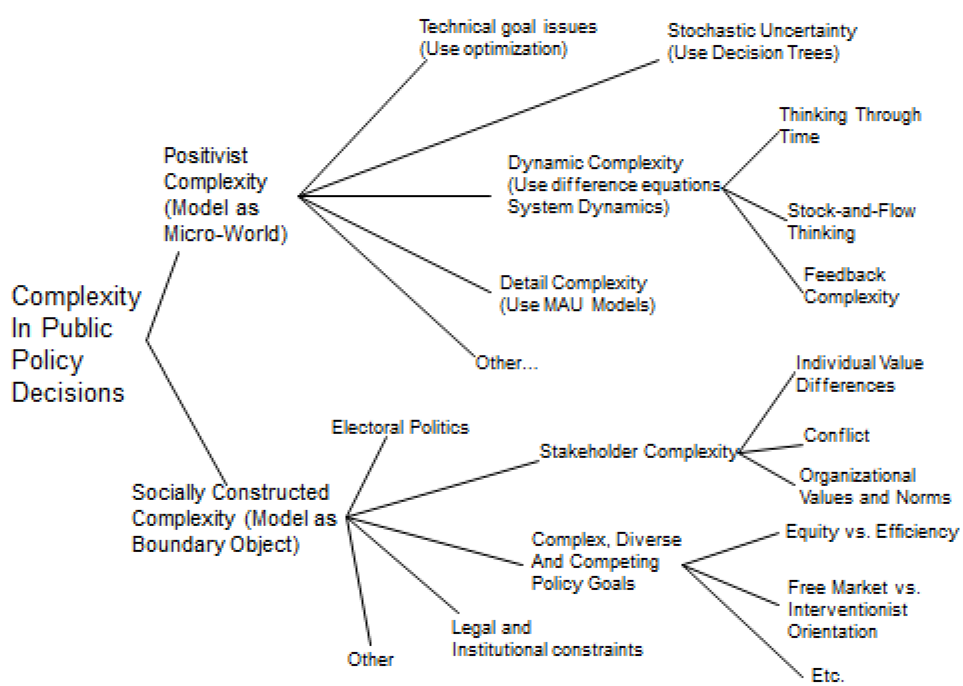
The Current State of Public Management Education. The current public management education has relied heavily on the traditional classroom learning which assumes that knowledge and skills which are needed for sustainable public management can be transferred from the instructor to the students through readings and lectures (Comfort & Wukich, 2013). According to Comfort and Wukich (2013), it is true that even the majority of courses on crisis management currently offered in MPA programs are designed and managed based on this traditional principle of teaching and learning environments. However, the rapid change in the public policy decision making environments, especially, the increase of complexity has brought the need for exploring a new set of qualities, which are expected to public managers, and the ways to nurture these qualities in MPA programs.

As the core qualities of successful public managers, the National Association of Schools of Public Affairs and Administration (NASPAA) have suggested MPA programs to pursue the five competencies: the ability (1) to lead and manage in public governance, (2) to participate in and contribute to the policy process, (3) to analyze, synthesize, think critically, solve problems and make decisions, (4) to articulate and apply a public service perspective, and (5) to communicate and interact productively with a diverse and changing workforce and citizenry. However, the detailed components of each type of competencies are not defined by the NASPAA. Rather, the NASPAA encourages institutions that run MPA programs to define the meaning and sub-components of the competencies—i.e., knowledge, skills, and abilities. Following this idea, as an effort to improve the competitiveness of the MPA program, the Rockefeller College of Public Affairs and Policy (the Rockefeller College, for short) has elaborated the NASPAA's five core competencies by group brainstorming among MPA faculty and has applied the sophisticated understanding of the competencies to the current MPA core courses of the Rockefeller College (See Appendix A).

A Proposal for Thinking about Complexity. Public managers and policy makers in the 21st century are required to manage complex systems whose boundaries spill over agency, jurisdictional, and sector boundaries, dealing with a great deal of uncertainty. Ever since Lindblom (1959) first brought up complexity as a new topic, the literature has reviewed many features of such “wicked problems” framing issues about how to deal with complexity in the public sector. Although various approaches to conceptualizing complexity do exist, much less attention has been paid to methods and approaches for teaching and learning in and about complex systems in public management settings.

Here, we suggest a taxonomy of “complexity in public policy decisions” encompassing positivistic and interpretive features of systems complexity. This taxonomy, shown in Figure 1, classifies the features of complexity in public management settings largely into two dimensions: (1) *positivistic complexity*, which is a bundle of objectively observable and measureable features that make public policy problems difficult to manage (such as decision-making in the face of stochastic uncertainty or feedback complexity within complex systems models); and (2) *interpretive complexity*, which results from the diverse interactions of multiple stakeholders with often competing points of view, leading to intra-group, organizational, or political conflicts.

Figure 1. A Taxonomy of Complexity in Public Policy Decision



Part II: The Pointe Claire Coastal Protection Planning Exercise—Toward a Simulation-Based Learning Environment.

Given the taxonomy, shown in Figure 1, we designed and built a SBLE to teach how to manage multiple dimensions of complexity based on the "double-looping learning model" that Sternman (1994) suggested as a teaching and learning model of complexity. This curriculum for teaching complexity within public policy decisions makes use of a simulation-based large-scale case focused on "Disaster Preparedness on the U.S. Gulf Coast in the face of Global Warming." The complete curriculum consists of a realistic system dynamics simulation model of the impact of hurricane grade storms on a typical coastal community plus a series of exercises that focus on stakeholder complexity and decision making within a community-based governing board tasked with planning for such storms in the face of future-possible global warming threats.

The Pointe Claire Regional Coastal Planning Exercise was a multi-component simulation-based exercise that spanned over ten weeks of activity in a core MPA class in modeling. The purpose of the exercise was two-fold—(1) In substantive terms, to teach students to use a complex simulation model as a tool to understand a multi-faceted set of interactions and come up with robust policy conclusions, and (2) In terms of the policy process, to teach students how to use complex models to help groups of public policy stakeholders come to agreement around policy goals. The class exercises were built around a system dynamics simulation of coastal protection dynamics, CoastalProtectSIM.

- Students engaged in an in-class exercise working with the C-ROADS simulation, a high fidelity simulation system used to forecast impacts of CO2 emissions on global warming over a 50 year plus time horizon (See Appendix B-1).
- Students drafted a memo detailing a way to use the C-ROADS simulator as part of the coastal protection planning process in the Pointe Claire Region (see Appendix B-2).
- Students participated in a group model-building exercise in which the class mapped out a system structure similar to the structure of the CoastalProtectSIM (See Appendix B-3).
- Students participated in two computer lab exercises where they formulated portions of the CoastalProtectSIM model to become more familiar with how the model was formulated in detail (See Appendix B-4).
- Students participated in role playing exercises in classroom discussions so that they gained a better feel for how key stakeholders took positions on coastal protection.
- Working in small groups, students "solved" the policy problem and drafted a policy memo with a supporting set of PowerPoint slides indicating what they found to be the "best" policy solution and why (See Appendix B-5).
- Students did background reading in three related perspectives on public policy formation—(A) readings on stakeholder analysis and management in the policy process, (B) readings in the creation of mini-publics as a way to achieve policy consensus, and (C) readings on organizational learning and systems thinking as goals of networks or organizations working in the public policy field.
- Students drafted individual papers using the three sets pf background readings in public policy plus their work with the simulator (See Appendix B-5)

Part III: Details of the CoastalProtectSIM model

Coastal Protect Sim was developed to replicate several types of real world complexity: (1) time delays in constructing costal protection; (2) cost sharing challenges for construction and annual maintenance; (3) impacts of costal land development on natural barriers; and (4) the timing of benefits and costs in net present value calculations for long range coastal flood risk planning. The model uses a random seed to create micro-worlds, whereby the probability of any particular storm may generate a surge large enough to exceed natural and man-made protection. In addition, a global warming scenario is built into the model that allows for the amplification of the storm surges based on severity of storms and sea level rise. Costs associated with mitigation and benefits from damages avoided are calculated in terms of their net present value at the OMB-required 7% discount rate. Coastal Protect Sim requires the decision maker to determine whether the long term benefits are worth the investment of short and intermediate term mitigation measures. The temporal boundary for the model is 40 years to allow for long term and short term tradeoffs to be explored. In this section we begin with a description of the model structure. We then provide base run behavior for three mircoworlds and two climate change scenarios. The section concludes with a description of several policy runs and a discussion of tradeoffs for each strategy.

Coastal Protect Sim Model Description. Coastal Protect Sim (Figure 2) has three model sectors and two model structures for accounting benefits and costs. All five areas of the model are discussed in this section of the paper: (1) structural mitigation protection; (2) land development and natural barriers; (3) storm intensity and climate change; (4) costs associated with damages and mitigation measures; and (5) benefits from cumulative tax revenue. Table 1 provides a legend for the causal map to help the reader identify each of the five variable types discussed in this section of the paper.

Table 1: Legend for Coastal Map causal map

Causal link color	**Coastal Protect Sim Model Structure**
Blue	**Policies to mitigate damages and minimize recovery costs**
Brown	**Natural barriers to protect the community**
Purple	**Storms and climate change**
Red	**Disaster damages and mitigation costs**
Green	**Benefits from tax revenue and damages avoided**

Coastal Structural Mitigation

Starting in the upper left corner of the model, Coastal Protect Sim captures the connection between the planning and implementation of structural coastal barriers. Community decision makers identify the desired level height of protection and project start time. However, the time to complete the plan formulation process is not within the control of the local decision maker. As the Corps of Engineers currently goes through a "Transformation" period, it is moving towards an accelerated planning process to address concerns the process is currently too expensive and too lengthy. The accumulation *Built Protection in Planning* reflects the delay between desired levels of mitigation and the time it takes to complete the reconnaissance and feasibility studies. In the Corps budgeting process, completed plans lead to *Built Protection Being Sited* through Preconstruction Engineering and Design (PED) investigations, which is an intermediate step before formal construction. The final accumulation *Finished Build Protection* is based on the rate of construction for protective structures along the coast. In the base run of the model, the total delay for these three stocks is 10 years, which corresponds to the average delay time in the USACE planning and construction process.

Projects that have been completed increase the *Total Coastal Protection* which reduce the amount of storm surge the community experiences directly (*Inches Above Protection Margin of Safety)*. The model assumes a threshold where storm surge will produce some degree of property damage. As storm surge rises above the total protection on the coast, the *Effect of Storm Surge on Damage* increases to a potential *Maximum Damage Per Acre Per Storm*, which has been set for the base run at maximum of $100K/acre. *Current Storm Damage* is also influenced by the *building codes effect on damage*, which represents a policy whereby floodplain managers are able to successfully implement codes to guarantee lower levels of property damage during the next storm event.

If the *Current Storm Damage* is higher than the protection provided by structural policies or strict building code enforcement, the resulting *percent damages* indicate the extent of damages in the community. If this percent is relatively large, the *landowner willingness for buyout* will increase as well. It is conceivable landowners would be willing to relocate during the recovery period, thus creating open space and increasing the level of *Undeveloped Coastal Land* and reducing *Developed Coastal Land*. The potential balancing feedback loop suggests an opportunity to minimize future damages. Alternatively, a *zoning regulation* can be enforced to restrict *development*, which would help to guarantee the balancing loop maintains its goal seeking behavior. There is a caveat with respect to the link between *percent damaged* and *landowner willingness for buyout*. Coastal Protect Sim has model structure (hidden in this view) that activates federal disaster assistance in very large disasters, which may reduce the willingness to relocate in certain cases.

Natural Barriers

The level of *Undeveloped Coastal Land* (center of Figure 1) acts as a natural barrier to protect against storm events. As this level increases, its *impact on Natural Protection* increases, which enhances the *natural environment* during major storm events. Communities that maintain large sand dunes between developed property and the ocean, as well as sustainable beaches solutions to import or relocate sand on the shore have more protection during hurricanes and major storm events. The natural barriers combine with structural protection to increase the *Total Coastal Protection*, which as previously discussed minimizes storm surge and flood damages. However, this added protection also increases the *perceived protection* in the community. A high *perceived safety for development* adds pressure on the community to expand and develop on the shore. As the *impact of safety on development* increases, it may add to *development* in the community. This balancing loop could play a dangerous role in the model, especially in circumstances with a long delay in between actual and perceived safety in the community.

Storms and climate change

The Coastal Protect Sim model operationalizes storms through two concepts: mean storm surge and volatility. *Storm Volatility* is formulated as a Random Normal with a range of -50 to 400 inches, Seed, which uses an *initial storm volatility* of 24 inches that can have an *impact of global warming* to amplify the volatility. The *Random Seed* effectively selects one possible future microworlds. During model testing several seeds were selected to represent the more interesting and challenging future worlds. To account for climate change, the model associates an impact on volatility by *Temperature Rise by 2052*, with an associated *percent increase in volatility per degree rise.* In the base run the temperature rise is set at zero. The *mean max storm surge* is set at 108 inches in the base run with the potential to increase based on the *impact of global warming on mean max surge.* In the base run, the percent increase associated with each degree in temperature is 5%. *Sea Level* is a third contributing factor to storm surge. It is set at zero in the base run. The fourth and final contributing factor is the *Effect of Storm track on surge*, whose purpose is to add a layer of uncertainty in the model. That is, not every storm is perfectly predicted. *Total Storm Surge* is the result of *Mean Max Storm Surge, Storm Volatility, Sea Level Rise,* and *the effect of storm track*. In most cases, *Inches Above Protection* is negative, which results in a zero *effect of storm surge on damage*. However, in those cases where this value is above zero, the effect can be rather large. For example, the initial coastal protection is slightly above 150 inches, so any run where the seed produces a value greater than 150 inches will result in potential damage. In the base run of random seed 20, *inches above protection margin of safety* is positive 3 times in the 40 year run.

Disaster damages and mitigation costs

There are two types of costs recorded in Coastal Protect Sim. First, the model records costs associated with the implementation of mitigation policies. For example, as shown in the upper left corner of Figure 1, the model records *current planning costs, current siting costs, current construction costs,* and *maintenance costs* at an annual rate which feed into a *Net Present Value of Current Adjusted Costs*. There are major financial challenges for many communities who wish to participate in structural mitigation measures on the coast. Even after project construction has been completed, communities must participate in cost-sharing for the maintenance of these projects. In the model, the costs are recorded and discounted at the OMB required rate of 7%.

The second cost in the model is from property that has been purchased or reclaimed by the state. Once again, even in cases where the federal government supports a buyout of local property, there is usually some level of cost sharing on the part of the non-federal partner. In addition, there are costs associated with the implementation of strict building code policies, which carry a direct burden to the homeowner. Finally, the cost to recover a community after disaster is recorded as stock of *Cumulative Storm Damages.* Taken together, these costs determine the level of successful (or failure) for a given set of mitigation policies.

Benefits from tax revenue and damages avoided

Benefits are shown in the lower left corner of Figure 1. Coastal Protect Sim allows the decision maker to implement a tax policy to offset the community cost-sharing burden. To be clear, taxes collected are for a single purpose. Taxes to be collected for other issues, such as crime, education, and infrastructure are beyond the scope of the model. The model calculates a *desired tax rate* based on the aforementioned *Net Present Value of Current Adjusted Costs.* The *total land value* is used to then determine an appropriate tax rate. With that said, the user must careful not to overburden their taxpayer, as unreasonable taxes could have an adverse impact on sustainable development.

The variable *Cumulative Damages Avoided* is calculated based on a model structure that replicates the one presented in Figure 1, with one important distinction. Essentially, there is a second model which runs without any government involvement. The resulting damages from the "no government" model is compared to the policy runs in the "government" model. The difference between *Cumulative Storm Damages* in these models is recorded as *Cumulative Damages Avoided. Cumulative Damages Avoided* is added to the revenue generated from taxes for a total *Cumulative Benefits and Damages Avoided.* The difference between this total and the *Cumulative Costs and Damages* is recorded as *Total Net Benefits.*

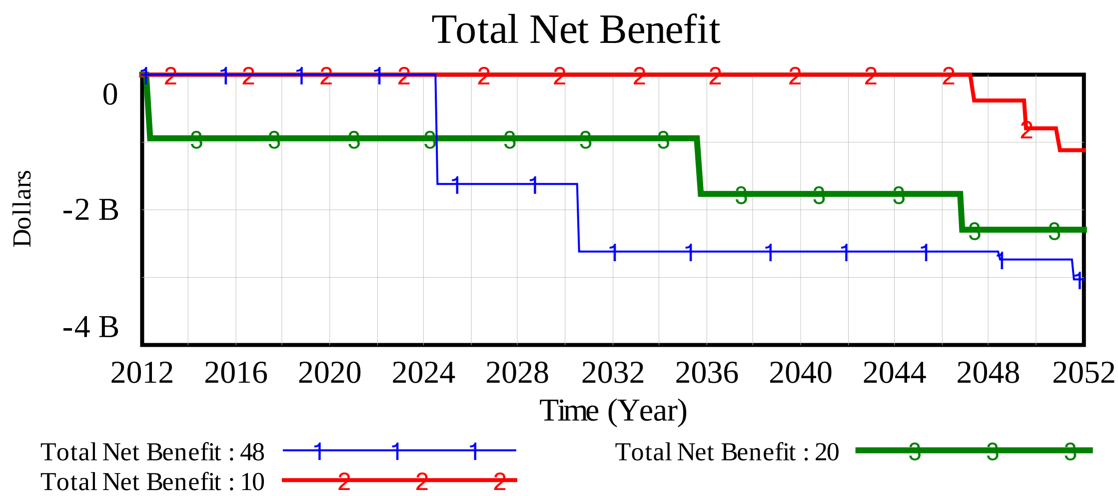
Model Behavior

The model generates storms and storm surges over the course of a 40 year period. The storms are randomly generated and a percentage of the storms may exceed the man-made and natural barriers and cause storm damage. Users read a case history about the leadership challenges facing the county executive of Point Claire. From their understanding of these challenges, users develop a flood risk management strategy that technically, financially, and politically feasible. The model is used to test strategies under various scenarios and communicate the results.

The following selection of model runs highlights different types of uncertainty and tradeoffs unique to this particular policy domain.

The Base Runs

The base run for each random world has the same set of assumptions. Pointe Claire begins as a community with minimal flood risk management policies in place. It relies heavily on natural barriers to provide flood protection. Therefore, the base run for each random seed highlights different types of storm "challenges". A policy mix that performs well under one random seed may not achieve the same level of success under another random seed.



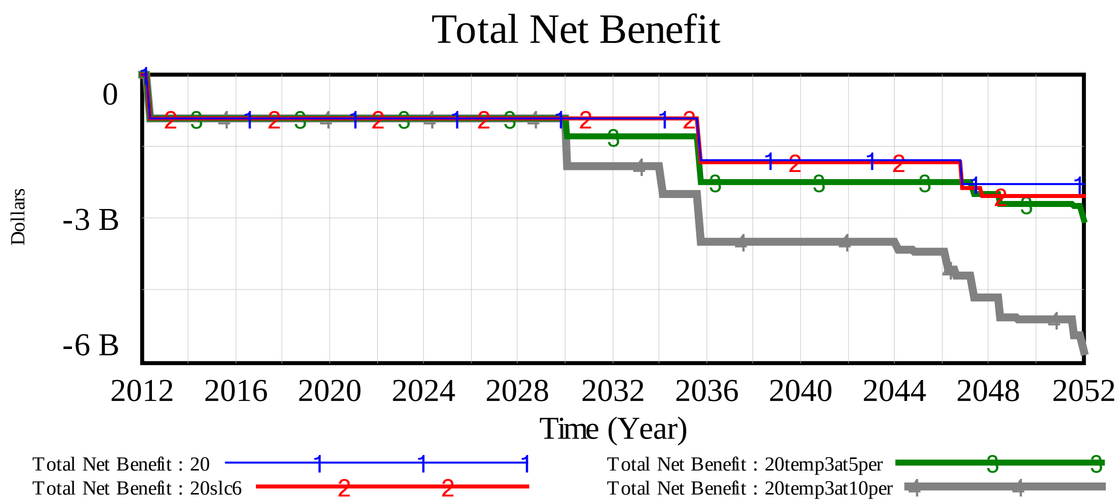
Random Seed 48: The base run in random world 48 experiences four events beyond the protection of its natural barriers. The first event occurs midway in the run, with a second event 10 years later. The final two events are rather small and occur at the end of the base run.

Random Seed 10: In the base run of random world 10, the community is hit with three events in a row. However, all of these events occur rather late in the run, starting at approximately year 30.

***Random Seed* 20:** In the base run of random world 20, the community is hit with an event almost immediately. The next event beyond its natural barriers occurs approximately 25 years later. A third event occurs another 10 years later, with each subsequent event slightly less damaging than the previous.

Global Warming

The model was run several times to reflect different climate change scenarios. Three examples under random seed 20 are presented in this paper. The base run with sea level rise at 6 inches has some impacts in the later years of the run. The total cumulative damages are similar to the base run. A second global warming run with parameter change for temperature rise of 3 degrees (5% surge per degree) results in relatively higher damages toward the end of the run. A final global warming run in random seed 20 had a 3 degree temperature rise with a 10% surge per degree. This global warming test results in a change in both frequency and severity of damage, with several more events creating damage in the later years. This final test shows cumulative damages nearly double the size of the base run.



Policy Runs

The Coastal Protect Sim model has several types of policy alternatives to explore. A description of each policy, with recommended policy values along with default values in the base run is described in Table 2. The recommended values are merely suggestions to decision maker to provide some boundaries and make it easier to keep track of many policy mix combinations. The contents in Table 2 were provided to the decision makers to make them aware of all policy options in Coastal Protect Sim model.

Table 2: Coastal Protect Sim Policies

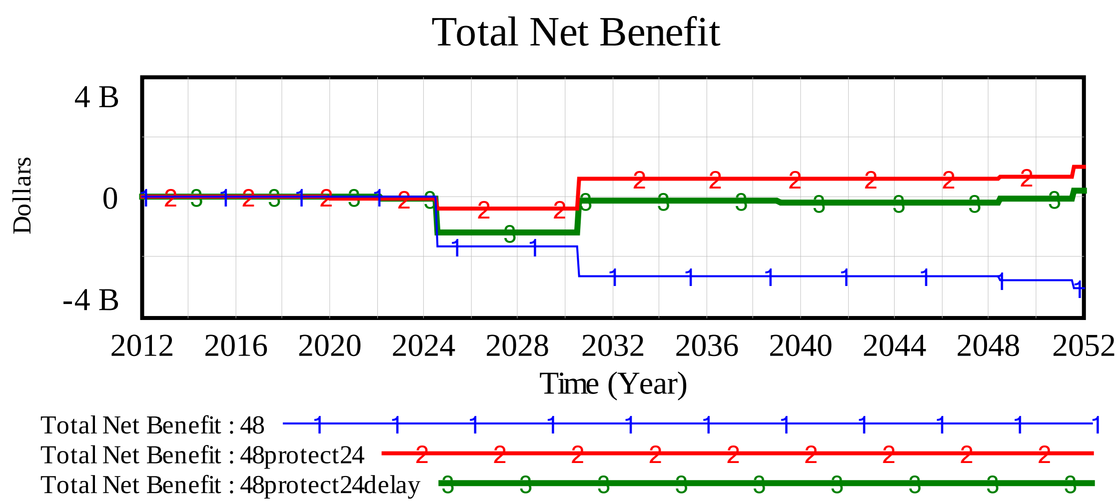
Policy Parameter	Description	Default/ Recommended Policy Values
Height of Protection	Built protection for Pointe Claire results in projects such as seawalls, beach replenishment, and barrier island replenishment. The height of built protection adds to the community's existing natural environment protection. It takes approximately 5 years to complete the initial planning studies and at least another 5 years to complete the construction project. The height of man-made protection will determine the construction and annual maintenance costs. In the real world, cost-sharing requirements make it difficult for some communities to participate in agreements with the Corps. Therefore, both construction and maintenance costs should be considered to determine the appropriate height of protection.	Default: 0 Policy values: 0,18, 24, or 36
Tax Rate for Protection	There are several costs to consider in the model: costs for planning, construction, and operations & maintenance. Taxes can cover the non federal share of these costs. If you set the tax rate higher than that cost of the project, your tax revenue benefits will accumulate. Be careful. If you set the tax rate too high, your taxpayers may revolt against you!	Default: 0 Policy values: between 0 and .002
Automated Tax Rate	You may notice it is difficult to set the tax rate just right. Instead of setting the tax rate for protection, you may opt to use the automated taxes feature. When this feature is activated, you will be guaranteed to collect taxes exactly at the cost of your height of protection	Default: 0 Policy values: 0 or 1

Building Code Policy	One way to avoid damages without clearing homes from the floodplain is to develop strict building codes for floodproofing and elevating structures above the base flood elevation level. Building codes won't eliminate all of the damage during a storm. Set the building code policy to any number between 0 and 1. This will be the percent of structures (the goal) you hope to be in compliance with your codes. Also, keep in mind that building codes come at a cost to the property owner. Building codes should be considered as part of a holistic flood risk management strategy. Since costs will be immediate and benefits will potentially occur only after damages are avoided, the year in which the building policy is implemented plays an important role in both cumulative costs and damages.	Default: 0 Policy values: between 0 and 1
Year of Building Code Policy	The enforcement of building code policies make structures less prone to storm surge damage. These policies reduce damages and save money when storm surges exceed the height of protection. Building codes increase property maintenance costs on homeowners and businesses. Unlike seawalls and large structural mitigation projects, building codes place more financial responsibility on the individual. Floodplain managers are accountable for the implementation of these policies. These policies are rather important, as FEMA Community Rating System (CRS) points and National Flood Insurance Program (NFIP) discounts depend on their successful implementation.	Default: 2020 Policy values: between 2012 and 2052
Buyout or relocation policy	Buyouts, relocations, and reclamation policies remove homes from the floodplain. Pointe Claire does not have the resources to remove homes before a disaster strikes. However, if you decide to implement a buyout policy, landowners will be inclined to accept a buyout during major events. They are less likely to accept a buyout during smaller events. Federal programs such as the FEMA Hazard Mitigation Grant Program help minimize reclamation costs on the local community. The buyout policy in Coastal Sim represents the percent of properties offered a buyout during the next event.	Default: 0 Policy values: 0 to 1

Year of Buyout Policy	Select the year when the buyout policy goes into effect. It is assumed that once the policy goes into effect, buyouts will be offered for every event after that year. Keep in mind, buyouts will not be offered immediately. Buyout offers are only extended to residents after events where Pointe Claire incurs damages. In this model, if not storm occurs after the buyout policy, then no land is reclaimed.	Default: 2020 Policy values: 2012 to 2052
Zoning Regulations	Each community faces a delicate balance between zoning for "open space" and zoning for land development. Zoning regulations prevent new development in flood prone areas. Development in Pointe Claire can change over time based on policy decisions. The value of the zoning policy is the percent of development prevented. Keep in mind that strict zoning policies lower the tax base in Pointe Claire. A lower tax base lowers the amount of tax revenue that may be collected to offset the cost of structural protection projects. Therefore, zoning regulations could generate costs for remaining homeowners.	Default: 0 Policy values: 0 to 1
Zoning Policy year	Select the year when zoning policies may go into effect. Zoning policies take effect immediately. Zoning regulations should be considered as part of a holistic flood risk management strategy. The year in which these policies go into effect may not lead to immediate implementation. Therefore, the year the zoning policy is implemented is important policy and determined by the user.	Default: 2020 Policy values: 2012 to 2052

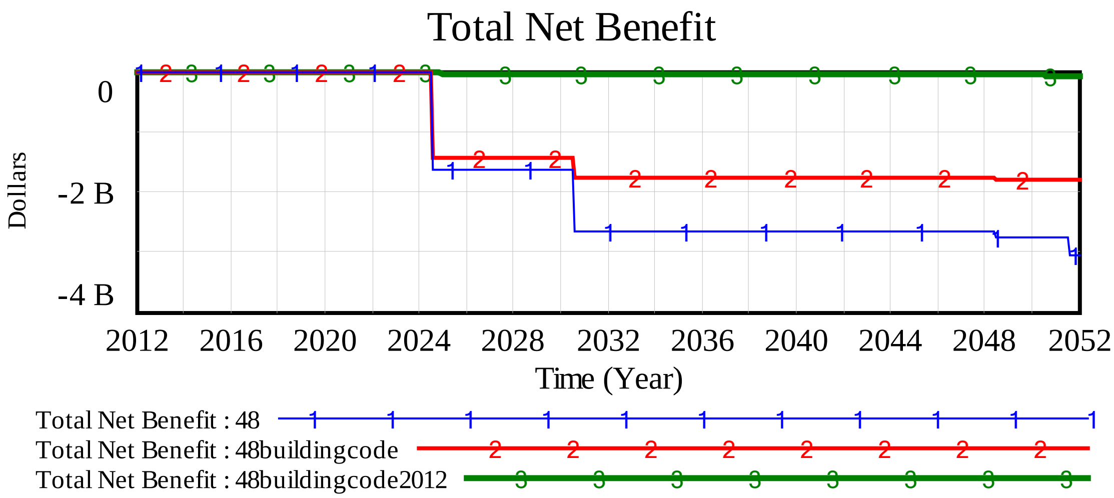
A few policy runs have been selected to illustrate some of the policy options in the model. The timing of costs and benefits present a formidable challenge to the decision maker, as some policies only yield a strong net present value due to events in the later years of the model run. Other policies could be hindered by factors beyond the community's control, such as delays in the Corps planning process. Yet other policies show that no single approach is enough to sustain development in this coastal community. The handful of policies selected for discussion in this paper highlight challenges in policymaking and strategic communication, as each policy mix holds a unique set of tradeoffs. For simplicity, each policy described in this section uses random seed 48 in the base run.

Structural Protection



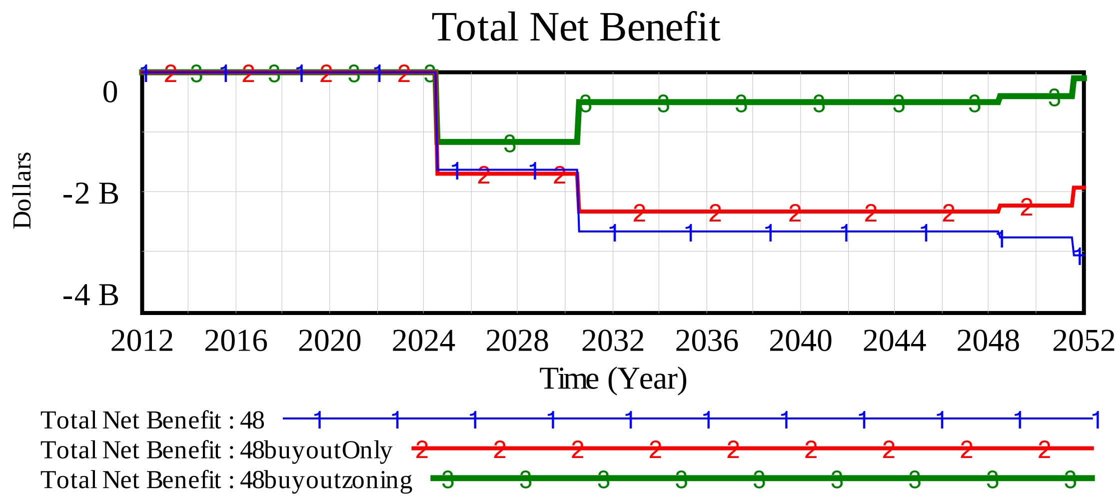
The policy run for structural mitigation is interesting for two reasons. First, on the surface the policy appears to be rather successful against the base case. Whereas the base run results in final total costs to the community in excess of 3 billion dollars, the coastal protection from engineered solutions yields a net benefit in damages avoided of nearly 2 billion dollars. Recall random seed 48 has four events that exceed the community's natural barrier protection. After the first event, the policy solution does not produce enough benefit to warrant the cost of the project. However, as the model continues to run, it is clear the benefits exceed the costs. Also important to note, the Corps of Engineers uses a 50 year life for most of its planning studies. The second interesting observation on this policy is its sensitivity to delays in the system. The model was run a third time to reflect an additional five year delay in the coastal protection project. This delay results in rather severe damages in during the first event. In fact, total net benefits of the policy just barely rise above zero, which is due to avoided damages in the last year of the run. This example shows two ways Coastal Protect Sim model can help decision makers identify and discuss the uncertainty and timing of costs and benefits in flood prone communities.

Building Codes



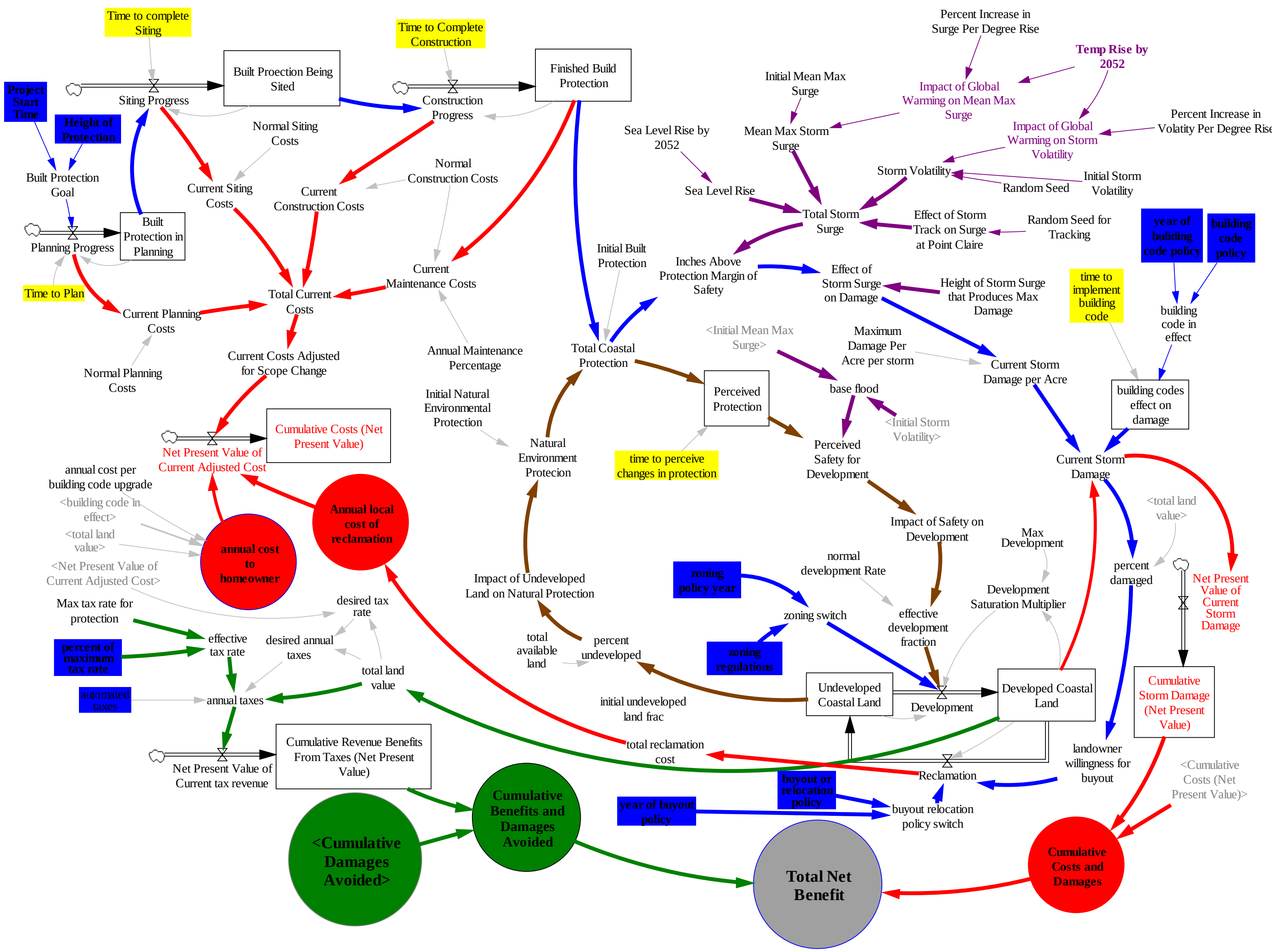
While a “building code only” approach does not quite produce robust outcomes in random world 48, the policy highlights an interesting challenge for decision makers. For this policy run, the community sets building codes at a goal of 100% compliance. To reflect the political capital needed to get such level of compliance, the policy goes into effect in 2020. Compared to the base run, the delay in implementation results in damages similar to the base during the first major event. However, with each subsequent event most of the damages are avoided. A third run of the model with an earlier implementation start date (2012) is a vast improvement on the same policy with a slower rollout strategy. In this run, building codes are fully implemented by the first major event and most of the damages are avoided. However, since building codes have a burden on the individual property owner, the result is a net zero benefit to the community.

Buyouts and Zoning



Perhaps the most realistic feature of the Coastal Protect Sim model is the fact that no single policy serves as the magic bullet in flood risk management. Flood risk management requires a holistic systems view of the problem. This is certainly true at the Corps today, where a new focus has been placed on coordinating structural and nonstructural measures. The “buyout only” approach barely outperforms the base case in random world 48. There are two inherent challenges with this policy. First, damages must be large enough for property owners to be willing to accept a buyout, but not too large to receive federal assistance to recover status quo ex ante. Second, buyout policies alone do not remove the pressure to redevelop on the coast. A third run of the model with buyouts and zoning policies prove to be a more sustainable solution. While net benefits are not quite above zero by the end of the run, these policies show that a holistic approach has more potential benefit. That is, by placing pressure on both the inflow and outflow of the land development sector stocks, the policy mix helps to contain future damages.

Figure 2: Coastal Protect Sim Model Structure



Part IV: A Survey-Based Preliminary Evaluation of the SBLE

The goal of the SBLE is to enhance the NASPAA's five core competencies which are necessary qualities to become competent public managers who can deal with complex public policy problems by providing MPA students with a comprehensive and well-designed complexity leaning environments. To measure the students' self-assessments on the potential effectiveness of the SBLE, the Pointe Claire Coastal Protect Case on the enhancement of the five core competencies, we conducted a survey to 44 MPA students who took the two classes at the Rockefeller College in the 2012 fall semester, in which we administered the SBLE case.

The survey questionnaire is designed to measure respondents' self-evaluation on (1) the effect of the SBLE case on the increase of students' interest in learning complexity and (2) the effect of the SBLE case on the enhancement of students' "self-assessed" five core competencies by 7-point Likert-type scale, ranging from agreeing on the statement "not at all (1)" to a very great extent (7)" (See APPENDIX D). The survey questionnaire consists of three sections: (1) Section I including questions asking about students' perceptional and emotional experience with the SBLE case regarding how the learning package affects learners' motivation to learn complexity; (2) Section II including questions asking about students' perceptions of how much the class activities on the SBLE case served to improve the five competencies; and (3) Section III including questions asking about students' demographic information and the past and current education and work experiences.

Part V: Implications and Future Work

This experience demonstrates the value of using simulation-based learning environments to build a more complete and useful understanding of public policy complexity in public management education. It explored the possible effectiveness of a curriculum designed to teach complexity using a simulation-based large-scale case study coupled with group exercises intended to emulate complex interactions between key stakeholders in the case. We believe that such simulation-based learning exercises can and will have implications beyond the MPA classroom, providing learning tools for public managers at many levels of government.

Simulation-Based Learning Environments. This case is an example of a simulation-based learning environment (SBLE). A simulation-based learning environment is a package of materials and scaffolded exercises designed around a simulation model. SBLEs can be designed for use with varying degrees of facilitation, ranging from stand-alone packages that require almost no external guidance to exercises used in classroom settings with significant instructor facilitation. Simulation-based cases are widely used in business education, but are relatively new in public management education (see JPAE article on teaching with simulations).

The use of the Pointe Claire SBLE described here supports the potential of SBLEs to teach complexity in public management education, The experience raised a number of questions and indicates directions for further research and SBLE development. The evidence from this case is promising, but the approach needs to be implemented in more classes and in other related disciplines. It needs to be formalized and subjected to careful evaluation and analysis from one or more rigorous frames of analysis.

This case can be viewed as the pilot phase in a larger research agenda examining the value of SBLEs for improving public management capacity for working with complexity. In the pilot phase, we explored the broad questions: Can SBLEs deliver the complexity learning outcomes needed for building capacity? And: What is the added learning value of an SBLE beyond traditional teaching?

Analyzing the case raised questions about how to revise it to make it more effective, and, more generally, what general insights could be applied to developing similar SBLEs for other learning audiences. For example, we see applications for teaching sustainability in many fields including business, environmental studies, and disaster management, for example. More work needs to be done to understand how to improve the approach, measure the learning outcomes, apply it across disciplines, and implement it with different types of learners. Some of the research questions include:

(1) What is the best way to evaluate participant learning about complexity? (2) What is the effect of the SBLE on participant learning? (3) What features of the SBLE most effectively promote learning about complexity—both complexity in the physical system and complexity in human small group decision making?

How can this kind of SBLE best be used across the range of potential learners? How do learner characteristics affect learning outcomes of SBLE use?

These types of SBLEs have the potential to secure thoughtful public engagement in sustainable planning across a wide range of domains that share features in common with coastal protection. The case described here focused on public management students, but the approach has potential for use with other groups, including community stakeholders. It will improve the ability of the public management workforce to engage the public in decision making about sustainable futures.

Appendices for

Simulation-Based Learning Environments to Teach Complexity: The Missing Link in Teaching Sustainable Public Management

The full appendices for this paper are contained in a supplemental file attached to the conference proceedings for the 2013 System Dynamics Research Conference. Below is an abbreviated table of contents indicating the broad contents of these appendicies:

Appendix A: Restatement and Elaboration of 5 NASPAA Core Competencies by MPA Faculty of the Rockefeller College. This appendix contains a statement of the 5 NASPAA Core Competencies plus additional elaborations on these competencies as adopted by the faculty of Public Administration and Policy at the Rockefeller College, University at Albany.

Appendix B.1 Global Warming and the Pointe Claire Regional Coastal Planning Commission—Part 1.A. This appendix sets up the basic conditions of the assignment for the rest of the class. The first part of the assignment is directed toward a class exercise where the students interact with the C-Roads Climate Change Simulator

Appendix B.2 Global Warming and the Pointe Claire Regional Coastal Planning Commission—Part 1.B (class exercise with C-Learn Model). Thus appendix contains the handout that was used in class for the C-Roads Simulator exercise.

Appendix B-3: Roles for Global Warming and the Pointe Claire Disaster Preparedness Case. The Pointe Claire Case had a number of class-based role playing exercises. This document describes the basic roles that students assumed during the class exercises.

Appendix B-4: Notes for Formulating a Simple Difference Equations Model for Pointe Claire Coastal Protection. The class had a homework assignment requiring them to formulate some of the key dynamic structures within the CoastalProtectSIM model. This is a worksheet that groups of students using during a class lab to get started on the homework assignment.

Appendix B-5: Global Warming and the Pointe Claire Regional Coastal Planning Commission—Part 2. The final assignment had two main parts. Working in small groups, each team crafted a short presentation that used the simulator to create a "solution" for the Pointe Claire Regional Planning Commission. In addition, as an individual assignment, each student drafted a policy memo addressed to the Director of the Commission giving her advice on how to use a formal simulation model to support policy formation. This document sets up both of those assignments as well as directs students to background readings on stakeholder analysis and management, material that had been previously assigned in another MPA core class.

Appendix C: End of Class Survey Administered Fall, 2012 (and again spring 2013)
When the class was complete, all students were asked to complete a survey giving their impressions of the overall exercise and linking the whole exercise back to NASPAA's five core competencies. That survey is reproduced in this appendix.