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Designing a Social Insurance Relocation Program for the Fictitious Country Storslysia

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A thesis
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ABSTRACT

This paper strives to design a relocation social insurance program for the fictitious country Storslysia. The program hopes to reduce Storlysia's property damage costs by incentivizing citizens to move out of high climate risk regions to low climate risk regions. As a byproduct of reduced property damage throughout the country, Storslysia should see an increase in economic standards and the overall well-being of their citizens.

This research case comes from the Society of Actuaries' 2023 Student Research Case Competition. The guidelines of the case required students to include an overview, program design, pricing/cost projections, risk mitigation strategies, assumptions, and data limitations. The case also supplied limited demographic-economic information on Storslysia prior property damage statistics dating back to 1960. Using advanced statistical analysis and modeling strategies, the risk level of each of the six regions throughout the country was determined to allow for correct program design goals. Altogether, the final program supplies incentive for both voluntary and involuntary movement of citizens from high-risk regions to low-risk regions.

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Chapter 1

Introduction

This report analyzes the effect of severe weather events on the country Storslysia and examines how the nation can reduce its exposure by implementing a relocation social insurance program. Our program seeks to reduce the total economic and psychological damage caused by natural disasters in Storslysia over the next one hundred years with great certainty. We plan to supply financial relief toward displacement costs for victims of involuntary relocation and to offer benefits to citizens that choose to voluntarily move out of higher-risk regions to lower-risk regions. The incentives are offered as annuities and lump sum payments, which will be managed on a per claim basis.

The benefits to voluntary relocators will cover economic pressures and reduce relocation costs to ease the transition of citizens from one region to another. These benefits will vary depending on where the relocators are from and where they are moving to. The same goes for involuntary relocators; however, they will also receive a standard lump sum amount to help with physical and psychological damages from the weather event as well. Structuring the benefits in this way will shift the population in a safe manner while reducing the current costs sustained from a severe weather event.

Chapter 2

Literature Review

The following analysis of the 2019 Society of Actuaries Student Research Case Competition first and second place reports intends to aid in grasping a better understanding of the requirements and strategies for a successful report. In the 2019 case, contestants must assume the role as chief actuary for an automobile insurance company, Safelite, found in the fictitious country Carbia. The insurance company is looking to design an autonomous vehicle insurance policy to remain competitive in an industry that projects a rapid shift towards autonomous features in automobiles.

Winning Report: "Safelite's New Autonomous Policy Proposal"

Submission Overview

The winning report for Safelite's new autonomous policy proposal case came from students of Darke. The students initialized their report with an executive summary that supplies a brief overview of the submission's goals and how they reached those throughout the report. Subsequently, the contestants then wrote a methodologies section that detailed the processes they used to draw conclusions and reach assumptions about their proposed autonomous vehicle policy. The methodologies used include ARIMA modeling, ordinary linear regression, competitive analysis, general research, and sensitivity analysis.

After presenting a high-level overview of the report, the Drake University students transitioned into a policy overview that covers their definition of autonomy, their recommendations for the policy structure, and new risks and liabilities associated with insuring autonomous vehicles. Initially, the students illustrated the widely accepted, six-category definition for autonomous vehicles. By presenting the traditional definition, the contestants were then able to change these definitions to fit the interests of their proposed policy.

Although autonomy reduces overall driving risk, new risks do arise with autonomy. The Drake University contestants list the potential new risks of autonomous vehicles, and mention cybersecurity as the primary risk of autonomy. Additionally, the students consider the difficulty of assigning liability within the scope of autonomous vehicles. They name potentially liable parties, other countries' legislation on the liability of autonomous accidents, and the importance of Safelite following Carbia's legislation on the matter.

The next step in developing the policy required a policy implementation strategy. The Drake University contestant's implementation strategy mentioned a demographic and target audience, regulatory outlook, and adoption timeline. The students referenced surveys that illustrate the young and male demographics to be the primary groups to buy autonomous vehicles. However, they additionally mention that the demographic of drivers is unlikely to matter because drivers do not control the vehicle. From their research, the contestants recommend that Safelite penetrate the commercial autonomous vehicle industry as soon as possible so they will have a first-mover advantage as autonomous vehicles become popular.

Since autonomy is not yet fundamental in the auto industry, little official regulatory legislation has been set forth. Thus, the report instead considered potential regulations for the future. Mentioned as one of the most impactful regulatory decisions, truck platooning regulations may significantly decrease the severity of accidents as trucks on the road must support a larger following distance. Other impactful regulations monitored by Safelite include Carbia's insurance requirements or specific laws regarding cyber security provisions, as these would influence the overall structure for Safelite's autonomous vehicle insurance policy. To conclude their policy implementation strategy, the contestants utilized a 22-year forecast to allocate a percentage of total vehicles to autonomous vehicles, semi-autonomous vehicles, and traditional vehicles.

Thereafter, the contestants completed a pure premium projection that first considered the impact of autonomous vehicles on claim frequency and severity. Then they applied these conditions to develop pure premium projections before and after autonomous vehicles. Initially, the report utilized ARIMA modeling to predict future pure premiums based on the previous ten-year data provided by Safelite. In doing so, the students developed an analysis of pure premium for traditional vehicles. Since the prior ten-year data only considered traditional vehicles, adjustment factors formulated pure premium projections for fully autonomous vehicles. These adjustment factors came from the educated assumptions on the impact of autonomous vehicles on frequency. Then, the contestants addressed projections on pure premiums for personal autonomous vehicles with and without cyber coverage, commercial autonomous vehicles, semi-autonomous vehicles, and traditional vehicles. Additionally, the students at Drake provided a 10-year pure premium forecast based on their pure premium calculations and recommended entry year.

To compute their sensitivity analysis, the students first listed assumptions for the sensitivity analysis regarding total exposure, traditional line, autonomous line, pure premium, and cyber risk. Next, they performed a sensitivity analysis based on the percentage of their total coverage that covers fully autonomous vehicles. The sensitivity analysis includes autonomous line percentages of 20%, 21%, 22%, 23%, 24%, and 25%. According to the sensitivity analysis, pure premium exposure decreases as the autonomous line percentage increases. Thus, the primary recommendation is for Safelite to aim to have 30% of their total coverage made up by autonomous vehicle insurance.

Finally, the report concludes with a list of data limitations, assumptions made to forgive these limitations, a justification for the corresponding assumptions, and a conclusion.

Submission Evaluation

At first sight, the overall design, layout, use of figures, and structure of the paper made the report quite easy to follow. The group did a fantastic job using clear yet descriptive tables to portray their ideas throughout the paper.

The executive summary began the literature by effectively detailing the contents of the report without an overwhelming number of details right away. From the executive summary, it was clear why and how the group wanted to introduce their autonomous vehicle policy. Continuing onto the methodologies section of the report, it was clear and obvious what statistical processes they used, why they used them, and how they used them. This was something that other submissions for the case failed to do, and often required thorough searching through the report's appendix to try to understand the processes of each report. Next, the group clearly defines the 6 levels of autonomy and groups these levels into different classes. Their unique approach to classifying vehicles allowed them to take a progressive approach to implementing the policy as they began by only insuring fully autonomous vehicles, and then moving to insuring semi-autonomous vehicles.

Within the policy implementation strategy, pure premium projections, 10-year projections and sensitivity analysis sections, the charts and illustrations made it easy to follow what the students were attempting to portray. A non-actuary is likely to be able to understand the points of the report because of the clear and concise nature of their writing coupled with the charts to provide visual feedback.

Second-Place Report: "Executive Report on Future Automobile Insurance Policy of Safelite"

Submission Overview

Students of UNC submitted the second-place report for Safelite's future automobile insurance policy. The case initially outlined the proposed policy design for Safelite's new autonomous vehicle policy. This policy design consisted of social background, launch date, liability coverage, overall insurance plan, policy type, and risk class. The social background portion clearly outlined how Carbia should approach their legislation on automobile insurance and provides footnotes to links that consist of more in-depth detail. The UNC students then propose a recommended launch date for the autonomous vehicle policy, supported by vehicle autonomy projections using outside research. Next, the report included details of what the autonomous vehicle policy would cover. The policy would cover the same liabilities as the traditional policy, and additionally cover hardware failure, software failure, and cyber hacking. Moreover, the risk classes will remain the same between the proposed autonomous vehicle plan and the traditional automobile policy. Finally, the research report notes what type of vehicles the policies cover, and which risk pools are most likely to initially purchase autonomous vehicles.

Once the report clearly details the policy, the group determined a pure premium estimate and a ten-year forecast. For the pure premium estimate, the UNC students chose to take a three-step approach. First, the students created a ten-year forecast of the expected pure premium for traditional vehicles as a baseline reference. They developed the baseline forecast by observing Carbia automobile data from 2009 to 2018, where they assumed no higher level of automation, to calculate pure premiums. The report clearly outlined the formulas used to find pure premiums as well as providing frequency and severity details to model their findings.

For the next step, the researchers acknowledged the impact of automation on the baseline results by applying modifiers to the original data used. The report notes two frequency modifiers: auto insurance fraud and human error. The students assumed that because autonomous vehicles have significantly more technology than traditional vehicles, the autonomous vehicles will be able to significantly reduce both human error and fraudulent claim frequencies. The UNC students then considered autonomy's impact on severity by applying modifiers to the data's severity.

After modeling baseline projections and applying modifiers to the baseline projections, the researchers developed their 10-year forecast for automobile insurance premiums. The pure premiums model consisted of the actual pure premiums for 2009 to 2018, followed by both steady state projections and pure premium projections after modifying for the autonomous vehicle's influence on frequency and severity.

The contestants approached the succeeding step in developing Safelite's autonomous vehicle policy by performing a sensitivity analysis on factors of choice to assess the influence of variations in these factors. The four factors analyzed in the sensitivity analysis included the new policy percentage of all policies sold by Safelite, human error reduction modifier, auto insurance fraud reduction modifier, and severity modifier. To wrap up the policy evaluation, the students were then able to supply recommendations for Safelite's autonomous vehicle policy and considered data limitations.

Submission Evaluation

The UNC students' report used strong data analysis and report structure to clearly develop an autonomous vehicle policy for Safelite. The submission was overall very well organized and easy to follow while still developing a useful autonomous vehicle policy. The use of footnotes specifically stood out throughout the report because the footnotes allowed for convenient tracing of sourced data.

In the beginning of the report, the introduction gave a brief yet effective summary to explain the relevance of autonomous vehicles and the need for a policy to cover the liability of autonomous vehicles. Specifically, the group identified their key numerical findings in the executive summary, which provided a useful strategy to summarize the key aspects of their proposed autonomous vehicle policy. The policy design section then included a strong definition for automation, a proposed launch date, the covered liability, the covered risk, and an overall insurance plan. Just as the first report included, the six levels of automation detailed the distinct categories for automation and how each category is insured.

At times, the report lacked detail because random and unsupported data limited the validity of the policy. Clear and obvious reasons for data usage is a significant requirement of the actuarial profession to ensure accuracy of findings. On the other hand, the liability coverage and risk classes stood out to me because the liabilities were incredibly detailed and well organized in a table, and the risk classes considered automation's influence on each general demographic.

Chapter 3

Methodologies

Below, Table 1 supplies a summary of the methodologies used to design the relocation social insurance program for Storslysia. Added details are in the appendices.

Table 1. Methodologies

Methodology	Application	Support	Justification
ARIMA Model	Future Annual Inflation	Appendix A	Earlier inflation data followed stationary time series trends
Frequency Projection Model	Future Weather Events	Appendix B	Model given to the team to for this purpose
Multiple Linear Regression	Population, GDP, & Average Annual Property Damage Forecasting	Appendix C, Appendix I, & Appendix K	Obtained data for every ten years from frequency projection model and needed to forecast data for the years in between
Confidence Intervals	Lower Bound of GDP	Appendix A	Find worst case scenario for cost allowance for program
Predictive Sigmoid Models	Relocation Forecasting	Appendix H	A useful way to forecast population movement

Chapter 4

Program Design

To assess the effectiveness of our program, our team set up a plan to watch key metrics (property damage, regional population, and program costs) yearly over our 100-year long-term goal. Our team understands that there is great uncertainty when forecasting that far into the future, but it is necessary to create noticeable change in the population of each region without disrupting the economy and daily life within those regions. However, our team understands that this program cannot go unchecked, so we plan to fully reassess our program at a short-term goal of 10 years. At the 10-year mark, there must be a noticeable shift in the populations of each region while additionally not seeing too rapid relocation throughout the country. Otherwise, the benefits offered by the program must change to keep the program on pace.

1. **Storslysia's shared socioeconomic pathways (SSPs):** Updated every 3-5 years. SSPs reflect assumptions about population growth, economic growth, the use of sustainable energy sources versus fossil fuels. By monitoring SSPs, we can find the emissions trend that Storslysia follows and more accurately predict the movement of factors such as GDP, population, and disaster frequency & severity. The factors that go into this do not significantly change year-to-year so a 3-to-5-year check-in would provide more information to get a more accurate assessment.
2. **Total Property Damage:** Reported yearly. Appendix C holds a graph and table with these expected values with and without implementing the program in current day (Ᵽ). For the program to be working, the average annual total property damage for Storslysia should be under the line of its current SSP without the program.

3. **Region Populations:** Reported yearly. Total and regional population will not be consistent year to year and will vary significantly on Storslysia's current SSP. However, the percentage of total population for each region should change if the program is working. Regions 2, 4, & 5 should see a decrease while regions 1, 3, & 6 should see an increase if the program is working. These population changes will be more prominent further into the program as shown by Appendix H.
4. **Program Costs and GDP:** Reported Yearly. Program costs should be well under 10% of GPA yearly as shown in Appendix K. There will be larger costs up front because of the creation of new housing but will decrease throughout the program.

Relocation Social Program Overview

The goal of our program is to mitigate Storslysia's displacement and property damage caused by weather events. The program uses annuities and lump sum benefits to encourage citizens to move proactively and help those forced to move after a weather event. The citizens of Storslysia can receive these benefits by filing a claim on a case-by-case basis. For a citizen of Storslysia to file a claim under our proposed program they must fall into one of two categories: a voluntary relocator or an involuntary relocator.

A voluntary relocator is someone looking to move from a hazardous area to a safer area before a weather event affects them. A financial benefit will help cover increased economic and housing costs. To receive this benefit, they must move prior to a weather event. An involuntary relocator is a victim of a natural disaster that has no choice but to move. We define citizens as displaced from their house when they are within the weather event's declared area and the cost of repairing the damage to their home exceeds the book value of the house, all of which is to be found by a claims adjuster. Involuntary relocators will have a part of their displacement costs covered, which includes property damage to their house, recovering household goods, and temporary housing.

Voluntary Relocation

The goal of our voluntary relocation program is to promote the migration of Storslysia citizens from historically disastrous regions to safer regions before future events occur. However, the program must also promote a gradual movement rather than a rapid movement to prevent population growth from outpacing available housing and resources for incoming citizens. By implementing this voluntary relocation program, we hope to see less people and properties affected by frequent and severe natural occurrences, all while maintaining or improving each region's economy.

To ensure the movement of citizens from dangerous areas to safer areas, our program will offer different benefits for voluntary relocation based on the region citizens are moving to and the region those same citizens are moving from. Our team determined the safety of each region by ranking each region on their property damage per person and property damage per household for different time periods. The time periods included 2016-2020, 2011-2020, 2001-2020, and 1962-2020. Subsequently, we averaged the rankings with equal weight, effectively placing more weight on more recent years and less on later year because more recent years fall within each time interval. Additionally, person per hectare provided further consideration since we want to prevent overpopulation in each region. Table 2 shows each ranking and the results of the ranking system.

Table 2. Region Rankings

Ranks	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Property Damage per Person (2016-2020)	3	6	2	5	4	1
Property Damage per Person (2011-2020)	1	5	4	6	3	2
Property Damage per Person (2001-2020)	1	6	3	5	4	2
Property Damage per Person (1962-2020)	1	5	2	4	6	3
Property Damage per Housing Unit (2016-2020)	3	6	2	5	4	1
Property Damage per Housing Unit (2011-2020)	1	5	4	6	3	2
Property Damage per Housing Unit (2001-2020)	1	5	3	6	4	2
Property Damage per Housing Unit (1962-2020)	1	5	2	4	6	3
Person Per Hectare	6	4	5	2	3	1
Ranking Average	2	5	3	5	4	2
Rank of Average Ranking	**2**	**6**	**3**	**5**	**4**	**1**

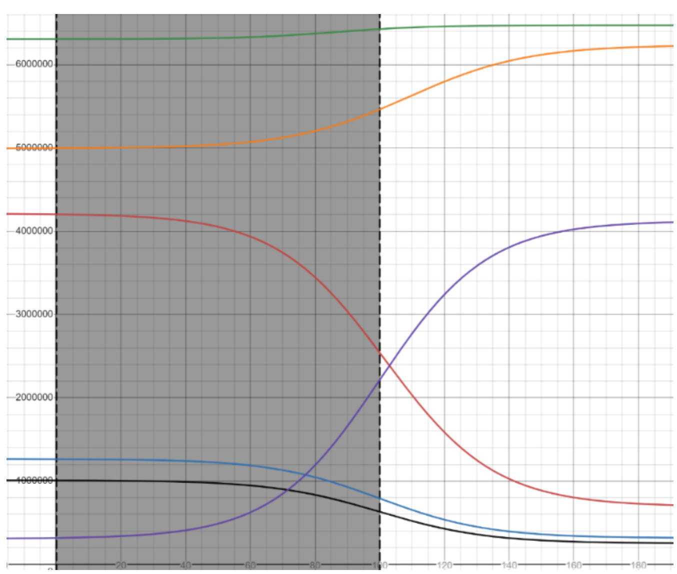
We found that the desirable regions were 6, 3, and 1 while the undesirable regions were 2, 4, and 5. Therefore, citizens voluntarily relocating to regions 6, 3, and 1 would receive the benefit while those relocating to regions 2, 4, and 5 would receive no benefit. Based off these realizations, we hope to see population shifts like table 3 over a prolonged period.

Table 3. Regional Population Goals

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Population	6,306,408	4,212,348	4,993,764	1,010,676	1,266,672	307,884
Hectares	2,442,659	3,522,311	2,353,615	3,438,613	2,067,059	1,556,199
Max PPH	2.65	2.65	2.65	2.65	2.65	2.65
Max population	6,473,046	9,334,124	6,237,080	9,112,324	5,477,706	4,123,927
Change in Population	103%	16%	125%	25%	25%	1339%
Desired Population	6,473,046	694,362	6,237,080	252,669	316,668	4,123,927
Difference	166,638	-3,517,986	1,243,316	-758,007	-950,004	3,816,043

From table 3, it is noticeable that although region one is a desirable region, we capped population per region at 2.65 persons per hectare before natural population increase to prevent overpopulation and allow for proper allocation of regions. Over a long time, we expect the population trends before population changes over time to follow the sigmoid trends in figure 1. The dark shaded region of the graph in figure 1 is our 100-year population goals for our relocation program.

Figure 1. Sigmoid Population Trends



The illustration in figure 1 hopes to meet the requirements of slow, gradual movement and preventing overpopulation. From the sigmoid functions, regions 1, 3, and 6 have population caps at 2.65 people per hectare, and regions 2, 4, and 5 have floors for their population to account for non-movers and people that find more benefit in staying in their region than taking relocation benefits. Each individual sigmoid function along with the equation for those functions are in appendix H. From on our population goals, we developed Table 4 that illustrates small, medium, and large benefits based on the region a citizen is moving from (rows) and the region they are moving to (columns):

Table 4. Voluntary Relocation Matrix

	Region 1	**Region 3**	**Region 6**
Region 2	Medium	Medium	Large
Region 4	Small	Medium	Large
Region 5	Small	Medium	Large

Considering the proportion of people expected to leave each region, we expect the total incoming population for regions 1, 3, and 6 to make up 67.32% of region 2, 14.50% of region 4, and 18.18% of region 5. By implementing this benefit structure, we hope to see movement throughout the regions that follow similar trends to the sigmoid functions in figure 1. Finally, population trends after adjusting population for natural population increases or decreases over time for each shared socioeconomic pathway is in appendix I.

Involuntary Relocation

We define a Storslysia citizen as displaced from their home when the cost of repairing the damages of a natural disaster exceeds the book value of the house, which is to be decided by a claims adjuster. Eligible people will have a portion of their displacement cost covered. The displacement costs defined by our policy include property damage to their house and relocation costs.

Since there is no data on the number of households or people affected by natural disasters, we must cover a straight percentage of each person's property damage and thus a percentage of total property damage. We plan to cover 35% of property damage initially. We also define relocation costs as temporary housing costs plus the cost of replacing household goods. To incentivize citizens to leave bad regions after a disaster, our program covers different portions of relocation costs based on where the citizens are moving as per Table 5. Additionally, citizens choosing to remain in the same region will still receive these benefits even if they choose to stay in those regions.

Table 5. Relocation Benefit by Region

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
% of Relocation Cost Covered	75%	20%	75%	30%	30%	100%

When the cost of repairing the damages of a natural disaster does not exceed the book value of the house, a citizen will still have a part of their property damage covered but will not be eligible for any other benefits of our involuntary relocation program. If a citizen wants to move after a smaller disaster, they should apply for the voluntary relocation program rather than the full involuntary relocation program.

Chapter 5

Pricing/Cost Projections

In the short-term implementation of our program, we expect to see significantly more costs with our program than without our program because we expect to see little movement of people immediately and more costs expended from our program initiation. However, in the long-term, we expect to see significantly less costs because people should leave high-risk areas to move to low-risk areas, creating less of an economic and psychological setback from natural disasters.

Voluntary Relocation

The cost of our voluntary relocation program is determined by the value of the benefits we offer and the number of people we project to accept these benefits as seen in Table 6.

Table 6. Voluntary Relocation Costs

	Small	Medium	Large
Monthly Annuity Payments	20% of living costs	35% of living costs	50% of living costs
Years	5	5	5
Monthly Interest Rate	0.25%	0.30%	0.35%

Lump Sum Benefit	2% of median owner-occupied house value	4% of median owner-occupied house value	6% of median owner-occupied house value

Living costs are equal to median rent and median monthly homeowner housing costs for a region combined. Based on our team's population models that consider both increase in population over time and shifting region populations within the country, we expect following number of households to receive the voluntary relocation benefit by moving to the following regions over one hundred years as shown in Table 7.

Table 7. Regional Movement

	Region 1	**Region 3**	**Region 6**
SSP 1	59,364	268,140	749,572
SSP 2	22,336	148,877	771,003
SSP 3	32,740	299,468	524,418
SSP 5	65,001	204,503	1,075,214

Altogether, we expect to see average annual costs for the voluntary relocation program as follows with significantly lower cost in earlier years and larger costs in later years as future generations begin to adopt the program more often according to our projections. The annual average over the one hundred years is in Table 8 below. Our team also expects to see a reduction in the 100-year average relocation costs as shown in Appendix D because of this program.

Table 8. Average Annual Voluntary Program Costs

	SSP 1	**SSP 2**	**SSP 3**	**SSP 5**

Average Annual Voluntary Program Cost (₱)	921,783,798.72	821,858,154.66	727,219,343.60	1,166,533,006.80

Involuntary Relocation

By holding property damage per household and person per household constant throughout each region, our team estimated future property damage costs with the program implemented. Then, we estimated the cost of covering 35% of these future property damage values in Table 9.

Table 9. Average Annual Involuntary Program Costs

	SSP 1	**SSP 2**	**SSP 3**	**SSP 5**
Average Annual Involuntary Property Damage Cost (₱)	267,088,596.87	266,733,680.99	218,647,998.95	320,932,515.71
Average Annual Relocation Cost (₱)	3,894,934,230.80	3,892,025,072.30	3,138,995,672.54	4,760,396,694.87

These actual costs will be higher in the early years and lower in later years as people begin to move out of high-risk regions. Involuntary costs are significantly higher than our voluntary costs. Thus, it is essential that we begin our voluntary relocation program immediately so that fewer citizens must file for involuntary relocation.

Cost Summary

The average annual cost of the program should be consistent year-to year because as involuntary costs decrease from relocation, voluntary costs should be increasing from the increased movement of people within the one hundred years. To ensure with a high degree of certainty that there is enough capital to cover the total costs of the program, we should hold the amount of annual capital that it would take to cover the program if Storslysia ends up as an SSP 5 country because it is most expensive to maintain this program.

Table 10 shows the total property damage costs in Storslysia with and without the program over a 100-year period. The program reduces the total cost in property damage for each individual shared socioeconomic pathway.

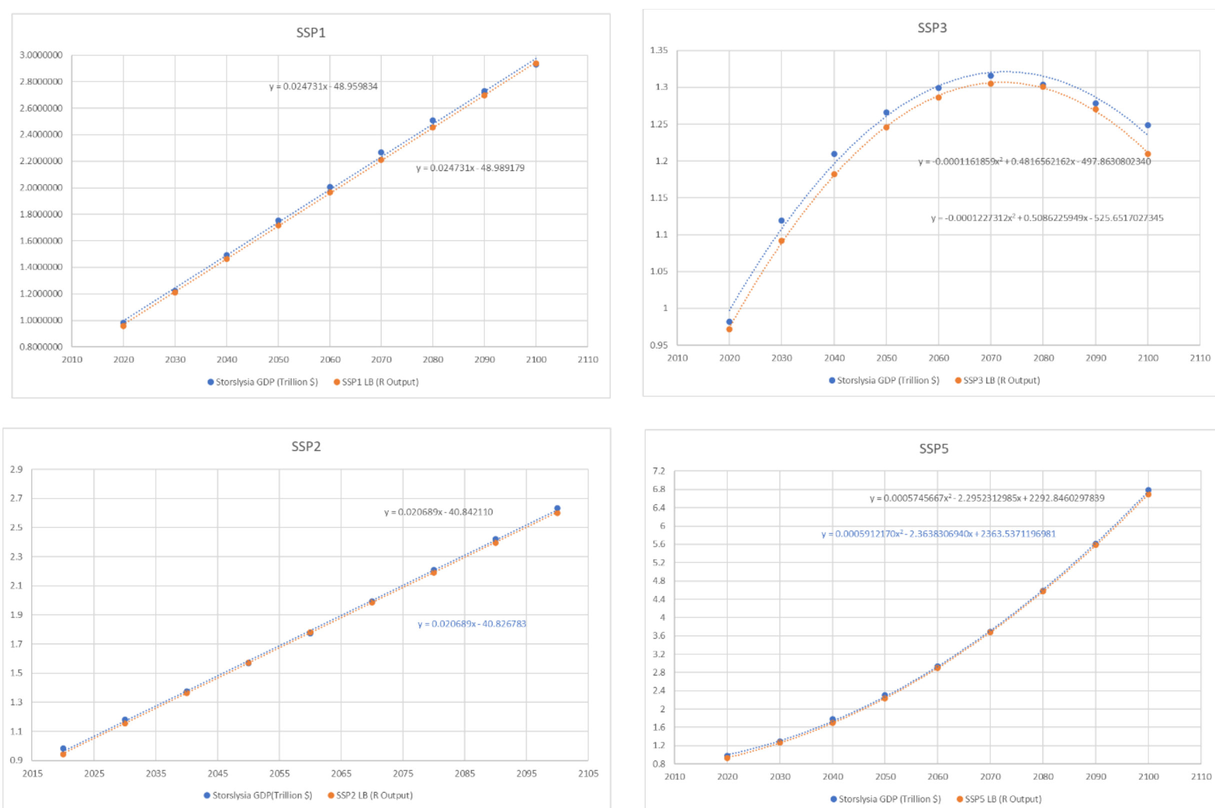
Table 10. Total Program Costs

	SSP 1	**SSP 2**	**SSP 3**	**SSP 5**
Total Property Damage W/ Program (Ꝑ)	76,311,027,675.82	76,209,623,141.18	62,470,856,842.12	91,695,004,488.22
Total Property Damage W/O	79,908,343,694.26	95,144,747,901.58	96,446,806,155.02	352,598,667,653.07

Program (Ᵽ)				

To ensure that we meet the program requirement of holding program costs below 10% of the GDP, we projected 10 percent of GDP for the next one hundred years for each shared socioeconomic pathway. Then, we applied a lower bound to these figures to ensure that the costs will not exceed the actual 10% GDP with a high degree of certainty. Costs must always remain below the orange lower bounds in figure 2.

Figure 2. SSP GDP Projections with Lower Bounds



Chapter 6

Risk Mitigation Strategies

As the new program develops, potential risks and unforeseen events may arise and have a material impact on the program. To prevent and reduce potential risks, we identify possible quantifiable and qualitative risks and provide risk mitigation plans listed in Table 11 and 12.

Table 11. Quantifiable Risks

Risks	Description	Impact	Risk Mitigation
1 Unpredictable Catastrophe Events	Catastrophe events occurring more often or with greater severity than anticipated	Lead to a higher-than-expected number of claims and payouts under the social insurance program	Make emergency response plans and develop contingency plans for catastrophic events
2 Insufficient Funding	Insufficient funding for the program due to the economic constraints	Lead to inadequate benefits or coverage of those affected by catastrophic events	Find and secure funding from multiple resources. Explore opportunities for cost-sharing with other stakeholders
3 Adverse Selection	Individuals are more likely affected by catastrophe or have higher risks of displacement	Lead to an imbalance in risk pool and high premium for other participants	Develop comprehensive eligibility criteria to ensure balance within the risk pool. Continuous monitoring and evaluation
4 Implementation Risks	Delays in program rollout or technical glitches in data collection and management systems	Inadequate coverage or delayed benefit payments	Monitor and evaluate the implementation risks regularly and change the implementation plan accordingly
5	Demographic trends such as population growth and aging are unpredictable	Affect the demand for relocation aid and the potential costs of displacement	Focus on developing contingency plans for demographic trends

Unpredicted Demographic Trends			

To prioritize the design and implementation of the insurance program for relocation in Storslysia, we use a risk matrix that combines the likelihood of a risk occurring and the severity of the risk to rank the quantifiable risks. In the likelihood and severity table (Table 12), we show the likelihood of the risks based on the probability of the risk occurring on a scale of 1 to 3, with 1 representing a risk that is very unlikely to happen and 3 a risk that is highly likely to occur. We also assess the severity based on the impact of each risk on a scale of 1 to 3, with 1 representing a minimal impact and 3 a catastrophic impact. Further explanation on the categorization of risks in their respective spot on the matrix can be found in Appendix N.

Table 12. Likelihood and Severity Risk Matrix

Likelihood/Severity	Minimal (1)	Medium (2)	Catastrophic (3)
Likely (3)	Low-3	Medium-6	High-9 Risk 1
Moderate (2)	Low-2 Risk 4	Medium-4 Risk 3	Medium-6 Risk 2
Unlikely (1)	Low-1	Low-2 Risk 5	Low-3

On top of quantifiable risks above, our team also named possible qualitative risks and the risk mitigation plans in Table 13.

Table 13. Qualitative Risks

Risks	Description	Impact	Risk Mitigation
1 Imperfect incentives for relocation	Incentives supplied are insufficient or too high	Insufficient incentive will discourage voluntary relocation, high incentives will lead to	Offer attractive incentives depending on the needs and preference of the population in a specific region. Publicize and

		overcrowding and increase risks in those regions	market to potential participations to increase awareness
2 Increasing risk of inequality	New policy may unintentionally worsen existing inequalities or create new ones	The inequalities may cause uneven participation and may further worsen economic disparities	Regularly check and evaluate the equity outcomes. Ensure the transparency and accountability of the program
3 Insufficient resources and housing	The resources and housing for people moving to certain regions are not enough	Lead to a delay of the implementation of the plan	Pre-plan and prepare to ensure the availability of the resource. Collaborate with other Storslysia task force for emergency purpose

Sensitivity Analysis

After careful research and utilizing actuarial judgment, we have selected certain assumptions for our project. However, it is important to note that these assumptions may deviate from our initial expectations. To account for any potential fluctuations, we conducted a sensitivity analysis to determine how these changes will influence our project's overall relocation cost.

We performed sensitivity analyses with the expected involuntary relocation, expected voluntary relocation percentage, and the number of months in temporary housing. Appendix E further elaborates on our assumptions of ranges. The program is never close to exceeding 10% of Storslysia's GDP with expected costs of 15-20 billion annually in the worst-case scenarios. Our team can also say with great certainty that the economic costs associated with the program will be less than the economic costs without the program in place. While the initial costs will be high, the program will ultimately save Storslysia money over the next one hundred years.

Chapter 7

Assumptions

1. **Risk Uniformity Within Regions:** The risk of property damage from a weather event is uniform across a given region. This means that moving from one part of a region to another part in the same region would not decrease the chance of a weather event.
2. **GDP and Population Follow Trends Similar to OECD Countries:** Storslysia has a similar GDP per capita to developed countries, so trends in GDP and population will more closely resemble ODEC SSP predictions rather than global SSP predictions.
3. **Property Damage Applies Only to Residential Property:** The property damage figures given in the files are only residential properties in Storslysia and not commercial properties. Therefore, relocation benefits will only belong to residential property owners and not commercial property owners.
4. **1.5% of Population is Involuntarily Relocated per Year:** This follows the latest trends in the U.S. which is a country that experiences a range of weather events like Storslysia.
5. **Average Relocation Time of 12 Months:** This follows the latest trends in the U.S. which is country that experiences a range of weather events like Storslysia.
6. **35% Increase in Supplies & Labor After a Weather Event:** This value was within the range given.
7. **The 2003 Inflation Figure Was Incorrect:** The 2003 inflation figure was impossibly large and instead adjusted to a more proper value based on a 3-year prior average.
8. **Persons Per Household is Constant:** We assume there will not be a fundamental change in the average number of people per household over the next one hundred years so we can use population projections to predict the number of households.

9. **Property Damage Does Not Include Household Goods:** Household goods are not in the property damage figure and must be accounted for elsewhere.
10. **Population Inflow to Safe Regions will Follow Consistent Trends:** The proportion of citizens coming from a specific region to another region will be proportionally equivalent each year.

Chapter 8

Data Limitations

1. **No Prior Emissions Data:** There was no sign which SSP Storslysia currently follows or is heading. Since each SSP affects numerous critical factors and varies in the long term, it made it difficult to create a single baseline model.
2. **Only 3 Years of Census Data & 2 Years of GDP Data:** With only three years or less of census and GDP data, it is incredibly difficult to accurately forecast growth or decline in Storslysia with great certainty.
3. **Only 60 Years of Weather Events:** With only 60 years of weather data, it is challenging to find the frequency of extremely severe weather events.
4. **The Number of Properties Damaged is Unknown:** When determining involuntary relocation, we had to assume the number of households that are affected by weather events since it was not included in the hazard data set.

Chapter 9

Conclusion

With an issue this large, there is not going to be a perfect fix. Weather events are not something that humans can control, but we can take measures to ensure each other's safety and well-being. Our team saw a reduction in property damage and involuntary relocation expenses in all SSPs with our program design. By implementing our recommended program, Storslysia can reduce the number of citizens affected without hurting its economy or disputing daily life with great certainty.

Chapter 10 Appendix A

GDP Confidence Interval and Inflation Projection Code

```
gdpdata = GDP_and_Max_Program_Cost_Sheet

GDPSSP1 = gdpdata$`Storslysia GDP (Trillion $)...2`

GDPSSP2 = gdpdata$`Storslysia GDP(Trillion $)`

GDPSSP3 = gdpdata$`Storslysia GDP (Trillion $)...4`

GDPSSP5 = gdpdata$`Storslysia GDP (Trillion $)...5`

year = gdpdata$Year


GDPFit1 = lm(GDPSSP1~year)

summary(GDPFit1)

predict(GDPFit1, gdpdata, interval="confidence",level = .95 )


GDPFit2 = lm(GDPSSP2~year)

summary(GDPFit2)

predict(GDPFit2, gdpdata, interval="confidence",level = .95 )


GDPFit3 = lm(GDPSSP3 ~ poly(year, 2, raw=TRUE))

summary(GDPFit3)

predict(GDPFit3, gdpdata, interval="confidence",level = .95 )


GDPFit5 = lm(GDPSSP5 ~ poly(year, 2, raw=TRUE))

summary(GDPFit5)
```

```
predict(GDPFit5, gdpdata, interval="confidence",level = .95)

Inflation = Inflation_Data
inflation_ts = ts(Inflation$Inflation, start = 1962, end = 2021, frequency = 1)
acfinf = acf(inflation_ts)
autoarimainf = auto.arima(inflation_ts, stationary = TRUE, seasonal = FALSE, ic =
"aic")
predinf = predict(autoarimainf, n.ahead = 100)
```

Chapter 11 Appendix B

Weather Events

The model given allowed for determination of weather events per region. The table below shows these outputs summed together for all Storslysia. Those tables are below.

Table 14. SSP Emission Projections (1)

	SSP1– 2.6 (Low Emissions)			**SSP2–3.4 (Medium Emissions)**		
Year	**Minor**	**Medium**	**Major**	**Minor**	**Medium**	**Major**
2020	45.836	5.305	2.109	45.836	5.305	2.109
2030	50.827	5.884	2.339	51.495	5.96	2.369
2040	54.561	6.315	2.511	57.219	6.623	2.633
2050	56.607	6.552	2.606	62.318	7.211	2.868
2060	57.152	6.616	2.628	66.047	7.644	3.039
2070	56.594	6.551	2.603	67.862	7.855	3.122
2080	54.942	6.36	2.528	67.997	7.871	3.129
2090	52.366	6.061	2.408	66.905	7.743	3.078

2100	49.815	5.765	2.292	65.163	7.542	2.997
2110	47.33	5.478	2.178	63.445	7.344	2.918
2120	44.907	5.197	2.067	61.748	7.146	2.841

Table 15. SSP Emission Projections (2)

	SSP3–6.0 (High Emissions)			**SSP5–Baseline (Very High Emissions)**		
Year	**Minor**	**Medium**	**Major**	**Minor**	**Medium**	**Major**
2020	45.836	5.305	2.109	45.836	5.305	2.109
2030	53.017	6.137	2.439	53.972	6.246	2.483
2040	60.871	7.046	2.801	65.736	7.608	3.025
2050	68.923	7.978	3.171	82.473	9.547	3.795
2060	77.679	8.992	3.575	106.424	12.318	4.896
2070	86.667	10.03	3.987	140.312	16.239	6.456
2080	94.844	10.977	4.364	186.441	21.579	8.578
2090	102.316	11.842	4.707	244.581	28.309	11.254
2100	109.645	12.69	5.045	312.209	36.135	14.365
2110	117.226	13.567	5.394	388.081	44.917	17.858
2120	125.063	14.474	5.754	472.198	54.651	21.728

Chapter 12 Appendix C

Property Damage

We found the average property damage for each severity level for all historical events. However, to account for large catastrophes, we calculated the Major grouping using a 1-in-3-year estimate more accurately for weather events between 100,000,000 – 1,000,000,000 and a 1-

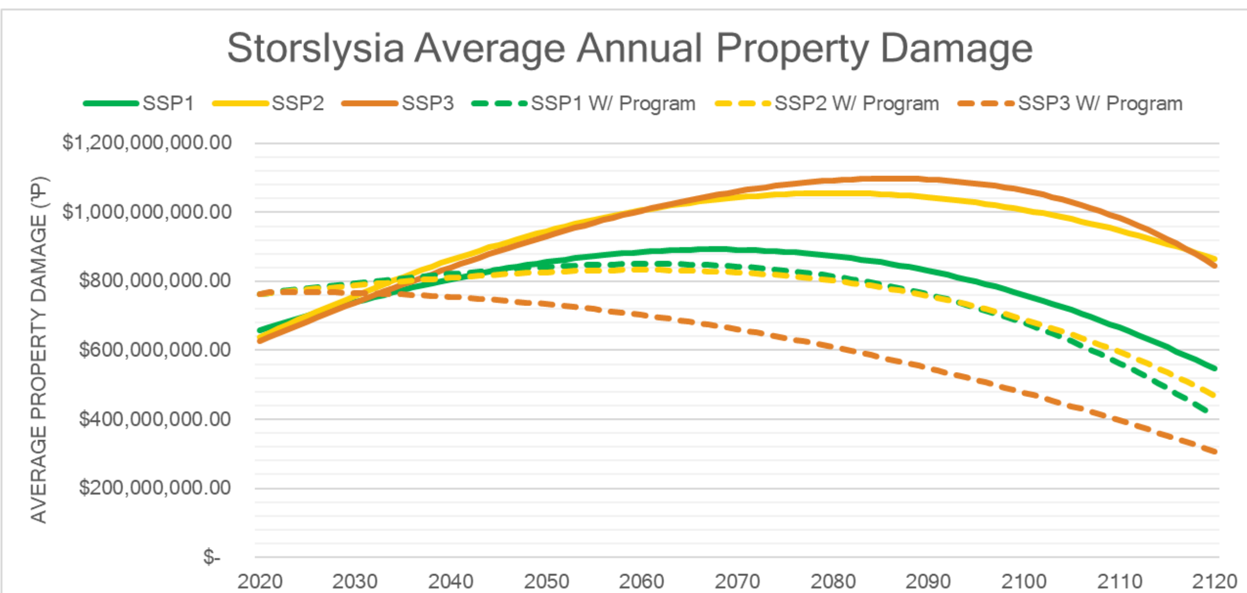
in-10-year estimate for weather events above 1,000,000,000. The difference in the adjusted averages is below.

Table 16. Average Losses from Severities

	Original All Data Averages	Adjusted All Data Averages
Minor	108,459.45	108,459.45
Medium	1,659,292.05	1,659,292.05
Major	369,302,305.20	364,573,674.36

The graph below shows how the average annual property damage for Storslysia should change after the implementation of the program dependent on the SSP. We avoid SSP 5 in the graph because its average annual property damage is almost ten billion by 2120, which deviates too greatly from the other data to be considered.

Figure 3. Average Annual Property Damage Projections



If the relocation program is effective, Storslysia should see a significant decrease in property damage over time as the citizens move to safer areas. Property damage will be similar with and without the program in the early years, but the difference will increase significantly as people begin to relocate.

Chapter 13 Appendix D

Relocation Costs

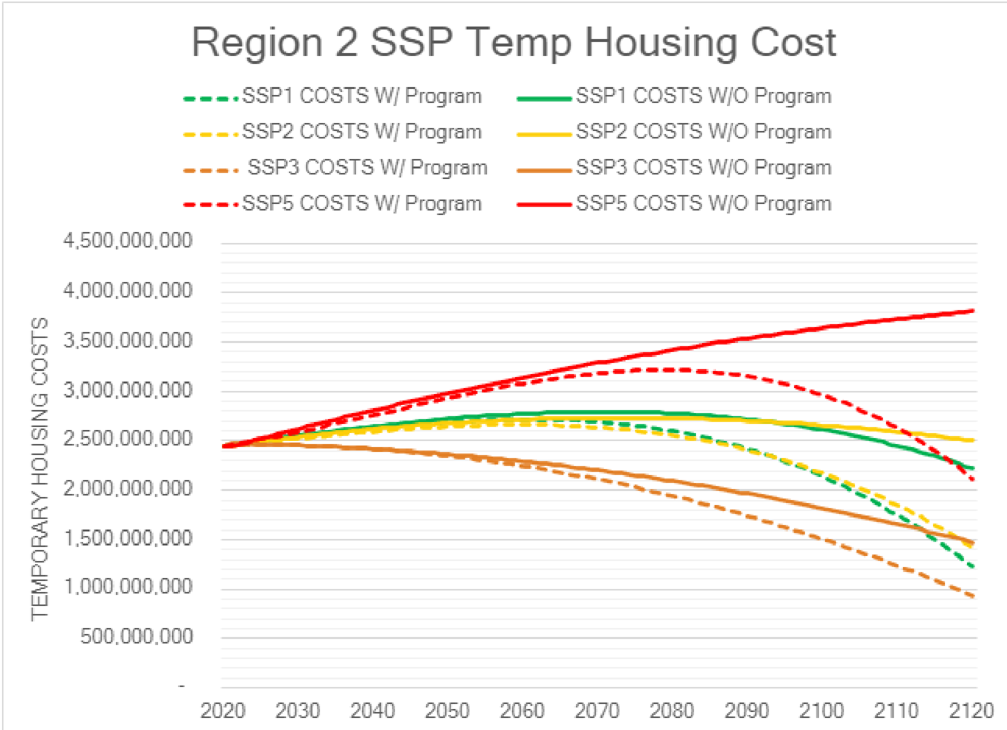
Below is a table showing the average relocation cost savings for the first 10 years of the program assuming 12 months temporary housing.

Table 17. First 10-Year Cost Savings

	SSP 1	SSP 2	SSP 3	SSP 5
Average for First 10-Years Relocation Cost Savings (₱)	78,340,464.52	74,177,333.26	76,487,386.31	74,022,097.08

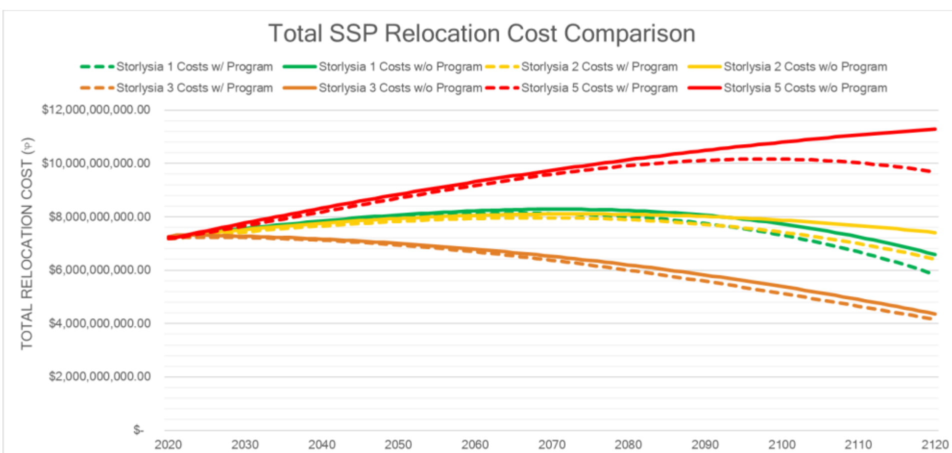
The graph below shows temporary housing costs for socioeconomic pathways with and without voluntary program for region 2 which is the most problematic region. Dotted lines decreasing from bold lines show how program is saving money.

Figure 4. Region 2 Temporary Housing Projections



The graph below is like the one above but shows relocation costs decreasing because of the voluntary program across the entire nation.

Figure 5. Total Relocation Cost Comparison



The table below shows the actual amount of money being saved each year because of the voluntary relocation program.

Table 18. Average Annual Relocation Reduction

	SSP 1	SSP 2	SSP 3	SSP 5
Average Annual Relocation Reduction w/ Program (₱)	247,941,766.99	269,608,118.95	151,143,882.46	377,386,368.13

Chapter 14 Appendix E

Sensitivity Testing

The chart below shows baseline, best, and worst-case scenarios for various quantified assumptions.

Table 19. Sensitivity Analysis Parameters

		worst case	baseline	best case
	months in temporary housing	24	12	6
Region 2,4,5	% involuntary population displacement	10.0%	2.0%	0.5%
Region 1,3,6	% involuntary population displacement	5.0%	1.0%	0.5%
Region 2,4,5	% expected voluntary mover	0.5%	2.0%	10.0%
Region 1,3,6	% expected voluntary mover	0.5%	1.0%	5.0%
	material and housing cost increase after weather events	50.0%	35.0%	5.0%

The table below shows the baseline % changes of expected voluntary movers with and without the program. When compared to the chart above, the best case is better, and the worst case is worse, showing how the sensitivity analysis is effective in this case.

Table 20. Percent Change of Voluntary Movers

baseline (% change)			
Storlysia 1	Storlysia 2	Storlysia 3	Storlysia 5
-0.009591	-0.009591	-0.009591	-0.009591
-0.010749	-0.007588	-0.013913	-0.003859
-0.010719	-0.008272	-0.012997	-0.005544
-0.010690	-0.008902	-0.012146	-0.007082
-0.010663	-0.009479	-0.011358	-0.008481
-0.010638	-0.010007	-0.010632	-0.009748
-0.010617	-0.010488	-0.009966	-0.010891
-0.010599	-0.010925	-0.009359	-0.011916
-0.010585	-0.011320	-0.008810	-0.012830
-0.010575	-0.011676	-0.008317	-0.013640
-0.010570	-0.011995	-0.007879	-0.014352

Chapter 15 Appendix F

Region Rankings

The region ranking evaluation parameters are below:

Table 21. Region Evaluation Parameters

	Region 1	**Region 2**	**Region 3**	**Region 4**	**Region 5**	**Region 6**
Population	6,306,408	4,212,348	4,993,764	1,010,676	1,266,672	307,884
Housing Units	2,791,896	2,523,732	2,212,536	496,548	566,592	135,480
Total Hectares	2,442,659	3,522,311	2,353,615	3,438,613	2,067,059	1,556,199
Median Household Value	260,765	248083	221267	121135	158255	175164

Value Factors	1	1.051119988	1.178508318	2.152680893	1.647752046	1.488690599
Property Damage (2016-2020)	143,628,091.67	2,702,242,637.81	53,900,389.62	25,526,914.17	25,258,669.80	693,317.43
Property Damage (2011-2020)	187,675,627.13	3,116,803,972.59	596,834,416.34	411,405,649.03	70,265,907.71	15,522,686.45
Property Damage (2001-2020)	629,474,544.59	4,369,474,063.15	596,834,416.34	421,022,823.48	118,868,931.96	22,165,862.87
Property Damage (1962-2020)	1,457,315,935.32	25,107,822,372.55	2,514,779,075.09	2,017,812,122.65	7,415,220,670.40	359,982,113.57
Equivalent Property Damage (2016-2020)	143,628,091.67	2,840,381,249.21	63,522,057.51	54,951,300.40	41,620,024.84	1,032,135.14
Equivalent Property Damage (2011-2020)	187,675,627.13	3,276,134,954.48	703,374,324.13	885,625,080.03	115,780,793.18	23,108,477.38
Equivalent Property Damage (2001-2020)	629,474,544.59	4,592,841,525.12	703,374,324.13	906,327,787.71	195,866,525.81	32,998,111.66
Equivalent Property Damage (1962-2020)	1,457,315,935.32	26,391,333,952.66	2,963,688,057.94	4,343,705,602.53	12,218,445,029.33	535,901,988.11
Property Damage per Person (2016-2020)	22.77	674.30	12.72	54.37	32.86	3.35
Property Damage per Person (2011-2020)	29.76	777.75	140.85	876.27	91.41	75.06
Property Damage per Person (2001-2020)	99.82	1,090.33	140.85	896.75	154.63	107.18
Property Damage per Person (1962-2020)	231.08	6,265.23	593.48	4,297.82	9,646.10	1,740.60
Property Damage per Housing Unit (2016-2020)	51.44	1,125.47	28.71	110.67	73.46	7.62

Property Damage per Housing Unit (2011-2020)	67.22	1,298.13	317.90	1,783.56	204.35	170.57
Property Damage per Housing Unit (2001-2020)	225.46	1,819.86	317.90	1,825.26	345.69	243.56
Property Damage per Housing Unit (1962-2020)	521.98	10,457.26	1,339.50	8,747.81	21,564.80	3,955.58
Person Per Hectare	2.58	1.20	2.12	0.29	0.61	0.20

Chapter 16 Appendix G

Population Goals

Using the ranking system above and setting each population largest person per hectare at 2.65 to avoid overpopulation and prevent large losses all at once, we developed the desired population model:

Table 22. Region Final Populations

	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Population	6,306,408	4,212,348	4,993,764	1,010,676	1,266,672	307,884
Hectares	2,442,659	3,522,311	2,353,615	3,438,613	2,067,059	1,556,199
Max PPH	2.65	2.65	2.65	2.65	2.65	2.65
Max population	6,473,046	9,334,124	6,237,080	9,112,324	5,477,706	4,123,927
Change in Population	103%	16%	125%	25%	25%	1339%
Desired Population	6473046	694362	6237080	252669	316668	4123927
Difference	166,638	-3,517,986	1,243,316	-758,007	-950,004	3,816,043

Chapter 17 Appendix H

Modeling Program Relocation Goals

The equation and graphs below model our goals for the population trends we expect each region to follow, without considering the increase or decrease in population over time. These graphs avoid accounting for population change over time to prove the movement patterns within each region most accurately. In the early years, we predict little movement from current residents and more movement as second, third, and fourth generations arise. Once we surpass 100 years, we expect desirable regions to plateau because of population constraints we considered, and we expect undesirable regions to floor due to non-movers that refuse to leave their region or that do not find the benefits more useful than remaining in their region.

Figure 6. Region 1 Population Model

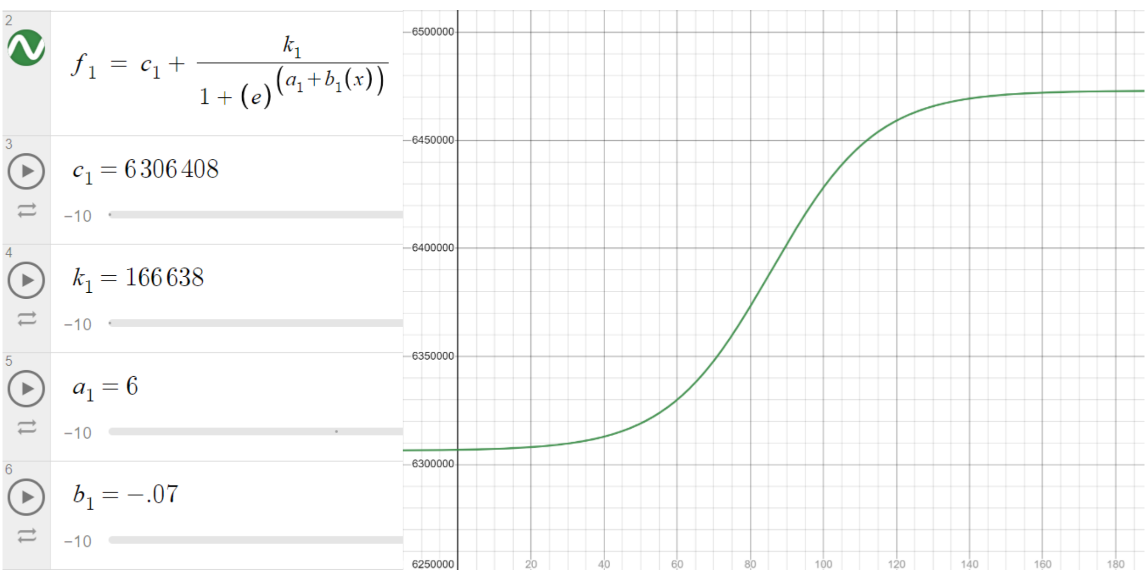


Figure 7. Region 2 Population Model

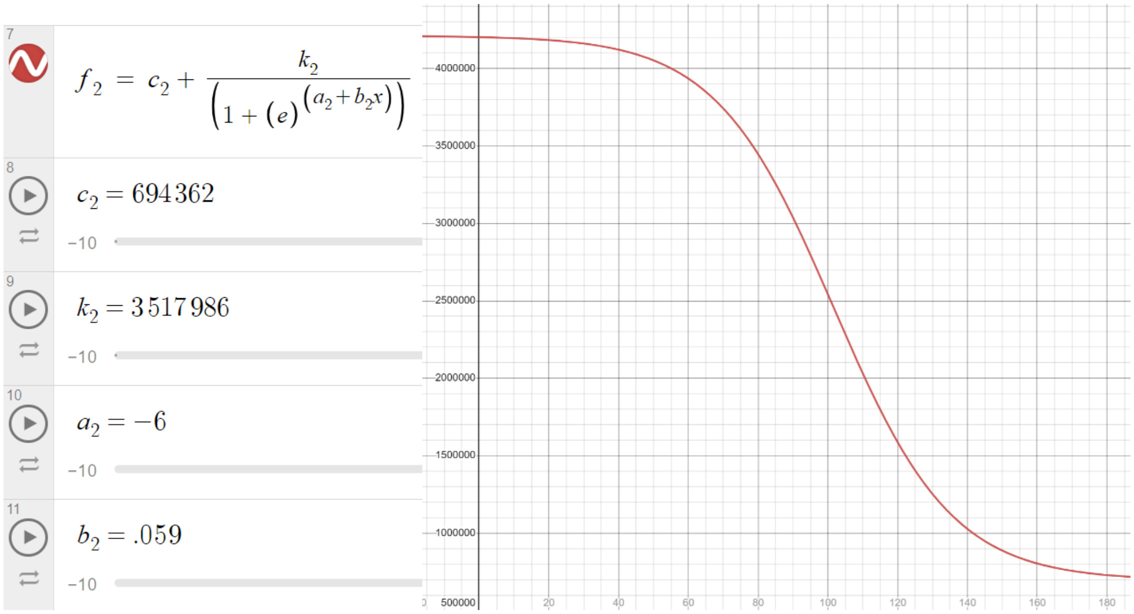


Figure 8. Region 3 Population Model

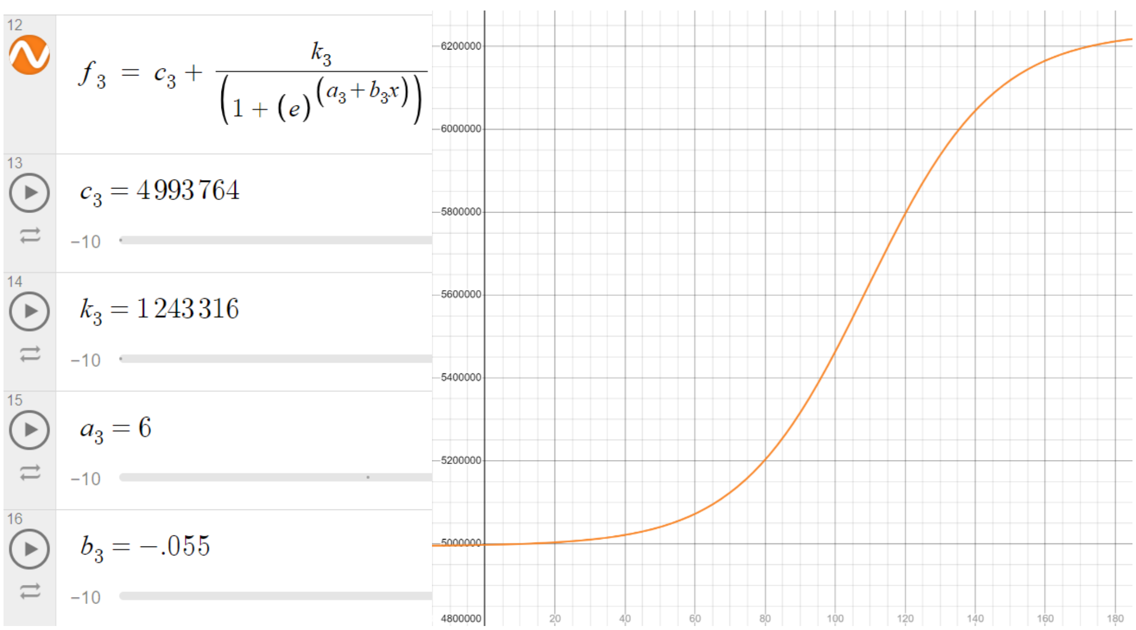


Figure 9. Region 4 Population Model

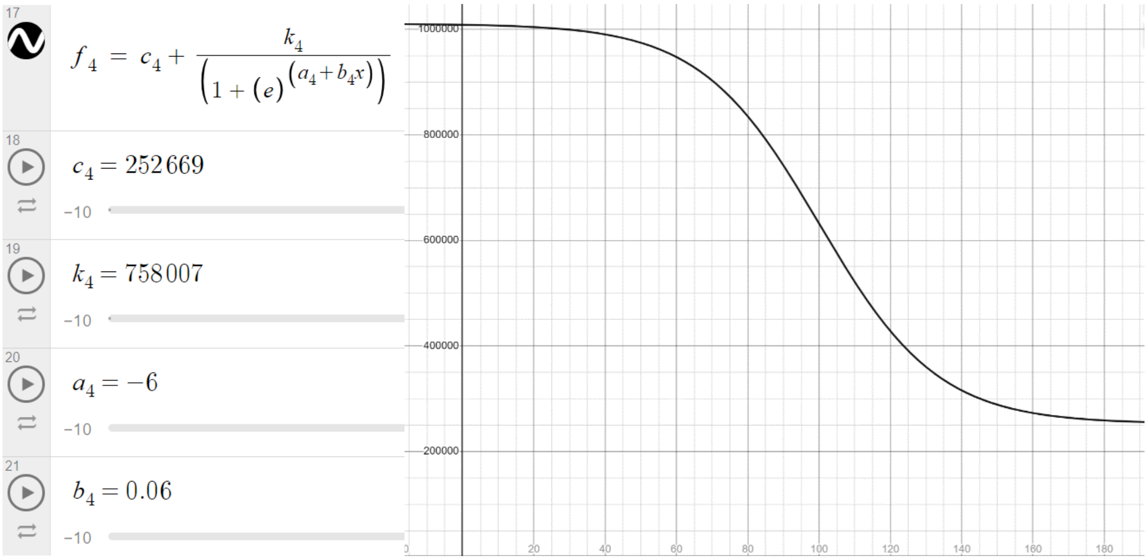


Figure 10. Region 5 Population Model

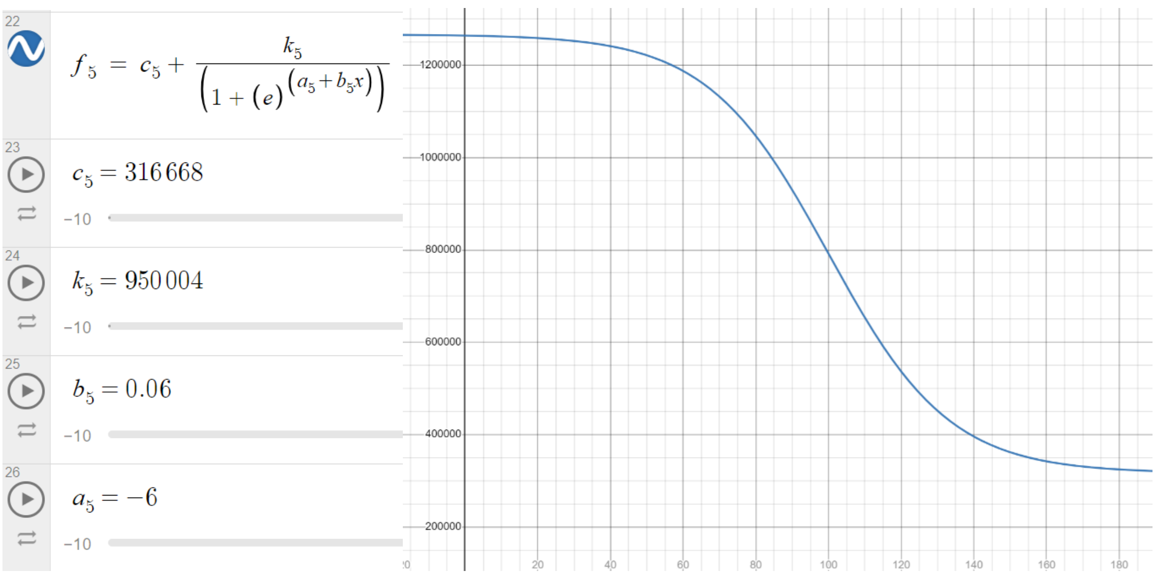
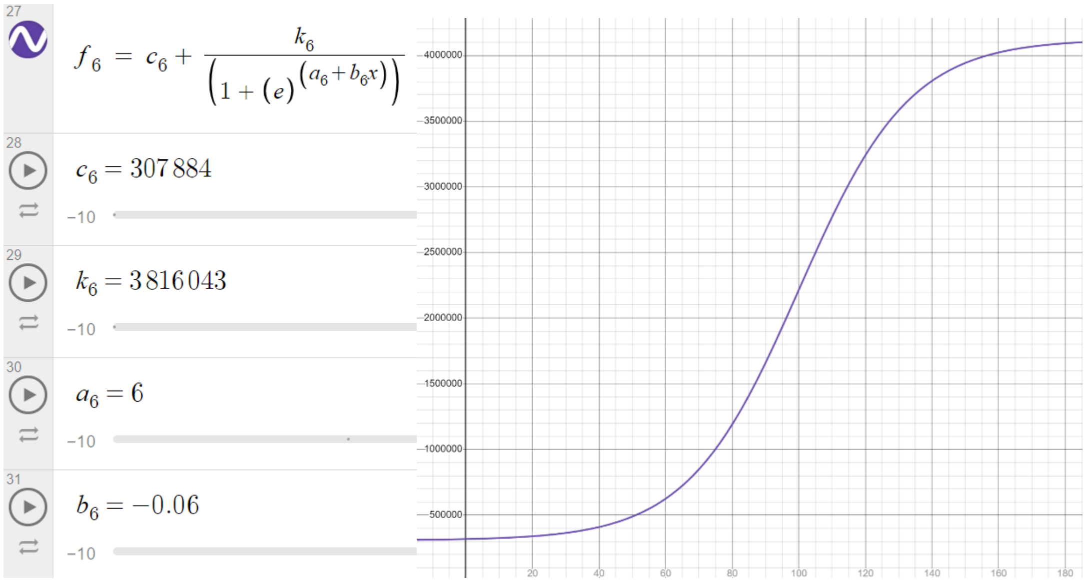
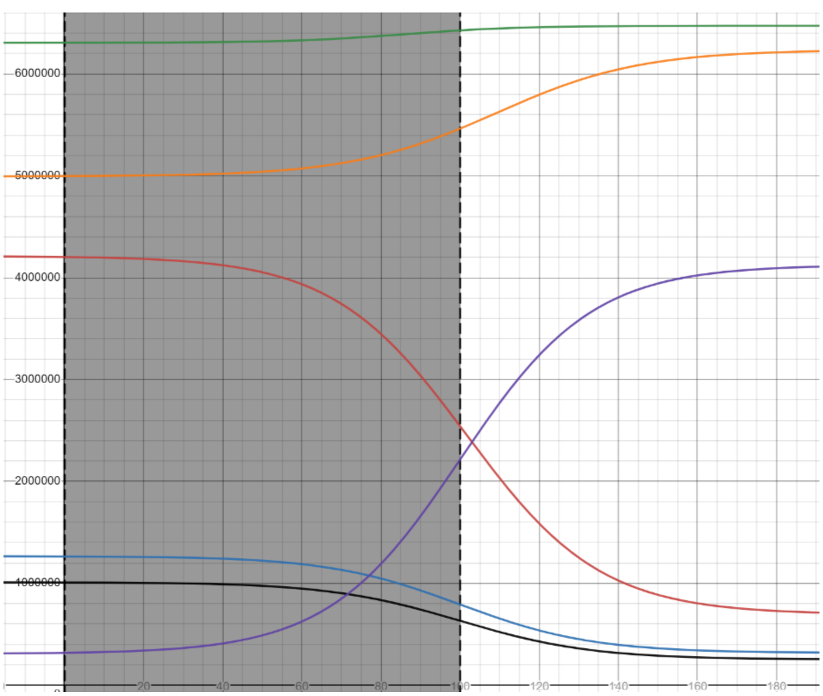


Figure 11. Region 6 Population Model



The following graph illustrates region functions combined with our 100-year program goals highlighted:

Figure 12. Combined Population Models



Chapter 18 Appendix I

Modeling Regional Population Trends

Once we were able to use the sigmoid functions above to project population shifts within the country because of our program, we could then apply population growth factors to find the difference in the population with and without our program in place. The population movement was determined by multiplying the growth rate of the OECD population trends on the IPCC scenarios website by Storslysia's population. We then fit a polynomial trendline to Storslysia's current region populations without with and without the program in place. When the program is not in place, the regions are expected to grow the same as the entire population would. However, when the program is in place, populations of the regions shift both by the IPCC growth/decline and the sigmoid function growth/decline. The following graphs represent our findings, where the orange trend shows that there is no program, and the blue trend represents that there is a program in place.

Figure 13. Region 1 SSP Population Trends

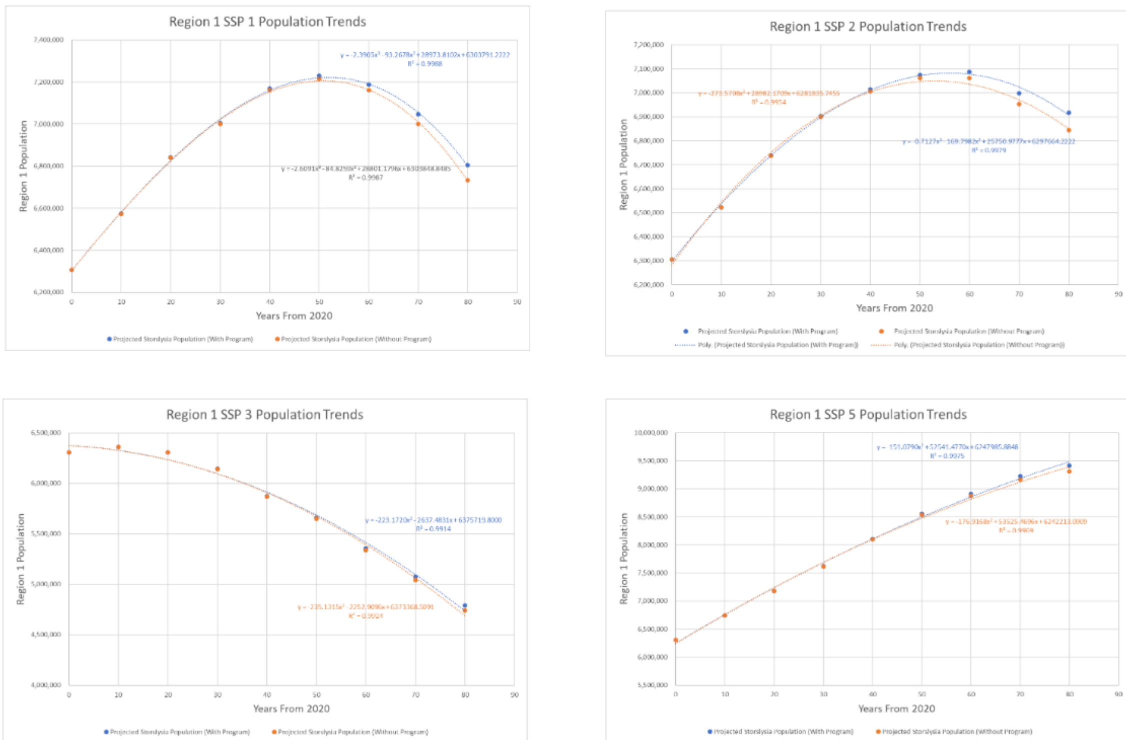


Figure 14. Region 2 SSP Population Trends

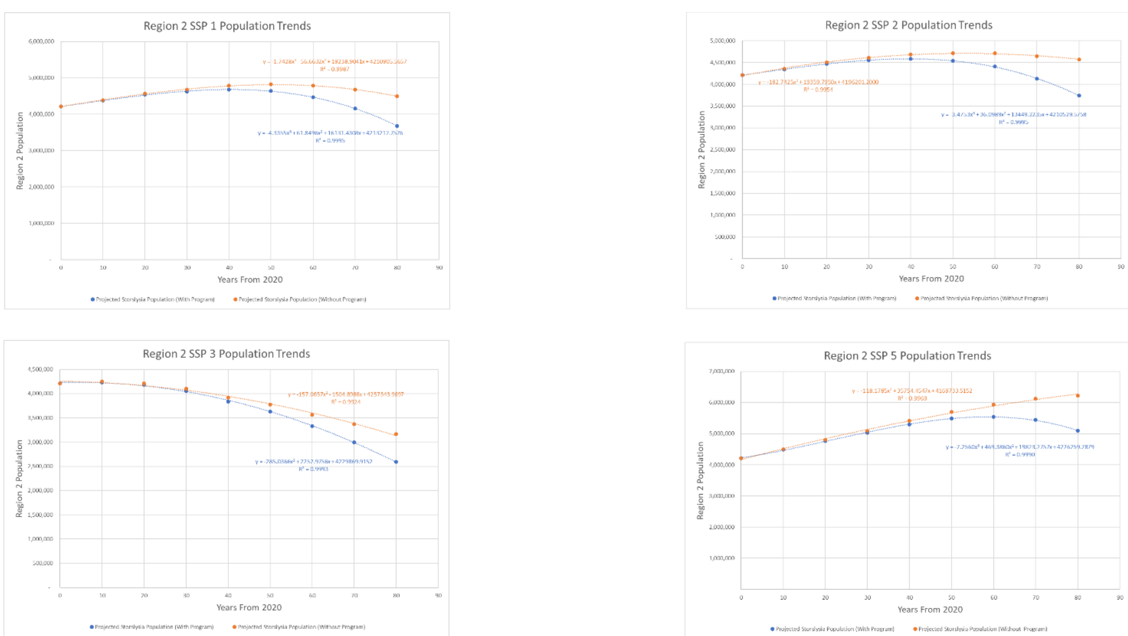


Figure 15. Region 3 SSP Population Trends

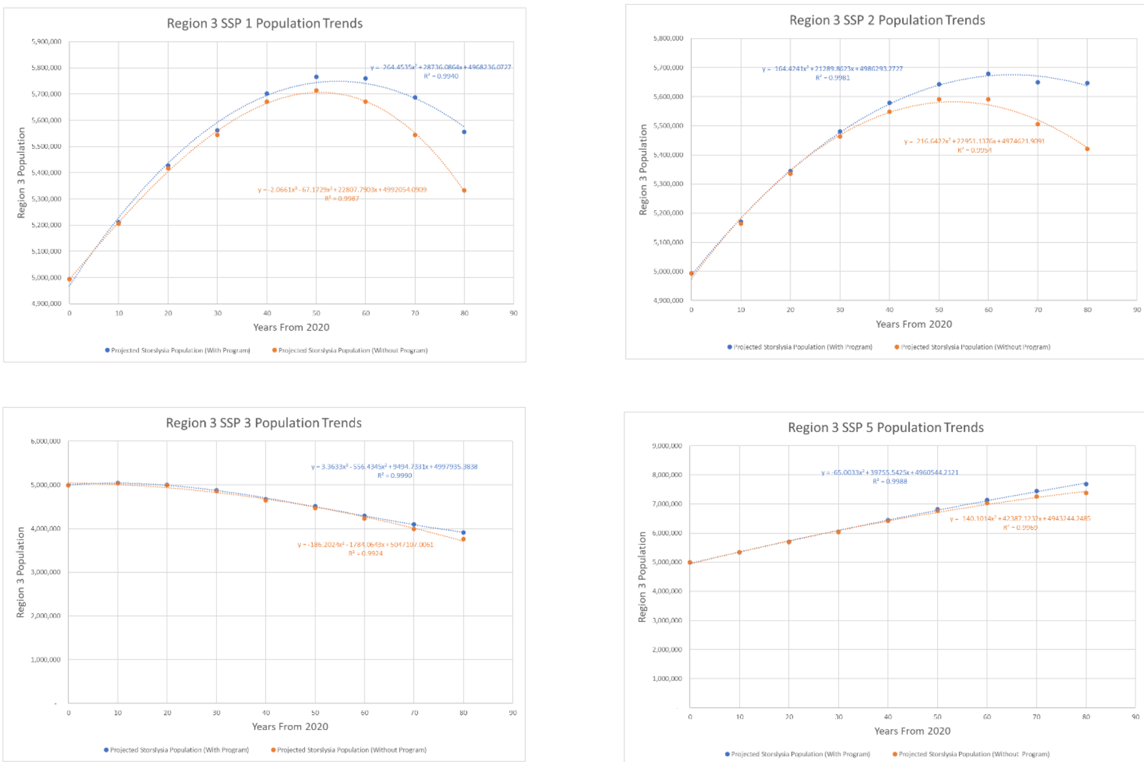


Figure 16. Region 4 SSP Population Trends

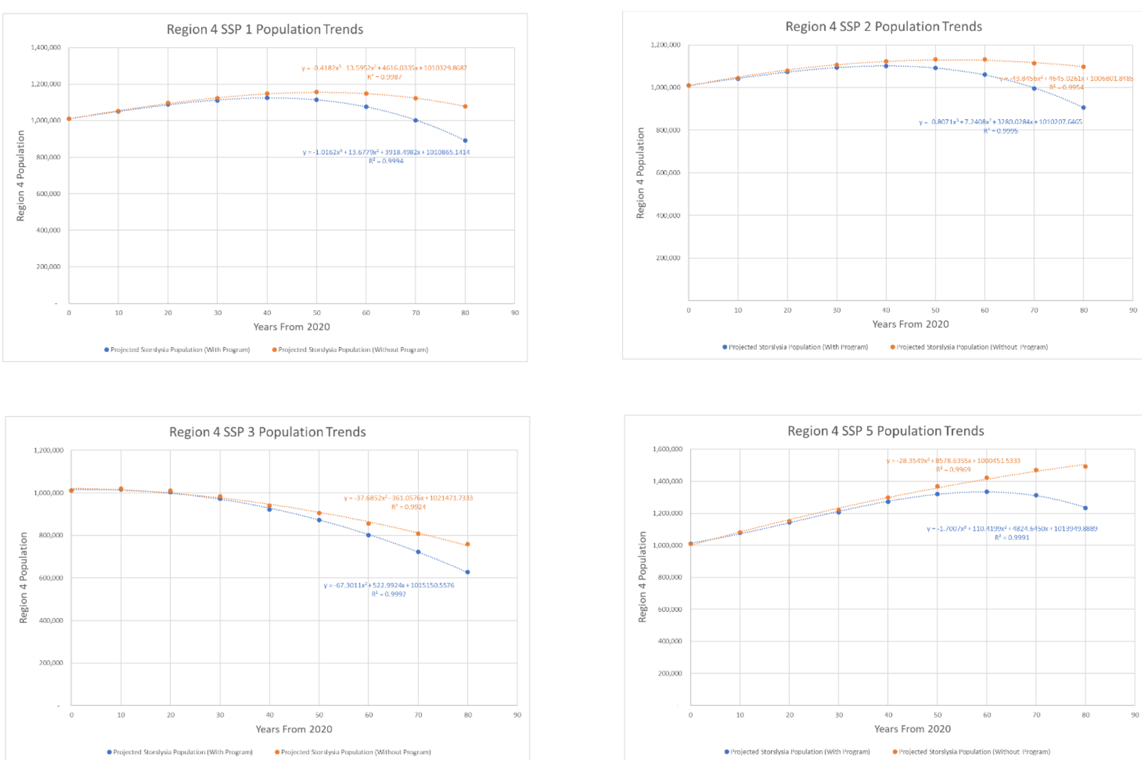


Figure 17. Region 5 SSP Population Trends

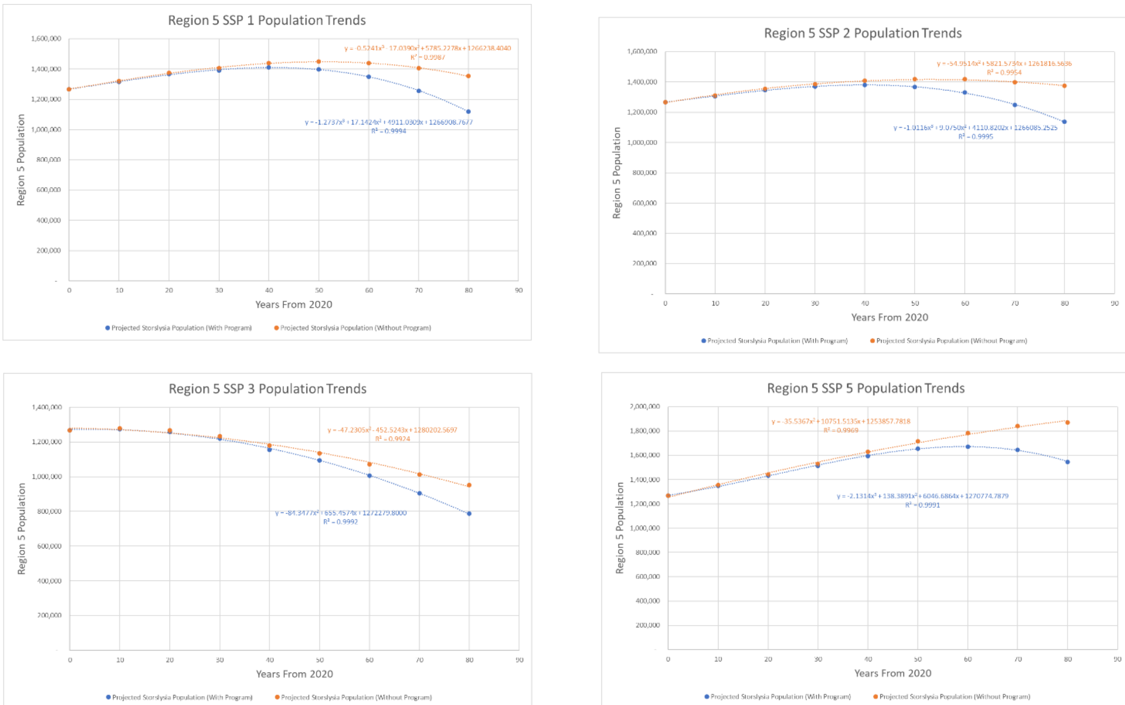
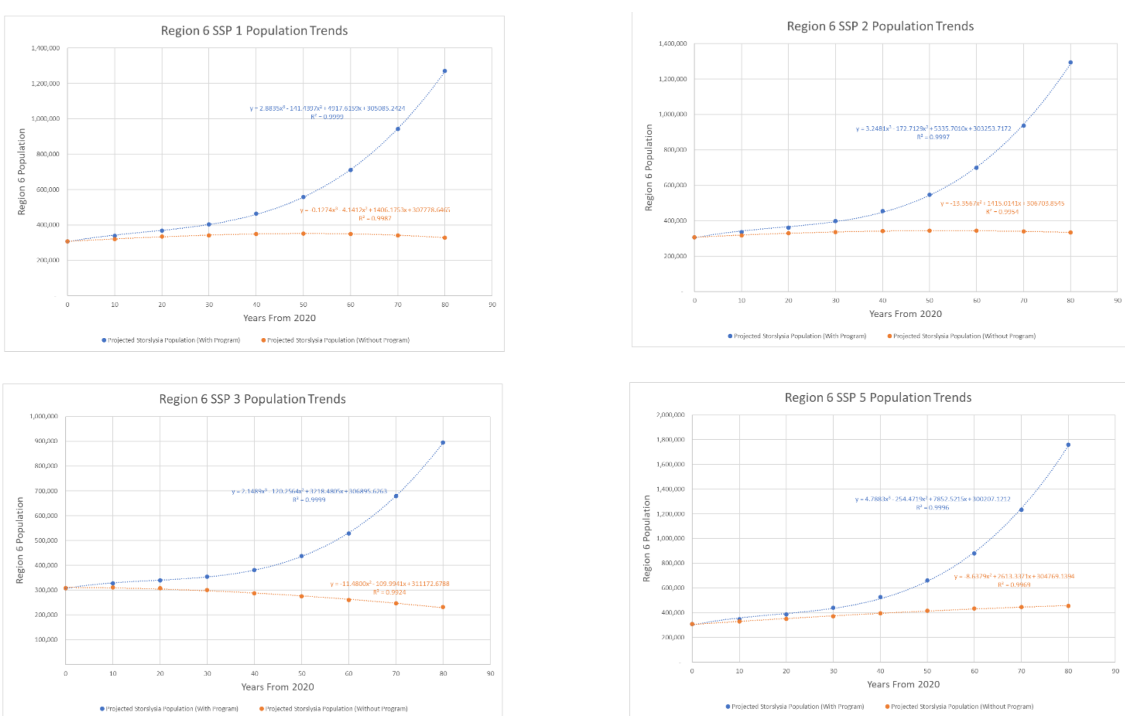


Figure 18. Region 6 SSP Population Trends



Chapter 19 Appendix J

Property Damage with Program Estimations

By holding People per household and average property damage per household per year constant, we were able to find a value for annual property damage based on our population projections with and without the program. The following data shows the numbers we used for property damage calculations and the amount of property damage in Storslysia for each year with our program in place.

Table 23. Property Damage per Household

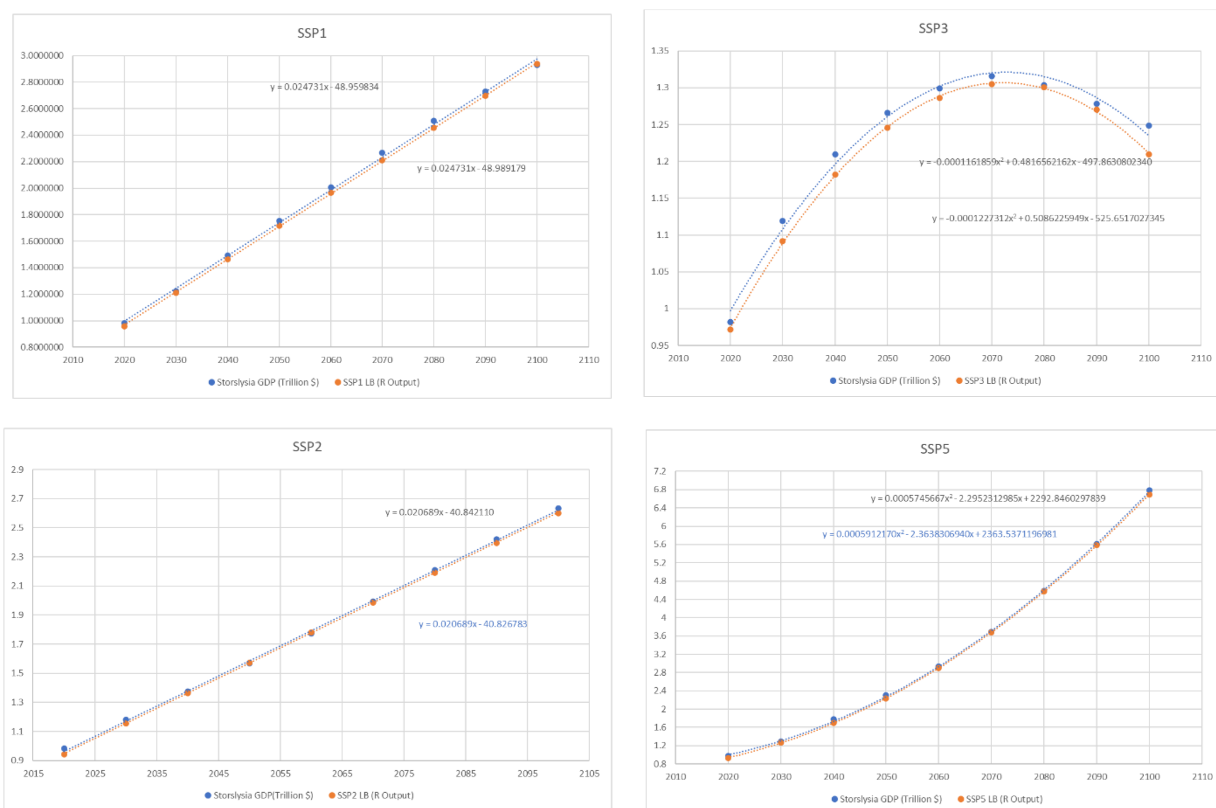
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6
Total Households (2016-2020)	2,376,180	1,634,628	1,865,736	403,548	500,448	110,052
Total Property damage (2016-2020)	143,628,091.67	2,702,242,637.81	53,900,389.62	25,526,914.17	25,258,669.80	693,317.43
Average Property damage per household per year	15.1112386	413.28098	7.2224031	15.814051	12.618029	1.57498
Person Per household	2.55	2.49	2.47	2.50	2.50	2.65

Chapter 20 Appendix K

GDP Data

We found GDP growth by using growth factors in the IPCC data for each shared socioeconomic pathway and applying them to Storslysia's 2020 GDP. The following graphs show the trend pf Storslysia's GDP for each shared socioeconomic pathway and apply lower bounds found in R to ensure that our costs can fall below 10% of the GDP for each year. In Storslysia currency, the chart below represents the lower bounds of 10% of the GDP for each SSP within each year.

Figure 19. GDP Projections with Lower Bound



Chapter 21 Appendix L

Inflation

We used ARIMA modeling in R for stationary, non-seasonal data to find projected inflation up to one hundred years in the future.

R code:

```
Inflation = Inflation_Data

inflation_ts = ts(Inflation$Inflation, start = 1962, end = 2021, frequency = 1)

acfinf = acf(inflation_ts)

autoarimainf = auto.arima(inflation_ts, stationary = TRUE, seasonal = FALSE, ic =
"aic")

predinf = predict(autoarimainf, n.ahead = 100)
```

Chapter 22 Appendix M

Voluntary Program Annuities

Table 24. Region 1 Annuity Benefit

	SSP1	SSP2	SSP3	SSP5
PV of Total Cost Small Benefit	2,601,468,013.20	978,815,267.55	1,434,742,651.31	2,848,494,412.88
PV of Total Cost over Time Medium Benefit	4,691,073,060.65	1,765,039,550.62	2,587,186,375.68	5,136,521,124.17
PV of Total Cost over Time Large Benefit	6,834,777,481.60	2,571,618,991.80	3,769,466,591.67	7,483,784,298.25
Average Annual PV of Cost Small Benefit	26,014,680.13	9,788,152.68	14,347,426.51	28,484,944.13

Average Annual PV of Cost Medium Benefit	46,910,730.61	17,650,395.51	25,871,863.76	51,365,211.24
Average Annual PV of Cost Large Benefit	68,347,774.82	25,716,189.92	37,694,665.92	74,837,842.98

	Small	**Medium**	**Large**
Percentage of Living Cost	0.2	0.35	0.5
Annuity	597.2	1045.1	1493
Months	60	60	60
Interest	0.0025	0.003	0.0035
Annuity PV	38,607.02	68,591.59	99,487.47
Lump Sum Percent	0.02	0.04	0.06
Lump Sum Value	5,215	10,431	15,646

Table 25. Region 3 Annuity Benefit

	SSP1	**SSP2**	**SSP3**	**SSP5**
PV of Total Cost Small Benefit	11,757,109,202.42	6,527,795,728.83	13,130,745,053.44	8,966,823,686.21
PV of Total Cost over	21,153,415,242.28	11,744,823,603.43	23,624,863,712.15	16,133,127,758.98

Time Medium Benefit				
PV of Total Cost over Time Large Benefit	30,799,237,228.00	17,100,388,009.22	34,397,650,384.86	23,489,730,778.09
Average Annual PV of Cost Small Benefit	117,571,092.02	65,277,957.29	131,307,450.53	89,668,236.86
Average Annual PV of Cost Medium Benefit	211,534,152.42	117,448,236.03	236,248,637.12	161,331,277.59
Average Annual PV of Cost Large Benefit	307,992,372.28	171,003,880.09	343,976,503.85	234,897,307.78

	Small	**Medium**	**Large**
Percentage of Living Cost	0.2	0.35	0.5
Annuity	609.8	1067.15	1524.5
Months	60	60	60
Interest	0.0025	0.003	0.0035
Annuity PV	39,421.57	70,038.76	101,586.50
Lump Sum Percent	0.02	0.04	0.06

Lump Sum Value	4,425	8,851	13,276

Table 26. Region 6 Annuity Benefit

	SSP1	SSP2	SSP3	SSP5
PV of Total Cost Small Benefit	25,575,368,979.17	26,306,593,908.32	17,893,122,807.84	36,686,262,002.27
PV of Total Cost over Time Medium Benefit	46,025,243,100.09	47,341,150,024.14	32,200,330,236.54	66,020,323,243.95
PV of Total Cost over Time Large Benefit	67,016,836,546.80	68,932,913,753.57	46,886,537,101.44	96,131,446,866.79
Average Annual PV of Cost Small Benefit	255,753,689.79	263,065,939.08	178,931,228.08	366,862,620.02
Average Annual PV of Cost Medium Benefit	460,252,431.00	473,411,500.24	322,003,302.37	660,203,232.44
Average Annual PV of Cost Large Benefit	670,168,365.47	689,329,137.54	468,865,371.01	961,314,468.67

	Small	Medium	Large
Percentage of Living Cost	0.2	0.35	0.5
Annuity	473.6	828.8	1184
Months	60	60	60
Interest	0.0025	0.003	0.0035
Annuity PV	30,616.68	54,395.47	78,896.96

Lump Sum Percent	0.02	0.04	0.06
Lump Sum Value	3,503	7,007	10,510

Chapter 23 Appendix N

Likelihood and Severity Risk Matrix

We also ranked the quantifiable risks based on the likelihood and severity risk matrix. Unpredictable catastrophic events risk has the highest severity since it has the potential to cause considerable damage to property and infrastructure, as well as loss of life. The likelihood of such an event is difficult to predict accurately, but we consider its likelihood high because the risk is increasing due to climate change and catastrophic events occurring more frequently. As a result, we ranked the risk of unpredictable events as high (9). The impact of insufficient funding could be high if it leads to inadequate coverage or benefits for individuals affected by catastrophic events. The likelihood of the risk is moderate because it depends on many factors, such as the availability of resources, and the likelihood can be estimated based on the size of the diversity and local economy. Therefore, we ranked the risk as medium (6). The impact of adverse selection could be moderate because it may result in a higher risk pool, which could increase the overall cost of the program. The likelihood is medium because it may depend on factors such as individual behavior and outreach behaviors. Therefore, the risk is identified as medium (4). We found the risk of implementation as low (2) since it is a common risk associated with any large-scale program implementation. The likelihood is medium, and it depends on the complexity and effectiveness of the program. The severity is minimal with potential for minor delays or technical difficulties. The risk of demographic trend is low (2) with low likelihood and medium severity.

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ACADEMIC VITA

BRADY PAINTER

EDUCATION

Bachelor of Science in Actuarial Science University Park, PA
Minor in Statistics and Mathematics Graduation Date: May 2023
Pennsylvania State University
Schreyer Honors College

ACTUARIAL EXAMS

Exam IFM - Investment & Financial Markets (Passed) July 2022
Exam FM - Financial Mathematics (Passed) August 2021
Exam P - Probability (Passed) July 2020
VEE Mathematical Statistics Credit (Earned) May 2021
VEE Accounting and Finance Credit (Earned) December 2021
VEE Economics Credit (Earned) May 2020

EXPERIENCE

P&C Actuarial Advisory Intern Philadelphia, PA
KPMG June 2022 - August 2022

- Investigate frequency and severity models, ultimate tables, and data triangles to predict future reserving requirements
- Apply statistical processes such as weighted averaging and Bornhuetter-Ferguson methods to identify trends in data
- Received training on P&C insurance, capital modeling, Power BI, Klass, and Alteryx to build industry knowledge
- Conduct research on captive insurance to compose a white paper on the benefits of actuarial analysis in managing captives

Finance Intern Hershey, PA
Hershey Entertainment and Resorts May 2021 - August 2021

- Organized around $5,000 in physical currency daily and documented all physical currency earned by the firm
- Delivered personal insight on cash flow management and studied how financial statements were used to make decisions

Insurance Intern Hershey, PA
Advanced Insurance Solutions May 2020 - August 2020

- Shadowed employees to better understand a real work environment and the insurance industry
- Executed tasks through Excel and Applied Epic to organize client policies and simplify business operations
- Coordinated a marketing campaign that included give-a-way raffles to engage clients in the company's 20th year anniversary

INVOLVEMENT/LEADERSHIP

Penn State Actuarial Science Club University Park, PA
Former Director of Technology August 2020 - Present

- Graduated from the Actuarial Science Boot Camp during the fall of 2020 by performing various career-preparing assignments
- Administered technical workshops for club members and oversaw technical operations as the Director of Technology
- Compiled the Penn State Actuarial Science Club Resume Book monthly for over 400 recruiters seeking Penn State students

Phi Chi Theta Business Fraternity University Park, PA
Fundraising Chair February 2020 - Present

- Earned acceptance into the business fraternity as 1 of 30 students accepted out of the 150 students that attempted
- Arrange fundraising events such as raffles and restaurant fundraisers to earn money for the organization and THON
- Compete in member-wide case competitions that are issued by real companies and apply to real business situations

OPP THON Committee University Park, PA
Supply Master September 2019 - Present

- Set up event and manage supplies for the 46-hour dance marathon that raises funds for children with pediatric cancer
- Pursue fundraising efforts that contribute towards the roughly $10 million in funds raised every year
- Ensure all THON supplies are in proper quantities and organized correctly in the Bryce Jordan Center as Supply Master

HONORS/SKILLS AND INTERESTS

- **Honors:** Phi Eta Sigma Honors Society, President's Freshman Award, Beta Gamma Sigma Business Honors Society
- **Computer:** Advanced with Excel, PowerPoint, and Word; Experience with VBA, SAS, Alteryx, and R programming
- **Economics/Investments:** Proficient knowledge in micro and macroeconomics as well as stocks, bonds, and derivatives
- **Language:** Proficient with Spanish language and culture through 7 years of Spanish coursework
- **Interests:** Pickup sports, exercising, golf, traveling, math, and spending time with friends and family