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DEPARTMENT OF RISK MANAGEMENT

SAFEGUARDING STORSLYSIA: A NATIONWIDE SOCIAL INSURANCE
PROGRAM FOR CLIMATE-RELATED DISPLACEMENT

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ABSTRACT

This thesis analyzes the effect of severe weather events on 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 100 years with great certainty. We plan to provide financial relief toward displacement costs for victims of involuntary relocation and to offer benefits to citizens that choose to voluntarily relocate out of higher-risk regions to lower-risk regions. This will be done through the use of annuities and lump sum payments which will be handled on a per claim basis.

Since many of the lower-risk regions maintain higher economic status, the benefits to voluntary relocators will cover economic pressures and reduce relocation costs. 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.

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Chapter 1

Introduction

The Society of Actuary (SOA) Research Institute Student Research Case Study Challenge is an annual case competition that provides college students a platform to apply their actuarial skills and solve real-world problems in a business setting. The competition requires two to five students to conduct an actuarial analysis based on a given case study situation, formulate solutions, and present recommendations in a report. Our team representing Pennsylvania State University participated in this year's case competition regarding a case of designing a social insurance program for relocation to help Storslysia manage its exposure to displacement risks caused by catastrophic climate events.

Case Overview

Climate change is a global phenomenon that attracts more and more people's attention. It is causing significant disruptions to ecosystems, weather patterns, and human societies. The severe destructive and frequent occurrence of natural disasters has always been a problem for mankind. This phenomenon has been exacerbated by climate change over the years. Hurricanes, floods, wildfires, and other natural disasters associated with climate change have caused the destruction of millions of homes and hundreds of millions of dollars in economic losses. In addition to the physical damage to people's property, natural disasters have also severely damaged people's mental health and resulted in more social unrest.

Storslysia, a fictitious country by the case, has been acutely threatened by the impact of climate-related catastrophes, especially for people living in high-risk regions. In order to prevent both property and psychological damage, there is an immediate need for a proactive social insurance program to help these residents evacuate high-risk areas before a disaster strikes. In the thesis, we will provide a comprehensive program design, including pricing and cost projections, assumptions, and risk mitigation strategies. The purpose of our program is to provide an appropriate and effective solution to help people at risk of being displaced in this area. By reducing property and emotional damage to residents and avoiding more injuries and deaths in the future, we will help people achieve a higher sense of well-being and a better life, while also making Storslysia's financial and social development healthier.

Literature Review

To ensure that teams have a clear understanding of the case competition's requirements, it is important to conduct a literature review of previous years case studies. Through the previous years' cases, we can have a preview of the case settings and different types of real-world problems. Meanwhile, we can learn from their approaches to their case solutions and identify some potential data analysis methods and models that can be used. We also compare the strengths and weaknesses of previous years reports to develop a better solution strategy. The literature review provides us valuable insights and helps our team develop an effective approach to the current case study.

In the literature review, I mainly focused on the case review of the winning team and comparisons between the top three submissions in 2019's case study to design an autonomous

vehicle insurance policy. In addition, analysis, suggestions and expansions of other team's ideas and strategies will be provided.

2019 Case Overview

In 2019's case study, Safelife is an insurance company selling personal and commercial automobile insurance policies in Carbia. With the current rapid development trend of the autonomous vehicle, the society is moving towards a new mobility ecosystem. Safelife anticipates that the current automobile insurance market may eventually decrease with future public adoption of autonomous vehicles. However, as autonomous vehicles become more popular, the government regulations and guidelines are expected to be developed, and new insurance products for autonomous vehicles are expected to be created. Safelife, as the leader of the automobile insurance industry, believes that being the first to design an insurance policy for autonomous vehicle owners could create a first-mover advantage. Effectively launching the new product and policy for the autonomous vehicle will have a revolutionary impact on the economy of Carbia and have a tremendous change in the universal approach to auto insurance.

In this case study, it is necessary to analyze the insurability of the autonomous vehicles and take considerations of potential risks and some other necessary factors. With the revolutionary changes in the auto insurance industry and the inception of autonomous vehicles, significant exposures occur and new risks emerge. Also, a design with a launch date for a new autonomous vehicle insurance policy is recommended, and a ten-year forecast of the loss cost estimates, also known as pure premiums, for the new policy is required. The development of the autonomous vehicle technology in the next decade will fundamentally transform the auto industry and the auto

insurance industry. A sensitivity analysis on management's goal that the new policy account for 20 to 25 percent of overall business by the year 2030 will also be provided.

Comparison and Reflection

In the autonomous policy section, the winning's team did thorough research and used the widely accepted SAE International's Level of Driving Automation to provide a clear and concise framework for defining the autonomous vehicles. They divided driving automation into six levels, starting from level 0 to level 5, and condensed these levels into three different groups. Then, the winning team used this framework to propose a two-fold approach for incorporating autonomous vehicles into Safelife's insurance policy, including a new policy exclusively for fully autonomous vehicles and a discounted policy for semi-autonomous vehicles. They also provided specific policy characteristics for each type of vehicle and offered a practical solution for Safelife to adapt to the emerging technology of autonomous vehicles. The winning team also considered the potential risks and limitations of autonomous vehicles and provided the impact and recommendations accordingly. They identified the most significant new concern of the risks and provided the competitive analysis to develop rates for the coverages. The report provided a comprehensive analysis of the potential sources of liability and highlighted the regulations in several countries. They assumed that the liability regulations of Carbia will be similar to those in other countries, then they provided a clear framework for Safelife's liability exposure and adjusted their pricing plan accordingly. They also provided extended analysis in the Appendix to further demonstrate the thoroughness and details to this issue.

In the new risks and liability part, the winning team mentioned that the autonomous systems are vulnerable under cyberattacks and it is easy to be hacked by malicious factors. It is

also mentioned by other teams that this problem will lead to severe criminal activities carried by hackers. In view of this problem, I think we can design some provisions related to cybersecurity risk to effectively determine which party takes the responsibility. The second-place team divided people pondering on purchasing an autonomous vehicle into three groups: early adopters (young tech lovers and wealth groups), disabled or handicapped people, and seniors. I think they could expand more on this. For example, they could make suggestions on the ways to modify policy for different populations. Additionally, Carbia is a primarily urban and suburban country with very few rural areas, and it has been observed that the earliest AVs are luxury cars and commercial fleets. They are used in highly “covered metropolitan” areas with extensive highways and well-mapped streets. Due to this situation, all of the first three teams are mentioned that Autonomous vehicles will infiltrate the personal auto and commercial auto markets. As a result, both the personal and commercial coverages are needed. For the second-place team, in the liability coverage session, they mainly focused on different types of injuries.

In the policy implementation strategy section, the winning team clearly identified their target audience and provided a timeline for the adoption of autonomous vehicles in the next decade. They also provided valuable insights on how to design their rating plans and highlighted the necessity of updating the regulations that could impact their premiums. This will create a competitive advantage to their policy design. Moreover, they used different graphs, such as bar chart, pie chart, and line chart, which organized the data in a structured way and gave a better visualization to help the audience understand the data easily.

In the sensitivity analysis section, the winning team provided a comprehensive analysis of Safelife’s goals and offered feasible recommendations to achieve them based on their findings. By identifying assumptions and limitations of the data, the report offered a realistic projection. They

also highlighted areas to improvement and offered tailored recommendations to alter Safelife's goal and to decrease pure premiums.

In the data limitations and assumptions section, the winning team acknowledged the limitations of the data used for analysis and they listed all the corresponding assumptions and justifications to address these limitations. The table provided by the winner's team was comprehensive and was transparent about its methodology. It can help the readers understand the potential uncertainties and biases in the analysis. If the winning team could expand more analysis on the justifications and the corresponding effects of the data limitations, the report will be more creditable and help the readers to make informed decisions. Also, the data provided by Safelife only included the ten years of Safelife claims data history for existing personal and commercial automobile policies. The results of its data analysis cannot stand for the whole automobile market. Although the winner's team assumed that proportions of data from the US analyzed were representative of proportions in Carbia, external data resources could also be used to make calculations and predictions and compare with the results from the data by Safelife. The second team made an important contribution by highlighting a viewpoint that is often overlooked when consider data limitations. They pointed out that the arbitrary factors such as natural disaster cannot captured by time series modeling. Additionally, ethical critiques regarding self-driving car and determining liability for car incidents were primary concerns for personal auto claims.

Overall, the winning team's report has several advantages, including the use of an organized table to generate and present important information clearly and effectively. It makes the information much easier to be viewed by the audience. Additionally, their unique and comprehensive thoughts and ideas of the winning team were supported by extensive justification, supporting calculations, and alternative considerations. The winning team included several

assumptions and complex estimates in the appendices and Excel workbooks, with the main report focusing on the conclusions, limitations, and their impacts on Safelife. Other teams also came up with a lot of good ideas, but they could have expanded on their analysis and made more suggestions accordingly to improve their reports.

Reflecting on my experience of conducting this literature review, I have come to appreciate the importance of planning and organization. When working on our own case project, we will conduct thorough research to determine the current market situation and propose solutions for both the present and future. The advantage of the winning team is not only to generate good solutions and analysis, but also to consider multiple perspectives and raise questions and suggestions accordingly. We will use various models and analytical methods, presenting them in different ways and providing supporting evidence to compare their pros and cons. This will enable us to determine and select the best model for the policy design.

As a student with limited working experience in the actuarial industry, I haven't had much exposure to real-world actuarial problems. Participating in the SOA's student case study challenge provides a valuable opportunity to gain hands-on experience in identifying issues and presenting my analysis. The symbiotic relationship of mathematics and computing led me to research pathways blending into the two disciplines to evolve more powerful outcomes. Although I haven't figured out my interest in either life insurance or property and causality insurance, through the research, I found that my interest in the non-traditional side of actuarial science has grown, particularly in combining it with data science. At this point, more and more organizations in various industries, such as technology, commerce, and healthcare, are becoming data-driven, and there is no doubt that data science will continue to make innovative progress in our lives.

The case study helps me to gain essential strategic and adaptive reasoning in the study of statistics and actuarial science. The integration of mathematics with computing widened the scope of problems that I am able to solve and facilitated challenging yet interesting opportunities to arise. This case study has instilled a passion in me to explore computing specializations like Algorithms and Data Structures. Within the consideration of my future career planning, I would like to go to a graduate school to learn more in the field of Data Science, combining aspects of statistics, mathematics, and programming to address real problems. Also, I look forward to working at an insurance company where I can design advanced algorithms and models with my acquired knowledge and expertise in both Actuarial Science and Data Science.

Chapter 2 Methodologies

Below, Table 1 provides a summary of the methodologies used to design the program.

Additional details can be found in the appendices.

Table 1. Methodologies

Methodology	Application	Support	Justification
ARIMA Model	Future Annual Inflation	Appendix A	Previous inflation data appeared to follow stationary time series trends
Frequency Projection Model	Future Weather Events	Appendix B	Model was provided to the team to for this purpose
Multiple Linear Regression	Population, GDP, & Average Annual Property Damage Forecasting	Appendix C, Appendix H, & Appendix J	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 G	A useful way to forecast population movement

Chapter 3

Program Design

Key Metrics & Timeframe

To assess the effectiveness of our program, our team established a plan to monitor 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 in order 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 be adjusted 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 determine 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 these do not significantly change year-to-year so every 3-to-5 year would provide more information to get a more accurate assessment.

2. **Total Property Damage:** Reported yearly. Appendix C contains a graph and table with these expected values with and without implementing the program in current day (P). 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 greatly 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 G.
4. **Program Costs and GDP:** Reported Yearly. Program costs should be well under 10% of GPA yearly as shown in Appendix J. There will be some 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 relocate proactively and help those forced to relocate after a weather event. The citizens of Storslysia can receive these benefits by filing a claim, which will be looked at 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 relocater or an involuntary relocater.

A voluntary relocater is someone looking to move from a hazardous area to a safer area before a weather event affects them. They will be given a financial benefit to help cover increased economic and housing costs. To receive this benefit, they must move prior to being affected by a weather event. An involuntary relocater is a victim of a natural disaster that has no choice but to move. They are considered 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 determined by a claims adjuster. Involuntary relocators will have a portion 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 impacted 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. It was found that the desirable regions were 6, 3, and 1 while the undesirable regions were 2, 4, and 5 (Appendix E). 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 developed Table 2 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 2. Voluntary Relocation Benefit 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 be made up of 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 appendix G.

Involuntary Relocation

A person is considered displaced from their house when the cost of repairing the damages of a natural disaster exceeds the book value of the house, which is to be determined 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 we are not given 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 is designed to cover different portions of relocation costs based on where the citizens are relocating as per Table 3. Additionally, citizens choosing to remain in the same region will still receive these benefits even if they choose to stay in those regions.

Table 3. 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 fails to exceed the book value of the house, a citizen will still have a portion 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 4

Pricing and Costs 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 are expected to 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 amount of people we project to accept these benefits as seen in Table 4.

Table 4. 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
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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 100 years as shown in Table 5.

Table 5. 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 much lower cost in earlier years and larger costs in later years as future generations begin to adopt the program more frequently according to our projections. The annual average over the 100 years is shown in Table 6 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 6. 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 7.

Table 7. 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 (₪)	3,894,934,230.8 0	3,892,025,072.3 0	3,138,995,672.5 4	4,760,396,694.8 7

These actual costs will be higher in early years and lower in later years as people begin to relocate 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 largely consistent year-to year because as involuntary costs decrease from relocation, voluntary costs should be increasing from the increased movement of people within the 100 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. More information can be found in Appendices C, D, and L.

Chapter 5

Risk Mitigation Strategies

Quantitative and Qualitative Risks

As the new program is implemented, potential risks and unforeseen events may rise 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 8 and 10.

Table 8. Quantifiable Risks

Risks	Description	Impact	Risk Mitigation
1 Unpredictable Catastrophe Events	Catastrophe events occurring more frequently or with a 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	Identify and secure funding from multiple resources, Explore more opportunities for cost-sharing with other stakeholders
3 Adverse Selection	Individuals are more likely to be affected by catastrophe or have higher risks of displacement	Lead to an imbalance in risk pool and a higher premium for other participants	Develop comprehensive eligibility criteria to ensure the risk pool is balanced. Continuous

			monitoring and evaluation
4 Implementation Risks	Delays in program rollout or technical issues in data collection and management systems	Inadequate coverage or delayed benefit payments	Monitor and evaluate the implementation risks regularly and modify the implementation plan accordingly
5 Unpredicted Demographic Trends	Demographic trends such as population growth and aging are unpredictable	Affect the demand for relocation assistance and the potential costs of displacement	Focus on developing contingency plans for 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 9), we identify 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.

Table 9. 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

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 identify its likelihood as 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 several 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 identified 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.

On top of quantifiable risks above, our team also identified possible qualitative risks and the risk mitigation plans in Table 10.

Table 10. Qualitative Risks

Risks	Description	Impact	Risk Mitigation
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1 Imperfect incentives for relocation	Incentives provided are insufficient or too high	Insufficient incentive will discourage voluntary relocation, high incentives will lead to overcrowding and increase risks in those regions	Offer attractive incentives depending on the needs and preference of the population in a specific region. Publicize and market to potential participations to increase awareness
2 Increasing risk of inequality	New policy may unintentionally exacerbate existing inequalities or create new ones	The inequalities may cause uneven participation and may further exacerbate economic disparities	Regularly monitor 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 due to various factors. To account for any potential fluctuations, we conducted a sensitivity analysis to determine how these changes will impact 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. Our assumptions of ranges are shown in Appendix E. 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 over time. While the initial costs will be high, the program will ultimately save Storslysia money over the next 100 years.

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

Table 11. Sensitivity Test Assumptions

		Worst Case	Baseline	Best Case
All Region	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%
All Region	material and housing cost increase after weather events	50.0%	35.0%	5.0%

The tables below show the scenario analysis on the percentage change of the relocation cost with and without the implementation of our program in the worst and best case. The worst-best case column indicates how the relocation cost savings will still be positive despite the worst-case scenario.

Table 12. Percentage Change of the Relocation Cost for Worst Case Scenario

Worst Case (% Change)

	Storslysia 1	Storslysia 2	Storslysia 3	Storslysia 5
2020	-0.03118	-0.03118	-0.03118	-0.03118
2021	-0.03231	-0.02922	-0.03541	-0.02555
2022	-0.03228	-0.02989	-0.03452	-0.02721
2023	-0.03226	-0.03051	-0.03368	-0.02872
2024	-0.03223	-0.03108	-0.03291	-0.0301
2025	-0.03221	-0.03159	-0.0322	-0.03134
2026	-0.03219	-0.03207	-0.03155	-0.03246
2027	-0.03218	-0.0325	-0.03096	-0.03347
2028	-0.03217	-0.03288	-0.03042	-0.03437
2029	-0.03216	-0.03323	-0.02994	-0.03517
2030	-0.03216	-0.03355	-0.02951	-0.03587

Table 13. Percentage Change of the Relocation Cost for Best Case Scenario

Best Case (% Change)				
	Storslysia 1	Storslysia 2	Storslysia 3	Storslysia 5
2020	-0.14332	-0.14332	-0.14332	-0.14332
2021	-0.12494	-0.12223	-0.12819	-0.11772
2022	-0.12512	-0.12301	-0.12742	-0.11974
2023	-0.12528	-0.12371	-0.12671	-0.12157
2024	-0.12543	-0.12436	-0.12605	-0.12323

2025	-0.12556	-0.12496	-0.12545	-0.12474
2026	-0.12569	-0.1255	-0.1249	-0.12609
2027	-0.1258	-0.12599	-0.1244	-0.12731
2028	-0.12591	-0.12644	-0.12395	-0.12839
2029	-0.12601	-0.12684	-0.12355	-0.12934
2030	-0.12611	-0.1272	-0.1232	-0.13018

Table 14. Difference of Percentage Change of the Relocation Cost Between Worst- and Best-Case Scenario

Worst - Best Case (% Change)				
	Storslysia 1	Storslysia 2	Storslysia 3	Storslysia 5
2020	0.143323	2020.143323	-0.143323	-2020.143323
2021	0.128190	2021.117723	-0.124938	-2021.122233
2022	0.127422	2022.119736	-0.125116	-2022.123005
2023	0.126710	2023.121570	-0.125277	-2023.123715
2024	0.126052	2024.123234	-0.125426	-2024.124365
2025	0.125447	2025.124739	-0.125562	-2025.124959
2026	0.124895	2026.126094	-0.125687	-2026.125500
2027	0.124396	2027.127307	-0.125803	-2027.125992
2028	0.123947	2028.128387	-0.125912	-2028.126438
2029	0.123549	2029.129343	-0.126014	-2029.126840
2030	0.123201	2030.130182	-0.126112	-2030.127203

Table 15 shows the baseline percentage 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 that the sensitivity analysis is effective in this case.

Table 15. Percentage Change of the Relocation Cost for Baseline

baseline (% change)			
Storslysia 1	Storslysia 2	Storslysia 3	Storslysia 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 6

Assumptions

- ❖ **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 being affected by a weather event.
- ❖ **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.
- ❖ **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 be provided to residential property owners and not commercial property owners.
- ❖ **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.
- ❖ **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.
- ❖ **35% Increase in Supplies & Labor After a Weather Event:** This value was within the range given.
- ❖ **2003 Inflation Figure Was Incorrect:** The 2003 inflation figure was impossibly large and was adjusted to a more appropriate value based on a 3-year prior average.

- ❖ **Persons Per Household is Constant:** We assume there will not be a serious change in the average number of people per household over the next 100 years so we can use population projections to predict the number of households.
- ❖ **Property Damage Does Not Include Household Goods:** Household goods are not included in the property damage figure and must be accounted for elsewhere.
- ❖ **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 7

Data Limitations

- ❖ **No Prior Emissions Data:** There was no indication which SSP Storslysia currently follows or is heading. Since each SSP affects many critical factors and varies greatly in the long term, it made it difficult to create a single baseline model.
- ❖ **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.
- ❖ **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.
- ❖ **Number of Properties Damaged is Unknown:** When determining involuntary relocation, we had to assume how many households would be affected since it was not included in the hazard data set.

Chapter 8

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.

Appendices

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)
```

Appendix B: Weather Events

Weather events were first calculated by region using the model given. The outputs were then summed together for all Storslysia. Those tables are below.

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

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

Appendix C: Property Damage

The average property damage for each severity level was found for all historical events. However, to more accurately account for large catastrophes, the Major grouping was instead calculated using a 1-in-3-year estimate 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 shown below.

	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

Using the adjusted average property damage for each severity level, the estimated number of weather events from Appendix (B), and the projected trends in population from Appendix (H), our team was able to predict the average annual property damage for the coming 100 years based on the 4 different scenarios. These values are listed below.

	SSP1	SSP2	SSP3	SSP5
2020	\$ 658,781,706.79	\$ 637,781,691.43	\$ 626,987,702.76	\$ 723,594,862.55
2021	\$ 667,406,810.22	\$ 650,519,669.50	\$ 638,465,415.76	\$ 723,112,024.62
2022	\$ 675,924,062.44	\$ 663,118,954.05	\$ 649,875,321.84	\$ 723,762,775.78
2023	\$ 684,329,694.15	\$ 675,575,253.16	\$ 661,214,771.19	\$ 725,584,240.27
2024	\$ 692,619,955.34	\$ 687,884,395.22	\$ 672,481,102.97	\$ 728,612,438.34
2025	\$ 700,791,117.51	\$ 700,042,325.69	\$ 683,671,644.30	\$ 732,882,323.96
2026	\$ 708,839,475.72	\$ 712,045,104.10	\$ 694,783,709.21	\$ 738,427,820.58

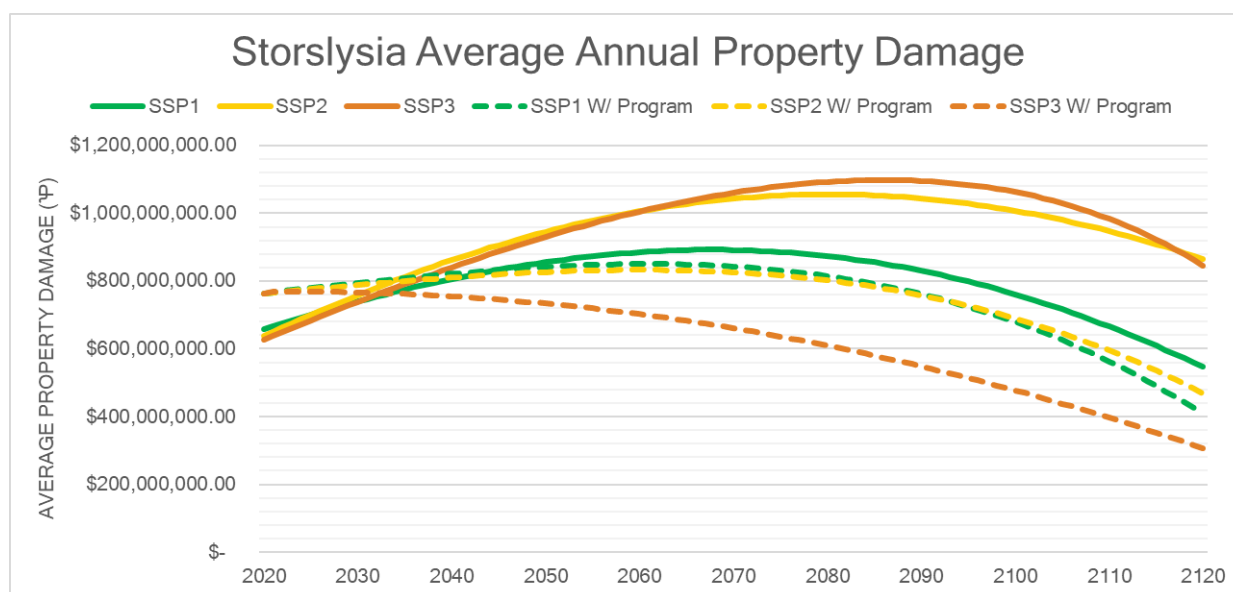
2027	\$ 716,761,350.53	\$ 723,888,901.11	\$ 705,814,597.60	\$ 745,281,855.33
2028	\$ 724,553,089.87	\$ 735,569,995.74	\$ 716,761,594.24	\$ 753,476,391.42
2029	\$ 732,211,070.86	\$ 747,084,772.71	\$ 727,621,967.63	\$ 763,042,459.12
2030	\$ 739,731,701.46	\$ 758,429,719.88	\$ 738,392,968.94	\$ 774,010,185.27
2031	\$ 747,111,422.07	\$ 769,601,425.77	\$ 749,071,830.94	\$ 786,408,821.42
2032	\$ 754,346,707.10	\$ 780,596,577.29	\$ 759,655,766.82	\$ 800,266,770.65
2033	\$ 761,434,066.38	\$ 791,411,957.42	\$ 770,141,969.10	\$ 815,611,613.19
2034	\$ 768,370,046.56	\$ 802,044,443.09	\$ 780,527,608.42	\$ 832,470,130.96
2035	\$ 775,151,232.39	\$ 812,491,003.13	\$ 790,809,832.39	\$ 850,868,330.88
2036	\$ 781,774,248.02	\$ 822,748,696.30	\$ 800,985,764.35	\$ 870,831,467.27
2037	\$ 788,235,758.13	\$ 832,814,669.34	\$ 811,052,502.14	\$ 892,384,063.19
2038	\$ 794,532,469.06	\$ 842,686,155.25	\$ 821,007,116.86	\$ 915,549,930.92
2039	\$ 800,661,129.92	\$ 852,360,471.46	\$ 830,846,651.52	\$ 940,352,191.51
2040	\$ 806,618,533.54	\$ 861,835,018.24	\$ 840,568,119.76	\$ 966,813,293.51
2041	\$ 812,401,517.48	\$ 871,107,277.05	\$ 850,168,504.48	\$ 994,955,030.91
2042	\$ 818,006,964.96	\$ 880,174,809.07	\$ 859,644,756.44	\$ 1,024,798,560.34
2043	\$ 823,431,805.69	\$ 889,035,253.66	\$ 868,993,792.85	\$ 1,056,364,417.52
2044	\$ 828,673,016.73	\$ 897,686,327.05	\$ 878,212,495.85	\$ 1,089,672,533.07
2045	\$ 833,727,623.30	\$ 906,125,820.93	\$ 887,297,711.08	\$ 1,124,742,247.63
2046	\$ 838,592,699.53	\$ 914,351,601.20	\$ 896,246,246.08	\$ 1,161,592,326.40
2047	\$ 843,265,369.15	\$ 922,361,606.75	\$ 905,054,868.69	\$ 1,200,240,973.07
2048	\$ 847,742,806.27	\$ 930,153,848.25	\$ 913,720,305.44	\$ 1,240,705,843.21
2049	\$ 852,022,235.96	\$ 937,726,407.08	\$ 922,239,239.85	\$ 1,283,004,057.07
2050	\$ 856,100,934.98	\$ 945,077,434.21	\$ 930,608,310.67	\$ 1,327,152,211.99
2051	\$ 859,976,232.30	\$ 952,205,149.22	\$ 938,824,110.11	\$ 1,373,166,394.16
2052	\$ 863,645,509.81	\$ 959,107,839.29	\$ 946,883,181.96	\$ 1,421,062,190.05
2053	\$ 867,106,202.82	\$ 965,783,858.30	\$ 954,782,019.68	\$ 1,470,854,697.35
2054	\$ 870,355,800.64	\$ 972,231,625.93	\$ 962,517,064.46	\$ 1,522,558,535.46
2055	\$ 873,391,847.15	\$ 978,449,626.81	\$ 970,084,703.12	\$ 1,576,187,855.61
2056	\$ 876,211,941.32	\$ 984,436,409.74	\$ 977,481,266.02	\$ 1,631,756,350.58
2057	\$ 878,813,737.73	\$ 990,190,586.90	\$ 984,703,024.89	\$ 1,689,277,264.05

2058	\$ 881,194,947.10	\$ 995,710,833.15	\$ 991,746,190.53	\$ 1,748,763,399.58
2059	\$ 883,353,336.78	\$ 1,000,995,885.37	\$ 998,606,910.48	\$ 1,810,227,129.28
2060	\$ 885,286,731.27	\$ 1,006,044,541.76	\$ 1,005,281,266.60	\$ 1,873,680,402.09
2061	\$ 886,993,012.70	\$ 1,010,855,661.27	\$ 1,011,765,272.51	\$ 1,939,134,751.88
2062	\$ 888,470,121.35	\$ 1,015,428,163.01	\$ 1,018,054,871.03	\$ 2,006,601,305.03
2063	\$ 889,716,056.14	\$ 1,019,761,025.73	\$ 1,024,145,931.38	\$ 2,076,090,787.98
2064	\$ 890,728,875.11	\$ 1,023,853,287.31	\$ 1,030,034,246.43	\$ 2,147,613,534.29
2065	\$ 891,506,695.94	\$ 1,027,704,044.26	\$ 1,035,715,529.74	\$ 2,221,179,491.54
2066	\$ 892,047,696.48	\$ 1,031,312,451.34	\$ 1,041,185,412.48	\$ 2,296,798,227.97
2067	\$ 892,350,115.21	\$ 1,034,677,721.09	\$ 1,046,439,440.32	\$ 2,374,478,938.82
2068	\$ 892,412,251.84	\$ 1,037,799,123.52	\$ 1,051,473,070.05	\$ 2,454,230,452.49
2069	\$ 892,232,467.75	\$ 1,040,675,985.70	\$ 1,056,281,666.19	\$ 2,536,061,236.46
2070	\$ 891,809,186.63	\$ 1,043,307,691.53	\$ 1,060,860,497.39	\$ 2,619,979,402.95
2071	\$ 891,140,894.97	\$ 1,045,693,681.37	\$ 1,065,204,732.70	\$ 2,705,992,714.44
2072	\$ 890,226,142.68	\$ 1,047,833,451.88	\$ 1,069,309,437.65	\$ 2,794,108,588.89
2073	\$ 889,063,543.67	\$ 1,049,726,555.71	\$ 1,073,169,570.22	\$ 2,884,334,104.88
2074	\$ 887,651,776.43	\$ 1,051,372,601.38	\$ 1,076,779,976.53	\$ 2,976,676,006.46
2075	\$ 885,989,584.71	\$ 1,052,771,253.09	\$ 1,080,135,386.47	\$ 3,071,140,707.85
2076	\$ 884,075,778.17	\$ 1,053,922,230.58	\$ 1,083,230,409.03	\$ 3,167,734,298.01
2077	\$ 881,909,233.01	\$ 1,054,825,309.04	\$ 1,086,059,527.45	\$ 3,266,462,544.97
2078	\$ 879,488,892.74	\$ 1,055,480,319.01	\$ 1,088,617,094.15	\$ 3,367,330,900.04
2079	\$ 876,813,768.87	\$ 1,055,887,146.38	\$ 1,090,897,325.43	\$ 3,470,344,501.81
2080	\$ 873,882,941.69	\$ 1,056,045,732.34	\$ 1,092,894,295.87	\$ 3,575,508,180.09
2081	\$ 870,695,561.07	\$ 1,055,956,073.39	\$ 1,094,601,932.55	\$ 3,682,826,459.58
2082	\$ 867,250,847.27	\$ 1,055,618,221.40	\$ 1,096,014,008.91	\$ 3,792,303,563.52
2083	\$ 863,548,091.84	\$ 1,055,032,283.65	\$ 1,097,124,138.33	\$ 3,903,943,417.07
2084	\$ 859,586,658.49	\$ 1,054,198,422.97	\$ 1,097,925,767.42	\$ 4,017,749,650.69
2085	\$ 855,365,984.05	\$ 1,053,116,857.83	\$ 1,098,412,168.93	\$ 4,133,725,603.27
2086	\$ 850,885,579.48	\$ 1,051,787,862.52	\$ 1,098,576,434.34	\$ 4,251,874,325.22
2087	\$ 846,145,030.87	\$ 1,050,211,767.32	\$ 1,098,411,466.02	\$ 4,372,198,581.35
2088	\$ 841,144,000.54	\$ 1,048,388,958.72	\$ 1,097,909,969.04	\$ 4,494,700,853.74

2089	\$ 835,882,228.18	\$ 1,046,319,879.71	\$ 1,097,064,442.51	\$ 4,619,383,344.40
2090	\$ 830,359,532.04	\$ 1,044,005,029.98	\$ 1,095,867,170.44	\$ 4,746,247,977.85
2091	\$ 824,575,810.14	\$ 1,041,444,966.30	\$ 1,094,310,212.17	\$ 4,875,296,403.60
2092	\$ 818,531,041.63	\$ 1,038,640,302.81	\$ 1,092,385,392.21	\$ 5,006,529,998.49
2093	\$ 812,225,288.11	\$ 1,035,591,711.44	\$ 1,090,084,289.55	\$ 5,139,949,868.98
2094	\$ 805,658,695.12	\$ 1,032,299,922.28	\$ 1,087,398,226.38	\$ 5,275,556,853.28
2095	\$ 798,831,493.56	\$ 1,028,765,724.02	\$ 1,084,318,256.13	\$ 5,413,351,523.42
2096	\$ 791,744,001.37	\$ 1,024,989,964.45	\$ 1,080,835,150.90	\$ 5,553,334,187.20
2097	\$ 784,396,625.09	\$ 1,020,973,550.96	\$ 1,076,939,388.03	\$ 5,695,504,890.07
2098	\$ 776,789,861.68	\$ 1,016,717,451.06	\$ 1,072,621,136.02	\$ 5,839,863,416.89
2099	\$ 768,924,300.30	\$ 1,012,222,692.97	\$ 1,067,870,239.52	\$ 5,986,409,293.62
2100	\$ 760,800,624.22	\$ 1,007,490,366.28	\$ 1,062,676,203.43	\$ 6,135,141,788.91
2101	\$ 752,419,612.87	\$ 1,002,521,622.54	\$ 1,057,028,176.07	\$ 6,286,059,915.62
2102	\$ 743,782,143.91	\$ 997,317,675.99	\$ 1,050,914,931.19	\$ 6,439,162,432.23
2103	\$ 734,889,195.50	\$ 991,879,804.30	\$ 1,044,324,849.01	\$ 6,594,447,844.21
2104	\$ 725,741,848.58	\$ 986,209,349.32	\$ 1,037,245,895.93	\$ 6,751,914,405.27
2105	\$ 716,341,289.34	\$ 980,307,717.93	\$ 1,029,665,602.97	\$ 6,911,560,118.51
2106	\$ 706,688,811.82	\$ 974,176,382.91	\$ 1,021,571,042.76	\$ 7,073,382,737.60
2107	\$ 696,785,820.55	\$ 967,816,883.79	\$ 1,012,948,805.11	\$ 7,237,379,767.73
2108	\$ 686,633,833.49	\$ 961,230,827.87	\$ 1,003,784,970.77	\$ 7,403,548,466.64
2109	\$ 676,234,484.93	\$ 954,419,891.21	\$ 994,065,083.55	\$ 7,571,885,845.44
2110	\$ 665,589,528.67	\$ 947,385,819.66	\$ 983,774,120.41	\$ 7,742,388,669.46
2111	\$ 654,700,841.35	\$ 940,130,430.01	\$ 972,896,459.49	\$ 7,915,053,458.99
2112	\$ 643,570,425.86	\$ 932,655,611.10	\$ 961,415,845.82	\$ 8,089,876,489.92
2113	\$ 632,200,415.07	\$ 924,963,325.08	\$ 949,315,354.60	\$ 8,266,853,794.36
2114	\$ 620,593,075.61	\$ 917,055,608.68	\$ 936,577,351.71	\$ 8,445,981,161.19
2115	\$ 608,750,811.95	\$ 908,934,574.53	\$ 923,183,451.35	\$ 8,627,254,136.50
2116	\$ 596,676,170.62	\$ 900,602,412.56	\$ 909,114,470.39	\$ 8,810,668,023.99
2117	\$ 584,371,844.69	\$ 892,061,391.48	\$ 894,350,379.22	\$ 8,996,217,885.34
2118	\$ 571,840,678.47	\$ 883,313,860.32	\$ 878,870,248.78	\$ 9,183,898,540.44
2119	\$ 559,085,672.42	\$ 874,362,250.01	\$ 862,652,193.35	\$ 9,373,704,567.62

2120	\$ 546,109,988.35	\$ 865,209,075.05	\$ 845,673,308.69	\$ 9,565,630,303.80
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The graph below shows how the average annual property damage for Storslysia is projected to change after the implementation of the program dependent on the SSP. SSP 5 is not included in the graph because its average annual property damage is almost 10 billion by 2120 while its average annual property damage more closely resembles those found in the graph.



If the relocation program is effective, Storslysia should see a significant decrease in property damage over time as the citizens relocate 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. The table below projects the total property damage for each shared socioeconomic pathway over a 100-year period in the future.

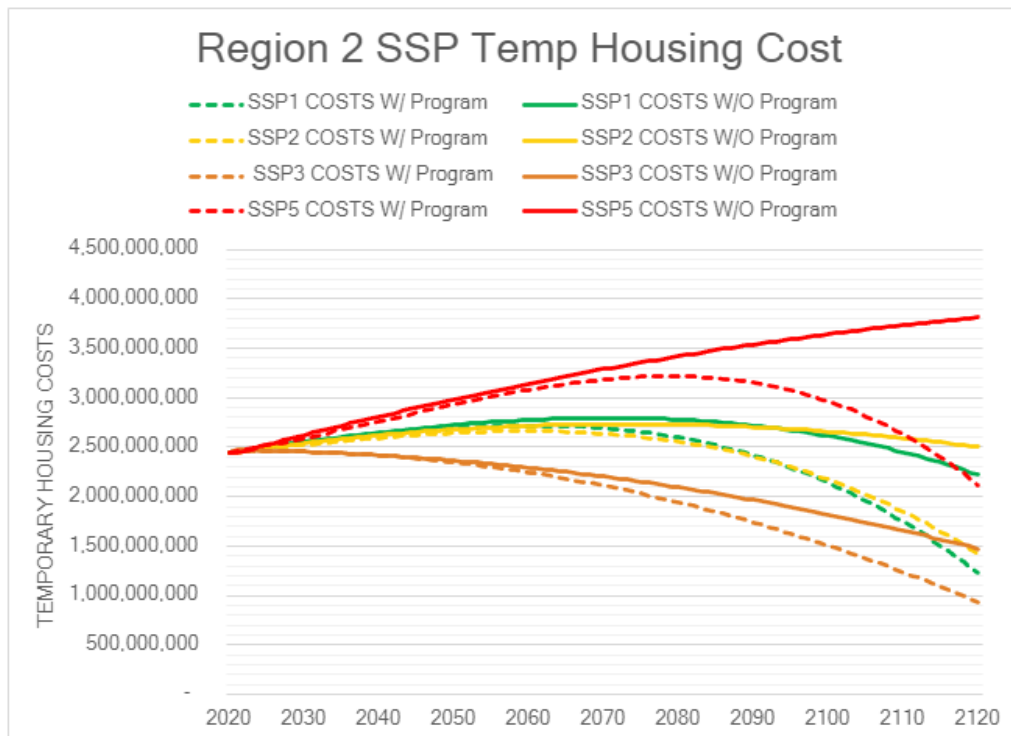
	SSP 1	SSP 2	SSP 3	SSP 5
Total Property Damage W/ Program (P)	76,311,027,675.82	76,209,623,141.18	62,470,856,842.12	91,695,004,488.22
Total Property Damage W/O Program (P)	\$79,908,343,694.26	\$95,144,747,901.58	\$96,446,806,155.02	\$352,598,667,653.07

Appendix D: Relocation Costs

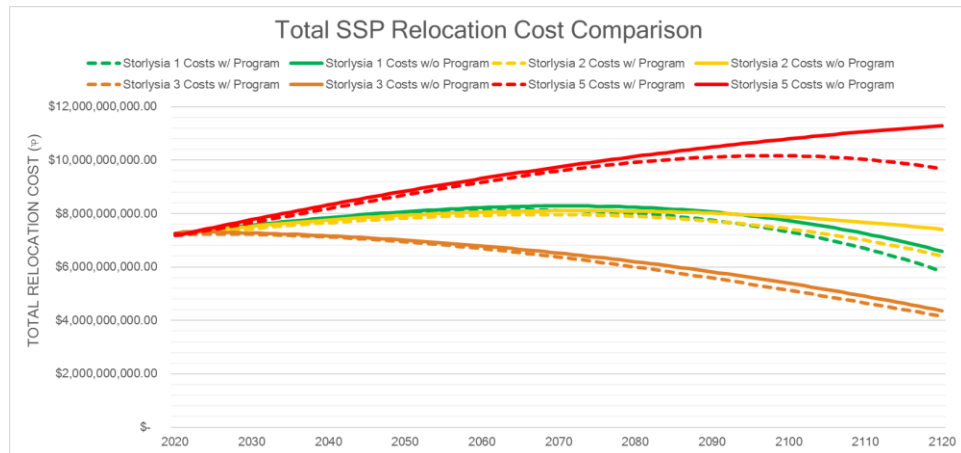
Below is a table showing the average relocation cost savings for the first 10-years of the program assuming 12 months temporary housing.

	SSP 1	SSP 2	SSP 3	SSP 5
Average for First 10-Years Relocation Cost Savings (‘P)	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 indicate how program is saving money.



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



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

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

Table below show 100 years of temporary housing cost % changes and total amount changes from a comparison of a program and without voluntary program. The cost savings start out slow but gradually increase exponentially overtime.

Storslysia 1 % Change	Storslysia 2 % Change	Storslysia 3 % Change	Storslysia 5 % Change	Storslysia 1 Change	Storslysia 2 Change	Storslysia 3 Change	Storslysia 5 Change
0.00%	0.00%	0.00%	0.00%	-	-	-	-
-0.12%	0.20%	-0.44%	0.58%	(237,628. 52)	404,602.1 6	(887,044.5 9)	1,156,241.6 9
-0.12%	0.13%	-0.35%	0.41%	(232,794. 49)	266,472.1 8	(699,469.3 2)	821,751.82
-0.11%	0.07%	-0.26%	0.25%	(228,158. 81)	138,383.7 9	(525,178.2 3)	511,822.31
-0.11%	0.01%	-0.18%	0.11%	(223,819. 11)	19,930.21	(363,973.0 3)	225,598.74
-0.11%	-0.04%	-0.11%	-0.02%	(219,914. 68)	(89,333.4 4)	(215,531.7 1)	(37,722.62)
-0.11%	-0.09%	-0.04%	-0.13%	(216,560. 77)	(189,749. 20)	(79,592.59)	(278,959.5 5)
-0.10%	-0.14%	0.02%	-0.24%	(213,843. 45)	(281,677. 55)	44,070.24	(498,937.9 8)
-0.10%	-0.18%	0.08%	-0.33%	(211,909. 31)	(365,618. 68)	155,738.59	(698,533.4 4)
-0.10%	-0.21%	0.13%	-0.41%	(210,870. 17)	(441,884. 04)	255,752.20	(878,519.7 8)
-0.10%	-0.25%	0.17%	-0.49%	(210,861. 70)	(510,875. 57)	344,298.01	(1,039,750. 67)
-0.10%	-0.28%	0.21%	-0.55%	(212,042. 09)	(573,006. 69)	421,632.15	(1,183,065. 14)
-0.10%	-0.30%	0.24%	-0.60%	(214,418. 65)	(628,614. 42)	488,064.09	(1,309,318. 24)
-0.10%	-0.32%	0.27%	-0.65%	(218,211. 06)	(678,166. 60)	543,883.44	(1,419,272. 11)
-0.11%	-0.34%	0.30%	-0.69%	(223,516. 70)	(722,000. 18)	589,269.62	(1,513,827. 06)
-0.11%	-0.36%	0.31%	-0.72%	(230,468. 55)	(760,576. 11)	624,590.68	(1,593,748. 40)
-0.11%	-0.38%	0.33%	-0.74%	(239,132. 22)	(794,210. 09)	650,073.45	(1,659,920. 82)

-0.12%	-0.39%	0.34%	-0.76%	(249,673.25)	(823,322.68)	665,948.75	(1,713,153.25)
-0.12%	-0.40%	0.34%	-0.77%	(262,194.38)	(848,311.97)	672,540.23	(1,754,265.44)
-0.13%	-0.41%	0.34%	-0.78%	(276,814.32)	(869,570.63)	670,086.58	(1,784,104.68)
-0.14%	-0.41%	0.33%	-0.79%	(293,689.18)	(887,467.59)	658,826.38	(1,803,476.82)
-0.14%	-0.42%	0.32%	-0.79%	(312,869.82)	(902,432.76)	639,114.14	(1,813,270.76)
-0.15%	-0.43%	0.31%	-0.78%	(334,581.73)	(914,842.22)	611,139.05	(1,814,257.56)
-0.16%	-0.43%	0.29%	-0.77%	(358,858.57)	(925,060.36)	575,136.10	(1,807,281.73)
-0.18%	-0.43%	0.27%	-0.76%	(385,816.30)	(933,533.60)	531,475.51	(1,793,193.37)
-0.19%	-0.43%	0.25%	-0.75%	(415,624.39)	(940,627.78)	480,373.86	(1,772,810.92)
-0.20%	-0.44%	0.22%	-0.73%	(448,369.18)	(946,722.85)	422,114.44	(1,746,967.43)
-0.22%	-0.44%	0.18%	-0.72%	(484,207.63)	(952,204.61)	356,912.53	(1,716,455.82)
-0.24%	-0.44%	0.15%	-0.70%	(523,261.29)	(957,515.08)	285,087.89	(1,682,157.02)
-0.25%	-0.44%	0.11%	-0.68%	(565,601.83)	(963,007.23)	206,875.91	(1,644,918.17)
-0.27%	-0.44%	0.06%	-0.66%	(611,353.31)	(969,082.91)	122,602.44	(1,605,510.10)
-0.30%	-0.45%	0.02%	-0.64%	(660,716.51)	(976,115.30)	32,479.90	(1,564,784.36)
-0.32%	-0.45%	-0.03%	-0.62%	(713,717.70)	(984,530.53)	(63,224.77)	(1,523,578.86)
-0.34%	-0.45%	-0.09%	-0.60%	(770,503.13)	(994,681.57)	(164,241.51)	(1,482,720.51)
-0.37%	-0.46%	-0.14%	-0.58%	(831,240.89)	(1,006,990.34)	(270,267.58)	(1,443,044.08)
-0.40%	-0.46%	-0.20%	-0.56%	(895,988.15)	(1,021,847.32)	(381,090.05)	(1,405,379.95)

-0.43%	-0.47%	-0.26%	-0.54%	(964,912.63)	(1,039,653.79)	(496,361.10)	(1,370,575.26)
-0.46%	-0.48%	-0.33%	-0.53%	(1,038,065.68)	(1,060,751.10)	(615,935.97)	(1,339,399.98)
-0.49%	-0.49%	-0.39%	-0.52%	(1,115,664.21)	(1,085,617.24)	(739,433.75)	(1,312,742.87)
-0.53%	-0.50%	-0.46%	-0.51%	(1,197,779.84)	(1,114,567.71)	(866,640.50)	(1,291,429.33)
-0.57%	-0.52%	-0.53%	-0.50%	(1,284,524.29)	(1,147,999.32)	(997,285.35)	(1,276,263.69)
-0.61%	-0.53%	-0.61%	-0.49%	(1,376,015.07)	(1,186,380.74)	(1,131,086.17)	(1,268,094.37)
-0.65%	-0.55%	-0.68%	-0.49%	(1,472,402.96)	(1,230,014.04)	(1,267,763.19)	(1,267,755.05)
-0.69%	-0.57%	-0.76%	-0.49%	(1,573,778.22)	(1,279,353.09)	(1,407,096.93)	(1,276,063.25)
-0.74%	-0.60%	-0.84%	-0.49%	(1,680,304.76)	(1,334,754.91)	(1,548,783.79)	(1,293,827.92)
-0.79%	-0.63%	-0.92%	-0.50%	(1,792,045.80)	(1,396,611.70)	(1,692,571.52)	(1,321,943.60)
-0.84%	-0.66%	-1.00%	-0.52%	(1,909,157.28)	(1,465,332.63)	(1,838,201.13)	(1,361,199.28)
-0.89%	-0.69%	-1.09%	-0.53%	(2,031,743.41)	(1,541,323.89)	(1,985,385.93)	(1,412,417.30)
-0.95%	-0.73%	-1.18%	-0.55%	(2,159,948.97)	(1,624,924.75)	(2,133,848.38)	(1,476,452.54)
-1.00%	-0.77%	-1.26%	-0.58%	(2,293,864.26)	(1,716,576.19)	(2,283,355.53)	(1,554,108.62)
-1.07%	-0.81%	-1.35%	-0.61%	(2,433,623.21)	(1,816,650.51)	(2,433,637.53)	(1,646,254.84)
-1.13%	-0.86%	-1.44%	-0.65%	(2,579,349.85)	(1,925,589.11)	(2,584,365.52)	(1,753,674.04)
-1.20%	-0.91%	-1.54%	-0.69%	(2,731,183.85)	(2,043,685.74)	(2,735,354.72)	(1,877,217.97)
-1.27%	-0.97%	-1.63%	-0.74%	(2,889,174.97)	(2,171,407.29)	(2,886,303.96)	(2,017,744.87)
-1.34%	-1.03%	-1.72%	-0.80%	(3,053,533.54)	(2,309,126.50)	(3,036,929.04)	(2,176,059.47)

-1.41%	-1.10%	-1.82%	-0.86%	(3,224,32 4.81)	(2,457,24 3.75)	(3,186,995. 24)	(2,352,980. 40)
-1.49%	-1.17%	-1.91%	-0.93%	(3,401,69 8.32)	(2,616,13 1.30)	(3,336,211. 65)	(2,549,324. 27)
-1.57%	-1.25%	-2.01%	-1.00%	(3,585,73 4.39)	(2,786,21 0.46)	(3,484,302. 84)	(2,766,007. 24)
-1.66%	-1.33%	-2.10%	-1.08%	(3,776,58 7.39)	(2,967,83 5.43)	(3,631,044. 28)	(3,003,742. 26)
-1.75%	-1.42%	-2.20%	-1.17%	(3,974,38 2.18)	(3,161,44 9.66)	(3,776,135. 91)	(3,263,462. 05)
-1.84%	-1.51%	-2.29%	-1.27%	(4,179,20 8.31)	(3,367,37 4.08)	(3,919,304. 74)	(3,545,944. 44)
-1.94%	-1.61%	-2.39%	-1.37%	(4,391,21 5.83)	(3,586,06 5.50)	(4,060,312. 59)	(3,852,015. 74)
-2.04%	-1.71%	-2.49%	-1.49%	(4,610,52 6.11)	(3,817,89 3.09)	(4,198,835. 71)	(4,182,531. 96)
-2.14%	-1.83%	-2.58%	-1.61%	(4,837,23 3.32)	(4,063,25 1.73)	(4,334,702. 16)	(4,538,326. 18)
-2.25%	-1.94%	-2.68%	-1.74%	(5,071,46 2.90)	(4,322,53 4.59)	(4,467,542. 55)	(4,920,147. 95)
-2.36%	-2.07%	-2.77%	-1.87%	(5,313,34 6.71)	(4,596,11 6.67)	(4,597,162. 28)	(5,328,941. 04)
-2.48%	-2.20%	-2.87%	-2.02%	(5,563,03 0.53)	(4,884,42 1.93)	(4,723,254. 56)	(5,765,520. 43)
-2.60%	-2.34%	-2.96%	-2.18%	(5,820,60 0.68)	(5,187,79 7.85)	(4,845,580. 14)	(6,230,626. 56)
-2.72%	-2.49%	-3.05%	-2.34%	(6,086,14 4.41)	(5,506,68 7.73)	(4,963,834. 73)	(6,725,167. 62)
-2.85%	-2.64%	-3.14%	-2.52%	(6,359,87 7.05)	(5,841,47 8.80)	(5,077,809. 82)	(7,249,954. 10)
-2.99%	-2.80%	-3.23%	-2.70%	(6,641,84 7.99)	(6,192,52 1.11)	(5,187,137. 54)	(7,805,843. 92)
-3.13%	-2.97%	-3.32%	-2.89%	(6,932,15 4.70)	(6,560,20 6.14)	(5,291,677. 34)	(8,393,596. 15)
-3.28%	-3.15%	-3.41%	-3.10%	(7,230,98 8.75)	(6,944,98 6.74)	(5,391,108. 32)	(9,014,086. 95)
-3.43%	-3.34%	-3.49%	-3.31%	(7,538,44 1.58)	(7,347,21 6.02)	(5,485,113. 79)	(9,668,150. 80)

-3.59%	-3.54%	-3.58%	-3.54%	(7,854,63 2.16)	(7,767,27 5.35)	(5,573,479. 21)	(10,356,62 2.26)
-3.75%	-3.74%	-3.66%	-3.78%	(8,179,67 4.19)	(8,205,59 4.48)	(5,655,945. 68)	(11,080,33 8.99)
-3.92%	-3.96%	-3.73%	-4.02%	(8,513,71 1.03)	(8,662,53 5.54)	(5,732,191. 57)	(11,840,10 3.25)
-4.09%	-4.18%	-3.81%	-4.28%	(8,856,81 1.15)	(9,138,48 6.81)	(5,801,997. 36)	(12,636,76 8.41)
-4.28%	-4.42%	-3.88%	-4.55%	(9,209,14 9.37)	(9,633,85 6.68)	(5,865,090. 40)	(13,471,15 2.37)
-4.47%	-4.67%	-3.95%	-4.83%	(9,570,83 4.94)	(10,149,0 37.48)	(5,921,192. 50)	(14,344,03 0.21)
-4.66%	-4.92%	-4.02%	-5.13%	(9,941,98 3.84)	(10,684,4 05.10)	(5,970,049. 83)	(15,256,35 6.05)
-4.87%	-5.19%	-4.08%	-5.43%	(10,322,7 13.18)	(11,240,3 83.27)	(6,011,367. 36)	(16,208,85 3.77)
-5.08%	-5.47%	-4.14%	-5.75%	(10,713,1 11.76)	(11,817,3 35.89)	(6,044,951. 55)	(17,202,39 3.80)
-5.30%	-5.76%	-4.19%	-6.08%	(11,113,3 46.28)	(12,415,6 71.88)	(6,070,403. 76)	(18,237,84 4.86)
-5.53%	-6.06%	-4.25%	-6.42%	(11,523,5 57.00)	(13,035,7 62.96)	(6,087,566. 41)	(19,315,96 3.07)
-5.77%	-6.38%	-4.29%	-6.78%	(11,943,8 08.27)	(13,678,0 10.53)	(6,096,147. 86)	(20,437,63 3.79)
-6.01%	-6.70%	-4.33%	-7.15%	(12,374,2 32.47)	(14,342,8 35.77)	(6,095,868. 03)	(21,603,63 4.42)
-6.27%	-7.04%	-4.37%	-7.53%	(12,814,9 79.49)	(15,030,5 84.63)	(6,086,426. 57)	(22,814,87 4.67)
-6.54%	-7.40%	-4.40%	-7.93%	(13,266,1 25.83)	(15,741,6 91.01)	(6,067,644. 64)	(24,072,12 4.32)
-6.82%	-7.77%	-4.42%	-8.34%	(13,727,8 23.03)	(16,476,5 21.77)	(6,039,199. 67)	(25,376,19 3.28)
-7.10%	-8.15%	-4.44%	-8.76%	(14,200,2 17.02)	(17,235,4 67.35)	(6,000,788. 75)	(26,728,00 2.38)
-7.41%	-8.55%	-4.45%	-9.20%	(14,683,3 59.05)	(18,018,9 12.99)	(5,952,227. 25)	(28,128,29 6.65)
-7.72%	-8.96%	-4.45%	-9.65%	(15,177,4 22.04)	(18,827,2 89.17)	(5,893,195. 60)	(29,577,93 1.53)

-8.05%	-9.38%	4.45%	-10.12%	(15,682,5 17.10)	(19,660,9 59.39)	(5,823,429. 99)	(31,077,76 6.03)
-8.39%	-9.83%	-4.44%	-10.60%	(16,198,7 72.55)	(20,520,3 17.96)	(5,742,691. 58)	(32,628,57 9.21)
-8.74%	-10.29%	-4.42%	-11.10%	(16,726,2 63.89)	(21,405,7 96.85)	(5,650,660. 21)	(34,231,27 8.68)
-9.11%	-10.76%	-4.39%	-11.61%	(17,265,1 29.62)	(22,317,7 15.75)	(5,547,108. 19)	(35,886,62 3.81)
-9.50%	-11.26%	-4.35%	-12.14%	(17,815,5 66.68)	(23,256,4 86.70)	(5,431,762. 98)	(37,595,45 1.46)
-9.90%	-11.77%	-4.30%	-12.69%	(18,377,5 66.53)	(24,222,5 36.01)	(5,304,347. 24)	(39,358,60 6.14)
-10.32%	-12.30%	-4.24%	-13.25%	(18,951,3 62.25)	(25,216,2 56.98)	(5,164,617. 25)	(41,176,92 3.25)
-10.77%	-12.85%	-4.17%	-13.83%	(19,537,0 13.95)	(26,238,0 01.35)	(5,012,281. 30)	(43,051,28 1.16)

Appendix E: Region Rankings

We began this process by creating a ranking system for the overall quality of each region. The safety of each region was ranked by property damage per person and property damage per property over different time intervals. Person per hectare provided an additional consideration for the desirability of a region because we hope to avoid large losses at once and dissatisfaction of citizens by overpopulating a region. For example, our team discovered region 1 to be a very safe region based on the frequency and severity of weather events within the region, but the region is already the most populous region at 2.58 people per hectare. Therefore, we hope to avoid much of a change in population in this region.

Because the value of property differed from region to region, weights were given to each region's property damage based on each region's median value of owner-occupied housing units. Additionally, more recent years were considered in the rankings more frequently, thus placing more weight on the more recent disasters. Each ranking was then averaged to determine the order of most damage to least damage amongst all regions.

	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

The final ranking for our region based on the size and safety factors above follow:

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

Appendix F: Population Goals

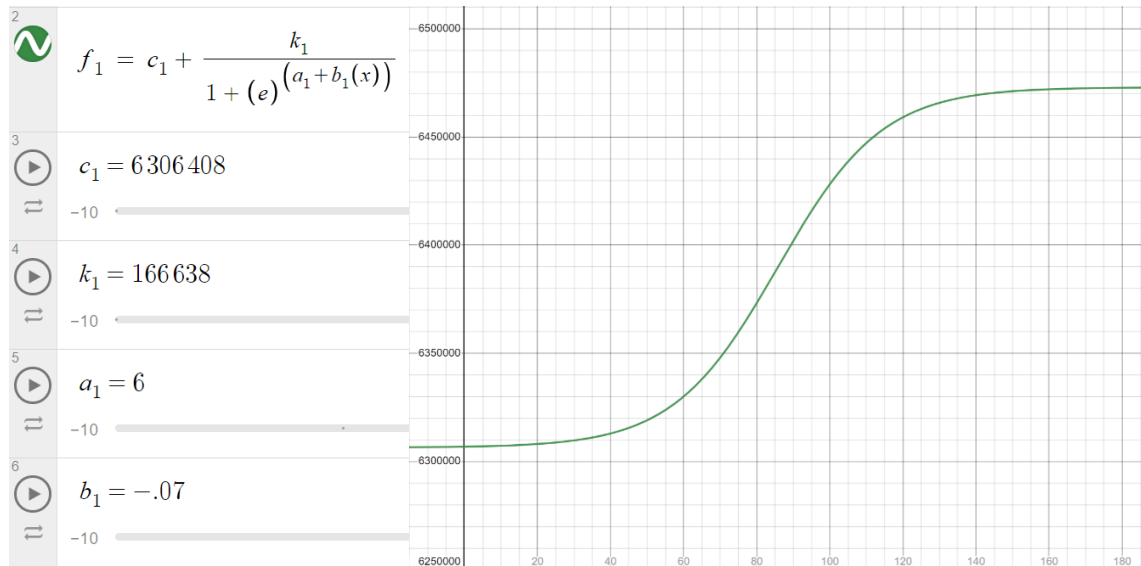
Using the ranking system above and setting each population maximum person per hectare at 2.65 to avoid overpopulation and prevent large losses all at once, we developed the desired population model:

	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

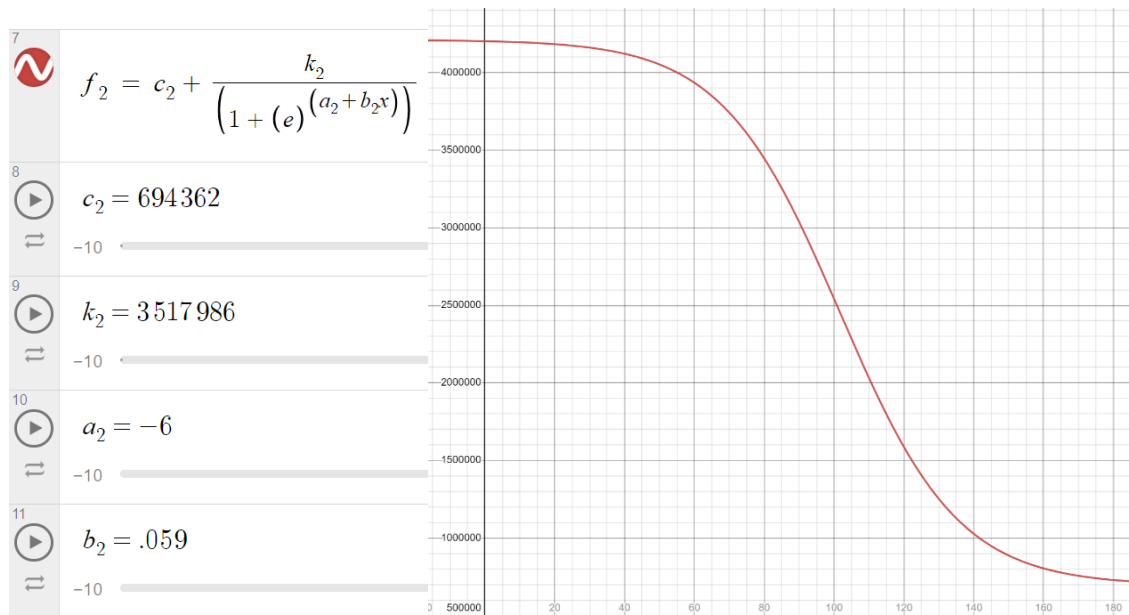
Appendix G: Modeling Program Relocation Goals

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 demonstrate the movement patterns within each region most accurately. In the early years, we predict little movement from current residents that are settled 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.

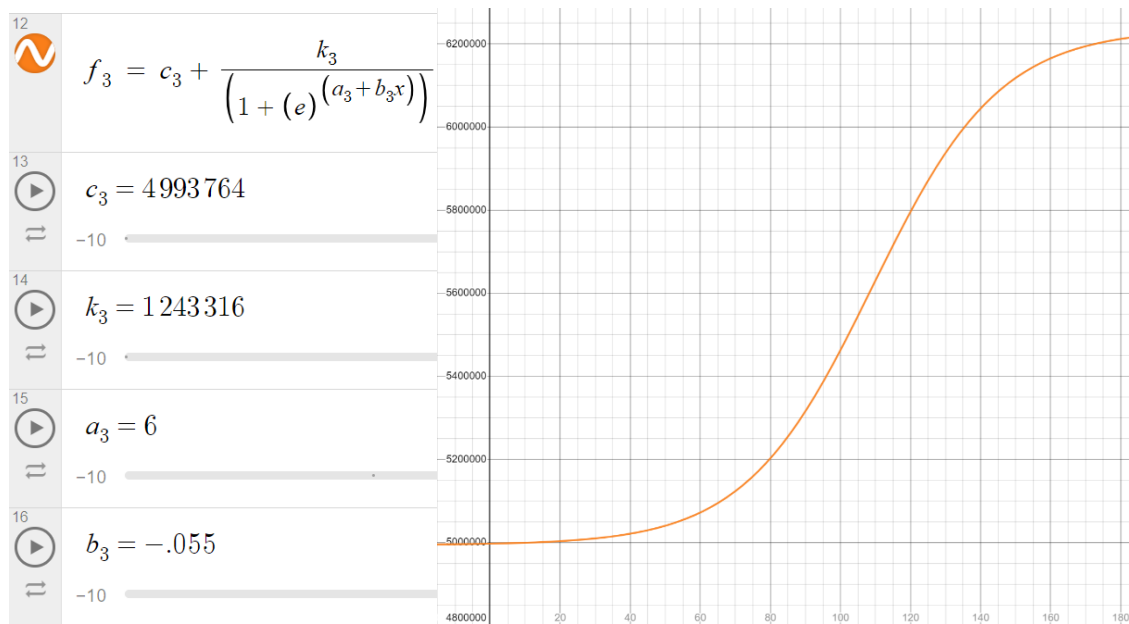
Region 1



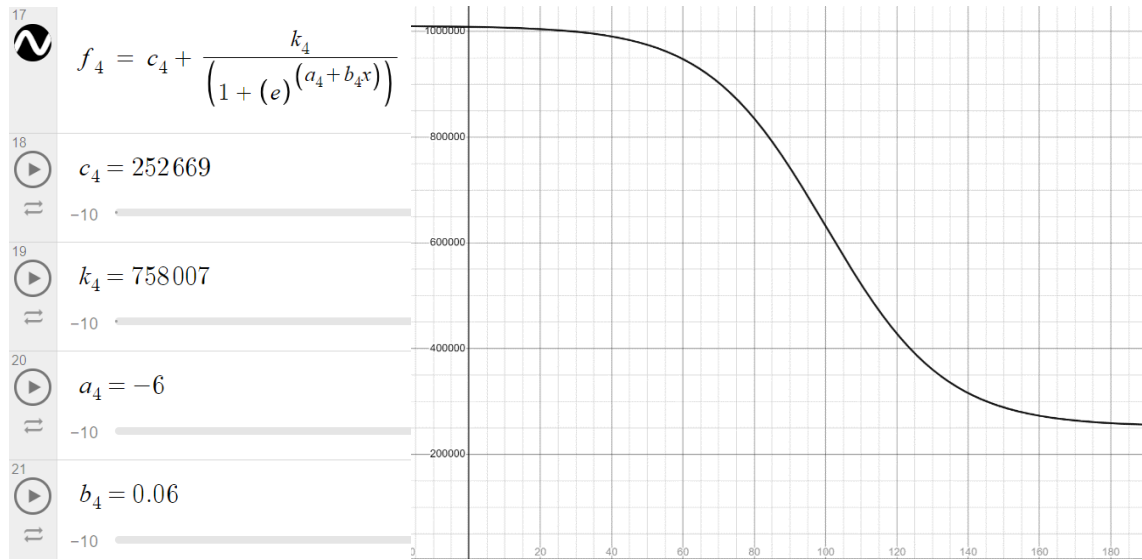
Region 2



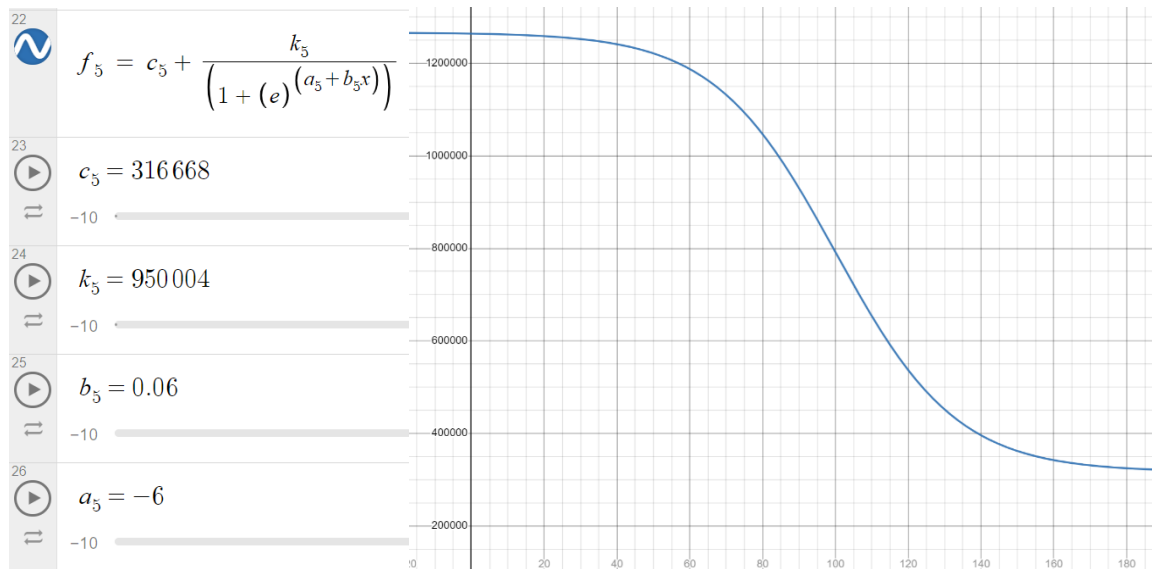
Region 3



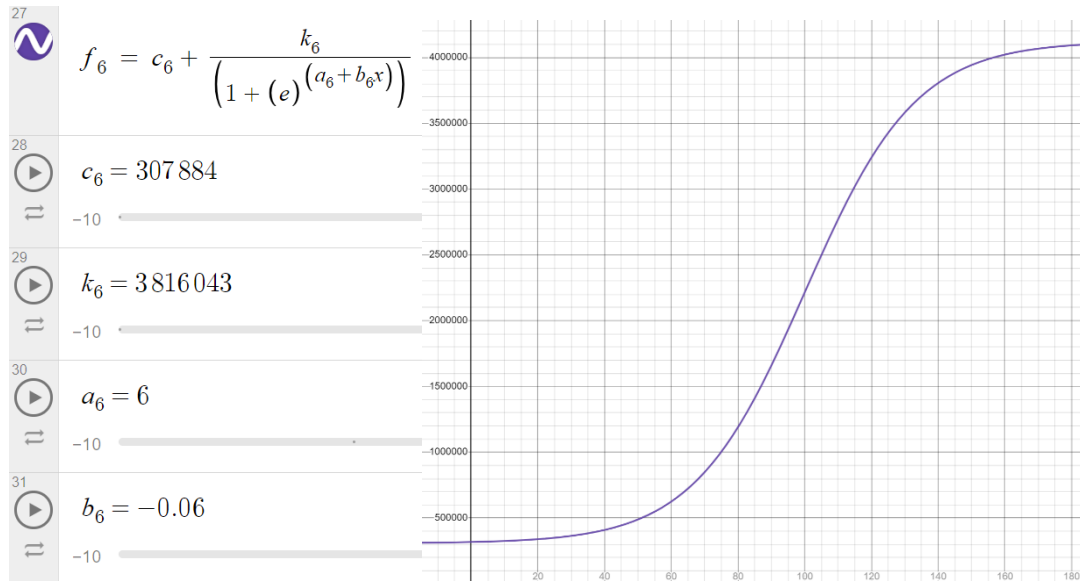
Region 4



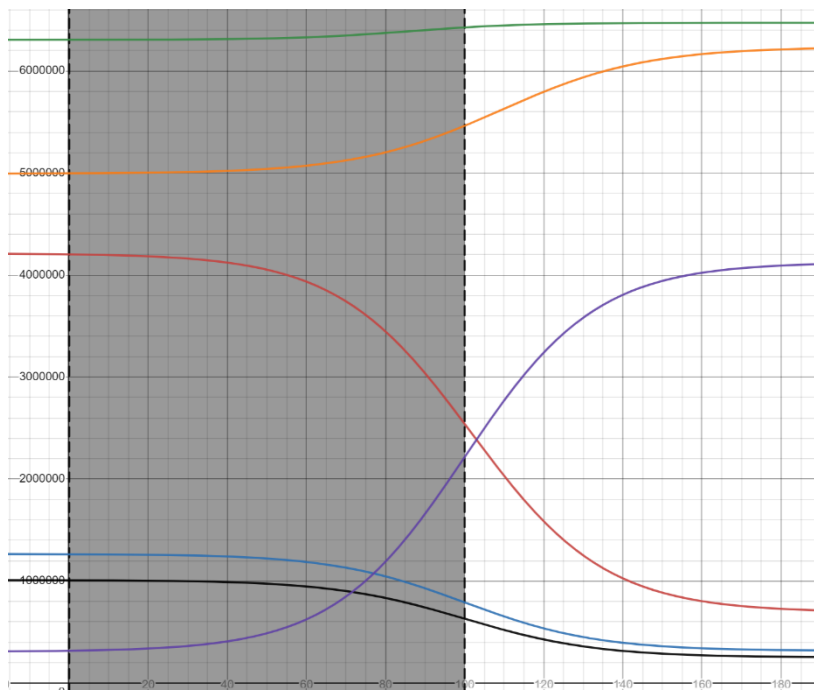
Region 5



Region 6



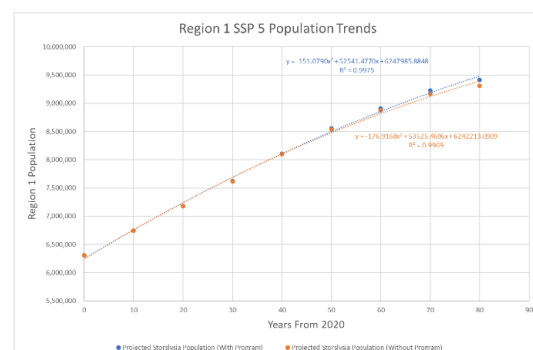
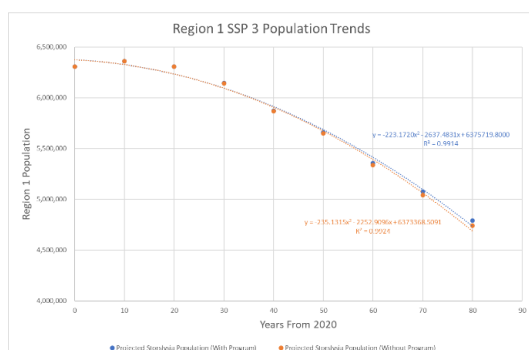
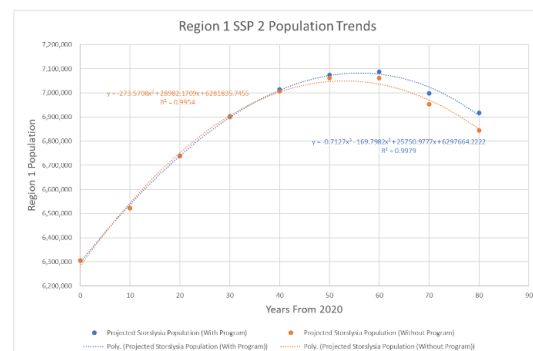
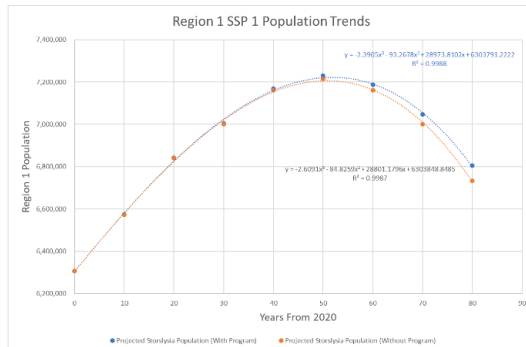
The following graph illustrates region functions combined with our 100-year program goals highlighted:



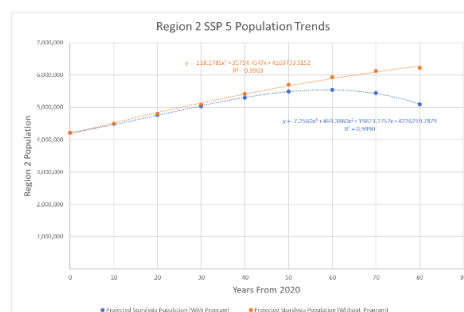
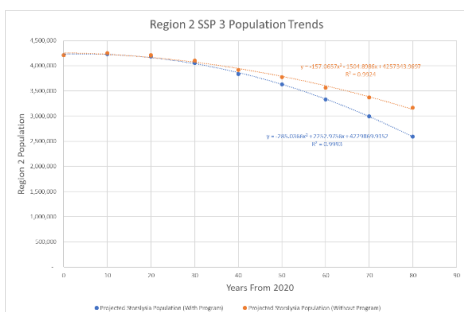
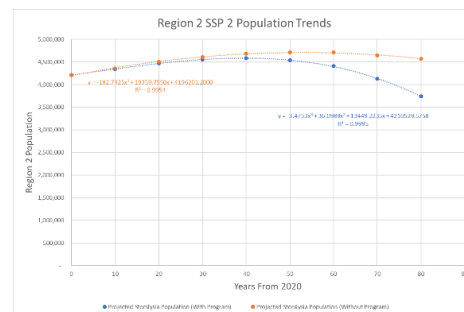
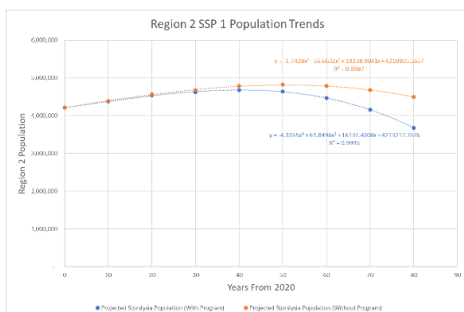
Appendix H: Modeling Regional Population Trends with and Without Program

Once we were able to use the sigmoid functions above to project population shifts within the country as a result of our program, we could then apply population growth factors to determine the difference in the population with and without our program in place. The population movement was found 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 whole 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 represents that there is no program, and the blue trend represents that there is a program in place.

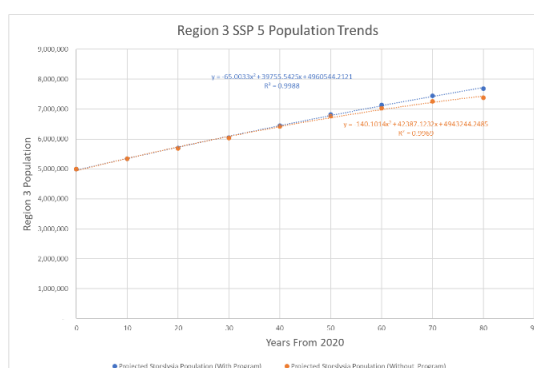
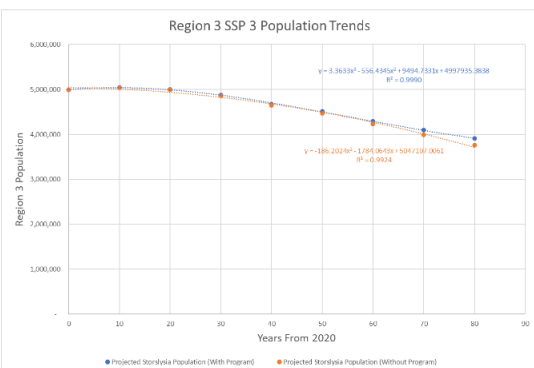
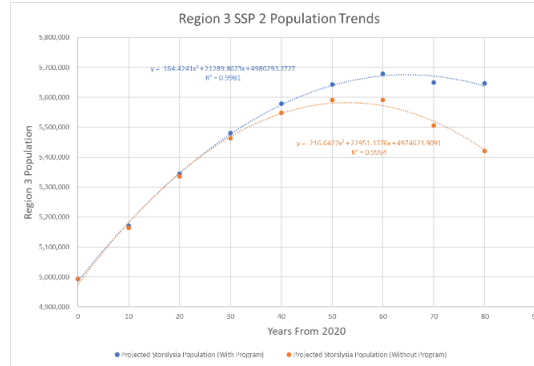
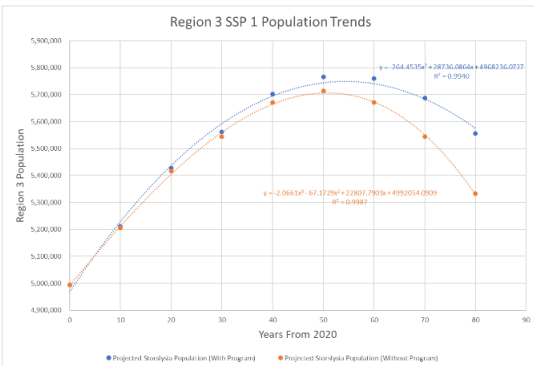
Region 1:



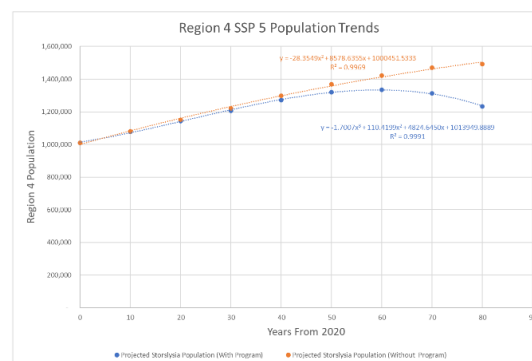
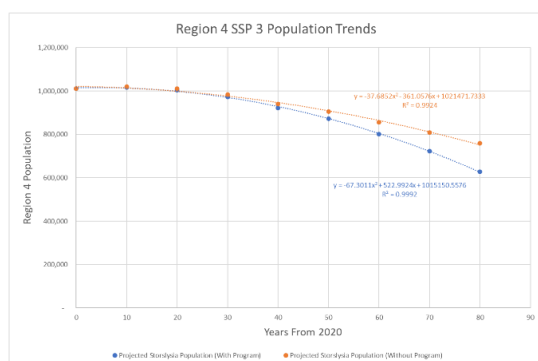
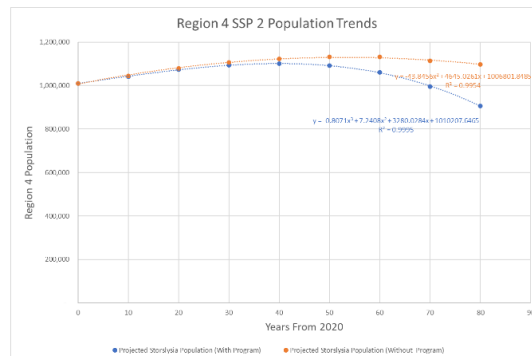
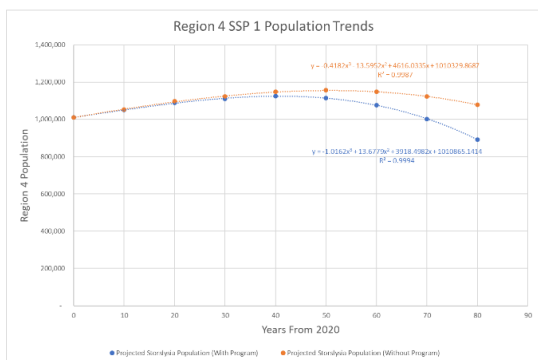
Region 2:



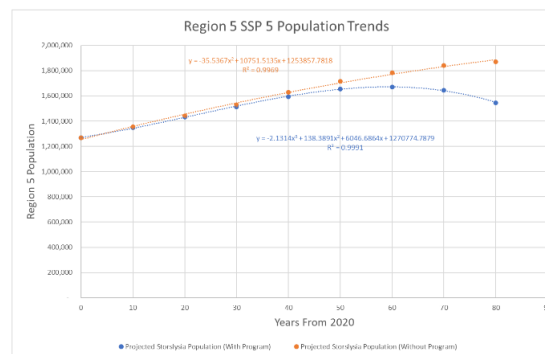
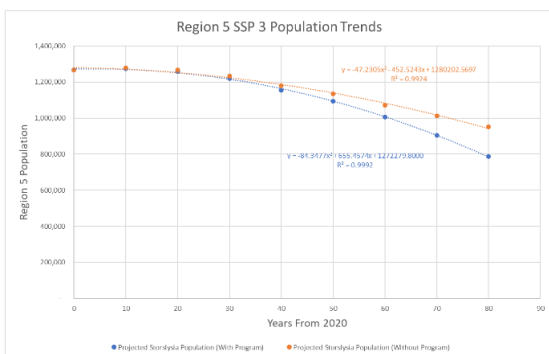
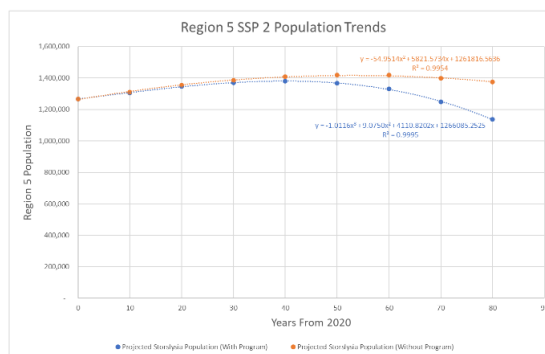
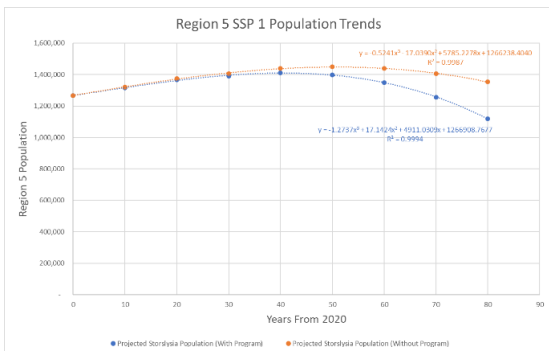
Region 3:



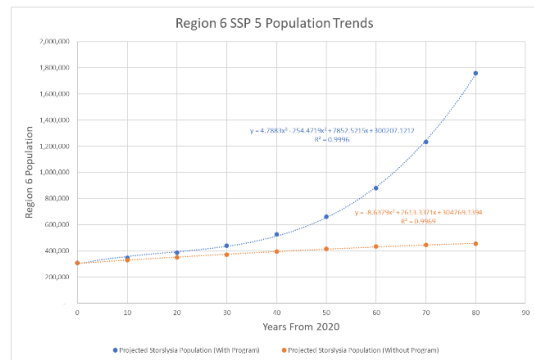
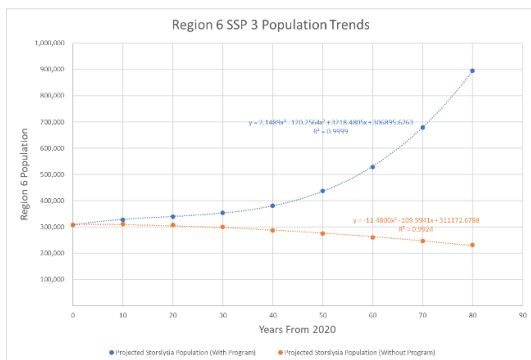
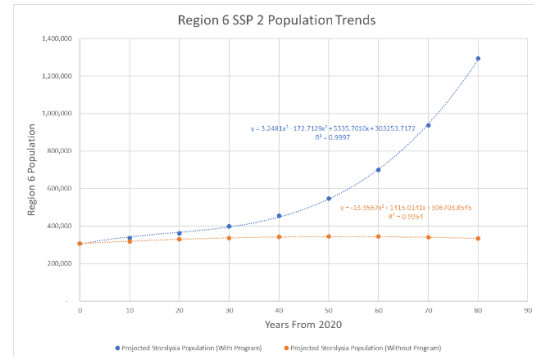
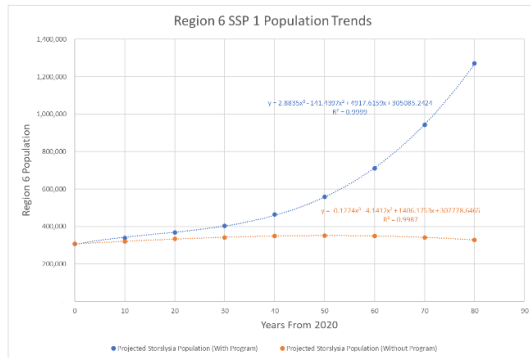
Region 4:



Region 5:



Region 6:



Appendix I: Property Damage with Program Estimations

By holding People per household and average property damage per household per year constant, we were able to determine 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.

	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	15.11123859	413.2809786	7.22240307	15.8140507	12.6180291	1.574977
Person Per Household	2.55	2.49	2.47	2.50	2.50	2.65

Year	SSP1 Cost w/ Program	SSP2 Cost w/ Program	SSP3 Cost w/ Program	SSP5 Cost w/ Program
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2020	764,090,470.17	764,090,470.17	764,090,470.17	764,090,470.17
2021	767,116,067.97	766,204,341.36	767,823,340.07	769,855,812.21
2022	770,123,511.96	768,705,440.74	768,064,744.18	773,864,852.25
2023	773,139,710.09	771,208,380.03	768,203,479.85	778,015,318.18
2024	776,160,873.64	773,710,177.63	768,240,418.75	782,300,081.48
2025	779,182,242.37	776,206,166.22	768,174,822.79	786,711,596.39
2026	782,199,137.76	778,693,833.63	768,007,597.03	791,242,734.64
2027	785,207,265.43	781,168,979.06	767,737,989.15	795,885,934.60
2028	788,202,806.62	783,628,598.59	767,366,852.76	800,633,629.91
2029	791,179,740.55	786,068,923.68	766,893,868.67	805,478,689.86
2030	794,135,083.26	788,486,567.06	766,319,090.61	810,414,011.21
2031	797,063,677.76	790,877,317.82	765,642,611.27	815,432,411.80
2032	799,960,872.62	793,238,636.01	764,864,055.30	820,525,952.40
2033	802,822,768.95	795,566,293.64	763,984,305.44	825,687,487.11
2034	805,644,689.08	797,857,324.31	763,003,063.87	830,909,869.20
2035	808,421,895.18	800,107,524.63	761,920,778.04	836,185,571.38
2036	811,150,135.31	802,313,527.39	760,736,709.07	841,507,422.24
2037	813,825,126.19	804,472,356.34	759,451,275.91	846,867,907.15
2038	816,441,740.09	806,579,791.82	758,065,062.65	852,259,861.02
2039	818,996,554.40	808,632,437.03	756,577,201.40	857,675,749.39
2040	821,483,992.46	810,626,977.17	754,988,241.31	863,108,424.75
2041	823,900,605.47	812,559,964.28	753,298,222.07	868,550,330.27

2042	826,240,900.95	814,427,222.62	751,507,627.10	873,994,760.41
2043	828,501,415.85	816,226,195.13	749,616,115.59	879,433,338.08
2044	830,677,023.18	817,952,639.54	747,623,339.21	884,859,725.74
2045	832,763,015.95	819,603,213.25	745,530,186.34	890,265,978.68
2046	834,755,976.97	821,174,537.13	743,336,314.10	895,644,531.46
2047	836,650,334.55	822,662,810.81	741,041,389.10	900,989,109.02
2048	838,442,231.99	824,064,626.80	738,646,272.59	906,291,275.12
2049	840,126,970.90	825,376,227.36	736,150,647.24	911,543,950.25
2050	841,700,279.75	826,594,220.26	733,554,553.18	916,740,373.38
2051	843,157,457.64	827,715,587.07	730,858,102.31	921,872,596.50
2052	844,494,211.81	828,735,764.55	728,061,306.15	926,933,466.73
2053	845,705,853.36	829,652,222.22	725,164,266.88	931,915,457.46
2054	846,788,082.96	830,460,698.83	722,167,059.00	936,811,826.39
2055	847,736,613.95	831,158,225.64	719,069,683.83	941,614,603.59
2056	848,546,785.14	831,740,630.05	715,872,709.21	946,316,640.73
2057	849,213,858.04	832,204,923.46	712,575,321.89	950,910,839.57
2058	849,733,583.83	832,547,295.15	709,178,020.65	955,389,642.33
2059	850,101,637.04	832,764,369.13	705,681,287.63	959,745,874.94
2060	850,313,734.16	832,852,813.19	702,084,329.36	963,971,614.64
2061	850,364,825.56	832,808,370.85	698,388,091.37	968,060,113.73
2062	850,250,971.93	832,628,071.49	694,591,781.57	972,004,235.16
2063	849,967,077.65	832,308,148.22	690,696,278.89	975,795,994.54

2064	849,509,288.97	831,845,207.63	686,701,282.63	979,428,319.83
2065	848,872,921.27	831,235,881.67	682,606,820.98	982,893,993.63
2066	848,053,221.95	830,476,333.68	678,412,563.72	986,185,532.16
2067	847,046,380.65	829,562,805.98	674,119,400.07	989,296,164.76
2068	845,847,242.77	828,492,743.72	669,726,979.99	992,217,508.15
2069	844,451,944.45	827,261,516.21	665,235,361.22	994,942,906.53
2070	842,855,396.32	825,866,172.42	660,644,644.36	997,464,745.23
2071	841,053,711.43	824,302,434.06	655,954,872.07	999,775,904.57
2072	839,041,756.95	822,568,276.61	651,166,127.39	1,001,868,815.96
2073	836,815,711.57	820,658,551.40	646,278,834.64	1,003,736,350.00
2074	834,370,862.03	818,570,382.81	641,292,312.10	1,005,371,385.42
2075	831,702,470.45	816,300,724.43	636,206,985.04	1,006,766,386.15
2076	828,806,712.41	813,845,437.83	631,023,350.41	1,007,913,346.33
2077	825,678,424.10	811,201,096.42	625,740,652.95	1,008,805,970.58
2078	822,313,812.24	808,363,925.18	620,359,369.34	1,009,436,305.27
2079	818,707,691.39	805,330,945.59	614,879,987.80	1,009,797,182.39
2080	814,855,805.10	802,098,369.98	609,302,156.36	1,009,881,521.99
2081	810,753,894.42	798,662,403.89	603,625,510.30	1,009,681,281.70
2082	806,397,633.89	795,019,670.23	597,850,975.43	1,009,189,793.91
2083	801,782,344.98	791,167,182.08	591,977,754.29	1,008,399,501.10
2084	796,903,334.01	787,100,332.91	586,006,780.42	1,007,302,838.72
2085	791,756,309.83	782,816,567.90	579,937,675.22	1,005,893,075.50

2086	786,336,996.57	778,311,689.42	573,770,527.41	1,004,161,853.56
2087	780,640,652.53	773,582,688.77	567,505,373.94	1,002,103,271.60
2088	774,663,052.86	768,625,818.61	561,142,329.07	999,708,532.24
2089	768,399,454.01	763,437,259.94	554,681,402.16	996,971,335.12
2090	761,845,604.12	758,013,647.58	548,122,704.76	993,883,687.97
2091	754,996,809.70	752,351,580.47	541,466,693.63	990,438,475.86
2092	747,848,747.58	746,447,684.92	534,712,219.21	986,628,549.76
2093	740,397,149.51	740,298,177.28	527,860,964.60	982,446,793.19
2094	732,637,351.00	733,899,250.93	520,911,792.22	977,884,823.35
2095	724,564,610.34	727,247,544.29	513,865,561.52	972,936,273.58
2096	716,175,069.72	720,340,041.42	506,721,558.54	967,593,682.88
2097	707,463,618.57	713,172,581.31	499,480,643.23	961,849,434.35
2098	698,426,414.39	705,741,778.25	492,142,064.61	955,695,994.85
2099	689,058,290.07	698,044,216.76	484,706,682.63	949,126,658.85
2100	679,355,399.91	690,076,544.80	477,174,212.41	942,133,857.51
2101	669,312,636.34	681,834,559.79	469,544,269.51	934,710,056.29
2102	658,926,542.37	673,315,686.15	461,817,737.84	926,847,658.17
2103	648,191,609.74	664,515,317.76	453,994,305.18	918,539,990.58
2104	637,103,503.58	655,430,894.79	446,074,003.99	909,779,461.88
2105	625,658,391.65	646,058,210.87	438,056,944.41	900,558,560.58
2106	613,851,582.66	636,393,865.41	429,943,152.37	890,870,131.12
2107	601,677,956.33	626,434,518.30	421,732,712.70	880,706,607.32

2108	589,134,028.18	616,176,337.43	413,425,654.54	870,060,878.12
2109	576,214,733.94	605,616,380.82	405,022,098.07	858,925,812.80
2110	562,915,735.45	594,750,411.87	396,522,091.86	847,293,399.21
2111	549,232,390.77	583,575,485.23	387,926,113.05	835,156,933.19
2112	535,160,383.67	572,087,389.11	379,233,407.91	822,508,897.81
2113	520,695,403.30	560,283,171.85	370,444,452.23	809,342,110.46
2114	505,832,808.15	548,158,988.02	361,559,706.01	795,648,611.56
2115	490,567,849.96	535,711,505.16	352,578,431.34	781,421,708.94
2116	474,896,716.49	522,937,312.57	343,501,516.37	766,653,418.90
2117	458,814,657.03	509,832,227.53	334,328,209.70	751,337,005.04
2118	442,316,977.20	496,393,706.24	325,059,402.17	735,465,364.13
2119	425,398,999.21	482,617,060.71	315,694,741.43	719,030,493.78
2120	408,056,867.24	468,499,802.83	306,233,881.18	702,025,267.72

Appendix J: 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 represent the trend of 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.

R code for lower bounds:

```
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))
```

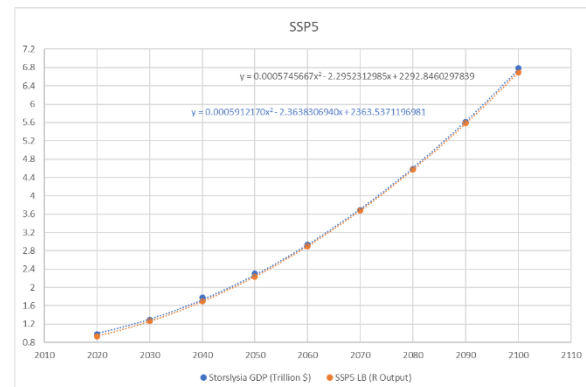
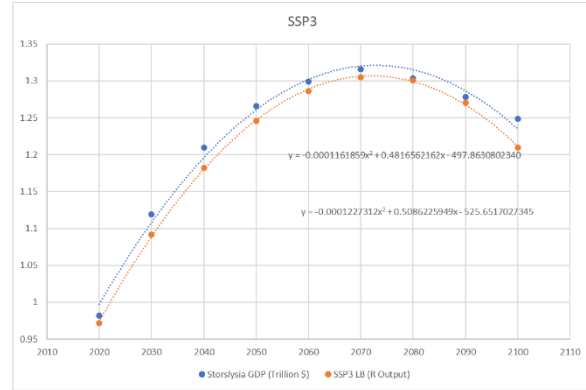
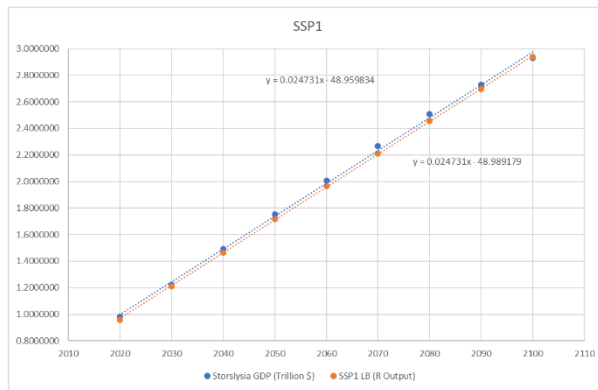
```
summary(GDPFit3)
```

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

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

```
summary(GDPFit5)
```

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



Year	LB of 10% GDP SSP1	LB of 10% GDP SSP2	LB of 10% GDP SSP3	LB of 10% GDP SSP5
2020	129,693,892,200.00	129,693,892,200.00	129,693,892,200.00	129,693,892,200.00

2021	131,065,921,200.00	128,184,423,900.00	130,279,173,124.32	127,788,550,596.18
2022	134,332,886,300.00	130,917,440,800.00	131,919,901,795.24	131,453,251,570.34
2023	137,599,851,400.00	133,650,457,700.00	133,528,204,883.14	135,269,753,066.69
2024	140,866,816,500.00	136,383,474,600.00	135,104,082,387.98	139,238,055,085.16
2025	144,133,781,600.00	139,116,491,500.00	136,647,534,309.79	143,358,157,625.74
2026	147,400,746,700.00	141,849,508,400.00	138,158,560,648.59	147,630,060,688.33
2027	150,667,711,800.00	144,582,525,300.00	139,637,161,404.29	152,053,764,273.22
2028	153,934,676,900.00	147,315,542,200.00	141,083,336,577.00	156,629,268,380.23
029	157,201,642,000.00	150,048,559,100.00	142,497,086,166.63	161,356,573,009.41
2030	160,468,607,100.00	152,781,576,000.00	143,878,410,173.24	166,235,678,160.72
2031	163,735,572,200.00	155,514,592,900.00	145,227,308,596.83	171,266,583,834.15
2032	167,002,537,300.00	158,247,609,800.00	146,543,781,437.35	176,449,290,029.76
2033	170,269,502,400.00	160,980,626,700.00	147,827,828,694.85	181,783,796,747.30
2034	173,536,467,500.00	163,713,643,600.00	149,079,450,369.28	187,270,103,987.21
2035	176,803,432,600.00	166,446,660,500.00	150,298,646,460.70	192,908,211,749.18
2036	180,070,397,700.00	169,179,677,400.00	151,485,416,969.08	198,698,120,033.33
2037	183,337,362,800.00	171,912,694,300.00	152,639,761,894.38	204,639,828,839.60
2038	186,604,327,900.00	174,645,711,200.00	153,761,681,236.69	210,733,338,168.04
2039	189,871,293,000.00	177,378,728,100.00	154,851,174,995.96	216,978,648,018.49
2040	193,138,258,100.00	180,111,745,000.00	155,908,243,172.13	223,375,758,391.18
2041	196,405,223,200.00	182,844,761,900.00	156,932,885,765.33	229,924,669,285.99
2042	199,672,188,300.00	185,577,778,800.00	157,925,102,775.44	236,625,380,702.98
2043	202,939,153,400.00	188,310,795,700.00	158,884,894,202.54	243,477,892,642.09
2044	206,206,118,500.00	191,043,812,600.00	159,812,260,046.61	250,482,205,103.38

2045	209,473,083,600.00	193,776,829,500.00	160,707,200,307.59	257,638,318,086.66
2046	212,740,048,700.00	196,509,846,400.00	161,569,714,985.57	264,946,231,592.19
2047	216,007,013,800.00	199,242,863,300.00	162,399,804,080.49	272,405,945,619.84
2048	219,273,978,900.00	201,975,880,200.00	163,197,467,592.39	280,017,460,169.67
2049	222,540,944,000.00	204,708,897,100.00	163,962,705,521.25	287,780,775,241.62
2050	225,807,909,100.00	207,441,914,000.00	164,695,517,867.05	295,695,890,835.75
2051	229,074,874,200.00	210,174,930,900.00	165,395,904,629.82	303,762,806,951.94
2052	232,341,839,300.00	212,907,947,800.00	166,063,865,809.54	311,981,523,590.25
2053	235,608,804,400.00	215,640,964,700.00	166,699,401,406.23	320,352,040,750.74
2054	238,875,769,500.00	218,373,981,600.00	167,302,511,419.89	328,874,358,433.41
2055	242,142,734,600.00	221,106,998,500.00	167,873,195,850.48	337,548,476,638.20
2056	245,409,699,700.00	223,840,015,400.00	168,411,454,698.08	346,374,395,365.17
2057	248,676,664,800.00	226,573,032,300.00	168,917,287,962.58	355,352,114,614.20
2058	251,943,629,900.00	229,306,049,200.00	169,390,695,644.09	364,481,634,385.29
2059	255,210,595,000.00	232,039,066,100.00	169,831,677,742.54	373,762,954,678.68
2060	258,477,560,100.00	234,772,083,000.00	170,240,234,257.94	383,196,075,494.19
2061	261,744,525,200.00	237,505,099,900.00	170,616,365,190.32	392,780,996,831.82
2062	265,011,490,300.00	240,238,116,800.00	170,960,070,539.66	402,517,718,691.57
2063	268,278,455,400.00	242,971,133,700.00	171,271,350,305.93	412,406,241,073.51
2064	271,545,420,500.00	245,704,150,600.00	171,550,204,489.20	422,446,563,977.44
2065	274,812,385,600.00	248,437,167,500.00	171,796,633,089.38	432,638,687,403.67
2066	278,079,350,700.00	251,170,184,400.00	172,010,636,106.57	442,982,611,352.02
2067	281,346,315,800.00	253,903,201,300.00	172,192,213,540.71	453,478,335,822.49
2068	284,613,280,900.00	256,636,218,200.00	172,341,365,391.79	464,125,860,815.08

2069	287,880,246,000.00	259,369,235,100.00	172,458,091,659.85	474,925,186,329.85
2070	291,147,211,100.00	262,102,252,000.00	172,542,392,344.84	485,876,312,366.74
2071	294,414,176,200.00	264,835,268,900.00	172,594,267,446.81	496,979,238,925.64
2072	297,681,141,300.00	267,568,285,800.00	172,613,716,965.76	508,233,966,006.83
2073	300,948,106,400.00	270,301,302,700.00	172,600,740,901.64	519,640,493,610.14
2074	304,215,071,500.00	273,034,319,600.00	172,555,339,254.50	531,198,821,735.63
2075	307,482,036,600.00	275,767,336,500.00	172,477,512,024.29	542,908,950,383.25
2076	310,749,001,700.00	278,500,353,400.00	172,367,259,211.07	554,770,879,552.98
2077	314,015,966,800.00	281,233,370,300.00	172,224,580,814.81	566,784,609,244.71
2078	317,282,931,900.00	283,966,387,200.00	172,049,476,835.47	578,950,139,458.74
2079	320,549,897,000.00	286,699,404,100.00	171,841,947,273.14	591,267,470,194.89
2080	323,816,862,100.00	289,432,421,000.00	171,601,992,127.74	603,736,601,453.17
2081	327,083,827,200.00	292,165,437,900.00	171,329,611,399.32	616,357,533,233.62
2082	330,350,792,300.00	294,898,454,800.00	171,024,805,087.86	629,130,265,536.19
2083	333,617,757,400.00	297,631,471,700.00	170,687,573,193.33	642,054,798,360.83
2084	336,884,722,500.00	300,364,488,600.00	170,317,915,715.79	655,131,131,707.70
2085	340,151,687,600.00	303,097,505,500.00	169,915,832,655.18	668,359,265,576.69
2086	343,418,652,700.00	305,830,522,400.00	169,481,324,011.56	681,739,199,967.81
2087	346,685,617,800.00	308,563,539,300.00	169,014,389,784.91	695,270,934,881.10
2088	349,952,582,900.00	311,296,556,200.00	168,515,029,975.18	708,954,470,316.51
2089	353,219,548,000.00	314,029,573,100.00	167,983,244,582.44	722,789,806,274.05
2090	356,486,513,100.00	316,762,590,000.00	167,419,033,606.66	736,776,942,753.64
2091	359,753,478,200.00	319,495,606,900.00	166,822,397,047.81	750,915,879,755.48
2092	363,020,443,300.00	322,228,623,800.00	166,193,334,905.96	765,206,617,279.49

2093	366,287,408,400.00	324,961,640,700.00	165,531,847,181.02	779,649,155,325.56
2094	369,554,373,500.00	327,694,657,600.00	164,837,933,873.09	794,243,493,893.82
2095	372,821,338,600.00	330,427,674,500.00	164,111,594,982.11	808,989,632,984.25
2096	376,088,303,700.00	333,160,691,400.00	163,352,830,508.06	823,887,572,596.69
2097	379,355,268,800.00	335,893,708,300.00	162,561,640,451.00	838,937,312,731.36
2098	382,622,233,900.00	338,626,725,200.00	161,738,024,810.87	854,138,853,388.16
2099	385,889,199,000.00	341,359,742,100.00	160,881,983,587.74	869,492,194,567.13
2100	389,156,164,100.00	344,092,759,000.00	159,993,516,781.57	884,997,336,268.23
2101	392,423,129,200.00	346,825,775,900.00	159,072,624,392.31	900,654,278,491.44
2102	395,690,094,300.00	349,558,792,800.00	158,119,306,420.05	916,463,021,236.84
2103	398,957,059,400.00	352,291,809,700.00	157,133,562,864.72	932,423,564,504.23
2104	402,224,024,500.00	355,024,826,600.00	156,115,393,726.39	948,535,908,293.87
2105	405,490,989,600.00	357,757,843,500.00	155,064,799,005.01	964,800,052,605.68
2106	408,757,954,700.00	360,490,860,400.00	153,981,778,700.55	981,215,997,439.62
2107	412,024,919,800.00	363,223,877,300.00	152,866,332,813.10	997,783,742,795.73
2108	415,291,884,900.00	365,956,894,200.00	151,718,461,342.58	1,014,503,288,673.91
2109	418,558,850,000.00	368,689,911,100.00	150,538,164,289.04	1,031,374,635,074.14
2110	421,825,815,100.00	371,422,928,000.00	149,325,441,652.46	1,048,397,781,996.68
2111	425,092,780,200.00	374,155,944,900.00	148,080,293,432.81	1,065,572,729,441.28
2112	428,359,745,300.00	376,888,961,800.00	146,802,719,630.14	1,082,899,477,408.05
2113	431,626,710,400.00	379,621,978,700.00	145,492,720,244.45	1,100,378,025,897.01
2114	434,893,675,500.00	382,354,995,600.00	144,150,295,275.69	1,118,008,374,908.09
2115	438,160,640,600.00	385,088,012,500.00	142,775,444,723.90	1,135,790,524,441.16
2116	441,427,605,700.00	387,821,029,400.00	141,368,168,589.05	1,153,724,474,496.48

2117	444,694,570,800.00	390,554,046,300.00	139,928,466,871.19	1,171,810,225,073.98
2118	447,961,535,900.00	393,287,063,200.00	138,456,339,570.30	1,190,047,776,173.59
2119	451,228,501,000.00	396,020,080,100.00	136,951,786,686.33	1,208,437,127,795.33
2120	454,495,466,100.00	398,753,097,000.00	135,414,808,219.36	1,226,978,279,939.25

Appendix K: Inflation

We used ARIMA modeling in R for stationary, non-seasonal data to determine projected inflation up to 100 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)
```

Year	Prediction
2021	0.0384
2022	0.049603
2023	0.046258
2024	0.043845
2025	0.042104
2026	0.040848
2027	0.039942
2028	0.039289

2029	0.038817
2030	0.038477
2031	0.038231
2032	0.038054
2033	0.037927
2034	0.037834
2035	0.037768
2036	0.03772
2037	0.037685
2038	0.03766
2039	0.037642
2040	0.037629
2041	0.03762
2042	0.037613
2043	0.037608
2044	0.037605
2045	0.037602
2046	0.0376
2047	0.037599
2048	0.037598
2049	0.037597
2050	0.037597

2051	0.037597
2052	0.037596
2053	0.037596
2054	0.037596
2055	0.037596
2056	0.037596
2057	0.037596
2058	0.037596
2059	0.037596
2060	0.037596
2061	0.037596
2062	0.037596
2063	0.037596
2064	0.037596
2065	0.037596
2066	0.037596
2067	0.037596
2068	0.037596
2069	0.037596
2070	0.037596
2071	0.037596
2072	0.037596

2073	0.037596
2074	0.037596
2075	0.037596
2076	0.037596
2077	0.037596
2078	0.037596
2079	0.037596
2080	0.037596
2081	0.037596
2082	0.037596
2083	0.037596
2084	0.037596
2085	0.037596
2086	0.037596
2087	0.037596
2088	0.037596
2089	0.037596
2090	0.037596
2091	0.037596
2092	0.037596
2093	0.037596
2094	0.037596

2095	0.037596
2096	0.037596
2097	0.037596
2098	0.037596
2099	0.037596
2100	0.037596
2101	0.037596
2102	0.037596
2103	0.037596
2104	0.037596
2105	0.037596
2106	0.037596
2107	0.037596
2108	0.037596
2109	0.037596
2110	0.037596
2111	0.037596
2112	0.037596
2113	0.037596
2114	0.037596
2115	0.037596
2116	0.037596

2117	0.037596
2118	0.037596
2119	0.037596
2120	0.037596
2121	0.037596

Appendix L: Voluntary Program Annuities

Region 1

	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
-----------------------	-------	--------	--------

Region 3

	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 Time Medium Benefit	21,153,415,242.28	11,744,823,603.43	23,624,863,712.15	16,133,127,758.98
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

Region 6

	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

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[scenarios?facet=none&Metric=GDP&Rate=Total&Region=OECD&country=SSP5+-](https://ourworldindata.org/explorers/ipcc-scenarios?facet=none&Metric=GDP&Rate=Total&Region=OECD&country=SSP5+-+Baseline~SSP1+-+2.6~SSP2+-+3.4~SSP3+-+6.0)

[+Baseline~SSP1+-+2.6~SSP2+-+3.4~SSP3+-+6.0](https://ourworldindata.org/explorers/ipcc-scenarios?facet=none&Metric=GDP&Rate=Total&Region=OECD&country=SSP5+-+Baseline~SSP1+-+2.6~SSP2+-+3.4~SSP3+-+6.0)

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ACADEMIC VITA

Xinyi Chen

EDUCATION

The Pennsylvania State University

Schreyer Honors College & Smeal College of Business & Eberly College of Science
Bachelor of Science in Actuarial Science, Bachelor of Science in Mathematics

University Park, PA
May 2023

ACTUARIAL EXAM & WORK EXPERIENCE

ASA Exam Progress

Exam P/1 & FM/2

Passed in 2021

VEE – Economics, Accounting and Finance, Mathematical Statistics

Course Taken in 2021&2022

Ernst & Young

Actuarial Internship

Boston, MA
Starting Jun. 2023

Synchrony Financial

Risk Management Internship – Model Validation

Stamford, CT
May. 2022 – Aug. 2022

- Managed model risk across model lifecycle including model validation, performance evaluation, and annual model reviews
- Performed model validation in line with pre-identified frameworks and delivered high-quality model risk validation reports
- Developed technical skills by running code using Python and SAS, attended Hackathon and gained UI design skills using Figma
- Learned modeling technique for credit and fraud models including traditional statistical models and AI/ML models

Penn State Actuarial Science Club

Assistant Director of Student Engagement

University Park, PA
Jan. 2022 – Present

- Organized workshops that provide student with insights and opportunities in the actuarial science field
- Managed social events and mentorship programs to create networking and career development opportunities for members
- Served as the main liaison between the main campus and commonwealth campuses to increase member involvement

RESEARCH & COMPETITION

Penn State Nittany AI Challenge 2022

Jan. 2022 – Sep. 2022

Top 6 over 59

- Lead ideation and concept exploration to create an application that assists students with notetaking and note reviewing
- Conducted market research through by collecting over 100 students' survey data to generate ideas for the application
- Determined the development cycle of the project and collaborated with software engineers on UI designing

Penn State Undergraduate Student Research Fair 2021

Jan. 2021 – May. 2021

First Place in Technology Category

- Forecasted stock prices based on historical company stock data using Markov Chain and Stochastic Model
- Fostered collaboration and consistency by working closely with team member and professor

CAMPUS INVOLVEMENT

Penn State Student Learning Center

Peer Tutor & Embedded Math Tutor

Scranton, PA
Jan. 2020 – May. 2022

- Tutored for Advanced Math, Beginner Statistic, and Beginner Economic courses for individual sessions
- Tutored PaSSS and Summer Bridge programs for first incoming students on precalculus in 2020 and 2021
- Presented at 2021 Annual Penn State All Learning Centers Conference on the topic of Strategies and Tools

Penn State Bounce Dance Organization

Vice President in the Activity Department

University Park, PA
Sep. 2021 – Dec. 2021

- Arranged showcase events to encourage campus involvement and fill the need for art activities for the student body
- Coordinated events by using Microsoft Office for the creation of posters, tickets, and master tracker lists

SKILLS & ACHIEVEMENTS

- Languages: English (Fluent), Mandarin (Native)
- Technical Skills: SAS, Python, Microsoft Excel
- Academic Excellence Award in Mathematics, President Sparks Award, Outstanding Scholar Award, Honors Scholarships