Storslysia Relocation Social Insurance Program

2022 SOA Student Research Case Study

JKS Advisory

Kenuka Wijayatunga
Sarah Liang
Jenny Zhang
Abiya Hanif
Ajaey Loganathan

Prepared for Storslysian Government

1. Executive Summary

With the growing risk of climate-related disasters, this report provides a high-level and holistic analysis of JKS Advisory's Social Insurance Program for Storslysia's exposure to displacement risk. Under the guise of the provided data, this report includes several research and data-driven assumptions to help project aggregated Government costs of our program and discusses the ethical consequences of it, as well as provide alternative methods such as a conservation program to help reduce the dire effects of climate change.

The implied program goes to 2040 and has two main sections: involuntary (reactive) and voluntary (proactive) relocations. JKS have provided grants and incentives for the latter, particularly for those who live in major-risk regions like 2 and 5. To ensure the program is successful, we have compared several different sensitivity analyses to our base case scenario of not having a program via a plethora of financial calculations such as NPV, to assure a 90% confidence of not exceeding 10% of Storslysia's GDP.

2. Program Design Considerations

One of the primary considerations made in the product design was deciding which regions we wanted to relocate from, and which regions were considered safe enough to relocate into. The graphs below illustrate statistics for average frequency, deaths, injuries, and cost for each of the Regions 1 – 6 in Storslysia. Some important data points to highlight are that:

- Regions 4, 5 and 6 have the lowest frequency of events. Regions 2 and 3 have the highest.
- Regions 4, 5 and 6 have the lowest average deaths per event. Region 2 has the highest.
- Regions 1, 2, 3, 4 and 6 all have low average injuries per event. Region 5 has the highest.
- Regions 1, 3, 4 and 6 all have low average cost per event. Region 2 has the highest.

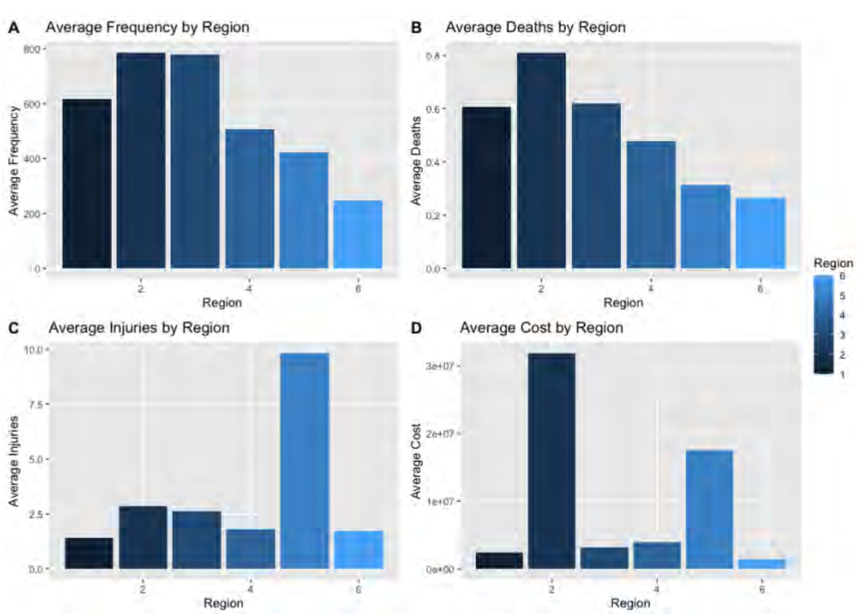

Figure 1: Regional Statistics

Thus, Regions 2 and 5 have been deemed the riskiest and these individuals will qualify for the voluntary relocation program. On the other hand, Regions 4 and 6 have been classified as the safest and will host the newly relocated individuals from Region 2. Regions 1, 3 and 5 will be left untouched by this program.

2a. Assumptions

Economic and Demographic Assumptions	
Population growth	Based on world population on given SSP scenarios
GDP growth	Based on world GDP on given SSP scenarios
Inflation	2% average global inflation
Population movement	-1% p.a. population out of region 2 and 6
Currency conversion	Based on provided currency conversion rate

Program Assumptions	
Property Grant	Ꝑ7,000 based on case studies and currency conversion rate
Individual Employment Grant	Ꝑ10,000 based on case studies and currency conversion rate
Business Employment Grant	Ꝑ10,000 based on case studies and currency conversion rate
Employment Programs	Ꝑ20,000/job based on case studies and currency conversion rate
Upgrading safety standards for existing houses	0.02% GDP based on average international spend for infrastructure upgrades and currency conversion rate

2b. Involuntary Relocation

Under Storslysia's involuntary relocation insurance program, all citizens who experience total loss of property due to climate-related catastrophes will be covered if they are older than 18 and they own a property in Storslysia or a mortgage. This policy will be compulsory to be purchased from the government. For a citizen to claim insurance funds, they must file a claim proving the property is a total loss due to a natural hazard event covered under our policy and their claim will be assessed. This insurance policy will cover the full replacement cost of home and contents less a Ꝑ5,000 deductible. In the case of landlord claims, a rental agreement must be provided.

The cost of involuntary relocation can be broken into the frequency and severity of hazard events, as well as the cost of temporary housing.

<u>Frequency</u>

Frequency was modelled based on Peril Type and Event Size (Minor, Medium, Major).

Peril Type:

Initially, the provided 'Hazard Events' dataset had many claims with multiple perils listed and no indication of a primary peril. Hence, the first step was to allocate a Peril Type by:

1. Group the claims data by 'Hazard Event' and calculate summary statistics
2. Scale all the values by a log factor to ensure comparability.
3. Identify which listed peril most closely resembles the claim. This was done by selecting the pair with the shortest Euclidean distance based on the calculated statistics.
4. Finally, groups with low observations e.g. Coastal, Gog, Heat, Landslide and Wildfire were grouped into an "Other" category

Event Size:
Event size was determined by first inflating historical property damage costs to 2022 present value using inflation rates and population growth. Population growth was accounted for as an assumption was made that hazard events will have a greater associated property damage for a larger number of people in the affected area. Once claims were inflated, events were classified into minor, medium and major with breakpoints at Ƥ500,000, Ƥ5,000,000 and Ƥ50,000,000. All events larger than Ƥ50,000,000 were separately modelled as extreme hazard events.

Modelling Minor, Medium and Major Frequencies:
The two key distributions considered for modelling frequency were Poisson and Negative Binomial. The comparison between the empirical and theoretical distributions for each of these can be found in the diagrams below. As seen in Figure 2, the Negative Binomial CDF fits the empirical data to a higher degree than the Poisson CDF as it allows for greater variance. Furthermore, a chi-squared test was conducted to assess the fit of the data against a Negative Binomial distribution. This yielded a p-value < 0.05, and thus, was selected as our distribution. Thus, our initial hypothesis was that the frequency was Negative Binomial distributed.

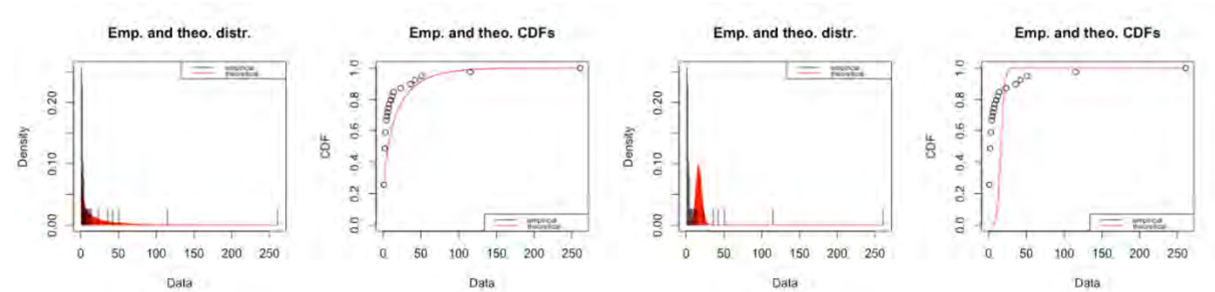

Figure 3: Empirical vs Theoretical Distribution for frequency (LHS – Negative Binomial, RHS – Poisson)

After creating separate datasets for each peril grouping and event size, the 80th negative binomial quantile was estimated to obtain a yearly frequency estimate. The 80th quantile was used to ensure that frequency would not be underestimated as it is necessary to keep total expenses below 10% of GDP with a high degree of certainty. In some instances, if there was a lack of data or the estimated frequency was 0, a frequency of 0.5 was instead used as there should always be a non-zero probability of an event occurring. The final estimated frequencies are as follows:

Peril	Minor Events	Medium Events	Major Events
Drought	0.5	0.5	0.5
Flooding	7	2	1
Hail	10	1	0.5
Hurricane/Tropical Storm	0.5	0.5	0.5
Lightning	4	1	1
Other	2	0.5	0.5
Severe Storm/Thunderstorm	4	2	1
Tornado	2	2	1
Wind	30	4	1
Winter Weather	7	1	0.5

During EDA, some regions were discovered to be more exposed to certain perils, therefore the frequencies of events were split amongst the regions. A ratio was determined by finding the historical occurrence of each peril in each region and this ratio was applied to split each frequency into the 6 regions.

Severity

Once frequency estimates for different sized perils for each region were obtained, severities needed to be estimated for the same categories of peril, size, and region. As seen in Figure 5 (which displays historical claim severity after accounting for inflation and population growth) there are no trends present. Consequently, severity prediction was modelled utilising historical averages.

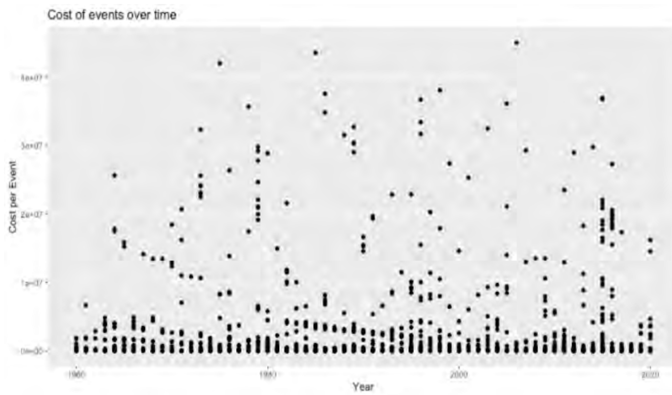

Figure 4: Historical claim severity (after inflation and population growth)

Catastrophic Events

The severity of Catastrophic events was modelled using Extreme Value Theory and the Peaks over Threshold (POT) method, which is a method that deals with the tail-end of a distribution.

- Using a Mean Residual life plot and its initial point of linearity, a threshold was selected, and Catastrophic events were defined as ones which exceeded the threshold of ₱50,000,000.
- MLE determines parameter estimates for a Generalised Pareto Distribution – common for modelling extreme events. The fit was confirmed using a Bootstrap test.

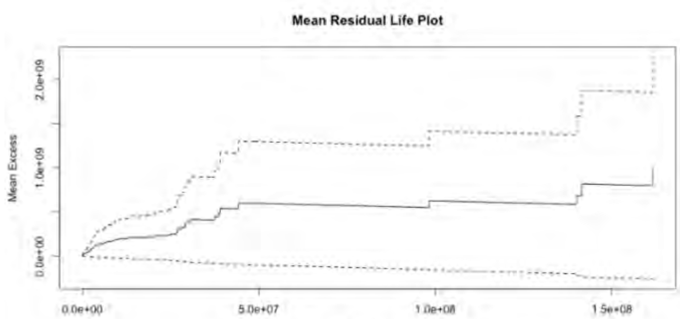

Figure 6: Mean Residual Life Plot on Catastrophic Data

To ensure certainty of program cost, the 80th percentile value was chosen for Catastrophic event severity. Similar to Minor, Medium and Major events, the 80th percentile of a Negative Binomial distribution was used for Catastrophic event frequency – supported by a chi-squared test.

Involuntary Relocation Costs

Within each category of Peril Type, Event Size and region, frequency and severity were multiplied together to obtain total estimated claims costs. The estimated frequencies for minor, medium and major events were inputted into the CO_2 emissions model to be projected until 2100. Thus, the total cost was projected using population growth and frequency projections over time. Finally, within each region, a proportion of the total damage costs for each year were assumed to be attributable to total loss (thus, resulting in involuntary relocation) based on property value distribution and likelihood of total loss. A multiplier of 125% was then added to consider the increased cost of labour and housing following a natural disaster and a multiplier of 157.5% was added to account for replacement of belongings and household items.

On top of the cost of rebuilding the destroyed homes, involuntary relocation costs also include temporary housing expenses associated with waiting for permanent housing. This was done by estimating the number of displaced individuals multiplied by 24 months and the cost of temporary housing per person per month to access temporary housing.

2c. Voluntary Relocation – Cash based Compensation Schemes

Scheme 1: Buy out properties

Within our program, we provide the citizens of Storslysia a buy-out option to incentivize voluntary relocation for those who live in regions 2 and 5 to move into regions 4 and 6. For this option to be successful, JKS have come up with data-driven assumptions and rates to project voluntary relocation costs, with the added benefit of a relocation home buyers' grant of Ᵽ5,000 (7,000 AUD from Revenue NSW). This will result in an aggregated expense of Ᵽ593.5m for this whole scheme over the duration of the program.

Given that voluntary relocation was covered for individuals in regions 2 and 5, we analyzed the median property value in both regions and took the lowest 5 ranges (≤ Ᵽ250,000) to identify the number of households most at risk. Cheaper houses are targeted due to the assumption that they are more prone to being destroyed in a catastrophic climate related event due to lower building standards/cheaper infrastructure material. To calculate projected buyout expenses for the selected households, a chosen buyout rate is multiplied with each property value range.

From a historical point of view via the RBA, there is at least a 15% upsell of properties when compared to the construction costs, which is why JKS have also assumed that the government will have incurred 85% of the costs associated with the property buyout and relocation of the citizens who want to move to safer regions 4 or 6. Note that this 85% is a historically driven estimation that we propose to stress test and adjust after the implementation year of 2022. When comparing the expenses of the houses that are out of the above threshold, we come to an expense that is logically not sound enough to make the program successful, as it would negatively impact our objective of trying to not exceed 10% of Storslysia's GDP.

Scheme 2: Employment Opportunities

When moving over 22,316 households to a new area in the first year of implementation, there are consequently more job opportunities created such as construction and material work, but JKS have created an incentive that will further boost the employability rate in both regions 4 and 6. JKS have projected the first-year cost to be Ᵽ231.4m and Ᵽ4.2b over the program duration. NSW Government has stated that when an investment of over 240,000 AUD is implemented in a program, it creates at least 12 new full-time jobs. JKS have utilized this metric in our employment projects with the market conversion rates from AUD to US and the given conversion rate to get from USD to Ᵽ.

This figure retains a strong and sustainable stance in employability rates for Storslysia which inherently boosts their economy and GDP. And although Ᵽ4.2b seems like a reasonably large figure, if we compare the base case, expenses remain to a constant range of 0.05%-0.04% of GDP, whereas with the program, our forecasts show that at implementation year the expense is 0.04% of the GDP but all subsequent years' expenses decrease to ~0.03% of GDP. Therefore, with a very high level of certainty, we are able to create an incentive which does not exceed 10% of Storslysia's GDP annually.

Scheme 3: Individual and Business Relocation Grants

Employment Grants

This financial support covers expenses such as moving costs, temporary accommodation, travel for employee and immediate family.
There are two types of employment grants:

1. *Individual Grants*: This program provides a ₱10,000 grant to eligible individuals who move to regions 4 and 6 for new employment, are a citizen on the date their employment commences and is employed full-time for at least 24 months over a 3-year period.
2. *Business Grants*: This program assists eligible businesses to relocate in regions 4 and 6 by providing a ₱10,000 grant to cover relocation expenses. Eligible businesses must be within an eligible industry and create at least 3 new full-time equivalent jobs in the new region. The increase in employment opportunities in regions 4 and 6 will further attract more skilled employees to voluntarily relocate.

Property Grants

Government property grants incentivize relocation by offering financial support to homeowners who move their principal place of residence into regions 4 and 6. This program provides ₱7,000 grant to eligible homeowners to support rent or down payment assistance. To qualify for a property grant, homeowners must have lived outside of regions 4 and 6 for over 12 months before moving to regions 4 and 6.

Scheme 4: In kind compensation – housing provided by the government

Facilitated through increasing the supply of housing in safer areas, particularly in region 6, where absolute vacancy is low. New housing development can occur on the city fringe (greenfield) or within existing urban areas (infill). To encourage adoption of this form of voluntary relocation, further investments in infrastructure and social services will improve relocators quality of life. This is particularly important for region 6, where total health care and social assistance revenue per capita is the lowest of all regions, suggesting that further infrastructure development is needed.

2d. Alternative methods to relocation

Upgrading housing safety standards

An alternative method to voluntary relocation would be upgrading safety standards for existing houses. For example, to help protect against wind damage, roofs can be reinforced using truss bracing, and hurricane resistant doors and storm shutters can be installed. For minor flooding, utilizing moveable flood walls and sealant can significantly reduce property damage. Similar measures can be applied to address each relevant hazard to improve the safety of existing houses. In general, adaptation spending on assets to improve their safety standards should constitute around 1-2% of total infrastructure spending per year.

Climate change conservation programs
An alternative to both voluntary and involuntary relocation is investing significant portion of funds into environmental conservation programs to minimize impacts of climate change over time. Some potential programs include:

- Renewable energy infrastructure e.g., solar energy which will minimize the use of fossil fuels and greenhouse gases that get released into the atmosphere.
- Employment of effective recycling and waste reduction initiatives.
- Deforestation protection and active reforestation which decreases harmful CO_2 gases.
- Promote the use of sustainable agriculture methods e.g., minimizing fertilizer use.

Increased community education

Form	Initiative
1. Education focused on minimizing the frequency and severity of events	Raising awareness about the causes of climate change and how to reduce its effects through sustainable practices e.g. recycling. This can primarily be taught during school/university classes, news broadcasts or community gatherings
2. Education related to safe practices in the case of natural hazard events	Involves things such as effective infrastructure for an evacuation and easily accessible shelters for risky areas. This can also include tips to reduce costs e.g. move the car from the street into the garage during times of hail risk.

3. Implementation Strategy Timeline

Figure 7: Implementation Timeline

4. Program Impact

Sensitivity analysis has been conducted based on the four provided climate scenarios. The climate scenarios range from Case 1, which is optimistic regarding conservation and predicts a decrease in natural hazard frequency, to Case 5, which assumes the 'worst-case' scenario and predicts an exponential increase in the frequency of natural hazard events. As seen in Figure 6, for all four cases, the Net Present Value (NPV) of the costs are higher without the program than compared to with the program by an approximate factor of 2x. However, it must be noted that until 2040 (the year which the scheme stops buying out and building new houses), the cost with the program is greater than the cost in its absence. Only in perpetuity where the impacts of the scheme can be observed are the savings generated. Figures 7 and 8 illustrate the increasing cost related climate related hazards such that Case 5 > Case 3 > Case 2 > Case 1.

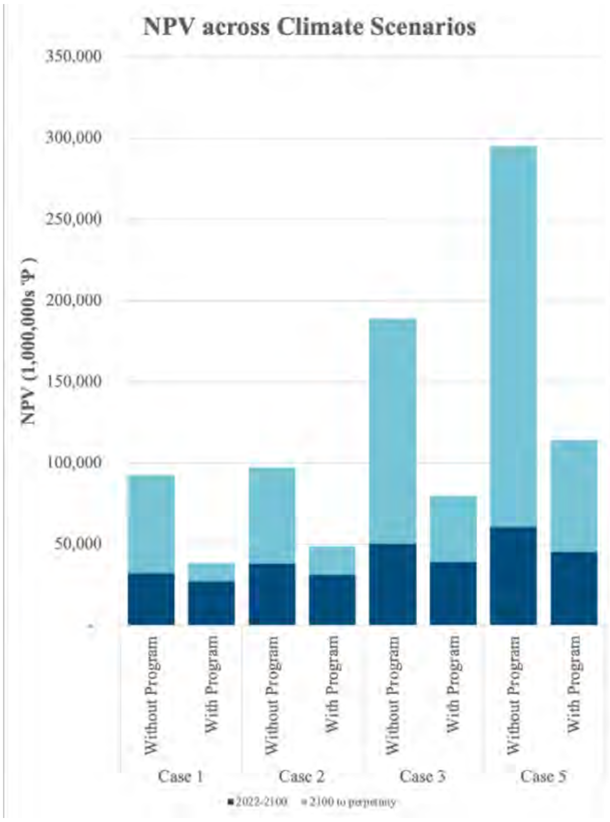

Figure 9: NPV across scenarios

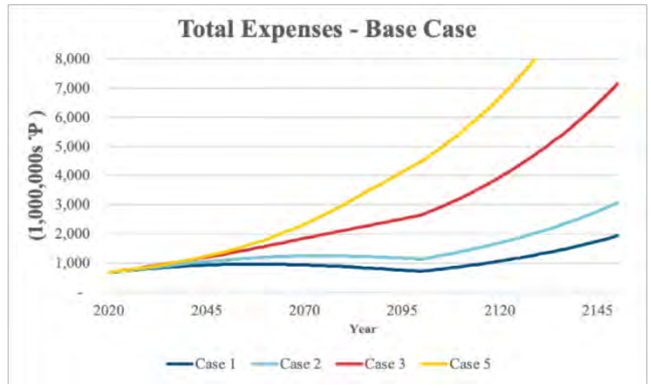

Figure 8: Total Expenses – Base Case

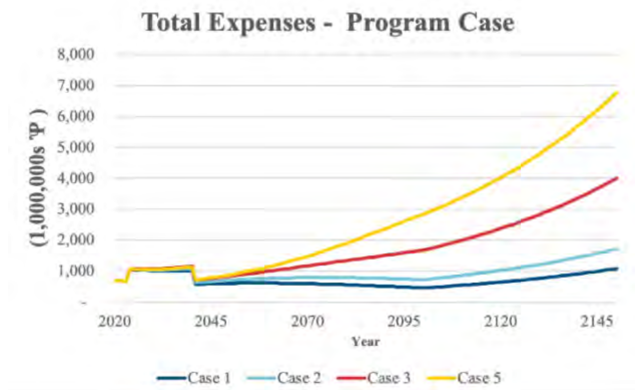

Figure 8: Total Expenses – Program Case

Outside of costs, another major benefit of our program is the reduction in deaths and injuries. By relocating individuals away from the riskiest areas, Case 2 sees a 47% decrease in the number of deaths and 39% decrease in the number of injuries by the year 2100. At the forefront of our scheme is the individual – not only providing monetary support but aiding health and wellbeing.

5. Risk Considerations

In the case of forced displacement and voluntary relocation, considerable risks involve:

- Pricing mismatch: citizens are charged an inappropriate premium for their risk profile.
- Unaffordable premiums: when pricing becomes too targeted such that premiums for higher risk properties become expensive and, in some cases, unaffordable. This risk should be managed through reinsurance, as well as cross subsidizing.
- Inadequate reserves: this occurs when inadequate reserves have been set aside for potential future claims due to underwriting errors or low investment returns.
- Homelessness: for forced displacement, the risk of homelessness increases as homeowners lose sources of income, support networks and often, their largest asset.
- Psychological impacts: being uprooted from one's community may cause adverse psychological effects e.g. depression and anxiety, loss of identity and social isolation.
- Unemployment: for forced displacement, joblessness risk increases as homeowners have difficulty finding employment after being uprooted from their home
- Social disarticulation: forced displacement may lead to the fragmentation of family and support networks, which can lead to a disconnection from one's community

Early identification and mitigation of these risks should be factored into government policies and planning strategies to support families undergoing catastrophe-related displacement or planned relocation triggered by climate change. Mitigation strategies include:

- Providing technical resettlement choices and support
- Providing housing design, materials, and construction support
- Ensuring local capacity for resettlement
- Providing access to health, education, and government services
- Promoting effective community involvement
- Providing livelihoods and income restoration support
- Ensuring strong institutional structures and political leadership to ensure proper documentation and support during implementation

6. Ethical Considerations

Equality vs equity when offering the voluntary relocation program. The proposed program is focused on buying out properties of lower economic value, to target those in lower socio-economic status, and reduce costs for the program. Although this does not achieve equality for all citizens, from a virtue ethics approach, targeting those that are more in need of financial assistance to relocate is the right way of moving forward, as the grants and extra employment opportunities created through the program will have a relatively more significant impact on those from a lower-socioeconomic background.

Ethics of voluntary relocation must be considered in relation to those that are moved. Although the program is voluntary, individuals may feel pressured to move as they are warned about the potential risks to their properties and lives. There may also be risks to mental health due to moving away from family and friends, or from an established working situation. In addition, inter-regional cultures may be drastically different, such as in Canada where certain regions predominantly speak French. This may cause extra struggle through having to learn another language. Although these are negatives that must be considered, from a utilitarian framework, they are necessary to achieve overall better outcomes for citizens. The initial hardship from relocating likely does not compare to the potential hardship from major property damage and loss of life without relocation, so it can be viewed as a necessary consequence for greater good in the future, thus aligning with utilitarian ethics. Investments into infrastructure in the safer regions, which is part of the program, further aim to foster a sense of community amongst relocated individuals, and the creation of employment opportunities aim to alleviate any hardship from loss of income due to relocation. When considered in addition to grants provided by the government, the overall benefits of the program far outweigh the negatives.

Another ethical consideration is regarding burden sharing, and the effect on current residents of a region of an influx in people moving in. Since the relocated individuals will mostly be of a lower socio-economic background, the question arises whether the quality of life of current residents is being reduced due to having to accommodate for people that may be struggling for employment, despite initiatives proposed to increase job supply in safer areas. In addition, in regions where further housing development is required, the compensation for loss of land, assets or livelihood, for example through the government taking over farmland to build houses, may not be adequate. For infill development, the increased housing density and possible loss of green spaces in residential areas may detract from existing resident's property value as well. However, when considering the common good approach to ethics, the individuals of a society have their own good inextricably linked to the good of the community. Thus, through the new jobs created and the investments into improved infrastructure in the region, society will holistically benefit from the voluntary relocation program, even if certain individuals may be worse off as a result.

7. Data Limitations

Hazard Data	Lack of granularity means that we are unable to discern the number of households and individuals impacted by each hazard event. Therefore, assumptions were made to estimate the number of impacted to model the involuntary and voluntary expenses of the program.
	Many events have multiple hazards listed in hazard type. The Peril Type was determined using the shortest Euclidean distance from listed perils.
Emissions Data	Atmospheric CO2 projections, world population projections and GDP projections are only available in increments of 10 years. Therefore, linear interpolation is used to project for the years in between.
	There are only 4 Shared Socioeconomic Pathways available, therefore we are only able to model the expenses associated with these scenarios.
	Projections only exist until 2150 – model is limited to be accurately projected until 2150 and assumptions of growth must be made to project into perpetuity.
Economic – Demographic Data	Data inconsistencies present in the inflation data. The identified rates were replaced by an average of inflation rates of the surrounding years.
	Population growth data and GDP growth data for Storslysia not available, therefore world projected growth rates used instead.
	Lack of granularity leads to many assumptions being made. Inability to model on an individual level and instead must model on the population of each region.

8. Final Recommendations

To provide a social insurance program that incorporates the highly uncertain levels of risk that climate change poses is one that will always need improvement. JKS Advisory has provided several cases with a controlled assumptions list that follow an actuarial judgement that is logical and rounded. Although these assumptions can be treated as varying components with a ranging margin of error due to a lack of historical and current data, JKS can say with a 90% certainty that without the program, Storslysia's expenses around displacement risk will only increase.

Thus, although there are ethical dangers surrounding the program, JKS has provided a comprehensive study that discusses how to mitigate risk as well as encouraging the act of reducing a countries carbon footprint via our SSP selections and our alternative methods such as an education/conservation program within the program.

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10. Appendix

Figure 1: Average Deaths by Peril

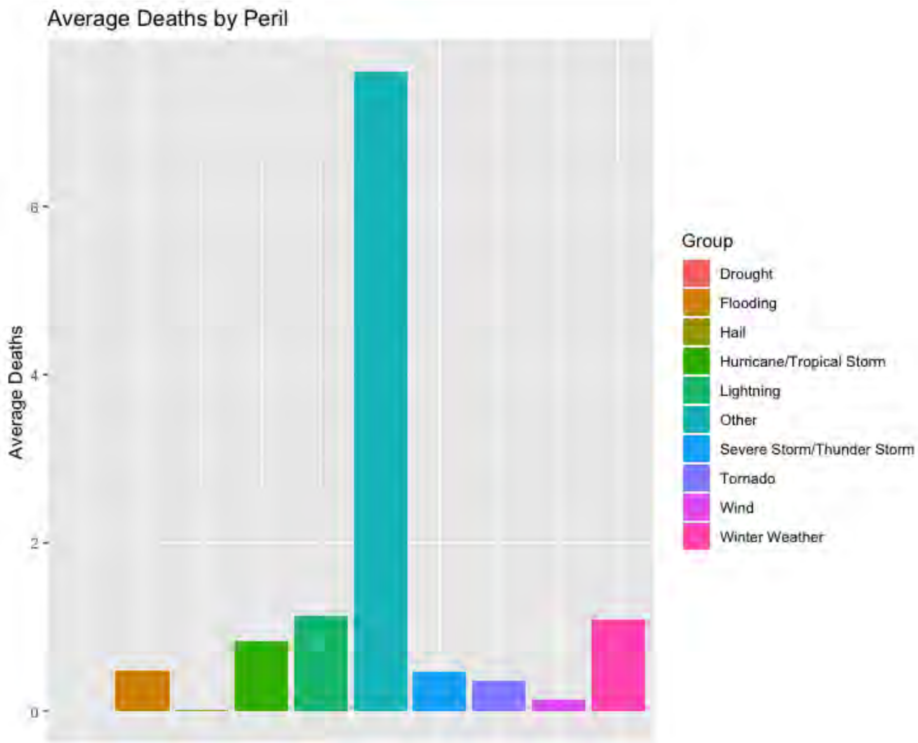

Figure 2: Average Injuries by Peril

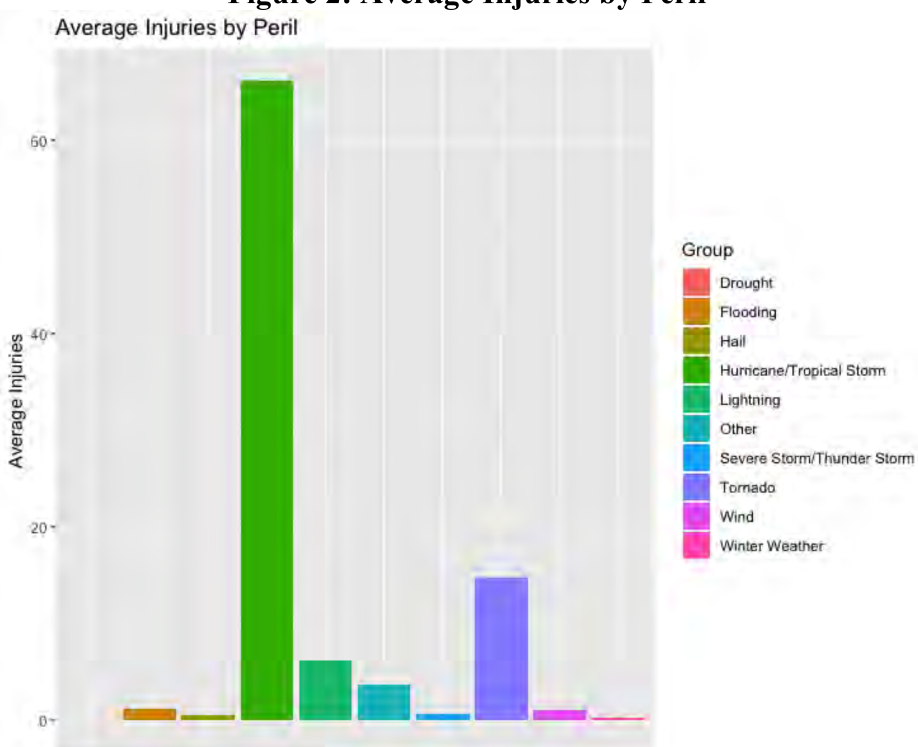

Figure 3: Average Cost by Peril

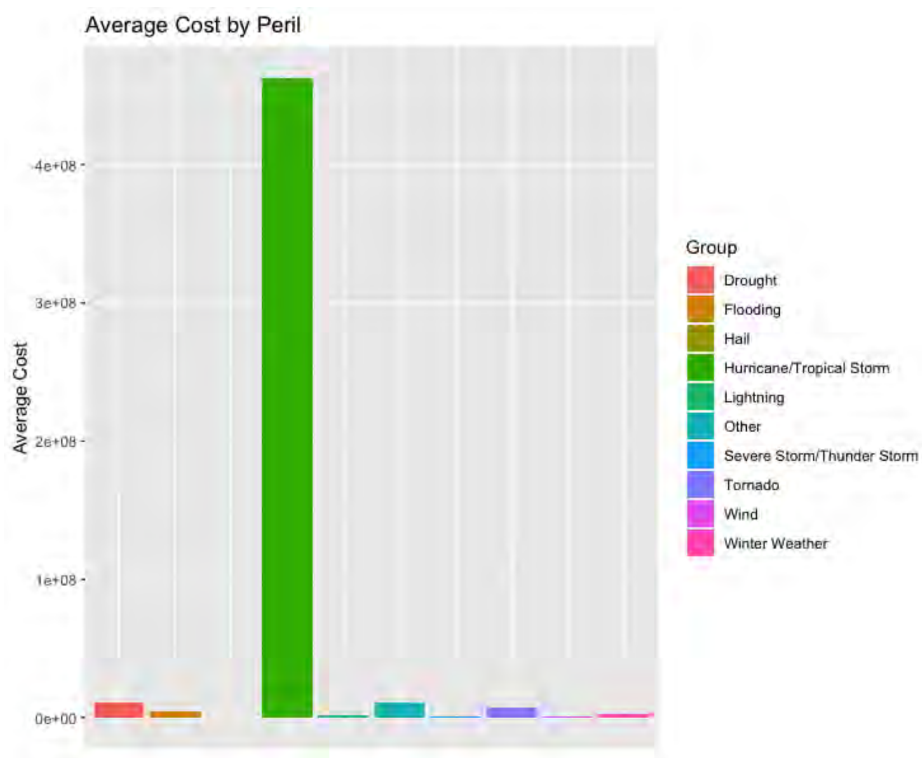

Figure 4: Event Frequency by Peril

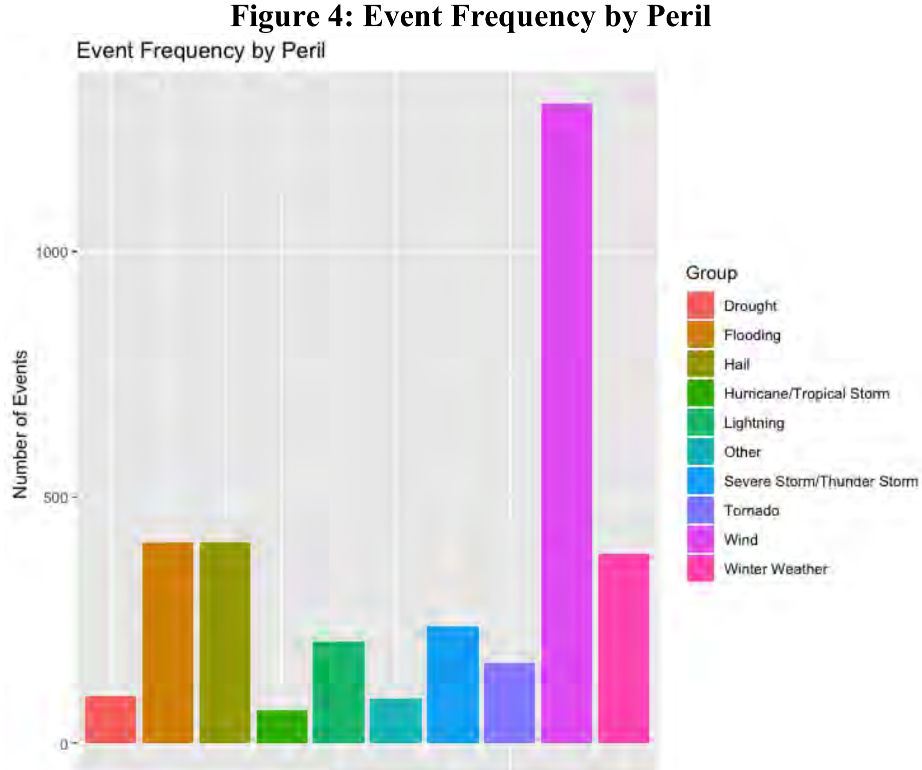

Figure 5: Frequency by Peril and Region

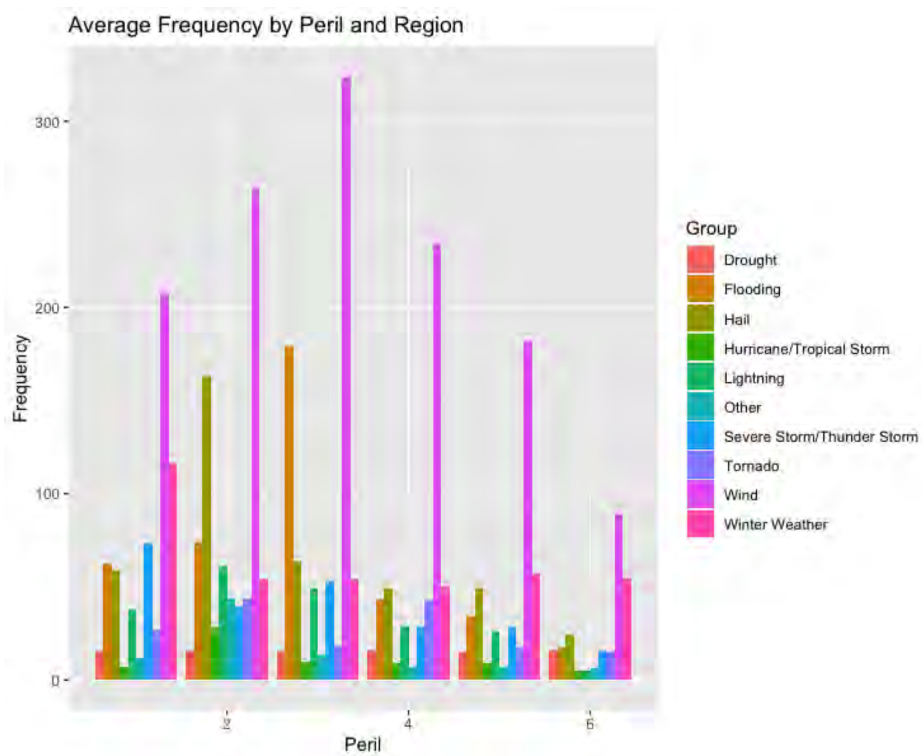

Figure 6: Average Cost by Peril and Region

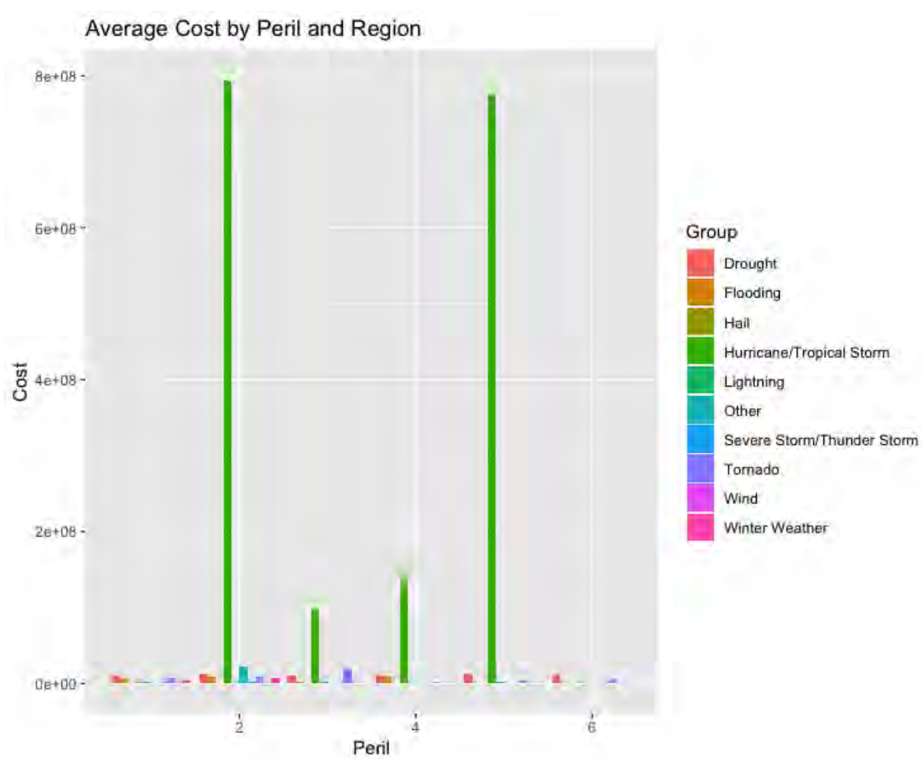

Figure 7: Average Cost by Peril and Region

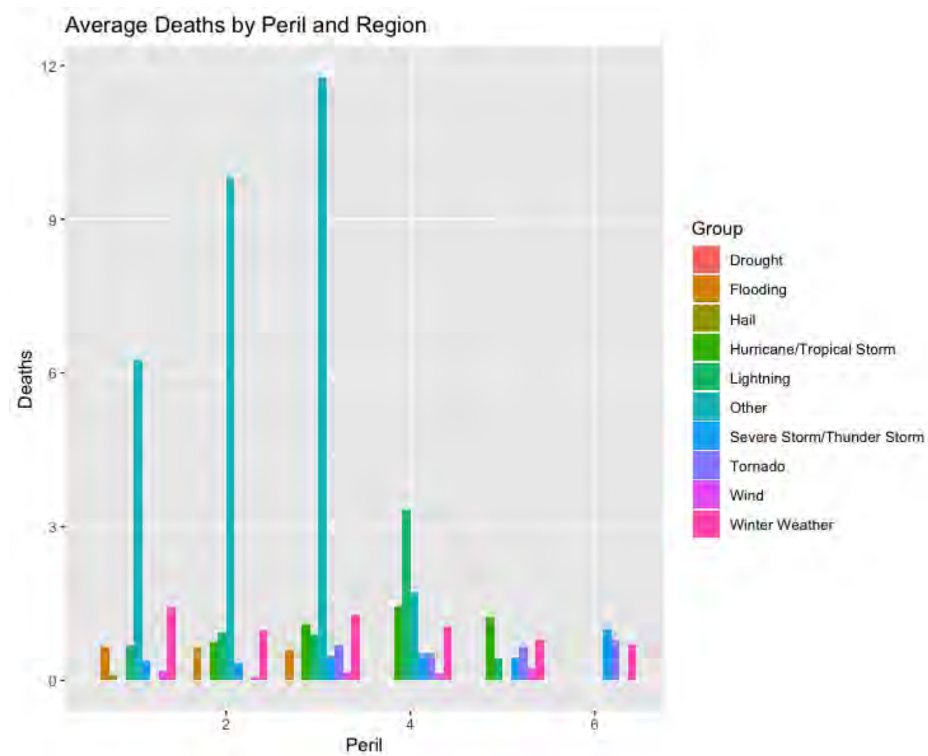

Figure 8: Average Cost by Peril and Region

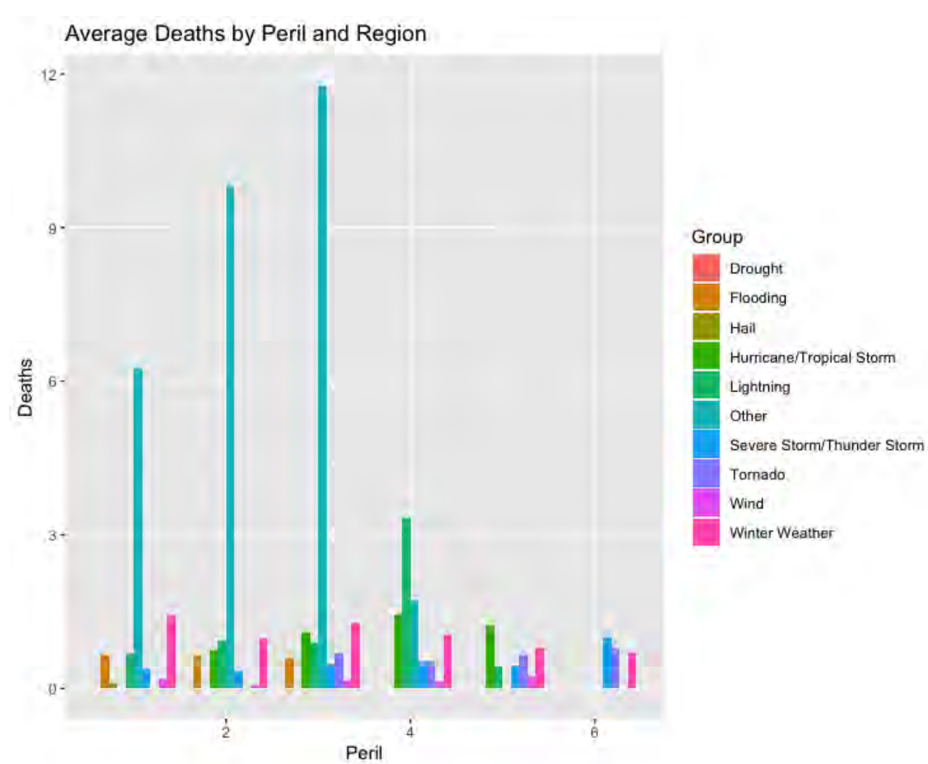

Figure 9: Parameter Stability Plot I

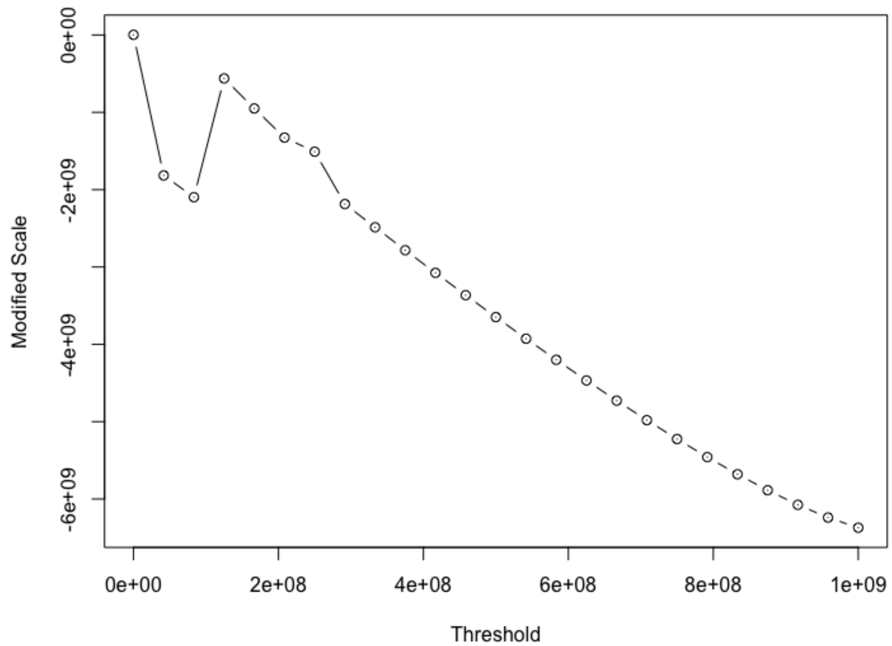

Figure 10: Parameter Stability Plot

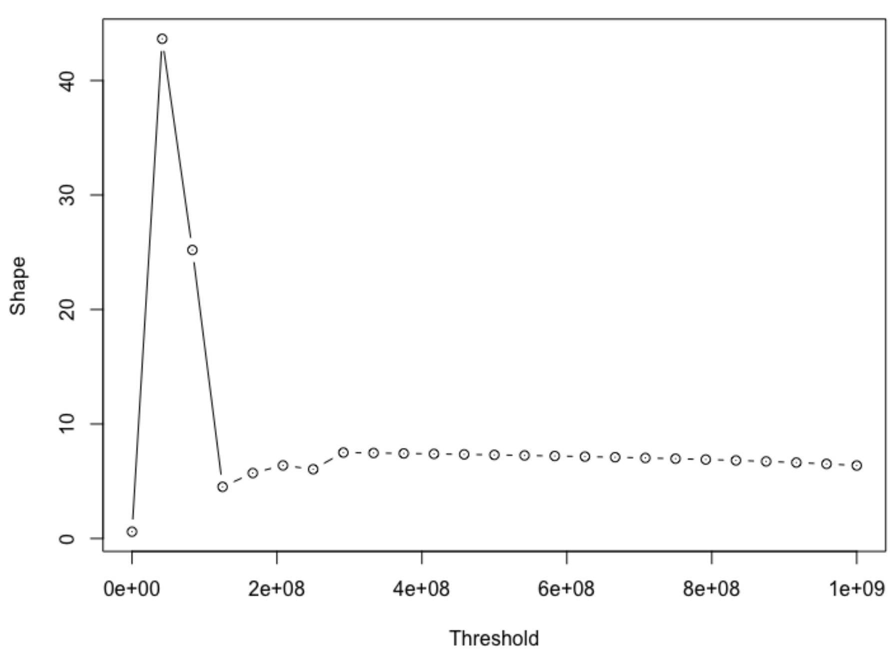

Figure 11: Frequency of Hazard Events over time

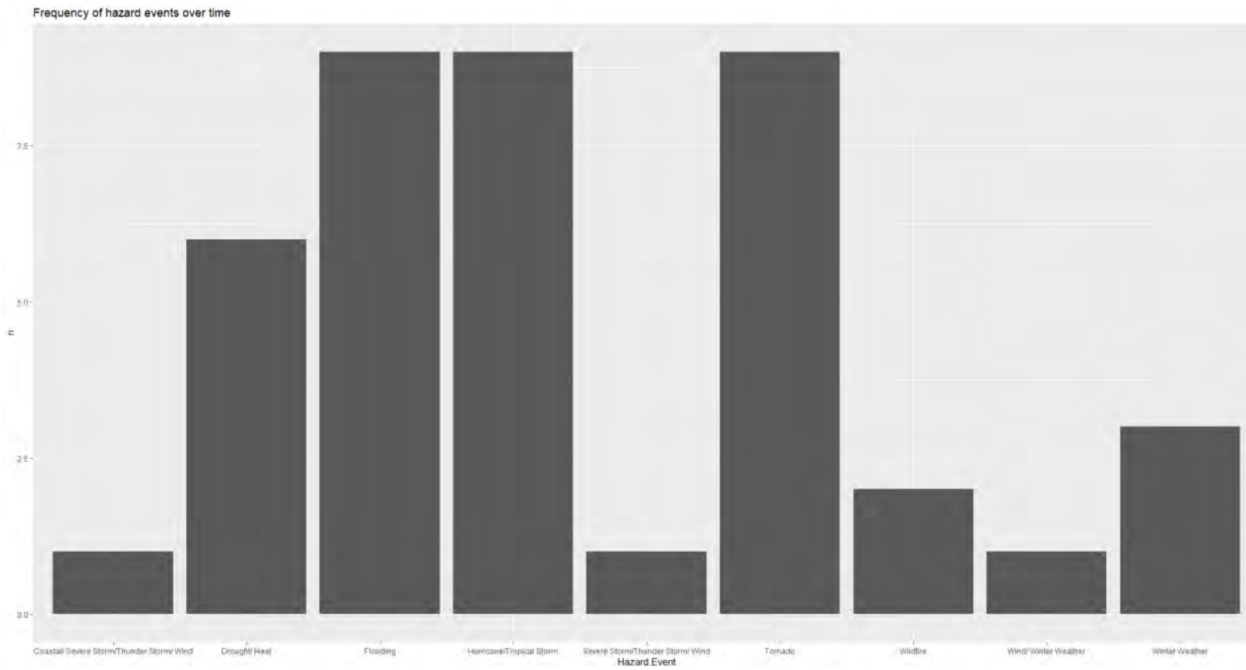

Figure 12: Frequency of Extreme Claims over time