# Program Design

The proposed program aims to relocate citizens of Storslysia from regions of high risk to areas with a lower probability of natural disasters. To identify the regions, the program will assign each region a score based on the overall severity and frequency of natural disasters in that area. The program will prioritise the relocation of people from the highest-risk regions, followed by those from the second-highest risk regions until no more relocation is necessary. We believe that the program will generally relocate population from the three bottom ranked regions to the three top ranked regions. The program will also provide financial and psychological assistance to those who file a claim due to natural disasters. The program has been split into two parts, namely voluntary and proactive, and involuntary relocation, each with specific requirements that must be met.

Voluntary/proactive relocation aims to encourage people to move to safer areas before a climate event happens. A citizen that has voluntarily or proactively relocated would have moved from an area identified as high risk to an area with lower risk based on our analysis.

The requirements for an individual to file a claim under our program is:

* Voluntary relocation: The individual can show proof that they permanently moved from a region of high risk to a region with lower risk in the last 5 years
* Involuntary relocation: Evidence of damage due to the natural disaster. Can include but not limited to photos, videos.
* Involuntary relocation: Estimated repair costs of the damages incurred / Cost to build a new home in that region

The program will provide coverage on the following items:

* Coverage to rebuild a standard home or purchase an existing non-owner-occupied home. All members who need to be relocated completely will have a subsidy equals to 80% of the owner occupied home
* Coverage to replace household goods, equal to 40% of the cost of the owner-occupied home. The cost of replacing household goods typically ranges from 40% to 75% of housing costs. The coverage is towards the lower end as we believe households have the ability to bring a proportion of households with them when relocating.
* General lump sum equals to three months of average household income, which is around 17k, to provide assistance.
* For involuntary relocation or household impacted by hazard events, temporary housing while the house is being rebuilt/repaired
* Lump sum of a specified amount if there is a death that occurs
* Coverage of hospital bills of a specified amount if there are injuries that occur due to the natural disaster
* Complementary therapy or psychology sessions to assist with the mental trauma with subsidized continued visits. The continued visits must have proof from the professional that they are due to the impact of the natural disaster or the relocation scheme.

A number of incentives are provided to promote proactive relocation. They include:

* No land tax on the house in the new region for 5 years after relocating
* Job training and employment opportunities to help individuals find a stable job

Quantitative Justification

* Frequency of Natural Disasters: Due to the high probability of natural disasters in various regions which may cause property damage, injury and death, relocating citizens from high to low risk areas reduces the likelihood of those three factors.
* Severity of Natural Disasters: Proactive relocation is cheaper than involuntary relocation, though coverage is provided for both. Due to the severity of the natural disasters, incentives to proactively can reduce the severity of the natural disaster.
* Individuals with lower socio-economic status are often the most vulnerable after severe natural disasters. The program’s prioritisation of these individuals ensures that those at most risk receive the necessary help first.
* From the most current data, these are some statistics about Storslysia. Image

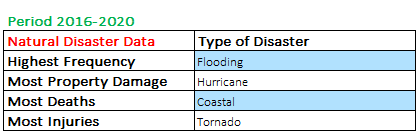
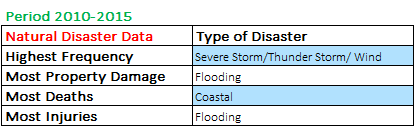
Qualitative Justification

* Economic Impact: Due to the funds restriction, coverage has been tiered to ensure that those in high risk areas can be treated. Although individuals in high risk areas may see a higher coverage which may reduce incentive to move, we believe that people place a higher emphasis on their life and individual property rather than willingly wait for the natural disaster. The coverage for high risk areas is mainly for those who are unwilling or unable to relocate.
* Societal Impact: Reduction of property damage, injury and loss of life is at the forefront of the program. Human life is extremely important, so prioritising human life and injuries are of the upmost importance.
* Limitations: Limitations are placed on the program so that it provides realistic expectations on those who may be affected by the natural disaster. It also aims to provide effective coverage if a natural disaster happens. Due to these factors, the limitations ensure that the program can operate with effectiveness and efficiency.

Short Term:  
The short-term time frame in which the program will be monitored will be over a 5 year period. During this time, continued monitoring of natural disasters will occur and continued relocation and coverage will be provided and monitored. The reason a 5 year timeframe will be considered a short term frame is because the program needs to be monitored over all regions and all types of natural disasters. For example, here is the difference of a 5 year timeframe for the country of Storslysia. We can see that there are a few differences between natural disasters over the years, ensuring trends are adapted to will greatly improve the quality of the program

Long Term:

The long-term time frame will be over a 130-year period. This is so continued observations of the natural disasters over that period can be monitored, and any changes in trends to the natural disasters can be adapted to. Additionally, due to natural population increases, the relocation program will need to ensure that it has enough capacity to continually relocate people whilst having enough citizens in each region to ensure the economy continues to improve. For example, a high-risk region may turn into a low risk region, thus individuals who may have relocated from that region may want to relocate back to that region. Hence, the program can be continually updated to consider this. Over the given period, there was an average of 55 natural disasters per year, with an estimated 325m property damage per year. Continued monitoring of these statistics will allow the program to be adjusted accordingly.



# Pricing/Costs

## Pricing Methodology

To price this relocation program, a score-ranking system was established for each region according to their risk profiles on the severity and frequency of natural weather hazards. This score is calculated by multiplying a severity measure and frequency measure for a given region:

After calculating the scores for each region, the regions were ranked by their respective scores with the highest being the riskiest while the lowest being the least risky. Hence, it was determined that the ranking order for Storslysian regions, from most to least risky, was 2, 5, 4, 3, 6 and 1.

Under the scheme, the objective was to relocate 55%, 50% and 25% of households from regions 2, 5 and 4 to relatively ‘safer’ regions 3, 6 and 1 respectively. This implied a relocation target of 1,795,486 households from regions 2, 5 and 4. Conversely, the maximum total available space for the safe regions 3, 4 and 1 was determined to be 1,810,050 houses which was sufficient to accommodate the relocated households. Additionally, it was assumed that the maximum intake for each regions equates to the maximum available houses in each respective regions.

Additionally, it was also crucial to consider the progress or timeline of the relocation in each region which was based on the risk profile ranking of each region. Essentially, the safest region with the lowest score was prioritised and so forth. Consequently, this suggests region 2 was prioritised to be the first relocation destination, followed by region 5 and finally region 4. The benefit of this prioritisation ordering allows to minimise the economic costs and impacts of the occurrences of natural hazards in the future. Moreover, this scheme also strives to achieve an even distribution of the total relocation target annually, which amounts to 260,000 households to be relocated per year. This is mainly to mitigate any irregular economic impacts due to uneven distribution of relocation per year. As a result, this program will actively run over a seven year time period.

A transition matrix for the household relocation discussed above is displayed below:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Regions** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **Year 6** | **Year7** |
| **1** | 260,000 | 260,000 | 260,000 | 107,823 | 0 | 0 | 0 |
| **2** | -260,000 | -260,000 | -230,000 | -230,000 | -200,000 | -120,000 | -88,053 |
| **3** | 0 | 0 | 0 | 119,390 | 260,000 | 260,000 | 235,486 |
| **4** | 0 | 0 | 0 | 0 | 0 | -80,000 | -44137 |
| **5** | 0 | 0 | -30,000 | -30,000 | -60,000 | -60,000 | -103,296 |
| **6** | 0 | 0 | 0 | 32,787 | 0 | 0 | 0 |
| **Total** | 260,000 | 260,000 | 260,000 | 260,000 | 260,000 | 260,000 | 235,486 |

### Economic Capital Budget

To implement this program, it was assumed that a budget amounting to 10% of Storsylsia’s GDP was given, which is equivalent to the requirement that the scheme’s costs should not exceed 10% of Storsylsia’s GDP. Additionally, there were also four cost components considered in this scheme which included voluntary relocation costs, proactive relocation costs, emergency displacement (or involuntary relocation) costs and other miscellaneous costs related to the relocation process and aftermath. A summary table of the scheme’s budget allocation is shown below:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Budgeting (ꝔBillions)** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **Year 6** | **Year 7** |
| Budget = 10% GDP | 129.69 | 129.69 | 129.69 | 129.69 | 129.69 | 129.69 | 129.69 |
| Voluntary Relocation Costs | (5.13) | (5.13) | (5.13) | (5.13) | (5.13) | (5.13) | (5.13) |
| Proactive Relocation Costs | (100.07) | (100.07) | (96.17) | (96.17) | (92.28) | (80.47) | (70.71) |
| Emergency Displacement Costs | (1.48) | (1.44) | (1.41) | (1.38) | (1.38) | (1.39) | (1.41) |
| Miscellaneous Costs | (10.52) | (10.52) | (10.13) | (10.13) | (9.74) | (8.56) | (7.58) |
| **Excess Budget** | 12.35 | 12.39 | 16.71 | 16.74 | 21.03 | 34.00 | 44.72 |
| **Solvency Degree of Certainty** | 89.16% | 89.24% | 95.27% | 95.30% | 98.23% | 99.97% | 100.00% |

In calculating the costs, proactive relocation cost for each region was calculated as 80% of average property price plus 40% of average property price for household goods plus another 3 months of average countrywide household income. Additionally, it was estimated that 5% of the relocation target will choose to voluntary relocate, due to flexibility in timing and zone selection. Each household will receive a subsidy of Ꝕ200M and this is accounted for in the voluntary relocation cost. Emergency displacement costs accounts for the temporary housing cost with disaster and the relocation cost associated with households that are impacted by hazard events within the project’s 7 years’ time frame. We assume that minor events affect 0.01% of the households in the impacted region, medium events affect 0.1% of the households, and major events affect 1% of the households. Miscellaneous cost equals to 10% of relocation cost, the capital should cover administrative expenses, labour expenses, legal costs etc.

As seen in the above table, it is observed that voluntary cost remains constant while all other costs were generally projected to decrease over the years. As expected, proactive relocation costs contributed the greatest to the total costs in this program due to housing and income stream compensation costs. In contrast, emergency displacement costs represented the smallest portion of total costs. This was due to the fact that the proportion of households needing to relocate due to emergency was relatively low from probability calculations.

A degree of certainty for the solvency of the program was also evaluated to assess the viability of this scheme. We define solvency here as when total costs remain less than our total budget. Referring to the last row of the above table, we view a relatively high degree of certainty in the solvency of this program. Moreover, an increasing trend in the degree of certainty could be seen over the projected years. Evidently, this is due to the reduction in aggregate costs over time and thus the chance of insolvency will also decline.

### Economic Costs

In this section, the projection of economic costs for this relocation scheme will be contrasted between two cases: (1) when the relocation scheme is implemented and (2) when there is no relocation scheme. For the purpose of simplicity, we will refer to the case where the relocation program is implemented as ‘*with’* case, and when there is no relocation program as the ‘*without’* case.

Firstly, to define economic costs, we have used the following formula:

where are coefficients in dollar per person units. However, this measure is based on a per natural hazard occurrence basis and thus to determine the total annual economic costs, it is required to multiply economic costs by annual frequency.

Given the frequency projection model, the frequency measure was split into four scenarios including SSP1, SSP2, SSP3 and SSP5 (baseline), and within each scenario, the occurrence of natural hazards were categorised into three cases: minor, medium and major. To distinguish between these cases, it was assumed that minor events has a total economic cost of less than Ꝕ2 million, medium events has a total economic cost between Ꝕ2 million and Ꝕ10 million, and major events has a total economic cost greater than Ꝕ10 million.

Using historical data, we categorised the past occurrences of natural hazards into minor, medium and large and thus determined the average frequency and economic costs which could be used as the initial values for projection. To add on, it was also assumed that the probability of entering SSP1, SSP2, SSP3 and SSP5 (baseline) was 30%, 30%, 30% and 10% respectively. The projected frequencies is shown below:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Projected Frequencies (Number of Hazard Events per Year)** | | | | | | | | | | | | | | | | | | |
|  | **Minor** | **Med** | **Major** | **Minor** | **Med** | **Major** | **Minor** | **Med** | **Major** | **Minor** | **Med** | **Major** | **Minor** | **Med** | **Major** | **Minor** | **Med** | **Major** |
| **Year** | **Region 1** | | | **Region 2** | | | **Region 3** | | | **Region 4** | | | **Region 5** | | | **Region 6** | | |
| **2020** | 9.762 | 1.857 | 0.524 | 19.429 | 2.524 | 1.524 | 19.857 | 1.857 | 1.048 | 10.286 | 0.952 | 0.190 | 8.524 | 0.238 | 0.286 | 3.857 | 0.571 | 0.095 |
| **2030** | 10.947 | 2.083 | 0.587 | 21.786 | 2.830 | 1.709 | 22.267 | 2.083 | 1.175 | 11.534 | 1.068 | 0.214 | 9.558 | 0.267 | 0.320 | 4.325 | 0.641 | 0.107 |
| **2040** | 12.002 | 2.283 | 0.644 | 23.887 | 3.103 | 1.874 | 24.414 | 2.283 | 1.288 | 12.646 | 1.171 | 0.234 | 10.480 | 0.293 | 0.351 | 4.742 | 0.703 | 0.117 |
| **2050** | 12.824 | 2.440 | 0.688 | 25.522 | 3.315 | 2.002 | 26.085 | 2.440 | 1.376 | 13.512 | 1.251 | 0.250 | 11.197 | 0.313 | 0.375 | 5.067 | 0.751 | 0.125 |
| **2060** | 13.425 | 2.554 | 0.720 | 26.719 | 3.471 | 2.096 | 27.309 | 2.554 | 1.441 | 14.145 | 1.310 | 0.262 | 11.722 | 0.327 | 0.393 | 5.305 | 0.786 | 0.131 |
| **2070** | 13.814 | 2.628 | 0.741 | 27.493 | 3.571 | 2.156 | 28.100 | 2.628 | 1.482 | 14.555 | 1.348 | 0.270 | 12.062 | 0.337 | 0.404 | 5.458 | 0.809 | 0.135 |
| **2080** | 13.957 | 2.655 | 0.749 | 27.777 | 3.608 | 2.179 | 28.390 | 2.655 | 1.498 | 14.706 | 1.362 | 0.272 | 12.187 | 0.340 | 0.408 | 5.515 | 0.817 | 0.136 |
| **2090** | 13.899 | 2.644 | 0.746 | 27.663 | 3.593 | 2.170 | 28.273 | 2.644 | 1.492 | 14.645 | 1.356 | 0.271 | 12.136 | 0.339 | 0.407 | 5.492 | 0.814 | 0.136 |
| **2100** | 13.812 | 2.628 | 0.741 | 27.488 | 3.571 | 2.156 | 28.095 | 2.628 | 1.482 | 14.553 | 1.347 | 0.269 | 12.060 | 0.337 | 0.404 | 5.457 | 0.808 | 0.135 |
| **2110** | 13.744 | 2.615 | 0.737 | 27.353 | 3.553 | 2.145 | 27.957 | 2.615 | 1.475 | 14.481 | 1.341 | 0.268 | 12.001 | 0.335 | 0.402 | 5.430 | 0.805 | 0.134 |
| **2120** | 13.696 | 2.606 | 0.735 | 27.258 | 3.541 | 2.138 | 27.859 | 2.606 | 1.470 | 14.431 | 1.336 | 0.267 | 11.959 | 0.334 | 0.401 | 5.411 | 0.802 | 0.134 |
| **2130** | 13.684 | 2.603 | 0.734 | 27.234 | 3.538 | 2.136 | 27.835 | 2.603 | 1.468 | 14.418 | 1.335 | 0.267 | 11.948 | 0.334 | 0.400 | 5.407 | 0.801 | 0.133 |
| **2140** | 13.969 | 2.657 | 0.750 | 27.801 | 3.611 | 2.180 | 28.415 | 2.657 | 1.499 | 14.718 | 1.363 | 0.273 | 12.197 | 0.341 | 0.409 | 5.519 | 0.818 | 0.136 |
| **2150** | 14.266 | 2.714 | 0.765 | 28.392 | 3.688 | 2.227 | 29.018 | 2.714 | 1.531 | 15.031 | 1.392 | 0.278 | 12.456 | 0.348 | 0.418 | 5.637 | 0.835 | 0.139 |

Evidently, the frequency projection model demonstrates that natural hazard frequency increases as the projected years increase. Contrarily, frequency decreases as the size of the natural hazard increases. Additionally, a graph of the short term and long term economic costs is illustrated below:

As expected, it is noted that without the program, the projected economic costs generally has an increasing trend in both short term and long term timeframes. This is due to the fact that the frequency itself has a positive relationship with time as explained above. However, interestingly, in the case with the program, it is observed that the annual economic costs decreases in the short term, but swiftly increases in the long term. This highlights the impact of this program as people relocate to safer regions in the short term in which will reduce the economic costs due to lower injuries and deaths. However, after the relocation program has concluded, the long term economic cost increases due to again, the increasing frequency effect as seen in the frequency projection model.

## Sensitivity analysis

It is difficult to assess which SSP scenarios Storslysia will end up into, it depends on government regulations, incentives, infrastructures, land-use planning etc. Therefore, our team decides to analyse the impact on economic costs when other probabilities of SSP Scenarios combination are applied in comparison with our baseline scenario. The scenarios analysed include:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Worst | Worse | Normal | Better | Best |
| SSP1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 |
| SSP2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.2 |
| SSP3 | 0.3 | 0.4 | 0.3 | 0.3 | 0.2 |
| SSP5 | 0.4 | 0.2 | 0.1 | 0 | 0 |

The scenarios will have little impact in the short term, thus our team focused on analysing its impact on long term economic cost:

In 2150, the best scenario will have an economic cost of Ꝕ996Million, which is a 56% reduction from the baseline scenario. The worst scenario will have an economic cost of Ꝕ5504Million, which is a 143% increase from the baseline scenario. This signifies the importance of environmental policies on economic costs.