LUMOS Consulting

Storslysia's Hazard Relocation Social Insurance Program

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1. Executive Summary

Storslysia is threatened by the increasing catastrophes caused by the escalating impact of climate change. The actuary team at Lumos consulting are working closely with the government to design a multi-peril social insurance program that covers all Storslysia population. The proposed objectives of the social insurance program include:

- To evaluate Storslysia's short- and long-term displacement cost arising from catastrophes, considering both voluntary and involuntary relocation.
- To encourage more residents to relocate voluntarily, thus reducing the potential property damage value in high-risk regions.
- To ensure the cost of the program is strictly under 10% of Storslysia's GDP.

To ensure the feasibility and sustainability of our proposed program, the following metrics require continuous monitoring in both short and long term.

- The actual frequency and severity of the disasters.
- The relocation rates among the regions in Storslysia.
- The current government policy, inflation rates and risk-free rates.
- The trends of material and labor cost associated with construction.
- The trend of climate change with impact on the environment.

Regions in Storslysia are categorised into 6 different risk levels based on a predetermined hazard risk index. The program design consists of a variety of incentives to encourage voluntary relocation. The report also considers the potential risks associated with the program and their corresponding mitigation measures.

By assessing the impact of the program on economic costs including displacement and incentive cost, there will be an average 8.3% and 6.2% reduction in cost compared with those without the program in the short and long term respectively. Sensitivity analysis is carried out to ensure the program's feasibility during extreme scenarios. The short- and long-term impact on economic capital is also considered in the report.

Overall, the program achieves the objectives of reducing the overall post-hazard displacement cost in both short and long term. The incentive proposed per potential victim is crucial to encourage voluntary relocation.

2. Program Design

2.1 Policy

Policy Requirements

- Only homeowners/landlords in Storslysia are covered under the insurance.
- Only residents assessed as potential catastrophe victims are entitled to incentives for voluntary relocation.

Claim Coverage

- The insurance covers the aggregate of property damage values, material and labor cost, cost of replacing household goods and temporary housing cost
- There is a deductible at 15% of the aggregate cost resulting from disasters averaged on each policyholder.

Incentives for Voluntary Relocation

- The present dollar value of incentive is ₱7500 per person per 10 years. Residents eligible for incentives can choose to receive the benefit through one of the methods below:
  - Lump sum of payments at the time of relocation.
  - Water and council payments subsidy.
  - Land tax reduction when purchasing the new relocated property.

2.2 Features

Disaster Index and moving rate

Based on historical data on different levels of disasters, a disaster index can be defined as the degree of severity for a whole region. Different grades are assigned for different levels of disasters. I.e., 1 for low damage disasters, 5 for median disasters, and 10 for high severity disasters:

$$Disaster\ Index = 1 \times No.of\ low\ disasters + 5 \times No.of\ median\ disasters + 10 \times No.of\ high\ disasters$$

Moving rate is defined as the percentage of population at risk for each region in each year. In general, the higher risk regions will have a higher moving rate. Based on the disaster index, different scenarios will have different moving rates according to Table 1.

Disaster Index			**I**	**II**	**III**	**IV**	**V**	**IV**
Range			(0, 25]	(25, 50]	(50, 100]	(100, 150]	(150, 200]	(200, inf)
Moving Rate (p)	Without	Short	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Long	0.0%	1.0%	2.0%	3.0%	5.0%	8.0%
	With	Short	0.0%	2.0%	4.0%	6.0%	10.0%	16.0%
		Long	0.0%	3.0%	9.0%	18.0%	27.0%	36.0%

Table 1 Disaster Index and different moving rate.

3. Assumptions

- Each household is assumed to have only one owner-occupied house/apartment.
- Short-term analysis includes yearly data from 2022 to 2026. Long-term analysis includes data from 2030 to 2150 on a 10-year basis.
- Properties in Storslysia do not have investment value, value increase is only associated with time value of money.
- The model assumes a completely competitive market where people purchase and sell houses/land in an instant with no opportunity cost.

- All regions are available for relocation, but people are only willing to move from high disaster index regions to low disaster index regions.
- There is no voluntary relocation in the short term without the program.
- Voluntary relocation rate increases with the frequency of disasters, this implies more residents are willing to relocate voluntarily in the long term.
- Future inflation rate and one-year risk-free rate are simulated using the log-normal assumption based on the fitting of the historical data (Appendix 1: Fitted and simulated results of the rates).
- Future economic growth is not influenced by the severity of the hazard.
- The social insurance program does not consider the correlation among the types of hazards.
- Furniture in rental properties is assumed to belong to the landlords, tenants will not be compensated for furniture damage.
- In the baseline model, we assume Storslysia follows SSP3-6.0 emission rules. During emergency displacement, 90% of victims will return to their original region after a temporary relocation in a safer region. The remaining 10% are not granted temporary relocation and they will stay permanently in the new region. The material and labor cost increases 25% post-hazard. The cost of replacing furniture and goods is 55% of the median housing costs per household.

4. Economic Costs

4.1 Projection Method

The base cost contains four parts which are property damage PD (Appendix 2: Projection of future property damage), material and labour cost ML, replacing household goods cost RH and temporary housing cost TH. When a resident moves out from a region, the potential hazard cost associated with the individual is reduced from the base cost. The reduction in percentage of population at risk is denoted as p. The program includes a deductible which is a percentage d of the base costs. IC corresponds to the incentive benefit provided for potential victim willing to relocate voluntarily (Appendix 3: Detailed derivation of the formulas). In different situations, the economic cost has different components and the formulas for each situation are shown below:

			Economic Cost
Without	Short	No moving	$PD + ML + RH + TH$
	Long	Moving out	$(PD + ML + RH + TH) \times (1 - p)$
		Moving in	$PD + ML + RH + TH$
With	Short	Moving out	$(PD + ML + RH + TH) \times (1 - p) \times d + IC$
		Moving in	$(PD + ML + RH + TH) \times d$
	Long	Moving out	$(PD + ML + RH + TH) \times (1 - p) \times d + IC$
		Moving in	$(PD + ML + RH + TH) \times d$

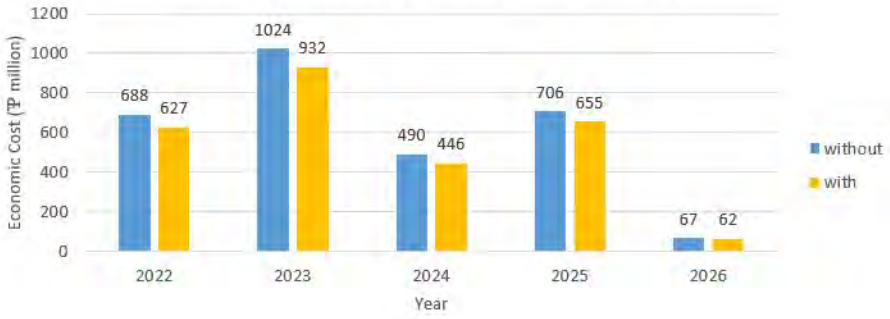
Table 2 Without program cost and with program cost

4.2 Economic cost without Program vs with Program

Short Term

The predicted short-term economic cost with and without the program is displayed in Figure 1. The economic costs without the program are higher than those with the program. In other words, there is a cost reduction due to the implementation of the program and the average cost reduction is around 8.3%. (Appendix 4: Detailed data of the economic costs in the short term)

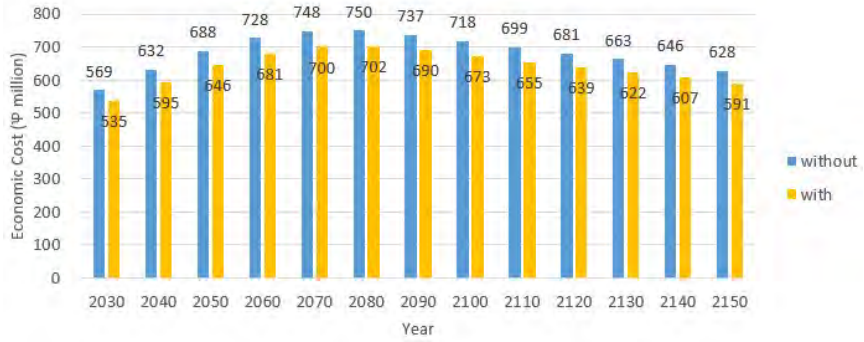
Figure 1. Comparison of Economic Costs - Short term



Long Term

Figure 2 depicts the estimated long-term economic cost with and without the program. The inclusion of the program reduces the potential economic costs. The average cost reduction is around 6.2%. Comparing to the short-term, the reduction percentage is smaller which can be explained by the different moving rates. Reduction in cost increases with the moving rates. In short term, there is no voluntary relocation without the program comparing to the large moving rate under program intervention. (Appendix 5: Detailed data of the economic costs in the long term)

Figure 2. Comparsion of Economic Costs - Long term

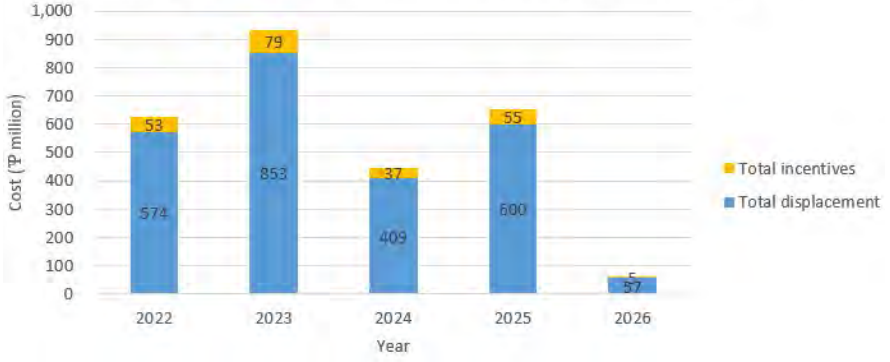


4.3 Displacement and incentive with program

Short Term

In short term, the frequency of disasters follows a negative binomial distribution. According to Figure 3, the incentive payments are small than displacement costs in the next five years. The incentive cost is ₱ 7500 per person for the risk population, and the average displacement cost is about ₱ 81806 per person in short term. There is a significant reduction if citizens are willing to move out from high-risk regions voluntarily under the program (Appendix 6: Short term displacement and incentive cost).

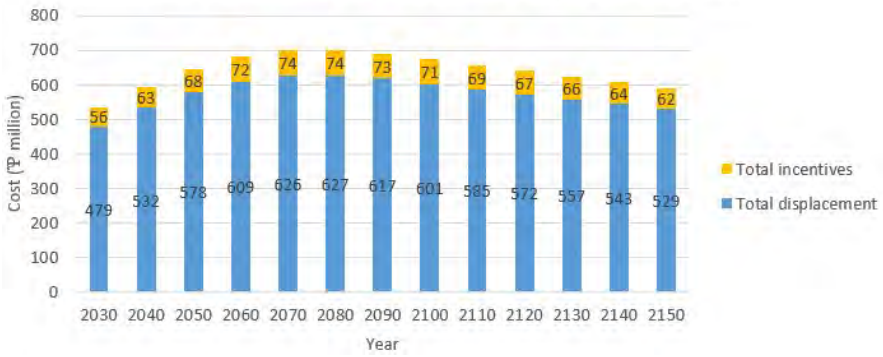
Figure 3. Displacement and incentives cost with program - Short term



Long-term

In long term, the frequency of disasters is predicted based on the SSP model. Figure 4 depicts that the incentive costs are small than displacement costs in the next 120 years. The average displacement cost is about ₱63530 per person in long term, which is smaller than it is in the short term since more citizens are voluntarily moving out from the high-risk region. The average displacement cost per person is still larger than the incentive cost indicating that there is a reduction in cost by implementing of the program (Appendix 7: Long term displacement and incentive cost).

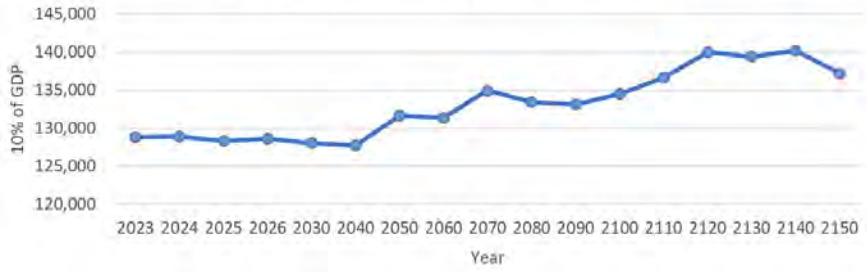
Figure 4. Displacement and incentives cost with program - Long term



4.4 10% of GDP Comparison

According to Figure 5, Storslysia's GDP increases in the future. However, when comparing the economic costs from the above analysis to the 10% of the predicted average GDP, the cost never exceeds the GDP value which reinforces our objective of cost controlling under 10% projected GDP (Appendix 8: Projection of Storslysia GDP).

Figure 5. The prediction of 10% GDP (in ₱ million)



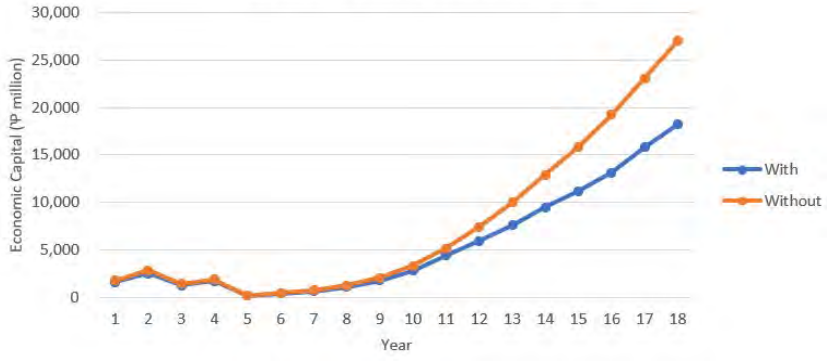
4.5 Economic Capital

Maximum economic costs can be obtained by considering the worst scenario:

- Choosing the 95 percentiles of the highest property damage among each hazard level (Appendix 9)
- Hazard frequency is evaluated under SSP5-Baseline assumption.
- 50% increase in post hazard labor and material cost, cost of replacing household goods after a catastrophe is 75% of housing cost and 100% of the hazard victims require temporary relocation.

The economic capital is the difference between the maximum and the base economic costs. Figure 6 displays an increasing trend in the future comparing the capital with and without the program. In the long term, the economic capital with the program will be significantly lower than that without the program (Appendix 10: Projection of the program economic capital).

Figure 6. Comparison of Economic Capital



5. Risk Management

5.1 Risk

Below is a Risk Categorization and Definition (RCD) analysis of the potential risks, the numbers range from 1 to 5 where 1 is the lowest severity and likelihood, vice versa.

Risk Category	Risk	Risk Division	Severity, likelihood	Explanation
Financial Risk	Unexpected economic downturn	GDP	(4, 2)	Low inflation and interest rate results in low GDP growth which impacts the budget of the program.
Financial Risk	Black swan event	Economy	(5, 1)	Unexpected large-scale events such as pandemic leading to massive shocks to the economy, causing problems such as unemployment, economic downturn.
Financial Risk	Change in currency value	Currency	(3, 2)	Change in Storslysia dollar against foreign currency influences the amount of foreign investment, leading to changes in output.
Ethical Risk	Equity risk	Ethic	(1, 4)	Different regions occupy different severity levels, but risk is shared evenly to all population under the program.
Ethical Risk	Discrimination risk	Incentives	(2, 4)	Same incentives across all disaster levels, discourage high risky population to move voluntarily
Environment risk	Underestimate the hazard severity	Liquidity	(5, 1)	More frequent large-scale catastrophes bring more property damage than projected.
Environment risk	Unexpected environment deterioration	Disaster	(3, 2)	The environment deteriorates more quickly than expected, making Storslysia more hazard prone.
Operational Risk	Administrative failures	Reserve	(4, 2)	Corruption in executive level which significantly reduces the catastrophe reserves.

Operational Risk	Underwriting risk	Reserve	(3, 2)	Incorrect identification of the potential residents at risk, causing increasing benefit payments.
Operational Risk	Human error	Reserve	(2, 2)	Error when building the model, causing miscalculation of the property damage and reserve requirements.

5.2 Mitigation

Financial risk

- Collect historical data for large scale economic events, create a new variable in the model to account for the abnormal downturn caused by such events. Thus, the impact the impact of these unusual downturns and regular economic shocks can be studied separately, allowing the policy makers to react to such situations readily.
- Storslysia's central bank is suggested to flexibly use fiscal and monetary policies to control the economic market and improve the resilience of the economy. In addition, policy makers must continuously monitor the shifts in politics and financial markets to revise the model. It ensures adequate preparation for currency and economy shocks.

Ethical risk

- Change incentives corresponding to disaster risk levels to avoid potential discrimination risk. Higher incentives should be granted to areas with greater risk, which could encourage residents in such regions to move out more voluntarily.

Environment risk

- The government is advised to promote the concept of environmental sustainability through different measures. For example, increasing the use of renewable energy instead of fossil fuels, which will reduce greenhouse emissions and decelerate climate change.
- Strengthen the regional infrastructure to enhance the capabilities to cope with hazards. In addition, establishing stricter building standards to build more hazard-resistant houses, reducing the potential severity of property damage.
- Introduce a comprehensive climate disaster data system, including risk maps for monitoring and management of disasters in medium- and high-risk areas. It helps develop appropriate disaster plans intended for different forms of catastrophes.
- Adequate planning in government land use. Avoid residential planning in high-risk areas.

Operational risk

- Disclose the information of cash flow intended for the insurance program.
- Set a dynamic program assessment system for the residents at risk. The system must be periodically monitored with the trend of disasters.
- Develop more comprehensive and detailed dataset for modelling. Continuously monitor and update the model also assists in mistake revision in the primary model.

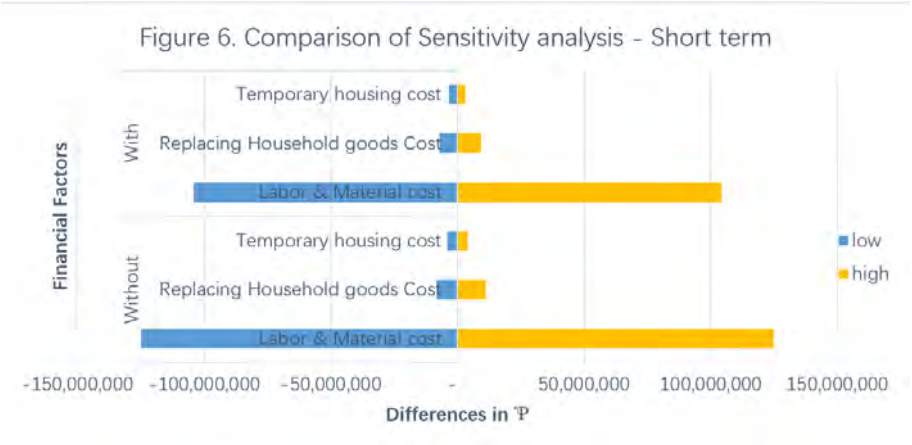
5.3 Sensitivity Analysis

The sensitivity analysis is constructed to demonstrate the financial impact of key assumptions. In the analysis, the percentage of victims returning to their original region after

a temporary relocation range from 80% to 100%, the rate of replacing household goods ranges from 40% to 75%, and the increasing rate of labor and material cost ranges from 0% to 50%. The difference in forecast hazard frequencies from SSP1-2.6 to SSP5-Baseline will also be considered.

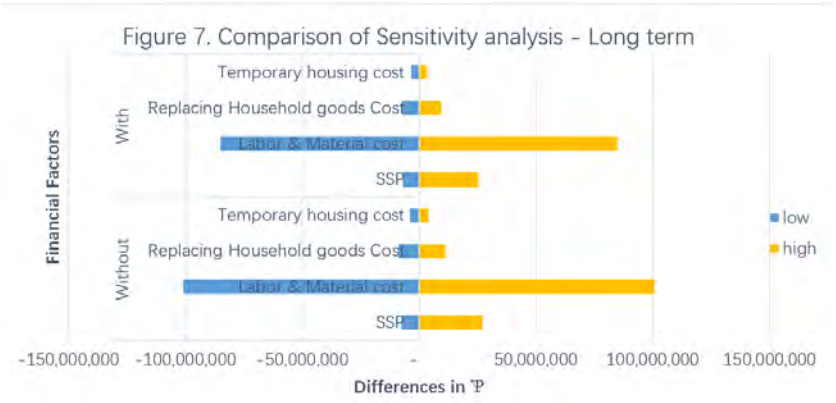
Short Term

In the short term, the program reduces all three types of cost according to Figure 7. The change in the growth rate of labor and material cost has the greatest impact on the short-term cost, while the temporary relocation expense exhibits the least impact. The presence of the program contributes to a 15% overall reduction in cost of material and labor where low indicates 0% increase and high indicates 50% increase. However, it exhibits minimal impact on changes in furniture acquisition and temporary relocation costs.



Long Term

Like the short-term scenario, the change in labor and materials costs have the highest impact on the long term cost observed in Figure 8. Choice of SSP assumption also plays a crucial role in the long-term cost. The cost increases 7% moving from SSP1-2.6 to SSP5-Baseline. The government must consider thoroughly about the emission plan in the future.



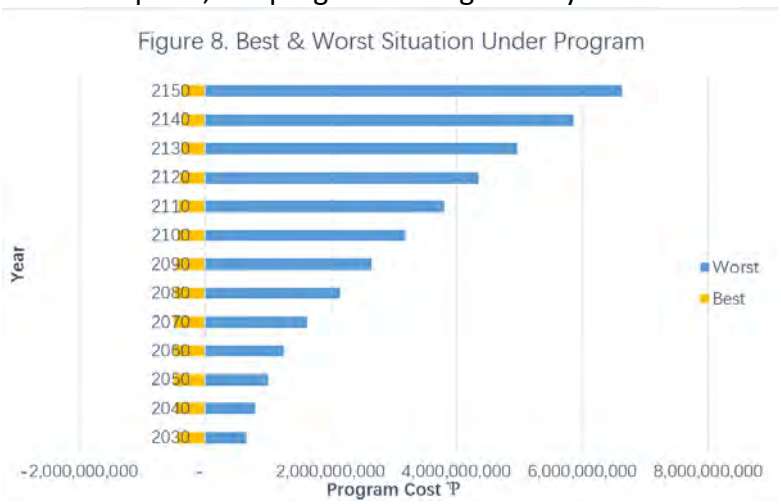
Stress Test

Based on the sensitivity analysis above, the projected scenario exhibits to two extremes cases under the four sensitivity indexes, including SSP, temporary housing cost index (TH_i), Replacing Household goods Cost index (RH_i), and Labor & Material cost index (ML_i).

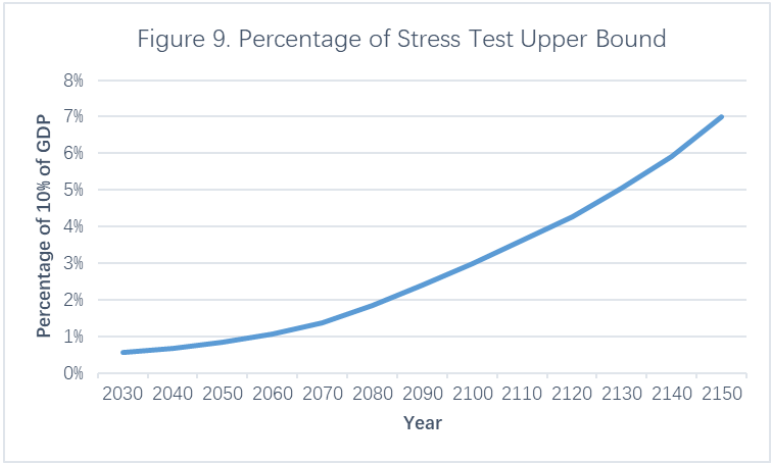
Sensitivity Index	SSP	TH_i	RH_i	ML_i
The best case	SSP1-2.6	0.8	0.4	0
The worst cast	SSP5-Baseline	1	0.75	0.5

Table 3. Parameters of the best and worst case

Comparing the two scenarios over time in Figure 8, the cost changes in the SSP1 scenario is significantly lower than that in the SSP5 case, which is approximately 5% of the cost changes in SSP5. Under SSP5 assumption, the program costs gradually increase.



It is obvious that the presence of the insurance program reduces the economic costs. A comparison is made between the cost under SSP5 and the 10% of minimum of the projected GDP. The highest program cost is about 7% of 10% of GDP (As shown in Figure 9 for year 2150). It indicates that the cost is still under 10% of GDP in the most extreme case.



Based on selected long-term and short-term economic growth, the frequency and severity of climate catastrophes, there is approximately 99% confidence that the cost with the policy will be lower than that without the policy under the baseline scenario. As the incentive increases, the number of people willing to move voluntarily will increase. The incentive benefit can be raised to ₱9185 before the cost without the program will be lower under the SSP1-2.6 assumption. When incentive payment is greater than ₱14450, the program is ineffective in all SSP scenarios, i.e., the confidence level is at 0% as the cost without the program will be lower in every scenario (Appendix 11: Detailed analysis of the critical value).

6. Data and Limitations

6.1 Data Selection

In this proposal, no external datasets are used to construct the analysis.

6.2 Data Limitations

Insufficient historical data

When estimating the future GDP, there are only two historical GDPs which is insufficient for a reliable projection of the future GDP. Time series cannot be applied as it requires a minimum of 5 GDPs. In addition, the inflation and risk-free rates is inconsistent with the GDP growth over 2019 to 2020. There is also no historical data for climate change. It limits the ability to observe a previous trend between the CO_2 emission, property damage and disaster frequencies.

The classification of hazards requires refinement

Hazard event categories are complicated. If each event's category is determined by the type of hazard which caused the most damage, the hazard classification process will be more efficient. For example, when a thunderstorm results in a flood which is the more disastrous hazard between the two, the classification of this event should specifically be flood.

The geographic information is not given

Climate is highly related to the geographical location. For example, precipitation in coastal or riparian areas is usually higher which results in the higher probability of flooding than other regions. Therefore, flood-related policy must be design more carefully for this area. In addition, there are regions exhibiting concentrated occurrence of a particular hazard such as the Tornado Alley in Mid-America. Thus, a comprehensive tornado insurance can be developed according to the extensive amount of historical data.

The information of victims is not fully provided

In this analysis, since the disaster severity is only categorised according to property damage, the number of victims is calculated based on the distribution of property value and persons per household. However, this could be inaccurate as victims experience different extent of property damage. Thus, the number of potential voluntary relocations will be underestimated. If the geographic information of disasters and the location of residents are provided. The number of affected residents could be estimated with less bias.

Lack of historical post-hazard relocation rates

For involuntarily movers, it is reasonable that some of them would become voluntarily movers after a hazard. Thus, the number of voluntary movers in the future can be projected with less error.

7. Conclusion

In conclusion, the proposed policy design achieves the required objectives. In the short term, the baseline program reduces 8.3% of economic costs on average. In the long term, the cost reduction is 6.2%. The projected economic costs associated with the program is always under 10% of Storslysia's GDP. The program also survives the stress test and sensitivity analysis with high degree of certainty. In the long term, the proportion of voluntary movers increase under the incentive scheme.

8. Reference

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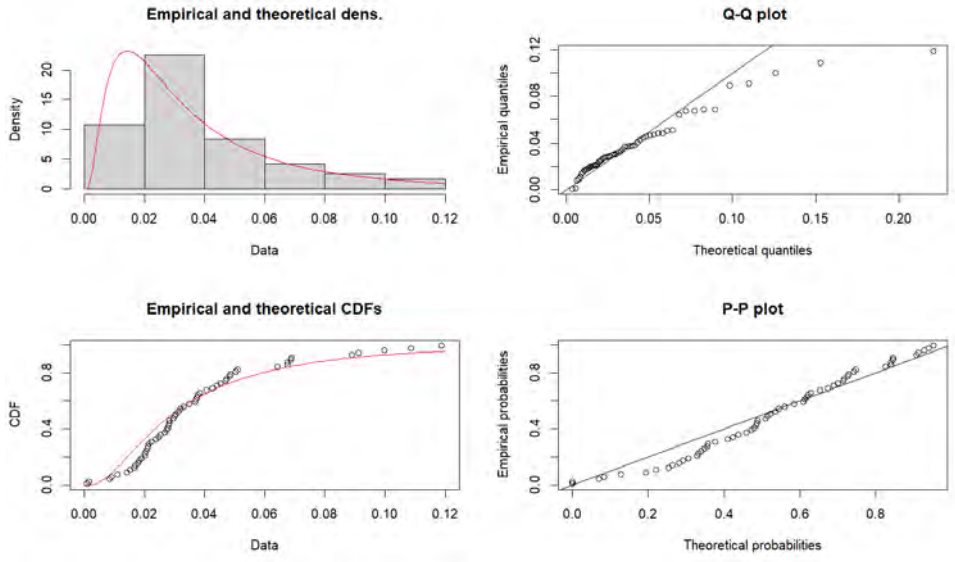
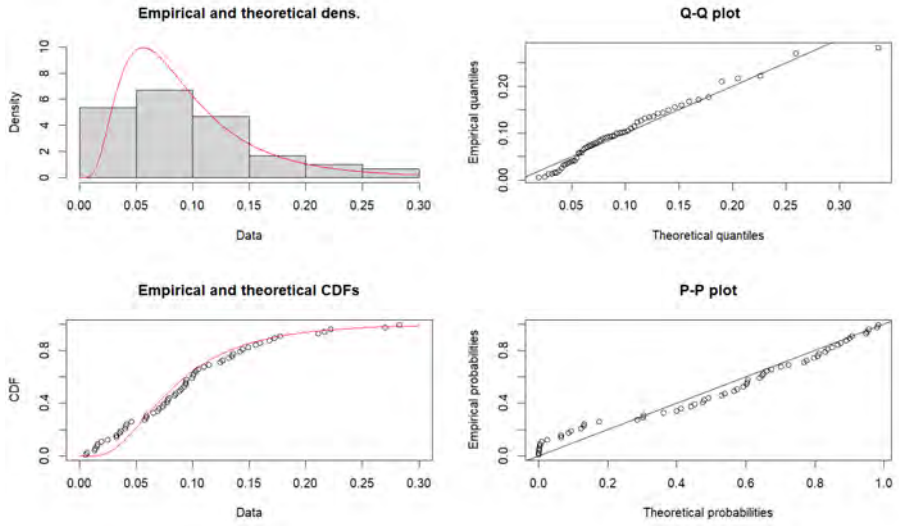
9. Appendices

Appendix 1: The fitted and simulated results of the inflation and one-year risk free rate.



Appendix 1A: Log-normal distribution fitted to historical inflation rate



Appendix 1B: Log-normal distribution fitted historical to one-year risk free rate

	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8	Sim 9	Sim 10	Sim 11	Sim 12
2021	0.012375819	0.033235928	0.018514777	0.015515193	0.015681423	0.013430958	0.020034584	0.05146634	0.118910696	0.012062697	0.026781104	0.016544989
2022	0.017331143	0.073188936	0.0133001	0.076546775	0.020787718	0.007026106	0.010652646	0.020885454	0.014866933	0.068543432	0.056263767	0.022640948
2023	0.075052138	0.016959125	0.031618753	0.022449766	0.04529497	0.091550133	0.059543705	0.017245016	0.119112559	0.029551785	0.030757997	0.044483554
2024	0.015536385	0.009537774	0.120442132	0.011523774	0.04135346	0.032424078	0.032262543	0.020056575	0.029554873	0.081176118	0.085443887	0.048002112
2025	0.020742727	0.013335178	0.029731943	0.031908854	0.025853145	0.025678303	0.052652123	0.009273861	0.009716101	0.01686837	0.06024531	0.032561243
2026	0.017377225	0.036558816	0.004143108	0.01148759	0.005359529	0.012870495	0.017916807	0.019180996	0.019280186	0.030957276	0.019368048	0.022704619
2027	0.022480519	0.023668717	0.016520691	0.031967407	0.022284238	0.031477835	0.012928912	0.074036132	0.018758976	0.008239353	0.050403185	0.017234754
2028	0.016202269	0.043581732	0.037728633	0.010895256	0.028674676	0.016081008	0.076287947	0.010192534	0.014302281	0.031010951	0.057767249	0.012651406
2029	0.01876767	0.017020124	0.039664878	0.020945576	0.148709444	0.063162682	0.045257498	0.040602659	0.044954153	0.006671683	0.055430742	0.103177901
2030	0.045411648	0.004705355	0.174276994	0.035543047	0.031667146	0.039564565	0.030711622	0.01388024	0.010496211	0.018741574	0.009392859	0.085311342
2031	0.053939699	0.03511703	0.011763884	0.015449618	0.045287792	0.053832675	0.006610864	0.006342436	0.060969459	0.012714399	0.111132393	0.024116081
2032	0.031580473	0.028495423	0.016747564	0.01836675	0.006940684	0.054344068	0.038722895	0.002152073	0.051819209	0.005816431	0.034289872	0.023913102
2033	0.045593464	0.00508139	0.029522381	0.01741123	0.065863259	0.028123927	0.031943663	0.088213476	0.053581843	0.029829699	0.019233789	0.005176981
2034	0.043165061	0.030653488	0.055069485	0.014908007	0.014659925	0.008061034	0.038616445	0.060931624	0.027433085	0.045103603	0.040491751	0.037478088
2035	0.030941309	0.046830331	0.101717552	0.031235189	0.004277542	0.041227556	0.025382199	0.043797582	0.019599636	0.006166654	0.016065357	0.025507767
2036	0.016845113	0.003096641	0.041039376	0.036162454	0.047570845	0.008581017	0.067758049	0.002838842	0.037318831	0.019912658	0.061001664	0.116663154
2037	0.041388405	0.025016153	0.031409713	0.044772201	0.012098617	0.015409254	0.060124449	0.098381975	0.020854189	0.013003909	0.04307381	0.02391765
2038	0.131278786	0.011159624	0.034674439	0.137328715	0.040981167	0.007185019	0.019593713	0.054923171	0.060468422	0.121356131	0.015873958	0.026005227
2039	0.024373195	0.058697913	0.137815525	0.03253873	0.044851468	0.028187008	0.058737996	0.00719139	0.04008731	0.028970672	0.099114254	0.056381295
2040	0.036317378	0.020250613	0.022249417	0.061657116	0.016131891	0.03580639	0.004855932	0.077762135	0.066536773	0.022630781	0.00494659	0.063958329
2041	0.050464601	0.055118504	0.114127184	0.058493784	0.040589463	0.037107385	0.028464352	0.020757278	0.0100107	0.056697838	0.009773868	0.049282976
2042	0.013234788	0.044374798	0.1249841	0.020289699	0.053719475	0.044719669	0.023155208	0.02365143	0.058585657	0.040740192	0.010426685	0.058805483
2043	0.019987142	0.093216551	0.016792567	0.030857283	0.014316133	0.012543399	0.009434472	0.033641817	0.060628004	0.023301219	0.024438984	0.023574864
2044	0.017559622	0.058088886	0.036301496	0.014273424	0.016528817	0.154148665	0.021426328	0.007986342	0.010060363	0.041655338	0.009919605	0.088176106
2045	0.017824351	0.036449518	0.020566287	0.020951846	0.025536882	0.029287707	0.014896817	0.060817205	0.008564504	0.138582185	0.03869956	0.012780758
2046	0.009801606	0.015922736	0.061966074	0.020756293	0.031707977	0.01095191	0.016842612	0.015690834	0.068052967	0.136764443	0.025319853	0.156266133
2047	0.024930422	0.080291969	0.010255774	0.054786	0.037030501	0.02983885	0.026837514	0.028288012	0.016008923	0.026420857	0.194064127	0.093562705
2048	0.047544669	0.011871835	0.020823857	0.009011563	0.016075574	0.024593458	0.077907549	0.082365322	0.029025367	0.07913384	0.053261989	0.004646111

*Appendix 1C: Header of 130 years * 100 simulations on inflation rate according to log-normal*

	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6	Sim 7	Sim 8	Sim 9	Sim 10	Sim 11	Sim 12
2021	0.011007576	0.013522324	0.012460888	0.020315523	0.04805087	0.116223445	0.015658738	0.06054918	0.022616516	0.013450431	0.021613741	0.039167649
2022	0.020284982	0.040898902	0.009860055	0.071002731	0.052471961	0.093381046	0.040145959	0.016698353	0.103362183	0.006456972	0.021227247	0.042432706
2023	0.015387107	0.012070655	0.009171427	0.005983068	0.042711427	0.015744449	0.006225968	0.059448437	0.058897862	0.170195266	0.070766588	0.022261626
2024	0.055938938	0.021032601	0.007015473	0.060151727	0.04775807	0.037680816	0.035809976	0.005867329	0.130731798	0.058260481	0.010502882	0.025546705
2025	0.069919262	0.004713505	0.101340012	0.012663277	0.008334029	0.03000677	0.013198461	0.127915717	0.031307944	0.02530465	0.024123421	0.024344467
2026	0.028685172	0.017670054	0.033168494	0.075455422	0.042041063	0.033742075	0.026333009	0.049427056	0.054131618	0.097555074	0.006948784	0.018821863
2027	0.055795724	0.003639188	0.029516774	0.032003813	0.007532472	0.006825389	0.028779171	0.030803942	0.022766367	0.06239964	0.04228912	0.030184693
2028	0.008171631	0.017007234	0.130870074	0.02318506	0.013095125	0.058151532	0.012684922	0.040140071	0.033413329	0.029314718	0.142684418	0.005387487
2029	0.075593994	0.030431648	0.015187014	0.05266631	0.021919076	0.044995663	0.031294042	0.029269496	0.015338374	0.027124317	0.011021417	0.060790603
2030	0.030647893	0.072029199	0.00595292	0.017509724	0.057293112	0.031787014	0.008799861	0.033503781	0.01836092	0.017215326	0.029670863	0.020880474
2031	0.042341577	0.036299252	0.120452932	0.041110259	0.061382817	0.126798919	0.02291884	0.03890657	0.042815564	0.036446151	0.023023473	0.029815521
2032	0.10956937	0.036985695	0.031388706	0.049720054	0.030422701	0.125345386	0.041310621	0.021646188	0.030575331	0.013077087	0.028564903	0.021255686
2033	0.060826675	0.06954431	0.032956609	0.044872474	0.012881615	0.016088969	0.022966249	0.061296584	0.060452595	0.133960044	0.013484173	0.044842166
2034	0.02191486	0.051691715	0.063528877	0.076666748	0.059882515	0.086345728	0.029425485	0.008413682	0.055685024	0.055868099	0.032675708	0.00437156
2035	0.025591156	0.017686098	0.024185422	0.082429122	0.079503916	0.018424413	0.104255849	0.062402776	0.065908889	0.085562466	0.007324837	0.005852828
2036	0.031907286	0.03502737	0.014934103	0.044581526	0.016011239	0.023771073	0.041879638	0.02264412	0.014296306	0.034062649	0.008076754	0.030152822
2037	0.018766534	0.049849803	0.086474021	0.126534549	0.034180548	0.064773092	0.069580392	0.012430716	0.050155188	0.042285504	0.027327742	0.018520549
2038	0.030084579	0.02213723	0.062883291	0.065757406	0.124126559	0.03537121	0.026977675	0.007531163	0.080205988	0.011611446	0.17118867	0.033335419
2039	0.077370846	0.010865122	0.039729232	0.054581365	0.019641157	0.052854919	0.00961247	0.071754196	0.113142792	0.046851084	0.067752443	0.017715644
2040	0.005427823	0.014085057	0.088269813	0.011291531	0.017730186	0.03009652	0.041844913	0.055308849	0.086253699	0.016532582	0.0475325	0.009697355
2041	0.021777118	0.031325912	0.027546447	0.013520914	0.021590012	0.035868041	0.016123562	0.045484971	0.052838536	0.144445172	0.072397846	0.026101317
2042	0.009025816	0.038131299	0.007314408	0.116887799	0.030142183	0.009582874	0.049244865	0.019683285	0.063543891	0.063040604	0.014783349	0.022591413
2043	0.08489529	0.010135973	0.003061157	0.017570363	0.012712056	0.027725748	0.06514029	0.033087263	0.053368774	0.073581792	0.017883236	0.010922267
2044	0.00768169	0.047693655	0.056651148	0.012426326	0.066097856	0.040094438	0.107006261	0.019699076	0.003631071	0.051519772	0.035632424	0.056749757
2045	0.029692033	0.01345581	0.136868845	0.015631254	0.011607132	0.024916215	0.021619644	0.047443346	0.043135257	0.028246899	0.013218284	0.022150428
2046	0.023100612	0.004263982	0.028706524	0.017868831	0.014751969	0.022929235	0.030568078	0.03875599	0.073611949	0.031861851	0.024408193	0.018301732

*Appendix 1D: Header of 130 years * 100 simulations on one year risk free rate according to log-normal*

Appendix 2: Projection of property damage in the short and long term

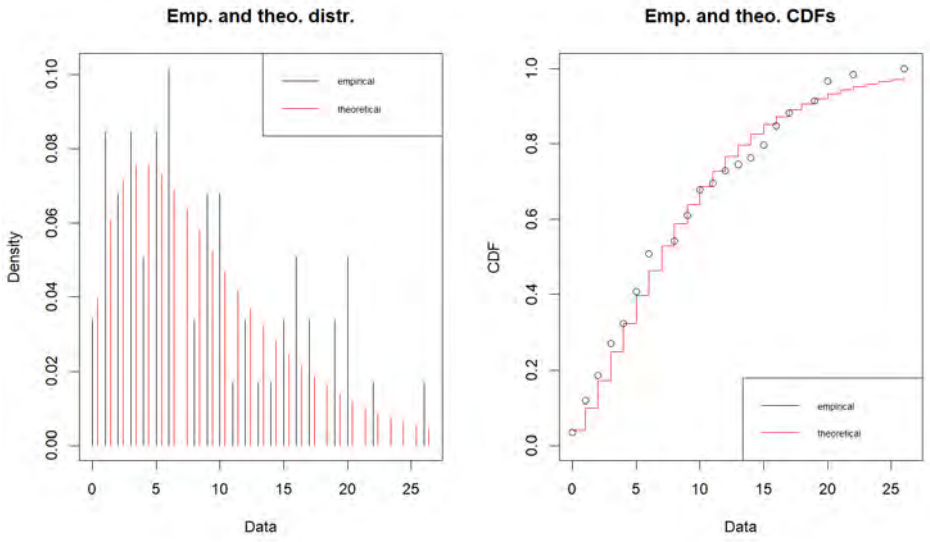
Method:

1. Convert all historical property damage value to 2020-dollar value using the historical one-year risk free rate
2. Categorise all the hazard damage into low, medium and high based on two benchmarks of Ψ2,000,000 and Ψ20,000,000.
3. Calculate the average property damage for low, medium high hazard level.

Average property damage – Average Ψ

	low	median	high
Region 1	572140	6817447	121224652
Region 2	531119	7249437	317447523
Region 3	471149	6833204	161711513
Region 4	420108	6775572	193658178
Region 5	411788	6686161	159689228
Region 6	396383	6617369	132186332

4. In the short term from 2022 to 2026, the hazard frequencies is simulated through fitted negative binomial distribution on the historical frequency data.



Fitted negative binomial distribution to the historical frequency data

In the long term up to year 2150, use the average historical frequency and the SSP model to predict future hazard frequency under different emission assumptions

Frequency Projection Model of Minor, Medium, and Major Hazard Events Per Year, as a Function of SSP Scenario

One can view the values below either as the expected number of events per year, or as 1 divided by the "return period". An expectation of 0.25 implies a return period of 4 years (on average, an event occurs every 4 years). An expected value that exceeds 1.00 indicates a return period of less than one year. For example, an expectation of 3 events per year equates to a return period of 4 months.

INPUT

Enter the Expected Number Hazard Events in 2020

Minor	8.695
Medium	1.237
Major	0.322

Region 1

	SSP1– 2.6 Low Emissions			SSP2–3.4 Medium Emissions			SSP3–6.0 High Emissions			SSP5–Baseline Very High Emissions		
Year	Minor	Medium	Major	Minor	Medium	Major	Minor	Medium	Major	Minor	Medium	Major
2020	8.695	1.237	0.322	8.695	1.237	0.322	8.695	1.237	0.322	8.695	1.237	0.322
2030	9.642	1.372	0.357	9.768	1.390	0.362	10.057	1.431	0.372	10.238	1.457	0.379
2040	10.350	1.472	0.383	10.854	1.544	0.402	11.547	1.643	0.428	12.470	1.774	0.462
2050	10.738	1.528	0.398	11.821	1.682	0.438	13.074	1.860	0.484	15.645	2.226	0.579
2060	10.842	1.542	0.401	12.529	1.782	0.464	14.736	2.096	0.546	20.188	2.872	0.748
2070	10.736	1.527	0.398	12.873	1.831	0.477	16.441	2.339	0.609	26.617	3.787	0.986
2080	10.422	1.483	0.386	12.899	1.835	0.478	17.992	2.560	0.666	35.368	5.032	1.310
2090	9.933	1.413	0.368	12.692	1.806	0.470	19.409	2.761	0.719	46.397	6.601	1.718
2100	9.450	1.344	0.350	12.361	1.759	0.458	20.799	2.959	0.770	59.225	8.426	2.193
2110	8.978	1.277	0.332	12.035	1.712	0.446	22.238	3.164	0.824	73.618	10.473	2.726
2120	8.519	1.212	0.315	11.714	1.666	0.434	23.724	3.375	0.879	89.575	12.743	3.317
2130	8.095	1.152	0.300	11.396	1.621	0.422	25.259	3.593	0.935	107.096	15.236	3.966
2140	8.095	1.152	0.300	11.083	1.577	0.410	26.841	3.819	0.994	126.181	17.951	4.673
2150	8.095	1.152	0.300	10.775	1.533	0.399	28.472	4.051	1.054	146.829	20.889	5.437

The risk amplification factor (RAF) ties the change in risk to the change in atmospheric CO2. The RAF is equal to the square of A / B, where "A" is the projected future level of CO2 and "B" is the level of CO2 in 2020.

Risk Amplification Factor (RAF)			
SSP1– 2.6	SSP2–3.4	SSP3–6.0	SSP5–Baseline
1.00000	1.00000	1.00000	1.00000
1.10890	1.12846	1.15665	1.17750
1.19036	1.24834	1.32802	1.43414
1.23499	1.35957	1.50368	1.79930
1.24687	1.44094	1.69473	2.32185
1.23472	1.48054	1.89081	3.06118
1.19864	1.48348	2.06918	4.06758
1.14243	1.45965	2.23228	5.38602
1.08681	1.42166	2.39212	6.81144
1.03259	1.38416	2.55753	8.46674
0.97974	1.34717	2.72847	10.30151
0.93104	1.31067	2.90495	12.31695
0.93104	1.27468	3.08695	14.51185
0.93104	1.23919	3.27448	16.88663

Example of projected region 1 hazard frequency

5. Calculate the projected property damage using the predicted frequencies and the average damage value for each hazard level.

Appendix 3: Detailed calculation of the variables used in calculating economic costs

Importance Index	Sign	Formula/Data
Given Index		
Housing Units	HU	Given
Owner-Occupied Housing Units	OHU	Given
Median Value of Owner-Occupied Housing Units	MVOOH	Given
Median Monthly Homeowner Housing Costs	MMHHC	Given
Temporary housing cost with disaster (per person per month)	THC	Given
Persons per Household, 2016-2020	PPH	Given
Sensitive Index		
Labor & Material cost index	ML_i	0.25
Replacing Household goods Cost index	RH_i	0.55
Temporary housing cost index	TH_i	0.9
Deductible discount	d	0.85
Incentive Cost per person	Ic	7500
Identify Index		
Property Value distribution index	PVD_i	$\sum_{1}^{13} \frac{probability}{mean\ preperty\ value}$
Risk Units	RU	$PD \times PVD\_i$
Risk Population	RP	$PU \times PPH$
Property damage	PD	-
Material and labor cost	ML	$ML\_i \times PD$
Replacing household goods cost	RH	$RH\_i \times MMHHC \times RU \times 12$
Temporary housing cost	TH	$TH\_i \times THC \times RU \times 3$
Incentive cost	IC	$Ic * RP$

Property value is divided into 13 ranges in the original dataset

Appendix 4: Economic costs comparison in the short term

Economic Cost in Ψ million in different region - Without Program; Short-term

Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total Cost
2022	191.58	461.58	2.61	11.54	10.79	10.14	688.22
2023	11.82	12.18	507.41	265.36	227.09	0.00	1023.86
2024	4.76	5.12	475.80	2.29	1.68	0.54	490.19
2025	179.75	14.37	9.78	265.36	227.09	9.60	705.95
2026	15.78	20.96	25.42	2.29	1.68	0.54	66.68

Economic Cost in Ψ million in different region - With Program; Short-term

Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total Cost
2022	174.57	419.96	2.41	10.70	10.01	9.46	627.11
2023	10.97	11.29	452.55	246.22	210.75	0.00	931.78
2024	4.41	4.75	432.44	2.13	1.56	0.51	445.80
2025	166.85	13.32	9.05	246.22	210.75	8.95	655.14
2026	14.65	19.42	23.54	2.13	1.56	0.51	61.81

Appendix 5: Economic costs comparison in the long term

Economic Cost in Ψ million in different region - Without Program; Long-term

Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total Cost
2030	81.61	275.12	75.41	64.49	48.47	24.06	569.16
2040	90.64	305.49	83.91	71.63	53.83	26.82	632.31
2050	98.75	332.94	90.36	78.00	58.62	29.32	687.99
2060	103.57	352.71	95.79	82.54	62.03	30.89	727.54
2070	106.46	362.35	98.49	85.09	63.96	31.86	748.20
2080	106.68	363.29	98.54	85.13	63.98	31.88	749.50
2090	104.92	357.51	97.01	83.66	62.87	31.38	737.34
2100	102.23	347.89	94.56	81.72	61.42	30.60	718.42
2110	99.54	338.74	92.13	79.49	59.74	29.83	699.47
2120	97.84	329.60	89.47	77.26	58.07	29.06	681.31
2130	95.15	320.90	87.06	75.34	56.63	28.11	663.20
2140	92.47	312.21	85.50	73.13	54.96	27.34	645.62
2150	89.97	303.54	83.29	71.22	53.53	26.58	628.13

Economic Cost in Ψ million in different region - With Program; Long-term

Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	total cost
2030	75.72	253.54	70.12	65.35	47.31	23.31	535.35
2040	84.09	281.53	78.03	72.57	52.55	25.97	594.75
2050	91.62	306.82	82.55	79.04	57.22	28.39	645.64
2060	94.39	325.05	87.51	83.64	60.55	29.92	681.06
2070	97.03	333.93	89.98	86.21	62.43	30.86	700.43
2080	97.23	334.80	90.02	86.26	62.45	30.88	701.63
2090	95.62	329.47	88.62	84.77	61.37	30.39	690.24
2100	93.17	320.61	86.39	82.80	59.95	29.64	672.56
2110	90.72	312.18	84.17	80.54	58.32	28.89	654.81
2120	90.78	303.75	81.74	78.29	56.68	28.15	639.38
2130	88.28	295.73	79.54	76.34	55.28	27.23	622.39
2140	85.80	287.73	79.51	74.10	53.65	26.48	607.26
2150	83.47	279.73	77.46	72.16	52.25	25.75	590.81

Appendix 6: Projected displacement and incentive costs in the short term

Incentive Cost in ₱ million in different region - With Program; Short-term

Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total incentives
2022	14.99	35.46	0.20	0.90	0.84	0.83	53.22
2023	0.92	0.94	38.50	20.66	17.72	0.00	78.75
2024	0.37	0.39	36.10	0.18	0.13	0.04	37.22
2025	14.06	1.10	0.74	20.66	17.72	0.79	55.08
2026	1.23	1.61	1.93	0.18	0.13	0.04	5.13

Displacement Cost in ₱ million in different region - With Program; Short-term

Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total displacement
2022	159.58	384.49	2.22	9.81	9.17	8.62	573.89
2023	10.05	10.35	414.05	225.56	193.02	0.00	853.03
2024	4.04	4.35	396.34	1.95	1.43	0.46	408.57
2025	152.79	12.22	8.31	225.56	193.02	8.16	600.06
2026	13.42	17.81	21.61	1.95	1.43	0.46	56.68

Appendix 7: Projected displacement and incentive costs in the long term

Incentive Cost in ₱ million in different region - With Program; Long-term

Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total incentives
2030	6.35	24.41	6.03	10.53	6.11	2.85	56.28
2040	7.05	27.11	6.71	11.69	6.79	3.18	62.53
2050	7.68	29.54	7.30	12.73	7.39	3.48	68.12
2060	8.14	31.30	7.74	13.48	7.82	3.66	72.13
2070	8.36	32.15	7.95	13.89	8.06	3.78	74.20
2080	8.38	32.24	7.96	13.90	8.07	3.78	74.32
2090	8.24	31.73	7.83	13.66	7.93	3.72	73.11
2100	8.03	30.87	7.64	13.34	7.74	3.63	71.25
2110	7.82	30.06	7.44	12.98	7.53	3.54	69.37
2120	7.61	29.25	7.23	12.61	7.32	3.45	67.46
2130	7.40	28.48	7.03	12.30	7.14	3.33	65.68
2140	7.19	27.71	6.84	11.94	6.93	3.24	63.84
2150	7.00	26.94	6.66	11.63	6.75	3.15	62.12

Displacement Cost in ₱ million in different region - With Program; Long-term

Year	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Total displacement
2030	69.37	229.13	64.10	54.82	41.20	20.45	479.06
2040	77.04	254.42	71.32	60.88	45.76	22.79	532.22
2050	83.94	277.28	75.25	66.30	49.83	24.92	577.52
2060	86.26	293.75	79.77	70.16	52.73	26.26	608.93
2070	88.66	301.77	82.02	72.32	54.37	27.08	626.23
2080	88.85	302.56	82.06	72.36	54.38	27.10	627.31
2090	87.38	297.74	80.79	71.11	53.44	26.67	617.13
2100	85.14	289.74	78.75	69.46	52.21	26.01	601.31
2110	82.90	282.12	76.73	67.57	50.78	25.36	585.44
2120	83.16	274.50	74.52	65.67	49.36	24.70	571.92
2130	80.88	267.26	72.50	64.04	48.14	23.89	556.71
2140	78.60	260.02	72.68	62.16	46.72	23.24	543.42
2150	76.47	252.79	70.80	60.53	45.50	22.59	528.69

Appendix 8: Projected Storslysia GDP

Using the projected inflation and one-year interest rate above, the GDP from 2021 to 2150, under the 2020-dollar value is calculated based on the below formula:

$$Region\ i\ GDP\ (Year\ n) = 2020\ GDP * \frac{\prod_{2020}^{n}(1 + inflation_k)^{k-2020}}{\prod_{2020}^{n}[1 + (1\ yr\ rf)_k]^{k-2020}}$$

$$i = Region\ number\ 1\ to\ 6$$

$$n = Target\ GDP\ Year\ [2020, 2150]$$

$$k\ takes\ value\ [2020, n]$$

$$inflation = the\ projected\ inflation\ rate\ in\ that\ year$$

$$1\ yr\ rf = the\ projected\ one\ year\ risk\ free\ rate\ in\ that\ year$$

Then compute average GDP across 100 different simulated rate scenarios for each year.

				Region 1 GDP	531,771,287.00				
	Min	Max	Average	Sim 1	Sim 2	Sim 3	Sim 4	Sim 5	Sim 6
2021	454,478,747.44	581,845,262.65	529,280,981.49	532,490,957.52	542,114,550.77	534,950,949.97	529,269,435.92	515,347,330.05	482,800,721.64
2022	441,648,783.09	599,991,918.54	527,235,686.75	530,949,336.92	558,931,647.52	536,773,237.36	532,009,198.44	499,833,006.98	444,669,250.78
2023	426,093,182.74	632,544,817.03	528,068,121.82	562,148,382.72	561,631,380.75	548,712,857.98	540,717,530.84	501,071,451.39	477,855,212.87
2024	429,532,837.70	617,091,078.09	528,405,829.75	540,639,345.63	555,308,511.81	610,517,932.14	515,915,432.96	498,008,561.93	475,434,468.75
2025	427,912,675.00	625,945,240.52	526,079,050.73	515,790,022.39	560,073,739.47	570,822,642.84	525,720,360.43	506,661,121.18	473,436,518.48
2026	378,769,175.72	661,593,415.35	527,093,526.33	510,120,137.82	570,469,151.30	554,786,199.87	494,450,638.90	488,825,828.60	463,877,685.01
2027	402,458,634.95	658,465,614.29	527,722,816.28	494,023,504.27	581,853,948.35	547,782,868.14	494,433,195.99	495,982,961.96	475,235,880.69
2028	385,146,686.65	674,856,402.23	526,506,840.23	497,958,671.39	597,057,848.48	502,666,026.95	488,494,400.12	503,610,273.47	456,341,212.27
2029	385,581,743.35	704,886,814.76	524,097,422.35	471,650,268.10	589,286,876.21	514,786,149.25	473,774,254.93	566,093,627.75	464,274,603.60
2030	376,512,410.15	693,265,354.27	524,849,223.98	478,406,531.98	552,279,434.68	600,924,277.78	482,170,955.32	552,373,027.43	467,774,278.74
2031	393,721,084.43	693,709,837.77	524,414,713.14	483,729,755.78	551,649,388.26	542,631,880.40	470,286,704.12	543,996,730.68	437,483,397.38
2032	385,897,490.33	740,805,106.04	523,924,055.32	449,729,583.04	547,132,784.82	534,928,915.92	456,240,061.84	531,599,740.16	409,881,295.62
2033	377,896,973.62	761,979,516.27	526,715,123.57	443,271,576.52	514,156,332.50	533,150,459.89	444,249,201.90	559,406,571.33	414,736,091.33
2034	378,874,600.82	893,965,470.96	526,538,610.06	452,489,184.25	503,871,058.19	528,909,739.25	418,766,598.79	535,538,063.56	384,849,208.09
2035	356,042,918.81	895,207,011.54	523,690,250.81	454,849,663.43	518,300,788.00	568,948,874.43	398,960,859.28	498,218,526.31	393,466,216.24
2036	351,170,869.66	810,900,795.13	522,033,032.38	448,210,477.53	502,311,141.03	583,582,894.09	395,745,332.06	513,694,319.84	387,628,217.77
2037	341,305,201.29	805,403,723.44	521,868,834.79	458,162,162.13	490,429,232.81	554,005,943.54	367,022,673.19	502,725,865.28	369,657,425.17
2038	318,069,404.58	793,811,992.54	520,441,657.69	503,171,433.80	485,162,093.62	539,302,662.36	391,670,208.25	465,542,027.88	359,594,140.87
2039	301,185,791.09	814,489,713.45	521,102,532.93	478,419,600.17	508,119,317.85	590,179,561.01	383,483,601.14	477,052,409.81	351,169,013.88
2040	305,717,209.85	838,517,923.61	523,701,129.24	493,117,988.67	511,208,642.73	554,376,042.72	402,582,323.36	476,303,222.67	353,115,559.07
2041	304,894,374.06	836,271,812.88	523,838,718.75	506,962,802.54	523,002,178.27	601,087,591.83	420,446,071.59	485,161,472.57	353,538,037.12
2042	302,949,676.61	825,971,726.02	531,624,669.20	509,077,507.91	526,147,602.86	671,303,793.47	384,082,265.06	496,265,564.86	365,842,320.39
2043	322,333,197.43	813,967,040.98	531,756,406.04	478,619,934.23	569,421,625.28	680,493,609.76	389,097,417.50	497,051,620.70	360,437,818.53
2044	319,309,350.63	817,597,942.90	533,655,857.33	483,311,668.72	575,071,434.40	667,388,235.88	389,807,297.20	473,940,823.56	399,962,553.17
2045	341,288,273.06	838,692,762.04	530,595,425.88	477,741,275.77	588,118,895.10	599,113,905.36	391,849,382.50	480,466,951.16	401,668,480.84
2046	356,215,920.33	880,268,443.29	533,331,652.69	471,531,246.97	594,946,515.76	618,484,113.00	392,960,969.86	488,495,318.40	396,965,404.92

*Header of 130 years * 100 simulations on GDP according to the simulated rates.*

	10% GDP LT						
Year	Region 1 Average	Region 2 Average	Region 3 Average	Region 4 Average	Region 5 Average	Region 6 Average	Total
2030	52,484,922,397.84	21,926,202,064.69	41,227,121,317.07	4,521,957,101.70	6,873,689,875.09	971,774,980.82	128,005,667,737.20
2040	52,370,112,923.58	21,878,239,038.04	41,136,938,005.23	4,512,065,431.98	6,858,653,847.89	969,649,247.00	127,725,658,493.72
2050	53,954,470,203.94	22,540,123,180.85	42,381,457,132.30	4,648,569,314.01	7,066,149,259.88	998,984,124.44	131,589,753,215.41
2060	53,833,859,843.97	22,489,736,765.04	42,286,717,201.00	4,638,177,855.88	7,050,353,519.46	996,750,985.38	131,295,596,170.72
2070	55,322,123,090.25	23,111,476,479.47	43,455,754,071.07	4,766,402,539.24	7,245,263,972.60	1,024,306,651.30	134,925,326,803.93
2080	54,700,375,321.09	22,851,733,936.33	42,967,368,654.15	4,712,834,455.08	7,163,836,752.16	1,012,794,794.20	133,408,943,913.02
2090	54,569,820,681.78	22,797,193,179.27	42,864,817,450.73	4,701,586,225.08	7,146,738,658.82	1,010,377,533.66	133,090,533,729.34
2100	55,129,485,221.29	23,030,999,713.05	43,304,436,236.71	4,749,805,388.29	7,220,035,146.70	1,020,739,900.07	134,455,501,606.12
2110	56,044,551,445.49	23,413,279,537.76	44,023,224,500.36	4,828,644,986.83	7,339,876,829.85	1,037,682,641.37	136,687,259,941.67
2120	57,394,399,680.67	23,977,194,731.10	45,083,535,812.81	4,944,944,212.10	7,516,659,755.75	1,062,675,509.48	139,979,409,701.90
2130	57,156,741,900.77	23,877,910,360.16	44,896,854,654.18	4,924,468,268.98	7,485,534,895.49	1,058,275,200.32	139,399,785,279.90
2140	57,480,064,608.33	24,012,982,275.94	45,150,825,964.04	4,952,324,867.54	7,527,878,866.29	1,064,261,622.78	140,188,338,204.92
2150	56,251,728,463.90	23,499,830,207.20	44,185,962,896.11	4,846,494,791.05	7,367,009,776.02	1,041,518,589.56	137,192,544,723.84

	10% GDP ST						
Year	Region 1 Average	Region 2 Average	Region 3 Average	Region 4 Average	Region 5 Average	Region 6 Average	Total
2023	52,806,812,181.56	22,060,675,359.45	41,479,967,059.40	4,549,690,243.46	6,915,846,182.96	977,734,872.24	128,790,725,899.07
2024	52,840,582,975.49	22,074,783,511.24	41,506,494,156.22	4,552,599,842.53	6,920,268,976.28	978,360,149.19	128,873,089,610.96
2025	52,607,905,072.78	21,977,579,543.36	41,323,724,711.50	4,532,552,951.99	6,889,796,305.83	974,052,044.04	128,305,610,629.50
2026	52,709,352,633.08	22,019,960,471.15	41,403,412,185.25	4,541,293,395.81	6,903,082,389.45	975,930,377.79	128,553,031,452.54

10% GDP for comparison in both long- and short-term.

Appendix 9: 5 percentile and 95 percentiles of the historical property damage

Average property damage - 95% Percentile ₱

	low	median	high
Region 1	1699405	16868364	363665297
Region 2	1690528	17181550	953769548
Region 3	1618582	16778225	531807174
Region 4	1566775	16501257	586737467
Region 5	1566776	16506560	490713571
Region 6	1533462	16181774	421738435

Average property damage - 5% Percentile ₱

	low	median	high
Region 1	19493	2187993	21462514
Region 2	10324	2212023	21937994
Region 3	8005	2187057	21295643
Region 4	5121	2187693	21660494
Region 5	4715	2176928	21433290
Region 6	4641	2173086	21170816

Appendix 10: Projected economic capital for the program

Economic Capital in ₱ million

Year	With	Without	Difference
2022	1575.07	1764.24	189.17
2023	2523.96	2831.49	307.52
2024	1271.10	1424.93	153.83
2025	1689.42	1857.11	167.69
2026	143.78	158.28	14.51
2030	385.84	448.75	62.91
2040	625.65	724.81	99.16
2050	1088.20	1226.74	138.54
2060	1746.03	2041.79	295.77
2070	2806.78	3309.75	502.97
2080	4371.20	5126.93	755.74
2090	5919.60	7400.54	1480.94
2100	7590.93	9981.88	2390.95
2110	9480.43	12881.30	3400.87
2120	11184.64	15895.43	4710.79
2130	13121.82	19222.00	6100.18
2140	15841.67	23058.82	7217.15
2150	18200.70	27029.91	8829.20

Appendix 11: Detailed analysis of the benefit payment critical value

The critical values leading to indifference in costs between with and without program, under different SSP assumptions.

Incentives ₱	SSP	Temporary relocation %	Replacing house goods	Labor & materials
9185	SSP1-2.6	0.8	0.4	0
14450	SSP5-Basline	1	0.75	0.5

The comparison of costs at the highest incentive. When the incentive exceeds 14400, the policy cost in 2030 will exceed the no-policy cost under SSP5-Baseline. For the other SSP cases, the future policy costs will be greater than the no-policy costs when the incentive is 14400.

Property damage -short term

Incentives: 14400

Year	Without	With	Difference
2022	2,454,425,452	2,350,642,129	103,783,323
2023	3,858,142,827	3,687,574,316	170,568,510
2024	1,916,553,535	1,830,662,191	85,891,345
2025	2,564,944,318	2,501,029,368	63,914,950
2026	225,160,250	219,151,869	6,008,381

Property damage -long term

Incentives: 14400

Year	Without	With	Difference
2030	720,049,531	720,046,471	3,061
2040	875,047,066	871,269,361	3,777,705
2050	1,097,413,082	1,092,702,889	4,710,192
2060	1,407,478,869	1,370,503,132	36,975,737
2070	1,849,033,535	1,776,639,253	72,394,283
2080	2,453,283,793	2,343,865,313	109,418,480
2090	3,195,594,651	2,905,971,313	289,623,338
2100	4,032,460,893	3,508,265,749	524,195,144
2110	4,975,718,584	4,195,303,714	780,414,870
2120	5,956,463,758	4,828,289,125	1,128,174,633
2130	7,042,328,887	5,548,430,506	1,493,898,382
2140	8,297,615,983	6,537,469,888	1,760,146,095
2150	9,598,025,051	7,416,426,743	2,181,598,308

The comparison of costs at the lowest incentive. When the incentive exceeds 9185, the policy cost in 2150 will exceed the no-policy cost under SSP1-2.6. For the same incentive, the policy cost in other SSP cases will be much lower than the no-policy cost.

Property damage -short term

Incentives: 9185

Year	Without	With	Difference
2022	1,635,126,506	1,556,039,947	79,086,558
2023	2,570,085,408	2,440,941,863	129,143,545
2024	1,276,570,925	1,211,762,221	64,808,704
2025	1,708,866,908	1,655,778,007	53,088,901
2026	149,993,273	145,083,602	4,909,670

Property damage -long term

Incentives: 9185

Year	Without	With	Difference
2030	1,361,675,679	1,351,519,499	10,156,180
2040	1,461,767,927	1,450,801,798	10,966,129
2050	1,516,557,950	1,505,211,415	11,346,535
2060	1,530,602,018	1,519,186,341	11,415,677
2070	1,516,494,096	1,505,148,696	11,345,400
2080	1,471,768,190	1,460,703,493	11,064,698
2090	1,402,570,140	1,392,100,329	10,469,811
2100	1,333,898,680	1,323,880,082	10,018,597
2110	1,274,411,140	1,274,393,332	17,808
2120	1,209,287,724	1,209,263,423	24,301
2130	1,148,406,595	1,148,334,810	71,785
2140	1,148,406,595	1,148,334,810	71,785
2150	1,148,406,595	1,148,334,810	71,785