How equity-centric disaster risk models reduce future climate risk.

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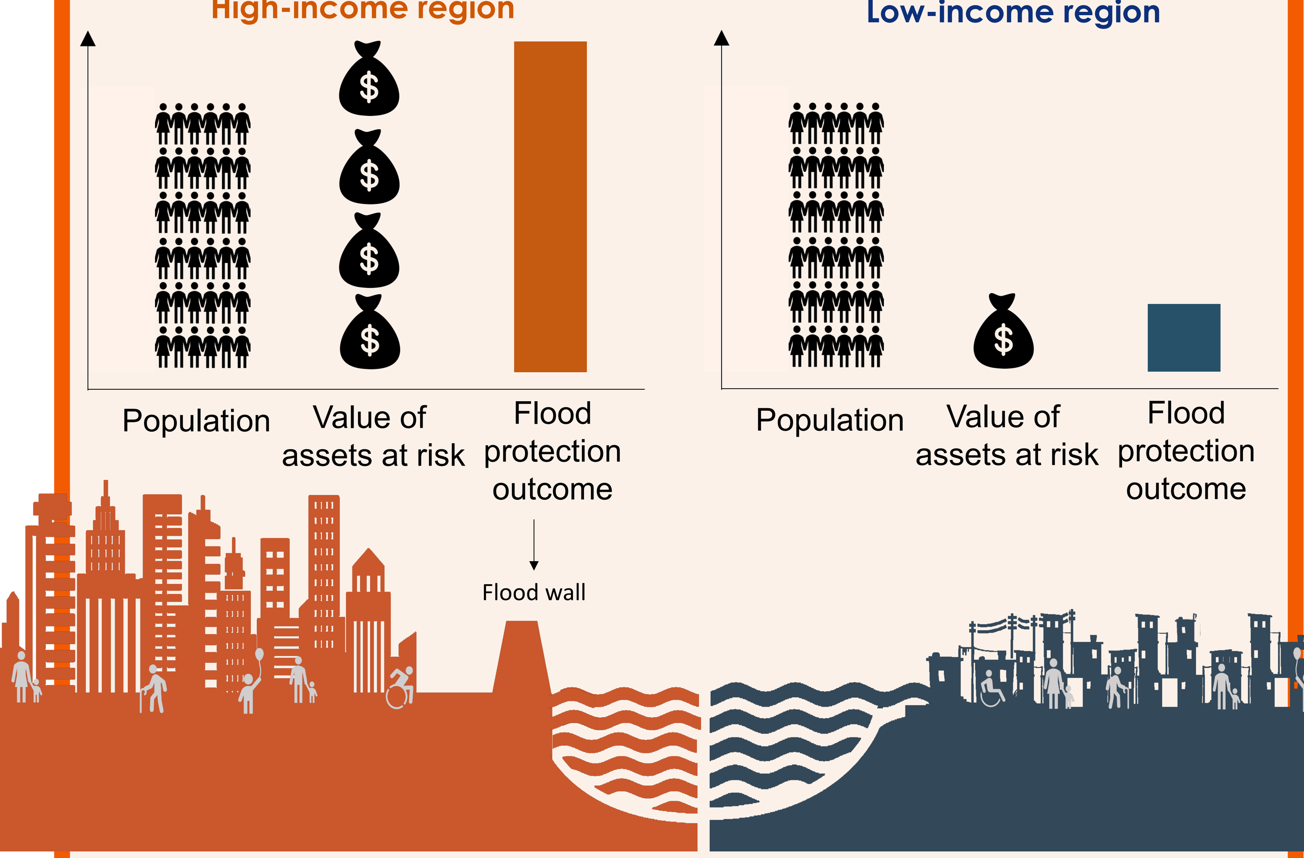
2-MINUTE TAKEAWAY

BACKGROUND Climatic hazards, along with underlying social inequalities, exert **non-linear impacts** on communities. To address future climate risk effectively, **risk metrics must account for these impacts**, informing policies and plans for vulnerable communities.

PROBLEM Conventional risk metrics measure asset-at-risk, obscuring the disparate impacts of disasters on communities. **Solely relying on such metrics could lead to inequitable planning outcomes**, and further exacerbate existing inequities.



METHODS **We model the differential impacts of coastal flooding on households of varying income levels in the Philippines, with and without future sea level rise**, by combining:

i) A probabilistic coastal flood hazard model [1];
ii) a direct consequence model (conventional asset-based approach); and
iii) the well-being loss model[2] which models the impact on household income and consumption over time and transforms these losses into an equivalent loss (utility/well-being loss) of the household with the average consumption level.

Our model contributes to existing loss studies by integrating losses over various return periods.

RESULTS
- **Low-income households are more exposed** to higher coastal flood levels and this worsens with future sea level rise.
- **Low-income households experience greater than asset losses** even at low flood depths.
- **Conventional asset-based risk metrics underestimate risk** to future sea level rise by a factor of four.
- **Relying on asset-based risk metrics could exacerbate poverty and inequity** as it obscures Barangays with the highest losses.

SIGNIFICANCE Equity-centric risk models like this can **help policy and decision makers target climate adaptation and risk reduction strategies to the most vulnerable** groups and places.

FUTURE WORK Since income is only one driver of differential risk, future work seeks to **other drivers of vulnerability** to sea level rise and **compare existing risk models** that account for other issues of inequity.

1 Inequity in coastal flood exposure currently exists and increases with future sea level rise.

No inequity in exposure → **Inequity** in exposure → **Increased inequity** in exposure → **Disproportionate increase** in exposure inequity

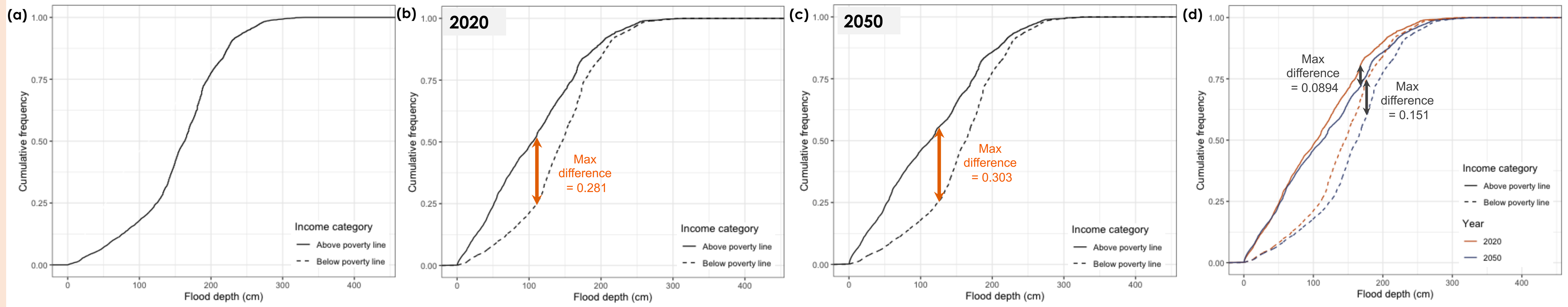


Figure 1. Cumulative distribution of exposure to a 1-in-100 year coastal flood in 2020 and 2050 under the RCP 4.5 scenario, for households in the Philippines below and above the international poverty line of US$2.15 per person per day (2017 PPP). Plot **(a)** shows the cumulative frequency of exposure if there was perfect equity in exposure. Plot **(b)** highlights the reality of unequal flood exposure as seen by the vertical gap between the two curves for 2020 (baseline scenario). This distance increases in 2050 (with future sea level rise) [Plot **(c)**] showing increased inequity in exposure. Plot (d) shows the disproportionate increase in exposure of households living under the poverty line, to coastal flooding due to future sea level rise.

- Households in the Philippines living at or below the international poverty line are more likely to be exposed to higher flood depths (Fig. 1b & c)
- Inequity in exposure is exacerbated by future sea level rise as seen by a wider vertical difference between the two income groups (Fig. 1c)
- With sea level rise, households below the poverty line are also likely to a disproportionate increase in exposure to coastal flooding.
- The inequity in exposure motivates our work to account for the effects of income disparities on risk, to better inform climate policies and avoid perpetuating or exacerbating existing inequities.

2 How do we account for these inequities in the way we model future climate risk?

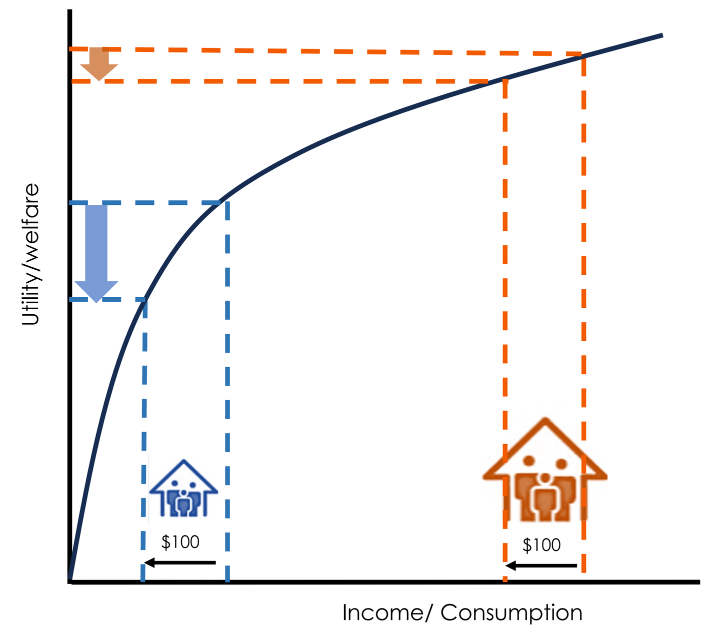


Figure 2a. The utility function – an fundamental concept in economics that shows how the same loss in income or consumption results in very different impacts on the of a high-income and low-income household. The function extent to which utility/well-being losses differ for the two income groups depends on the value of the elasticity of the marginal utility of income. The higher the elasticity, the steeper the curve and the higher the impact on low-income households.

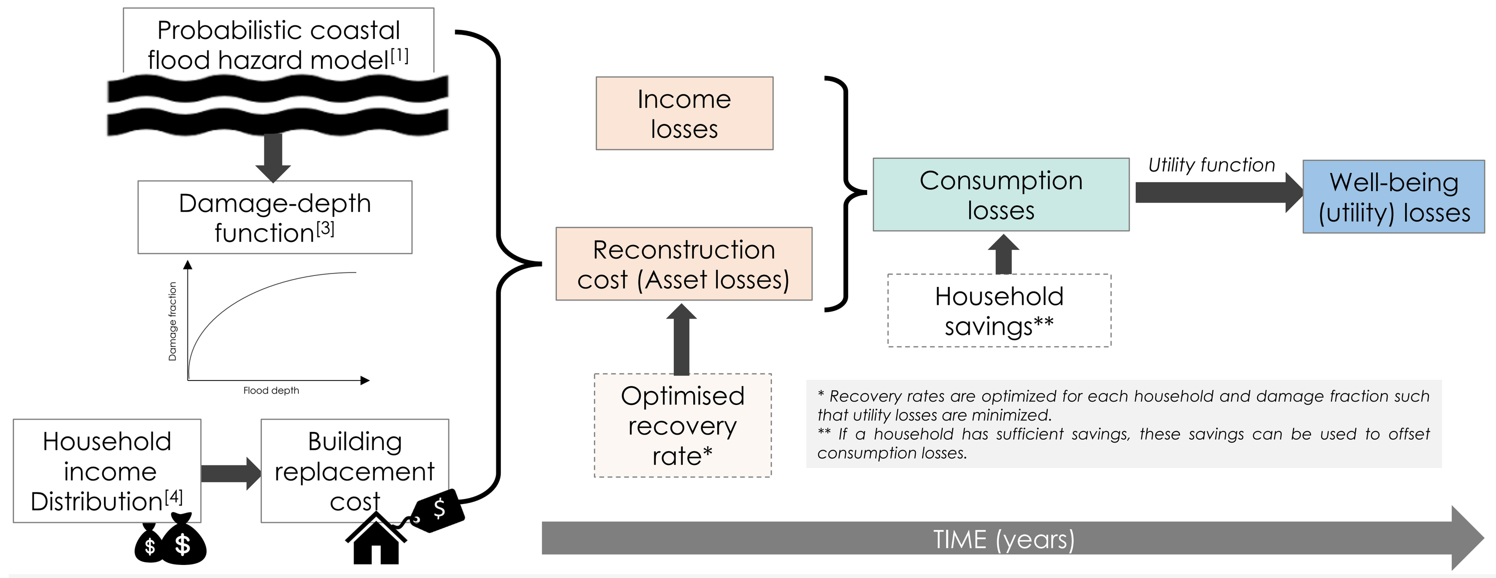
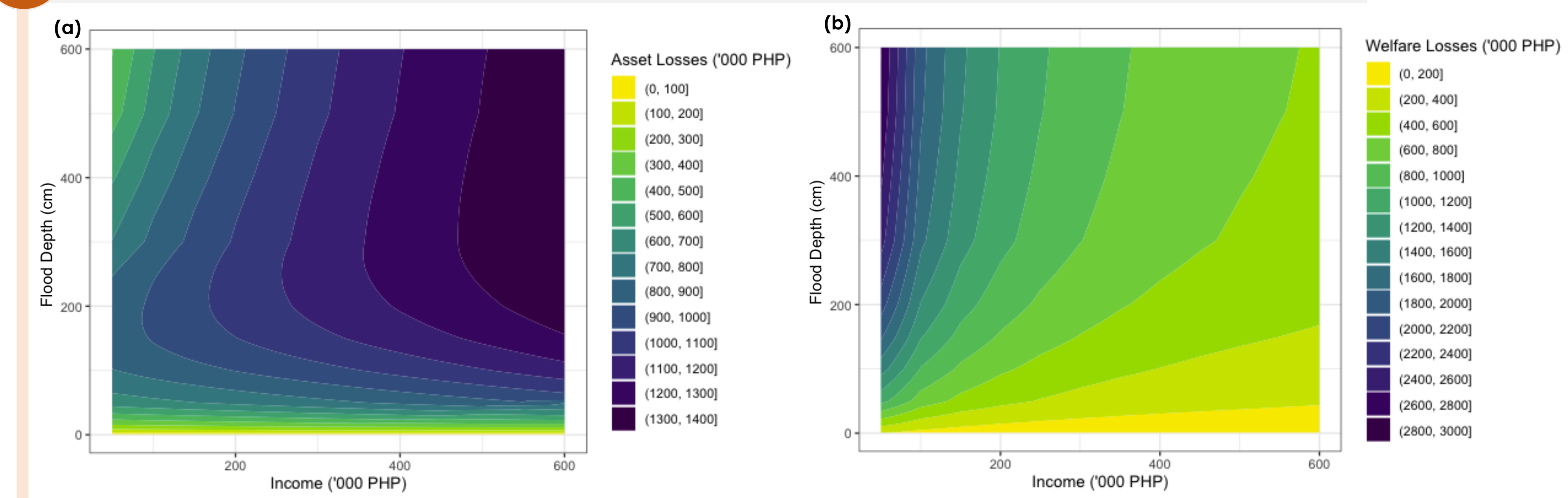


Figure 2b. Overview of the well-being loss model, which was adapted from Markhvida et al. (2020)[2]. This approach simulates the impacts on household income and consumption over time, and transforms losses into the equivalent losses of the household with the average consumption level, via the utility function.

- The utility function explains why impacts on different income groups are non-linear (Fig. 2a) .
- In addition to asset losses, the well-being loss model accounts for the loss of income after a disaster, which includes the need for alternative housing (Fig. 2b). It also adjusts for the use of savings to cushion consumption losses.
- The model also optimizes the rate at which households recover. Households typically want to recover as quickly as possible, but sometimes, they may choose to spread recovery costs over a longer period to minimize impact on their overall well-being.
- We contribute to existing well-being loss studies by computing the average annual well-being losses by integrating over 12 return periods (1 to 10,000 year), instead of computing well-being losses based on the average annual asset losses.

3 Income differences drive disparities in flood losses.



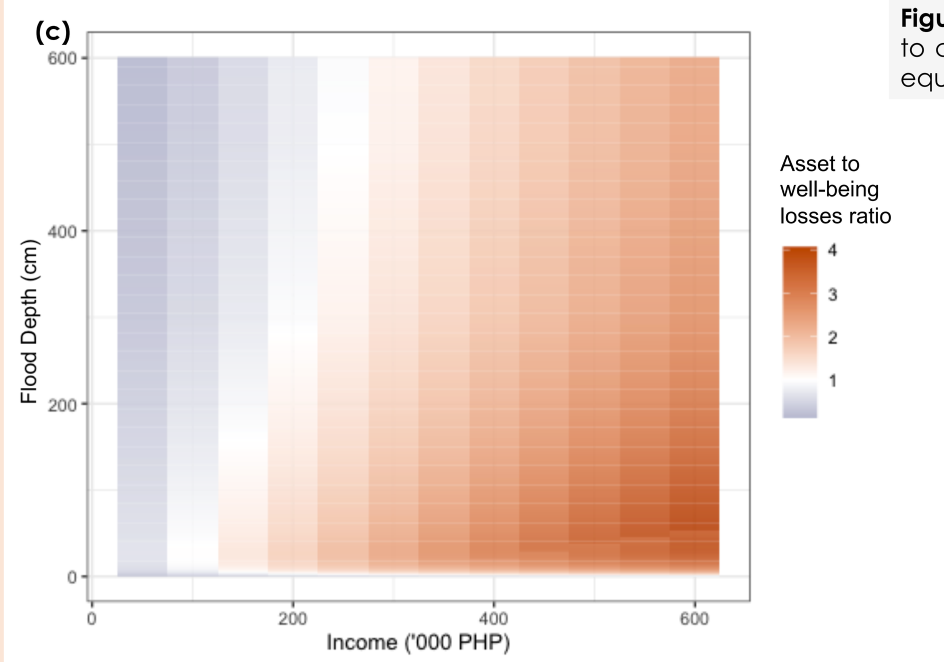


Figure 3. Sensitivity of (a) asset losses, (b) well-being losses, (c) asset to well-being loss ratio to changes in flood depth and income. A ratio of 1 means asset and well-being loss are equal.

- Generally, asset losses increase with flood depth and income (Fig 3a). The reason why losses increase and then decrease with flood depths at the lowest income level is due to households recovering too quickly and incurring reconstruction costs.
- Well-being losses are extremely sensitive to changes in income at lower income levels (Fig. 3b), which is consistent with the non-linearity of the utility function (Fig. 2a). This highlights the need for targeted interventions, which can only be properly informed if risk metrics account for issues of inequity (income being only one example).
- The asset to well-being loss ratio is below 1 for low-income households and increases past 1 with increasing income and decreasing flood depths (Fig. 3c). This again highlights the fact that disproportionately larger well-being impacts accrue to those living in poverty.

4 Accounting for differential risks more equitably informs climate policies and decisions, thus reducing future risk to the vulnerable.

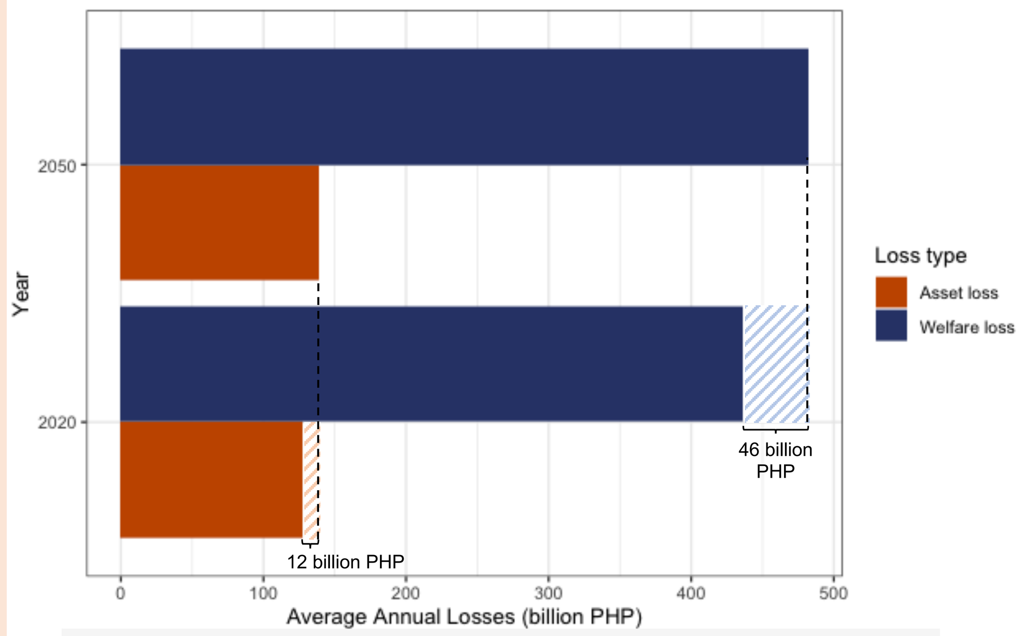


Figure 4a. Average annual asset and well-being losses from coastal flooding in the Philippines in 2020 and 2050 under the RCP 4.5 scenario.

- Average annual well-being losses are significantly higher than asset losses both now and in future, owing to the non-linearity of impacts on the low-income. This means that we could be severely underestimating real losses especially in countries with high levels of income inequality.
- We also find that the additional well-being losses due to sea level rise are almost four times that of asset losses. Consequently, if future climate adaptation budgets are allocated based on asset losses alone, we would be severely underprepared for its impacts.

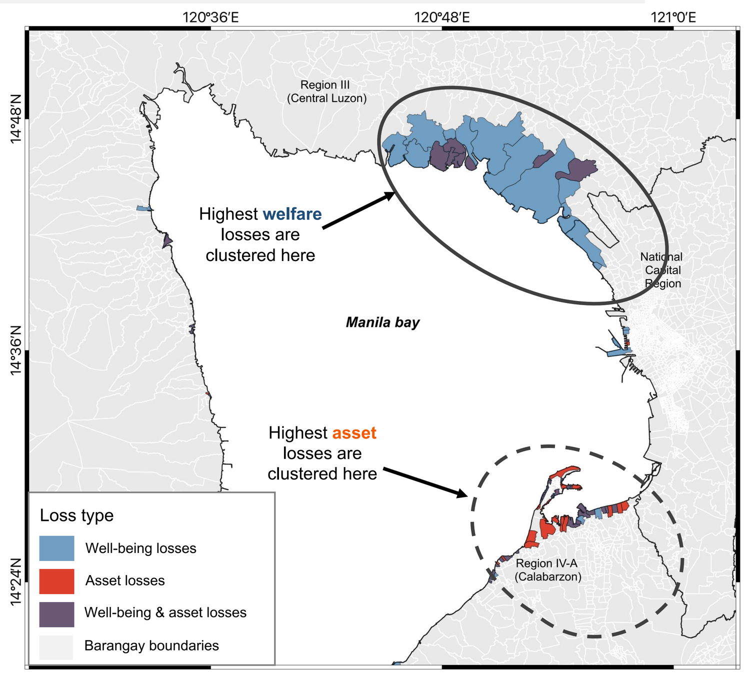


Figure 4b. An example of how asset loss metrics could lead to inequitable outcomes. This map shows the top two quintiles of Barangays (smallest administrative unit in the Philippines) with the highest average annual asset or well-being losses from coastal flooding in 2050 (RCP 4.5).

- The clusters of Barangays with highest well-being losses are generally distinct from those with highest asset losses.
- This example demonstrates how the relying on asset-based metrics could obscure areas with high well-being losses (circled solid), which more often than not, are low-income Barangays.

References & Data sources:
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Acknowledgements: This project is supported by the Ministry of Education, Singapore, under its MOE AcRF Tier 3 Award MOE2019-T3-1-004, awarded to the Southeast Asia Sea-level (SEA2) programme.

This project also benefited from the invaluable guidance and support from Prof. Adam Switzer and Asst. Prof. Perrine Hamel from the Earth Observatory of Singapore, NTU. In addition, we would like to thank Lim Tian Ning from the Disaster Analytics for Society Lab for her inputs on the visualisations in this poster.