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Flood Damages in an Infrastructure Climate Risk Stress Test: A Case Study of a Solar Power Plant Project

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ABSTRACT

Climate change presents significant risks not only to the environment but also to financial systems. In response, climate risk stress testing (CRST) has become an important tool for regulators and financial institutions. However, most applications of CRST to date have focused on real estate and mortgage exposures, with little attention given to infrastructure assets. This paper addresses that gap by exploring methodologies to analyze flood-related physical risk for infrastructure in the context of CRST. The study applies the hazard–vulnerability–exposure approach by combining global flood hazard data from the Aqueduct tools, depth-damage functions, and simplified assumptions on asset exposure. A case study on an anonymized solar power plant project in Indonesia is conducted to demonstrate the methodology. The analysis produces estimates of financial loss using both single-event damage and Expected Annual Damage (EAD), which can then be integrated into project-level financial stress tests. The results show that this framework provides a practical and transparent way to quantify climate-induced flood risk for infrastructure, offering a starting point for regulators, development finance institutions, and multilateral development banks. At the same time, several weaknesses are identified, including the coarse resolution of global hazard maps, generic vulnerability functions are not calibrated for local conditions, and the absence of considerations for flood protection and indirect financial impacts.

Keywords: Flood Damage; Climate Risk Stress Test; Infrastructure Finance; Vulnerability Assessment

ABSTRAK

Perubahan iklim menghadirkan risiko yang serius tidak hanya bagi lingkungan, tetapi juga bagi sistem keuangan. *Climate Risk Stress Testing* (CRST) menjadi salah satu instrumen bagi regulator dan lembaga keuangan untuk mengantisipasi risiko tersebut. Namun, sebagian besar penerapan CRST saat ini lebih berfokus pada properti dan hipotek, tidak pada aset infrastruktur. Penelitian ini mencoba mengisi kesenjangan tersebut dengan mencari pendekatan yang cocok untuk menakar kerugian fisik akibat banjir di proyek infrastruktur. Analisis dilakukan menggunakan kerangka *hazard–vulnerability–exposure* dengan memanfaatkan peta bahaya banjir dari Aqueduct Tools, *depth–damage function*, serta asumsi paparan proyek. Perhitungan menghasilkan dua nilai utama, yaitu kerugian dari kejadian tunggal berdasarkan periode banjir dan *Expected Annual Damage* (EAD). Nilai kerugian ini dapat digunakan sebagai dasar untuk melakukan *stress test* terhadap arus kas proyek. Hasil penelitian menunjukkan bahwa kerangka ini dapat digunakan untuk mengalkulasi risiko banjir akibat perubahan iklim pada infrastruktur, serta menawarkan titik awal bagi regulator, *development finance institution*, dan *multilateral development bank*. Meski demikian, terdapat beberapa kelemahan dalam pendekatan ini, termasuk resolusi peta banjir global yang masih kasar, fungsi kerentanan yang bersifat umum dan belum dikalibrasi dengan kondisi lokal, serta belum adanya pertimbangan mengenai proteksi banjir dan dampak tidak langsung dari adanya banjir.

Kata Kunci: Climate Risk Stress Test; Kerusakan Banjir; Pembiayaan Infrastruktur; Penilaian Kerentanan

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INTRODUCTION

Climate change is one of the greatest challenges of our time (Boros, 2020). This challenge manifests through multiple transmission channels, including finance. It is, therefore, not an overstatement to argue that climate change constitutes a financial risk (Netto et al., 2021), and poses a significant threat to global financial stability (UNEP, 2024). Addressing those challenges has become increasingly urgent.

Over the past decades, awareness of climate risks has grown, including within the financial and banking industries. As a result, significant efforts have been made to examine and analyze financial risks arising from climate change and the transition to a low-carbon economy (Reinders et al., 2023).

This trend is also evident in Indonesia, with regulations and guidance published by the Financial Services Authority (*Otoritas Jasa Keuangan*, OJK). An example is the Climate Risk Management Scenario (CRMS), published in 2024 (OJK, 2024a). The document guides on implementing the Climate Risk Stress Test (CRST), which builds on a pilot CRST conducted by OJK and 11 major banks in Indonesia back in 2023 (OJK, 2024a).

However, despite these efforts, relatively few studies have focused on developing CRST methodologies for the infrastructure asset class. Furthermore, existing CRST methodologies found in national regulations or central bank guidelines are typically limited to the mortgage asset class. For example, it is outlined in the recent OJK Climate Risk Management and Scenario Analysis (CRMS) framework, which primarily focuses on flood-related physical risks for residential properties. The knowledge gap is critical for at least two reasons: First, infrastructure assets are inherently exposed to climate risks, particularly physical risk such as coastal and riverine flooding (Assab, 2025). Second, some organizations manage portfolios that are largely composed of infrastructure assets, such as development finance institutions and multilateral development banks.

This paper seeks to address the gap outlined above. However, given the extensive scope of climate risk stress testing, it will be limited to the physical risk of flooding arising from climate change. Additionally, the analysis focuses solely on the direct physical damage caused by flooding. This focus is important because there has been comparatively less attention in the literature on physical climate-related financial risk (Ranger et al., 2022).

Accordingly, the research question addressed in this paper is: “How can climate-induced flood-related physical damage to infrastructure assets be analyzed and considered in climate risk stress testing?” Specifically, this paper seeks to examine methodologies for estimating potential financial losses resulting from flooding in the infrastructure asset class.

A solar power plant project has been selected as a case study to apply the proposed flood-risk quantification framework within the infrastructure CRST context. This asset type is particularly relevant for two main reasons. First, solar power plants are physically exposed to flood hazards due to their extensive ground coverage and low-lying installation sites. Second, the availability of project-level technical and financial data allows a quantitative assessment of how physical damage translates into financial loss. As such, the solar power plant serves as a representative case to test the applicability and practical value of the proposed methodology for infrastructure assets.

LITERATURE REVIEW

The main challenge of CRST is linking climate-induced flood risk with financial risk, as outlined in the introduction, is scarcely addressed in the literature. Most literatures focus on mortgages. For example, Krijgsman (2021) highlighted the need of standardized flood risk assessment framework for financial institutions and examined methods for estimating the flood damage to real-estate portfolios. Building on this, Wu et al. (2024) outlined a similar methodology for analyzing flood risk but placed greater emphasis on its financial implications. They argued that two major financial risks in real-estate portfolios are market risk (referring to potential property loss) and credit risk (referring to an increased likelihood of mortgage default). Similarly, Auzepy and Bannier (2025) discussed the European Central Bank’s (ECB) CRST, which focused on banks’ mortgage exposures to flood risk and assessed the resulting impacts on credit risk.

As noted in the previous paragraph, flood risks in CRST predominantly address mortgages, and this is also evident in guidelines provided by national banks and financial authorities for commercial banks. In Indonesia, for example, OJK (2024b), provides technical recommendations for flood analysis in the mortgage sector, assigning percentage of asset value as the impact of flood in IDR, based on the location (city/regency level) of the mortgage and its flood risk level.

Bank Negara Malaysia/BNM (2024) offers similar guidance for the mortgage sector, but with more detailed technical specifications. In the technical guideline, BNM requires banks to analyze a 1-in-200-year flood event with assessments conducted at a minimum resolution of postcode level. Similarly, De Nederlandsche Bank (DNB) in its working paper (Caloia & Jansen, 2021) requires flood risk analysis in the real estate sector using flood maps provided by the Dutch Government. These maps provide inundation depths for specific locations at the postcode level, ranging from 1 to 5 meters for 50, 500, and 2,000 year return periods. Hong Kong Monetary Authority (2021) adopts a similar approach but allows banks greater flexibility in assumptions and methodologies, providing only projected mean sea level rise as a reference.

To further examine the methodology widely used in flood risk analysis in CRST, this paper adopts the IPCC risk framework. As explained by Krijgsman (2021) and expanded by Wu et al. (2024), risk can be expressed in the following formula:

$$R = H\,x\,V\,x\,E$$

Where R is risk or the expected value loss; H represents the *hazard*, which is the intensity of flooding; V represents vulnerability, which refers to the degree to which an asset or system is prone to harm from the hazard; and finally, E represents exposure, which is the level of the asset exposed to the hazard.

This conceptual definition of flood risk is applied in CRST by several authors (Assab, 2025; Krijgsman, 2021; Wu et al., 2024), although its direct linkage to financial risk remains underexplored in the literature. The analytical structure based on hazard (probability), vulnerability, and exposure builds upon the general framework for assessing climate risk in infrastructure proposed by Dawson et al. (2018). Since flood events are probabilistic in nature, the associated damage must also be represented as probabilistic outcomes. Accordingly, the return period becomes a critical variable in estimating expected damage.

Within the CRST context, expected damages can be derived by integrating the potential flood depths across multiple return periods (Assab, 2025). The resulting financial value does not represent an actual or guaranteed monetary loss, but rather an indicative measure of the magnitude of potential financial impact that a project may face under different flood scenarios. One way to interpret this value is by comparing it with a flood insurance premium. Ideally, the project proponent should ensure that the premium paid remains lower than the expected damage value to optimize cost efficiency in risk mitigation (Mühlhofer et al., 2024). This metric serves as a bridge between physical flood risk and financial stress testing, providing a quantifiable basis for evaluating asset vulnerability to climate-induced shocks. The following subsections review existing methodologies in the literature according to hazard, vulnerability, and exposure.

Hazard

In the context of climate risk, a hazard refers to the occurrence of an extreme climate event (Field et al., 2012). This paper focuses on flooding as the hazard. Several approaches to analyzing flood hazard are discussed in the literature. The first approach involves advanced hydrological modeling, as demonstrated in studies by Kondrup et al. (2022) and Becher et al. (2023). While this method produces highly analytical results, it requires significant resources, which makes it less practical for CRST applications. The second approach utilizes available flood maps provided by governmental entities, as seen in studies by Caloia & Jansen (2021), Hong Kong Monetary Authority (2021), OJK (2024b) and Bank of England (2022). While this approach is more practical, these maps often lack granularity and typically only indicate risk levels without specifying flood intensity, such as inundation depth, as highlighted in OJK (2024b). This limitation reduces their utility for infrastructure asset analysis, which requires more precise data to estimate potential financial losses.

The third approach is the use of open-source flood models or maps, particularly the Aqueduct Flood Tool (Ward et al., 2020). This tool has been employed in several studies, including Assab (2025); Krijgsman (2021); Netto et al. (2021); and Wu et al. (2024). Aqueduct provides data on inundation depth (measured in meters) and probabilities across different return periods, making it more suitable for infrastructure asset analysis. This study adopts the last approach.

Vulnerability

Vulnerability in climate risk refers to the susceptibility of exposed assets to experience negative impacts from a hazard (Field et al., 2012). In CRST, vulnerability assessment is essential as it converts the physical value of a hazard into the expected financial value of resulting physical damage. The literature on this particular aspect is relatively limited. Some central banks provide flexibility for financial institutions to assess expected damage, as seen in the guidelines of Bank Negara Malaysia (2024) and the Hong Kong Monetary Authority (2021). Other institutions, such as DNB, recommend the use of impact functions in vulnerability analysis (Caloia & Jansen, 2021). Impact functions correlate monetary loss from physical damage with inundation depth from a hazard (Slager & Wagenaar, 2017). A similar approach is adopted by Assab (2025) and Krijgsman (2021), who rely on impact functions or depth–damage functions, most commonly using the global depth–damage dataset from Huizinga et al. (2017). We found that this depth-damage function is widely referenced in the literature (Assab, 2025). The dataset from Huizinga et al. (2017) is based on a global literature review and allows for adjustments based on continent and country. Therefore, this approach is selected for the present study.

Exposure

According to IPCC, exposure refers to the presence of people, livelihoods, economic assets, social and cultural assets, investment, infrastructure, services, ecosystems, and species that are subject to potential climate hazards (Field et al., 2012). Since this paper focuses on physical damage to infrastructure, the exposure analysis follows the simplification employed by Assab (2025), which estimates the proportion of the infrastructure assets directly exposed to flooding. For example, when assessing road infrastructure, instead of considering the entire length of a highway, only a representative segment (e.g., a 500-meter stretch) might be analyzed as being exposed to flood risk.

ANALYSIS

As discussed in the literature review, the flood analysis will be conducted by following a combination of tools identified in the literature, as illustrated in Figure 1.

For the case study, an anonymized project was selected to ensure confidentiality. The project is a ground-mounted solar power plant located in the Province of West Nusa Tenggara, Central Indonesia. The site is identified as being at risk of flooding using the Aqueduct tool.

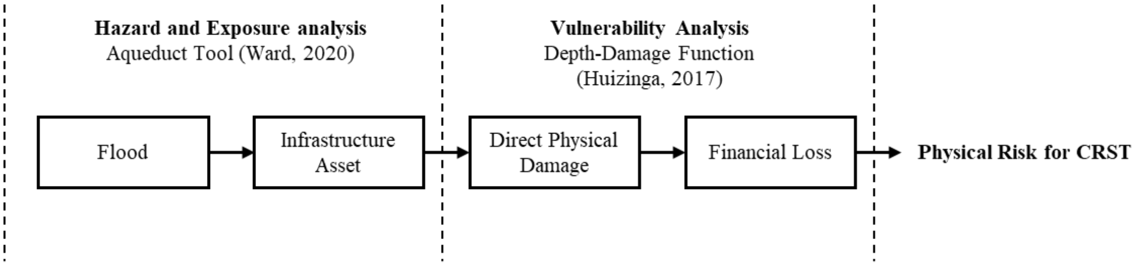

Figure 1. Flood Analysis Framework

The site represents a typical ground-mounted solar power installation in Indonesia, typically situated in lowland coastal areas that are exposed to flood hazards driven by sea level rise and land subsidence. This type of project was chosen because flooding and storms are major climate events that impact solar power plants (Silva et al., 2021). Aqueduct distinguishes between two types of flooding: coastal and riverine. This project is primarily exposed to coastal flooding driven by sea level rise and land subsidence.Figure 2 presents the flood map, where the dark pixels indicate flood hazards, with the project located within the mapped area.

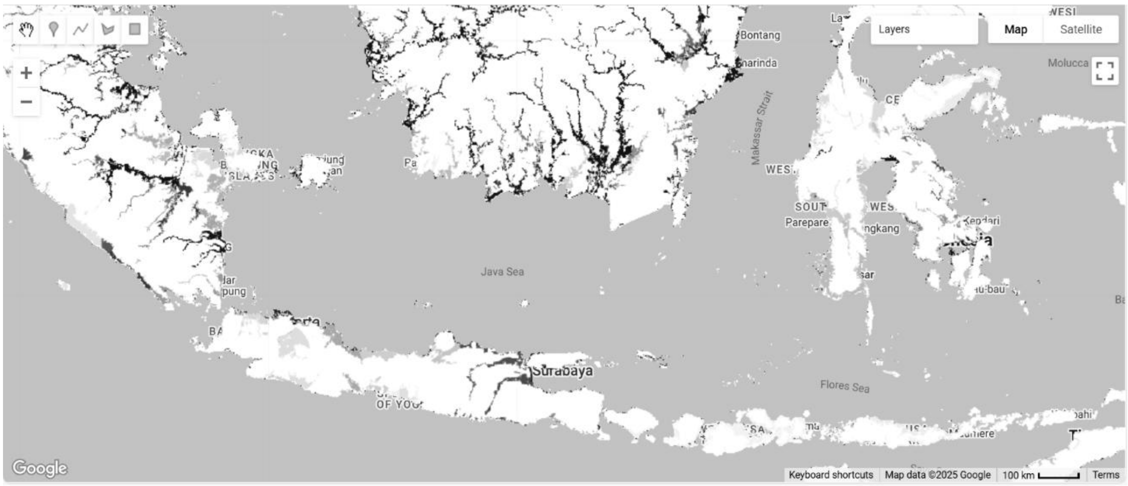

Figure 2. Flood Hazard Map

From the flood intensity shown in Figure 2, the exposure and vulnerability analysis can be carried out. The project area covers approximately 37.7 hectares; however, it is assumed that only a minor yet significant portion, namely the solar panels, is affected. Based on this assumption, the exposure is estimated to be 10% of the total project area. For the vulnerability assessment, the depth–damage function proposed by Huizinga et al. (2017) is applied, as shown in the following Table 1.

Table 1. Example of Depth-Damage Function

Depth (m)	0	0,5	1	1,5	2	3	4	5	6
Damage	0,00	0,21	0,37	0,60	0,71	0,81	0,89	0,97	1,00

From the Aqueduct tool, the flood hazard intensity data can be exported in table format. As noted earlier, the project is expected to be impacted by coastal flooding. The model provides multiple scenarios for 2030 and 2050; for the purposes of this paper, the high-emission scenario (RCP 8.5 from the IPCC) combined with land subsidence in 2050 is selected to illustrate the magnitude of the risk. The flood intensity—expressed as inundation depth and probability of occurrence—is presented in Figure 3.

By combining the depth-damage function and flood intensity, the expected damage from flooding on the project can be determined. For CRST applications, two approaches exist: one that estimates the expected damage from a single event and another that estimates the expected annual damage (EAD) (Wobus et al., 2019).

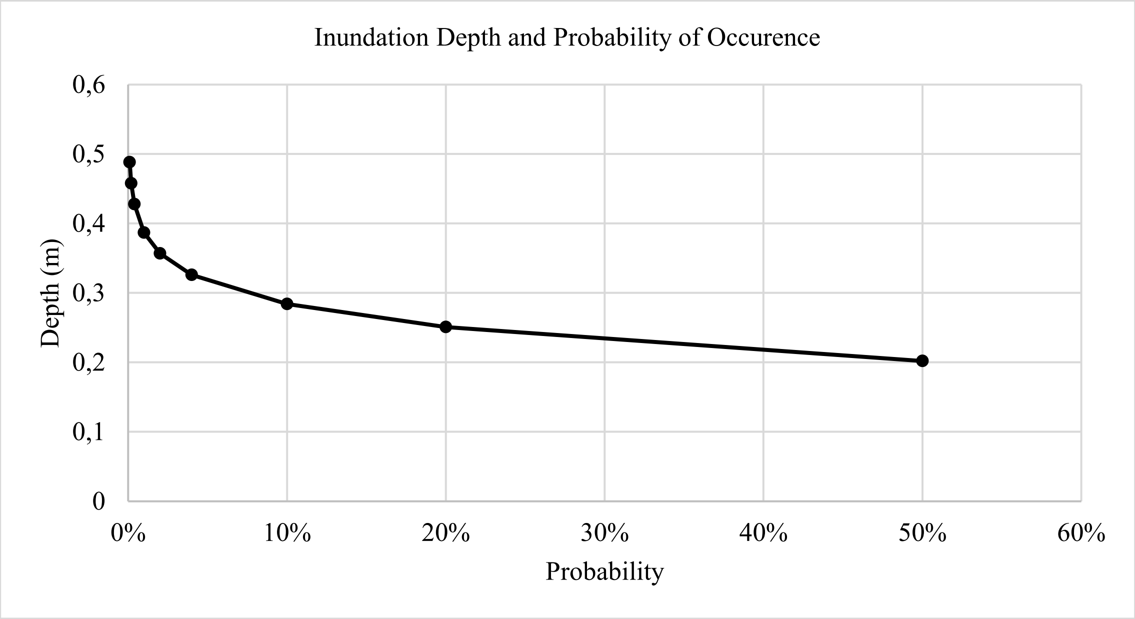

Figure 3. Flood Inundation Depth and Probability of Occurrence

The first approach is to select a return period and analyze the damage from that particular event. For example, the return period might be chosen to be 100 years, reflecting the intensity of the flood hazard. The inundation depth corresponding to the 100-year return period is 0.387 meters. The expected damage from the depth-damage function provided by Huizinga et al. (2017) can be calculated using the formula below:

$$Expected\ Damage = D(l)\ \times Max\ Damage$$

In this formula, D represents the percentage of direct physical damage from flooding, l is the inundation depth in meters, and Max Damage refers to the maximum potential loss per square meter, adjusted for country and asset class, expressed in euros. Using an inundation depth of 0.387 meters, along with the project area and the assumed exposure, the estimated physical damage amounts to IDR 98,651,609,197 or USD 5,989,392 (with max damage of IDR 2,616,754/m^2).

The second approach is to calculate annual damage based on all return periods, rather than just a single return period. This method is similar to the analysis conducted by Assab (2025). The expected damage can be expressed as an integral by the following formula:

$$Expected\ Damage = \int p(l)D(l)dl$$

where p(l) is the probability of flooding at depth l, and D(l) represents the corresponding physical damage. Since the Aqueduct tool provides flood hazard data at discrete return periods, the formula can be adapted into a summation:

$$Expected\ Damage = \left(\sum_{j} p_j\ \times D(d_j) \right) \times M$$

Here, j denotes the flood return periods (ranging from 2 to 1000 years in Aqueduct), pj is the probability of flood occurrence at return period j, D(dj) is the damage associated with inundation depth dj, and M represents the maximum damage value from Huizinga et al. (2017), as expressed in €/m². The resulting calculation of direct flood damage for the project is presented in the following Table 2.

Table 2. Project Flood Damage Calculation

Return Period	Probability	Inundation Depth (m)	Damage Percentage	Base Damage (IDR/m2)	Project Damage (IDR)
2	50%	0,202	11%	1.365.851	51.492.571.209
5	20%	0,251	14%	1.697.171	63.983.343.433
10	10%	0,284	16%	1.920.305	72.395.496.155
25	4%	0,326	18%	2.204.294	83.101.872.347
50	2%	0,357	20%	2.413.904	91.004.197.631
100	1%	0,387	22%	2.616.754	98.651.609.197*
250	0,4%	0,428	24%	2.893.981	109.103.071.670
500	0,2%	0,458	26%	3.096.830	116.750.483.236
1000	0,1%	0,488	28%	3.299.679	124.397.894.801
				Expected Annual Damage (IDR/year)	**52.707.489.993**

** First approach calculation*

Table 2 shows that the Expected Annual Damage (EAD) is estimated to be IDR 52,707,389,993, equivalent to approximately USD 3,200,000. This value represents the annualized loss from climate-induced flooding under the modeled scenarios. In the context of a Climate Risk Stress Test (CRST), the EAD can serve as the baseline financial impact used to evaluate the project's resilience to flood risk and its ability to withstand long-term climate pressures.

For example, this financial value can be used to stress test the project's cashflow. Assuming that the damage is absorbed as a reparation budget for the project, this amount would increase annual operating expenses, thereby decreasing the Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA). Since part of the project's funding is through debt, this would weaken the debt servicing capacity of the project, typically calculated using the debt service coverage ratio (DSCR) and loan life coverage ratio (LLCR).

The analysis yields two key values: single-event losses based on a selected flood return period and the Expected Annual Damage (EAD). Drawing from the literature, it is recommended that both values be used for stress testing. The single-event approach captures the impact of an extreme flooding scenario, testing the project's resilience under severe conditions. In contrast, the EAD reflects the average annual burden of climate-induced flooding, providing insight into the project's capacity to sustain such risks over its entire lifecycle.

The analysis shows how flood risk can be systematically quantified for CRST by breaking it down into hazard, vulnerability, and exposure components, which can be assessed separately and then integrated. The primary objective of this framework is to provide a method that is both simple and robust for estimating financial losses resulting from climate-induced flooding. The approach developed in this paper is sufficiently practical to be applied or adapted by financial institutions conducting CRST for infrastructure assets. Its primary strength lies in its explicit linkage of climate and financial risk analysis, moving beyond the purely engineering-based perspective that dominates much of the existing literature. Nevertheless, several limitations remain unaddressed and are discussed below.

The first limitation concerns the relatively low resolution of Aqueduct's flood hazard maps. The underlying data have a spatial resolution of approximately 10 km × 10 km (resized to 1 km × 1 km for visualization) (Ward et al., 2020). This resolution is too coarse for asset-level analysis, where the objective is to assess how flooding physically affects specific infrastructure components. In this case study, the flood hazard was treated as directly affecting the project site, but it was not possible to distinguish whether the inundation would impact, for instance, the solar panels, control rooms, or other supporting facilities.

This limitation also complicates exposure analysis: due to the coarse resolution of the hazard map, the proportion of the project considered exposed can only be assumed, which makes the resulting financial loss estimates highly sensitive to these assumptions. This issue becomes even more pronounced for linear infrastructure, such as roads and railways, where it is difficult to determine which segments are truly exposed.

Recognizing this limitation, several CRST guidelines, such as those from Bank Negara Malaysia (2024) and Caloia & Jansen (2021), require flood hazard analysis at a minimum of postcode-level resolution. Future research should, therefore, prioritize developing higher-resolution climate-induced flood models that can provide inundation depths at an asset-relevant scale to improve the robustness of CRST.

The second limitation is related to the oversimplification of vulnerability analysis when using Huizinga et al. (2017). While the depth–damage functions they provide are practical and widely cited, they are based on a global review of literature, which limits their precision at the level of specific infrastructure types and local conditions. The functions are limited to six broad asset classes (i.e., residential, commercial, transportation industrial, agricultural, and infrastructure), which means that assets outside these categories must rely on approximations.

In this study, for instance, the solar farm was treated as "industrial," even though its characteristics and susceptibility to flooding may differ significantly from those of other categories. Furthermore, the maximum damage values from Huizinga et al. (2017) are expressed in 2010 euros, requiring both currency conversion and adjustment to 2025 Indonesian prices. These layers of approximation and adjustment reduce the accuracy of the vulnerability analysis. To strengthen future CRST applications, locally calibrated depth–damage functions should be developed for Indonesia, ideally tailored to a broader range of infrastructure asset classes, including renewable energy facilities.

The third weakness involves the omission of flood protection measures in the analysis. Climate adaptation measures, such as protection against flood events, has often been overlooked in renewable energy discussion (Silva et al., 2021). In this paper, flood protection refers to design standards or physical structures that reduce the intensity of flooding, such as land grading and construction of dikes in power plant projects (Silva et al., 2021).

Unlike some studies (Krijgsman, 2021; Wu et al., 2024), this paper did not account for existing defenses or adaptation measures, which likely led to an overestimation of risk. By assuming that even low-return-period floods could cause serious damage, the results may exaggerate the project's vulnerability. Although there is a growing body of research on the role of flood protection and climate adaptation (Assab, 2025; Krijgsman, 2021), this area remains underdeveloped, particularly for application in CRST.

In practice, protection levels are often defined by the return period of flood events they are designed to withstand. Incorporating this information would allow for a more realistic estimation of Expected Annual Damage (EAD). For instance, if the project were assumed to have protection against a 10-year flood, the loss estimates in Table 2 would shift significantly compared to a no-protection scenario, as shown in Table 3 and Figure 4. The expected damage using flood protection results in IDR 1,350,532,882 per year, or approximately USD 82,000 annually.

Table 3. Project Flood Damage Calculation with Flood Protection

Return Period	Probability	Inundation Depth (m)	Damage Percentage	Base Damage (IDR/m2)	Project Damage (IDR)
2	50%	0	0%	-	-
5	20%	0	0%	-	-
10	10%	0	0%	-	-
25	4%	0,042	2%	283.989	10.706.376.192
50	2%	0,073	4%	493.600	18.608.701.476
100	1%	0,103	6%	696.449	26.256.113.042
250	0,4%	0,144	8%	973.676	36.707.575.515
500	0,2%	0,174	10%	1.176.525	44.354.987.081
1000	0,1%	0,204	12%	1.379.374	52.002.398.646
				Expected Annual Damage (IDR/year)	**1.350.532.882**

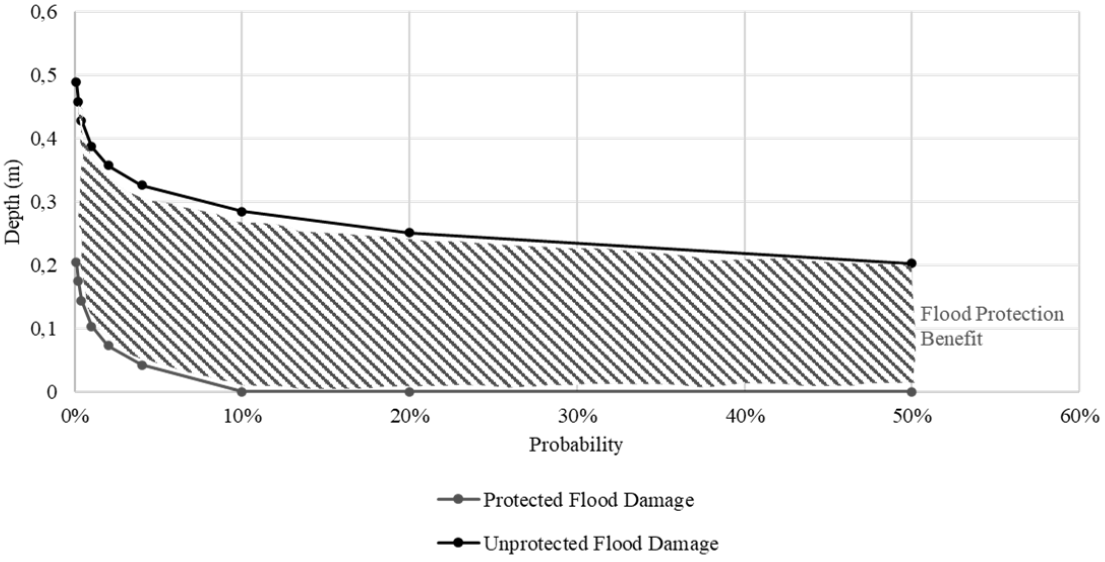

Figure 4. Protected and Unprotected Flood Damage with 10-Year Flood Protection

To contextualize this figure, the result can be compared with the typical insurance premium for solar power plants that includes flood coverage. Based on industry data, the average premium ranges from USD 4–10 per kW per year (Schwab et al., 2020). For a project with an installed capacity of 26 MW, this translates to an annual insurance cost of approximately USD 182,000, or between USD 104,000–260,000 across the typical range. Thus, the estimated premium exceeds the expected annual damage, which is reasonable since insurance premiums generally cover a wider set of hazards beyond direct flood impacts. Hence, this comparison suggests that the calculated expected damage is realistic and provides a credible basis for assessing flood-related financial risk within the CRST framework.

Finally, this paper does not account for the indirect impacts of flooding. In CRST, physical damage represents only one channel of risk transmission. Flooded infrastructure can trigger broader socioeconomic consequences, e.g., supply chains, disruptions to communities, or regional economies. For revenue-generating assets, flooding can also lead to prolonged income losses, even when physical repairs are relatively minor.

By limiting the scope to direct physical damage, this analysis underestimates the full financial implications of flood events. Moreover, the study does not extend the stress testing to capture the broader set of financial risks—such as credit risk, operational risk, market risk, and liquidity risk—which banks typically assess. Future research should, therefore, expand the framework to integrate both direct and indirect impacts, linking physical risk to the wider financial system. So, incorporating these broader considerations would make CRST more comprehensive, practical, and valuable for banks, regulators, and development finance institutions.

CONCLUSION

This paper set out to explore how flood-related physical risk can be analyzed for infrastructure assets in the context of CRST. Through a combination of literature review and a case study of an anonymized solar power project, the study applied the hazard–vulnerability–exposure framework to estimate potential financial losses from climate-induced flooding.

The review showed that most existing guidance and applications of CRST remain focused on real estate and mortgage portfolios, leaving a clear gap for infrastructure assets. By applying tools such as Aqueduct flood maps and Huizinga et al.'s (2017) depth-damage function, this paper demonstrated a practical method to quantify both single-event losses and expected annual damages at the project level. Importantly, the methodology allows for a direct link between climate hazards and financial outcomes, a connection that remains limited in current practices.

However, the analysis also highlighted several limitations that need to be addressed in future studies. The resolution of global flood maps remains too coarse for asset-level analysis. While the depth-damage function is widely used, it is generic and not tailored to Indonesian infrastructure. Assumptions about exposure introduce uncertainty, and the absence of flood protection measures or consideration of indirect impacts from flooding likely leads to over-/under-estimate real risks. Furthermore, the financial stress testing in this study was limited to direct damage, leaving out other important risk channels such as credit and market risk.

In addition, the scope of this study is intentionally narrow. The analysis focuses on a single solar power plant project, selected to illustrate the methodological application rather than represent the full diversity of infrastructure assets. As such, the results are not directly generalizable to other sectors or geographies without adjustment. Furthermore, the financial translation of physical damage relies on simplified assumptions regarding asset value and replacement cost, serving only as an indicative estimate rather than a precise valuation. These limitations define the exploratory nature of this study and should be considered when interpreting the results.

Despite these weaknesses, the paper provides an initial step in extending CRST methodology for infrastructure assets. For regulators, MDBs, and development finance institutions, the proposed framework can serve as a baseline that can be further adapted, localized, and scaled up. Future research should aim to develop country-specific damage functions, improve the granularity of hazard data, and integrate flood protection standards. In addition, further research is needed to link physical losses to credit, operational, and market risks to further enhance the value of the framework for financial institutions and regulators.

In short, while the approach presented in this paper is not definitive, it offers a practical pathway to bridge the gap between climate-related flood risk and financial stress testing for infrastructure assets, an area that will only grow in importance in the years ahead.

ABOUT THE AUTHORS

The authors are part of the Environmental, Social, and Technical Evaluation Division at PT SMI. Their primary responsibilities include evaluating the Environmental, Social, and Governance (ESG) aspects of infrastructure investments within PT SMI. In addition to evaluation tasks, the authors are also actively involved in developing frameworks and methodologies related to climate change analysis at PT SMI, ensuring that climate risks are systematically integrated into investment decision-making processes.

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