MULTI-HAZARD IMPACT ASSESSMENT FOR VOLCANIC AND STORM HAZARDS: THE SAINT VINCENT CASE STUDY

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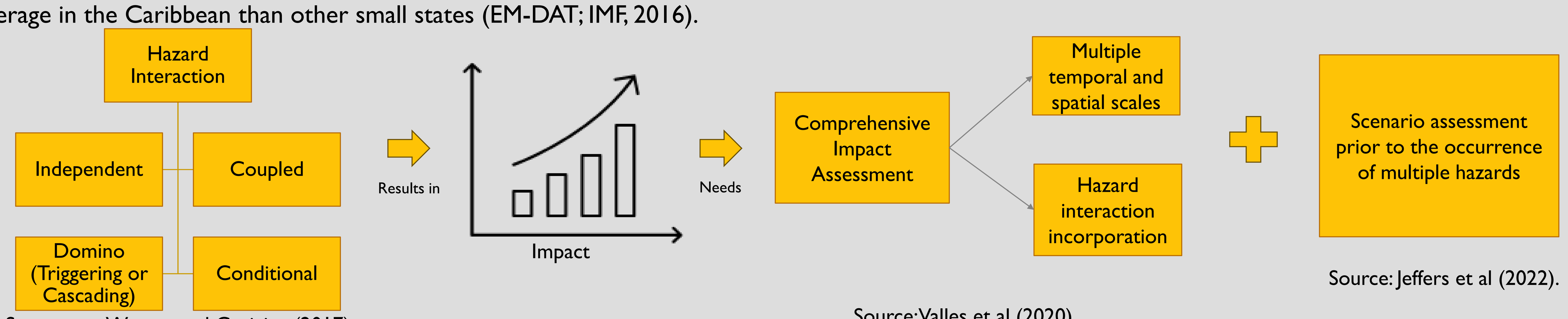
INTRODUCTION

Development in disaster risk management literature starts to acknowledge the connections between natural hazards, disaster, and the impact of hazard interconnections.

Small-island Developing States (SIDS) are susceptible to a broad range of risks coupled with a constrained capacity to manage them effectively. The Caribbean is one of three geographical regions in which SIDS are located, with a high vulnerability to multi-hazard events. Natural hazards occur more frequently and cost more on average in the Caribbean than other small states (EM-DAT; IMF, 2016).



Source: van Westen and Greiving (2017), UNDRR, 2020, Hielkema et al., 2021.

Source: Valles et al (2020) and Gill et al (2016).

Source: Jeffers et al (2022).

METHODOLOGY

Main Objective: to assess multi-hazard impact in Saint Vincent, focusing on the interaction of volcanic and storm hazards.

*On-going

Retrospective Assessment Presented with Impact Chains

Observational review and/or reassessment of database records to analyze events of interest that have already happened.

↓ Presented into

Conceptual models based on cause-effect chains that include all major factors and processes assigned to hazard, vulnerability, and exposure components.

Purposes

1. Assessing impacts of past events and potential future situation.
2. Identifying the significant hazards and their associated exposed elements-at-risk for further risk assessment.
3. Identifying impacts quantification and qualitative information of an event.
4. Understanding of risk pathways.

Developing Direct Compounding Hazards Scenario

Takeaways from Retrospective Assessment and Impact Chain.

↓

Assess the interaction between volcanic and storm hazards and the associated risk.

↓

Identify the parameters required for hazard simulation.

↓

Recreate previous event for retrofitting the model.

↓

Simulate the scenario.

Simulation Tools

FALL3D

LISEM

Impact Assessment Presented in Multi-risk Scenario Graph*

Hazard footprint results from the simulations.

↓

Exposure assessment of the elements-at-risk.

↓

Impact assessment from the exposure assessment.

↓

Tree-like graphical representation of how multi-hazard events are triggered, interrelated, and how they can cause cascading impacts in different sectors over time.

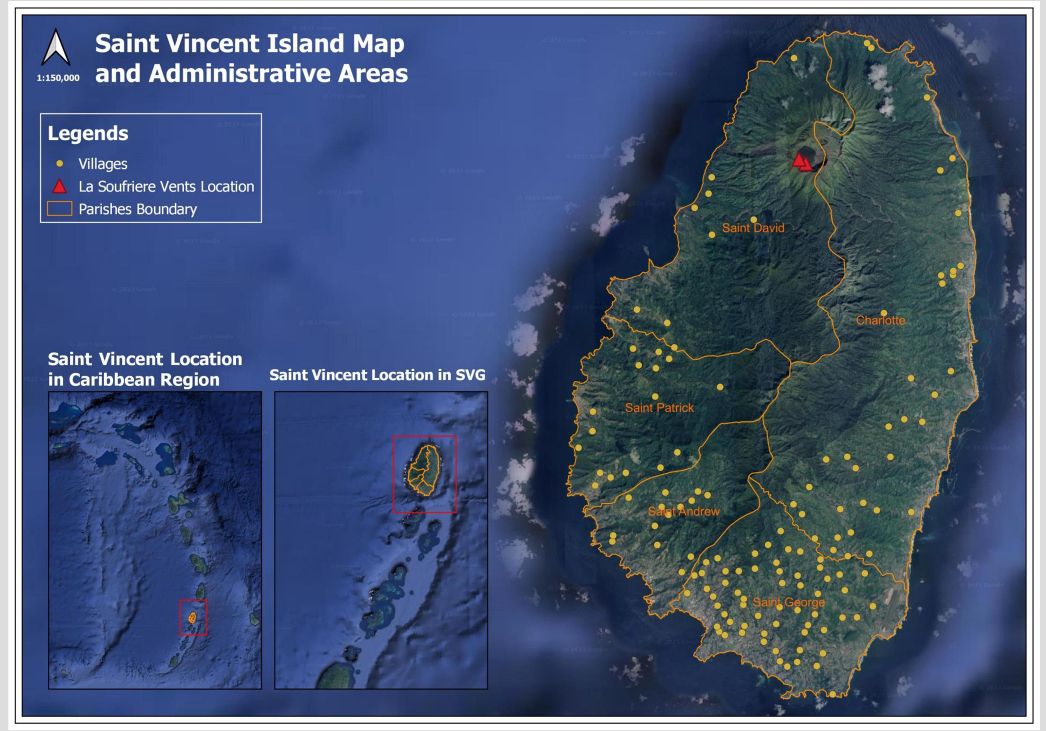
Purposes

1. Assessing impacts of an event / consecutive events and incorporating the interaction between hazards.
2. Including time aspect in the assessment.
3. Further can be used to identify the risk reduction measures and resilience aspect.

CASE STUDY

Saint Vincent is the main island of Saint Vincent and the Grenadines, an archipelagic state in the Eastern Caribbean. The northern part of the island is occupied by an active volcano, La Soufriere.

Main hazards:

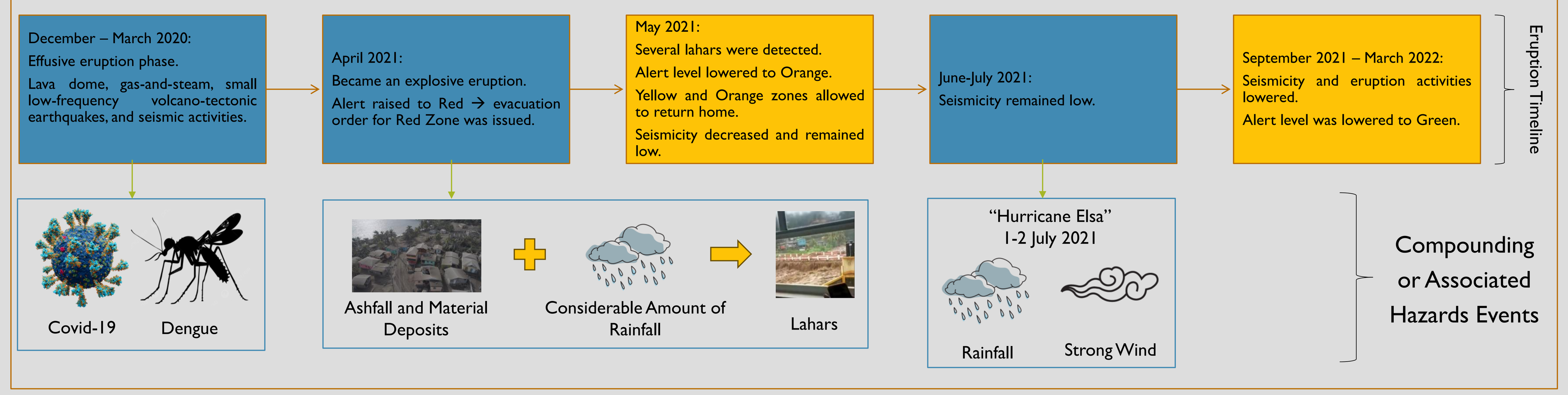


Data were obtained from the Government of Saint Vincent and the Grenadines.

THE 2021 EVENT

In 2021, a devastating compounding event between Hurricane Elsa and La Soufriere eruption occurred in Saint Vincent.

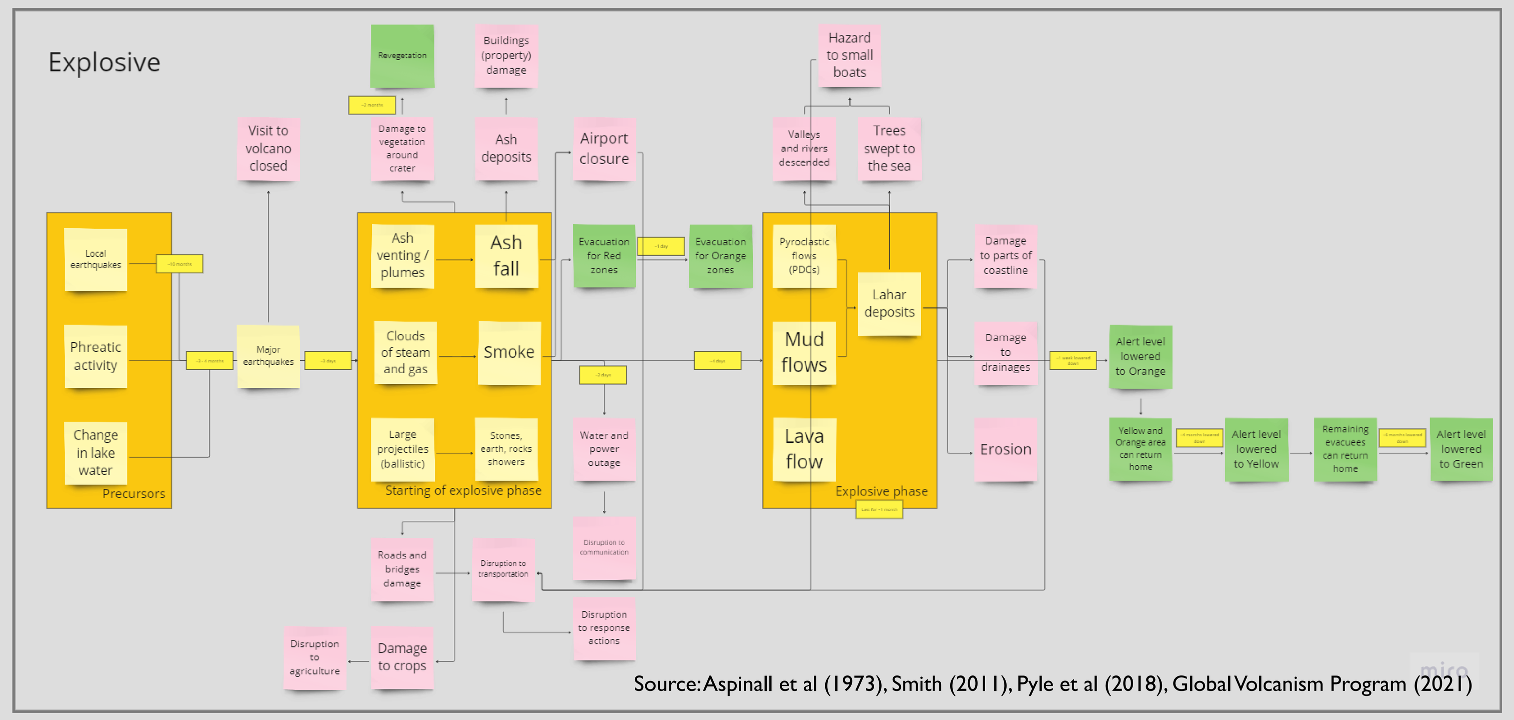
Source: Global Volcanism Program (2021).



HISTORICAL EVENTS AND RETROSPECTIVE ASSESSMENT

Volcanic Events

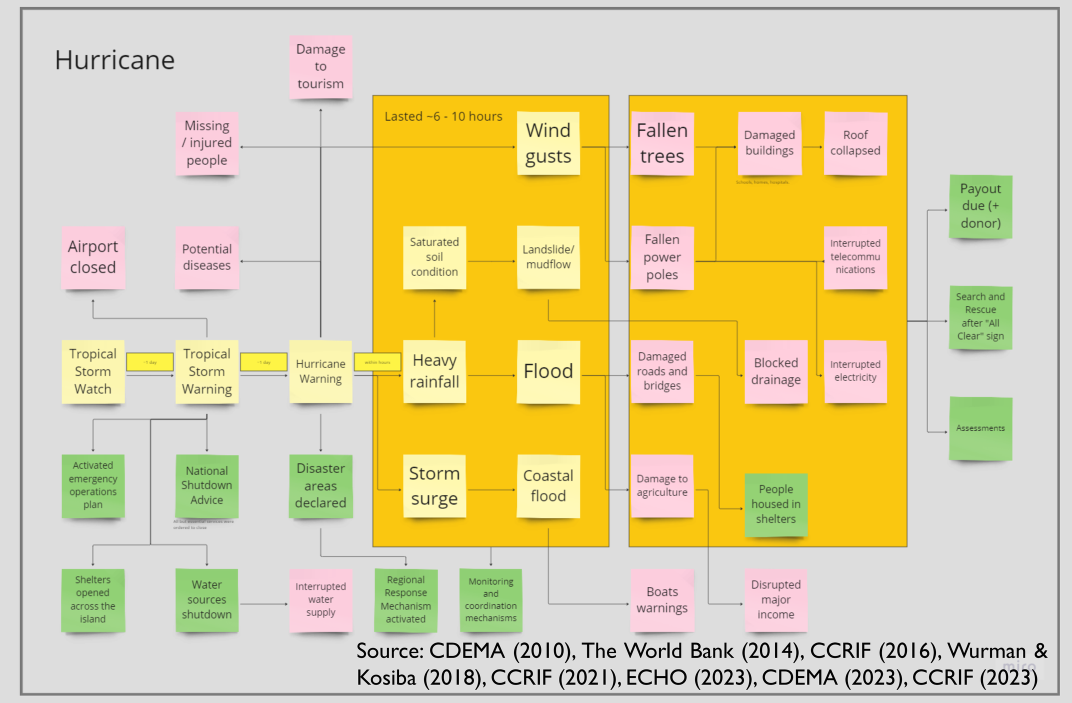
The eruption in 1812, 1901/02, 1971, 1979, and 2021 were used as the reference and basis of the retrospective assessment and impact chains.



Source: Aspinall et al (1973), Smith (2011), Pyle et al (2018), Global Volcanism Program (2021)

Storms / Hurricane Events

Hurricane Tomas (2010), Tropical Storm Matthew (2016), Harvey (2017), Hurricane Elsa (2021), and Tropical Storm Bret (2023) were used as the reference and basis of the retrospective assessment and impact chains.

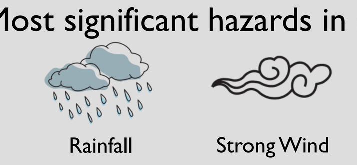


Source: CDEMA (2010), The World Bank (2014), CCRIF (2016), Wurman & Kosiba (2018), CCRIF (2021), ECHO (2023), CDEMA (2023), CCRIF (2023)

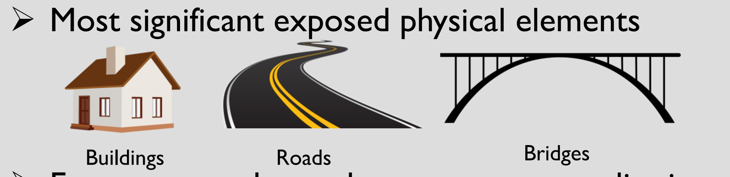
Takeaways from Impact Chains

- Explosive eruptions generate the most significant volcanic hazards.

- Most significant hazards in storm events:



- Most significant exposed physical elements

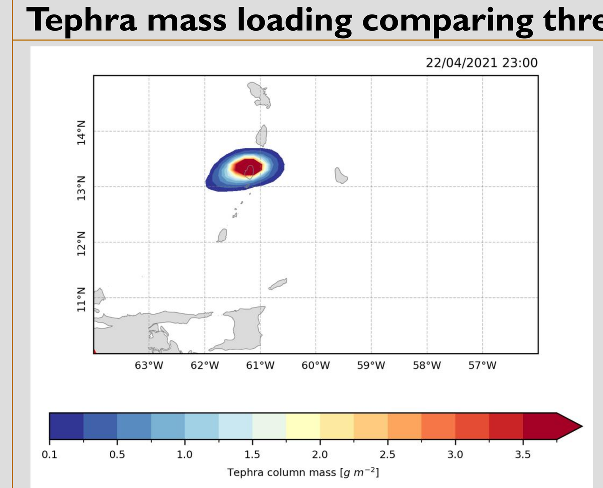


- Economy and settlements are qualitative impacts in the events

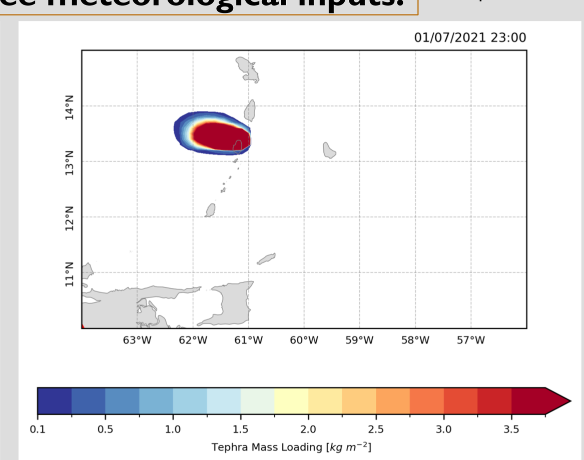
DIRECT COMPOUNDING HAZARDS SCENARIO

Tephra mass loading comparing three meteorological inputs.

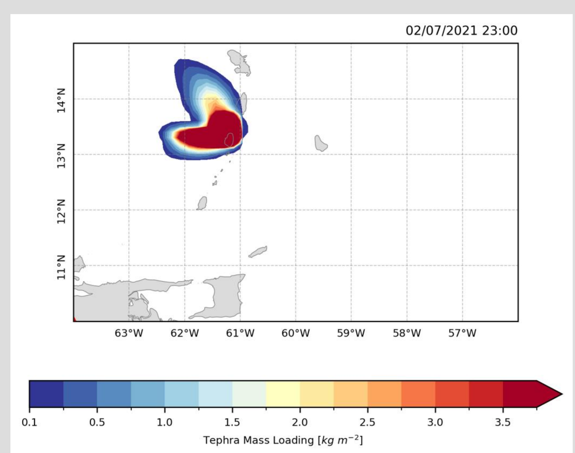
The tephra models use material parameters from the 1979 eruption (Source: Poret et al 2017).



April 2021, the actual time of 2021 eruption.



1st July 2021, Hurricane Elsa was approaching Saint Vincent



2nd July 2021, Hurricane Elsa approached Saint Vincent

Lahar modeling with assumption of different conditions.

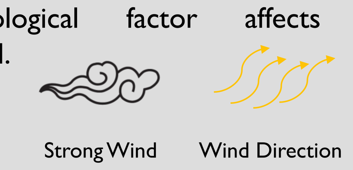
The lahar models incorporate 2-year return period of rainstorm of 20.62 mm/hr (Source: fastflood.org). Source for ash materials: Gueugneau et al (2023) and USGS (2016).

Lahars Water Height Footprints

Lahars Solid Height Footprints

Takeaways from Direct Compounding Hazards Scenarios

- Meteorological factor affects tephra dispersal.

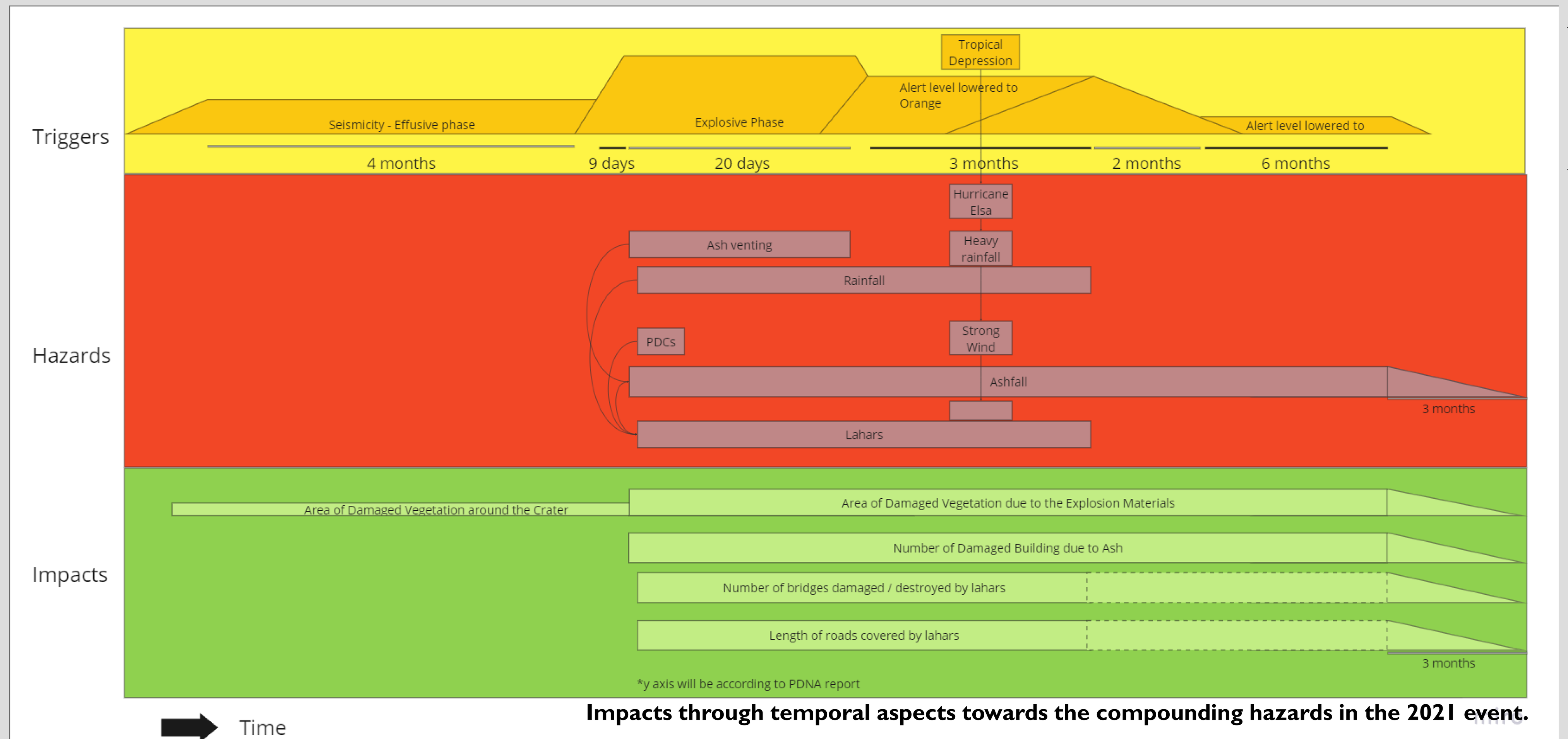


- There is not much difference in water height for lahars with and without ash material.
- The solid height for lahars with ash material is approximately 45% more than without ash material.
- The spreading for both solid and water height of lahars with ash material is wider than lahars without ash material.

IMPACT ASSESSMENT WITH MULTI-RISK SCENARIO GRAPH**

**Preliminary result

There is no change or increase in the impacts because they are defined by the quantity of each sector, which in Saint Vincent is not the case because the whole island was affected. ⇒ Degree of damage changes for each sector, but the work is currently still on going.



Impacts through temporal aspects towards the compounding hazards in the 2021 event.

NEXT STEPS

Since the multi-risk scenario for the scenario simulation is still on-going, comparison with the 2021 event cannot be done. Hence, the next step of this study is to finalize the multi-risk scenario graph for the scenario simulation for comparison in the change of impact.

CONCLUSIONS

1. Retrospective assessment is beneficial to assess the impact of a disaster event for better mitigation plan, as well as identifying significant hazards and elements-at-risk for more targeted impact and risk assessment.
2. Compounding volcanic eruption and storm is a low-probability event but has high-impact, therefore needs to have a scenario assessment to prevent future risks.
3. Storms affect secondary hazards such as lahars through the heavy rain that comes with it, as well as the strong wind and wind direction towards tephra dispersal.
4. Ash does not affect lahars for water height but does for solid height and the spreading of the lahars.
5. Change in impacts can be investigated through the amount and value of an element, or degree of damage of an asset.

LIMITATIONS

1. The tephra model used 1979 volcanic parameters which might me irrelevant in 2021.
2. The comparison for each tephra and lahar models only using one parameter (meteorological factor and ash coverage).

RECOMMENDATIONS

1. Using volcanic material parameters from the 2021 eruption for more relevance results.
2. Using another or combined parameters to compare the interaction effect between tephra and lahar models.

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SCAN US!

List of References

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