A314

Traffic Safety of Evacuation Routes in the Event of a Large-Scale Volcanic Eruption in Kagoshima City: An Empirical Analysis

○Andreas KELER, Masato IGUCHI

Introduction

A future large-scale Sakurajima eruption may show precursors similar to 1914, requiring area-based evacuation orders that could include both Sakurajima Island and central-western Kagoshima [1]. Pumice fall may reach ~0.1-2.0 m near the crater and remain substantial up to ~30 km, with wind direction strongly shaping impacts [1]. Kagoshima City's "Massive Tephra Fall Response Plan" guides pre-eruption evacuation to district shelters based on household counts [2]. Fig. 1 shows zones A-E, household distribution, shelters, and 45 suggested route variants for evacuating 301,933 households (April 2025) within 6 hours.

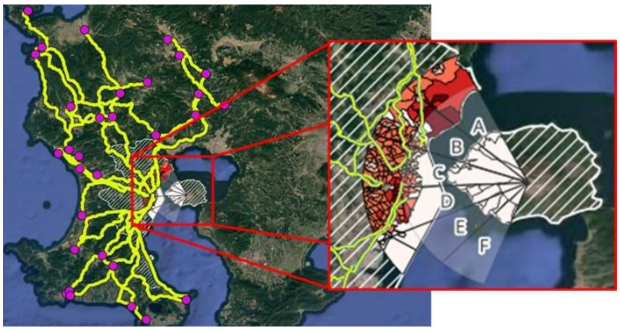

Fig. 1. Kagoshima City evacuation zones (A-F), routes, and shelters for an east-wind Sakurajima eruption scenario, based on the "Massive Tephra Fall Response Plan" [2].

We evaluate the safety of suggested evacuation routes using historical crash records (2019-2024) and relate risk to evacuated households. Assuming one passenger car per household (Massive Tephra Fall Response Plan), we estimate the expected traffic flow rate q [veh/h].

Methodological Approach

After digitizing the evacuation routes using automated image segmentation and data conversion, we matched them with historical road crash records (2014-2019) from Japan's National Police Agency (Fig. 2a, red dots). We tested multiple matching methods to later incorporate route directionality and restricted intersection movements. Using crashes per route (Fig. 2b), we computed crash frequency $F_{yr}=C_{ri}/5$ [n/y] and the crash density $F_{km\bullet yr}=C_{ri}/L_{ri}\cdot 5$ [n/(km·y)] for the 45 digitized routes [2].

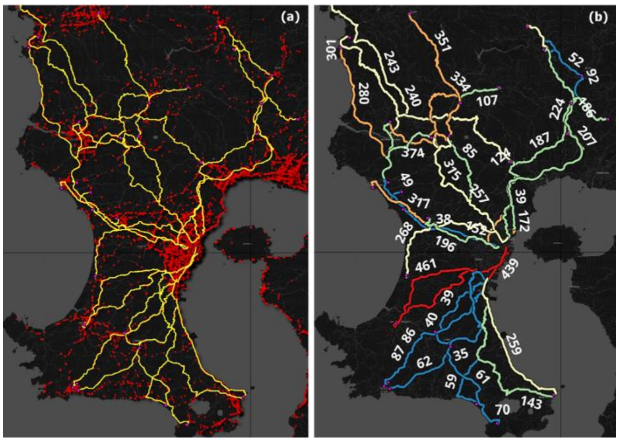

Fig. 2. (a) Crash locations (2019–2024; red) and suggested evacuation routes (yellow). (b) kNN matching within 10 m; labels indicate crashes per route.

Preliminary Results and Discussion

Initial results suggest crash frequency and density vary with district household density and route length (Fig. 3). However, Figs. 4 and 5 show two relatively short Zone D routes (<50 km) with the highest crash counts; both (D-1-1-1, D-1-12) serve the most populous districts, reflected in household bars and flow-rate coloring estimated from households only (no background traffic).

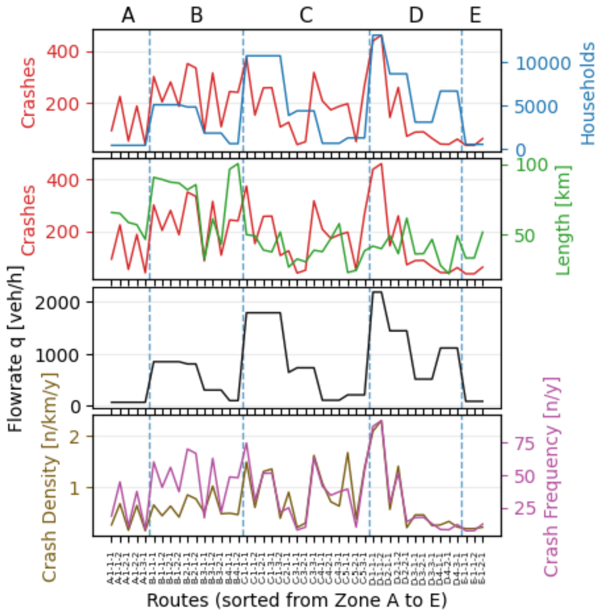

Fig. 3. Plots of crash frequency and density along 45 routes (zones A-E) with route length and household number.

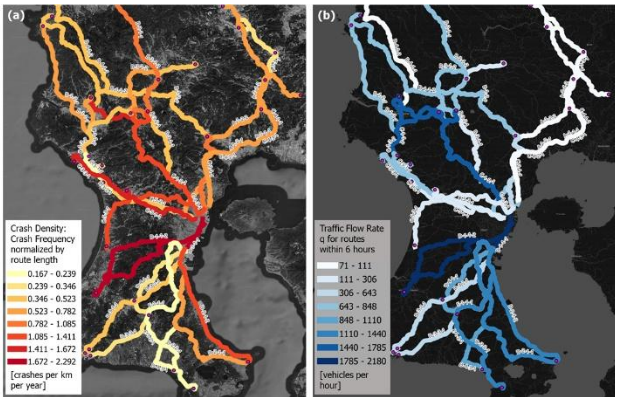

Fig. 4. Visualized (a) Crash density $F_{km \bullet yr}$ [n/(km·y)], and, (b) Flowrate q [veh/h] for the 45 routes.

In Fig. 5 crash density [n/(km·y)] is indicated by the warm color classes, and the estimated evacuation flow rate q [veh/h] by the blue classes; route IDs are labeled on the right, with dashed lines separating zones.

Next steps include segmenting routes by road-network elements, classifying intersections, conducting user-type and AADT-based safety analyses, and estimating alternative routes to the same destinations.

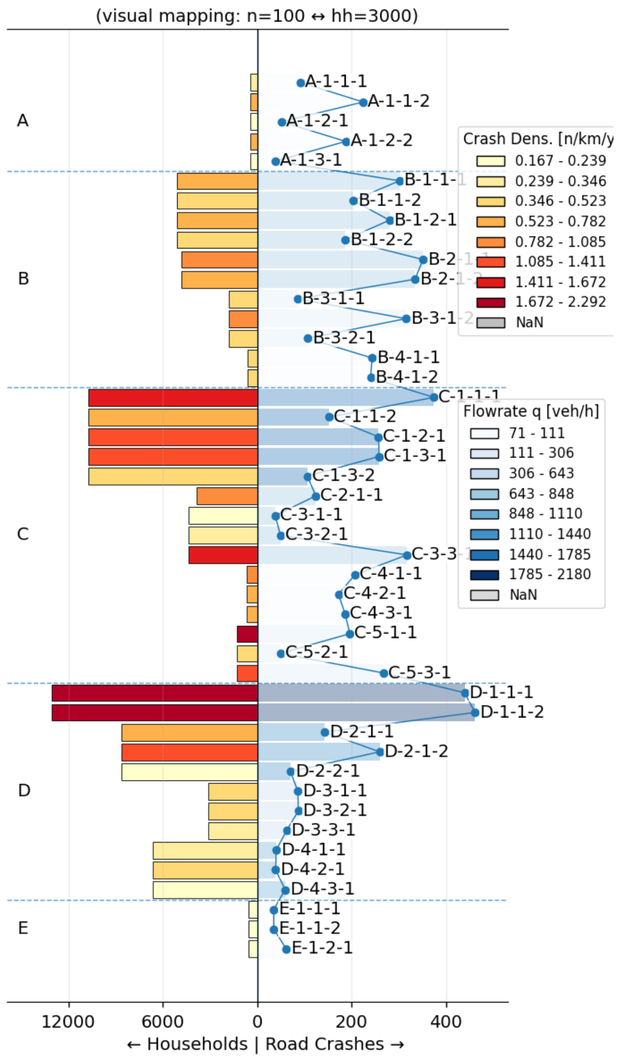

Fig. 5. Safety-demand overview for 45 evacuation routes (zones A-E): households (left; n=100↔hh=3000) versus matched crash counts (right).

References

[1] M. Iguchi, "Integrated Research on Large-Scale Eruption at Sakurajima Volcano," *Journal of Disaster Research,* vol. 20, no. 2, pp. 186-196, 2025.

[2] Kagoshima-City, "Kagoshima City Plan for Responding to Massive Tephra Fall [鹿児島市大量軽石火山灰対応計画]," Kagoshima City Hall, Kagoshima, 2023. Accessed: January 15, 2026.