Optimal Acoustic Flow Monitor Placement - Mt. Ruapehu, New Zealand

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Introduction

Lahars are an important and destructive subset of mudflows that can occur with composite volcano activity. Ash, water, and debris travel at rates of up to 30 m/s, reaching as far as 100km from the source. These events are extremely dangerous and put surrounding populations at high risk of property damage, injury, and even death.

Acoustic flow monitors (AFM) utilize infrasound sensors to remotely detect lahar events and provide advance warning to nearby populations. Our research synthesizes existing knowledge and GIS techniques to determine optimal locations for a new array of sensors near Mt. Ruapehu, New Zealand to monitor flow movement.

Research Question:
What are the optimal locations for new arrays of acoustic flow monitors around Mt. Ruapehu, New Zealand?

Methods and Data

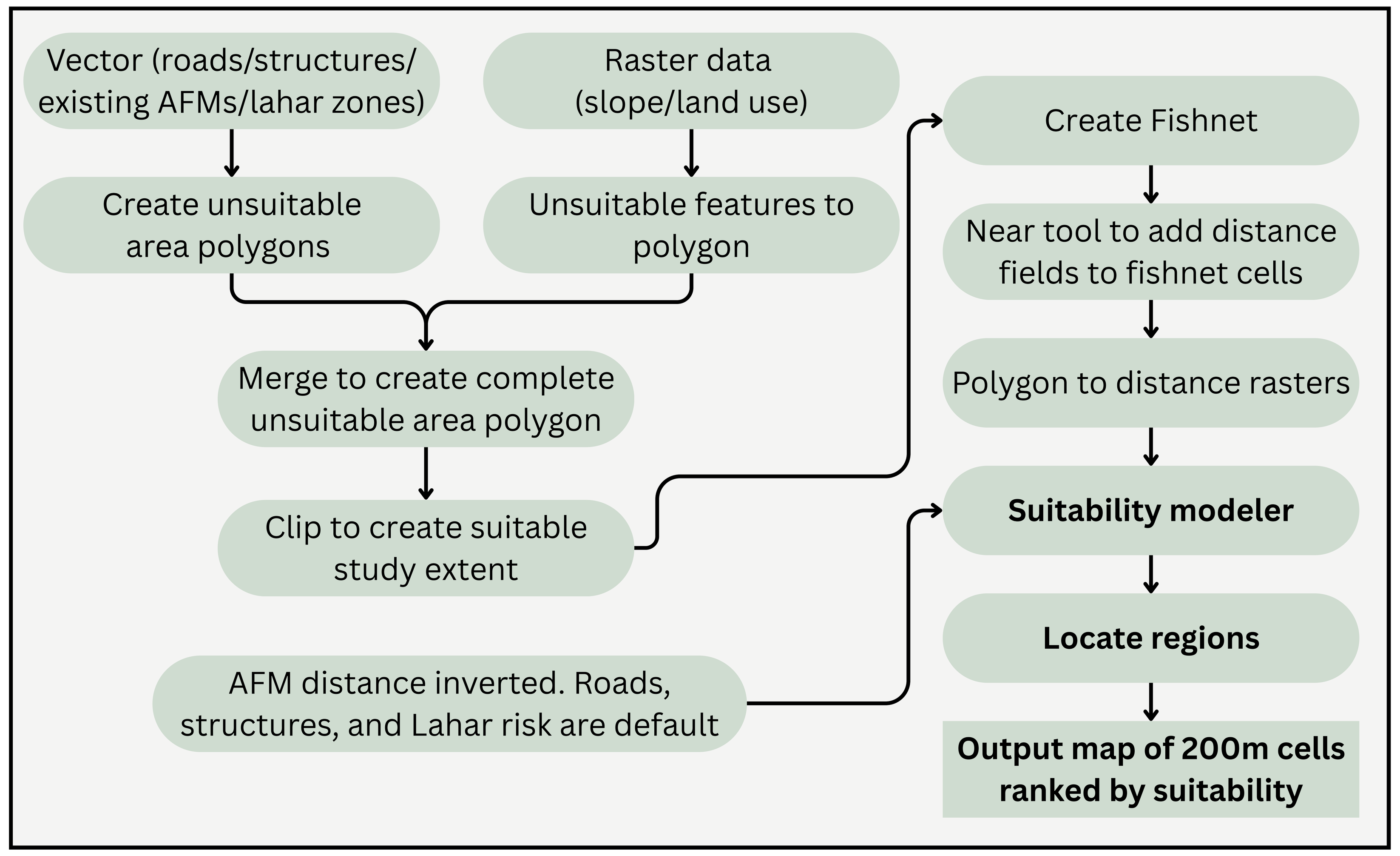

Fig. 1 - Simplified Workflow Map (see fig. 4 for more more detailed methods)

Datasets Used:
Road Data: ArcGIS Online - LINZ (Land Information New Zealand)
Structures: ArcGIS Online - LINZ
Existing AFM: Georeferenced from Natural Hazards and Earth System Sciences
Lahar Danger Zones: Horizons Regional Council
Slope: ArcGIS Online - ESRI
Land Use: ArcGIS Online - Shanon Tait

Fig. 2: AFM in Field (USGS, 2013)

Results

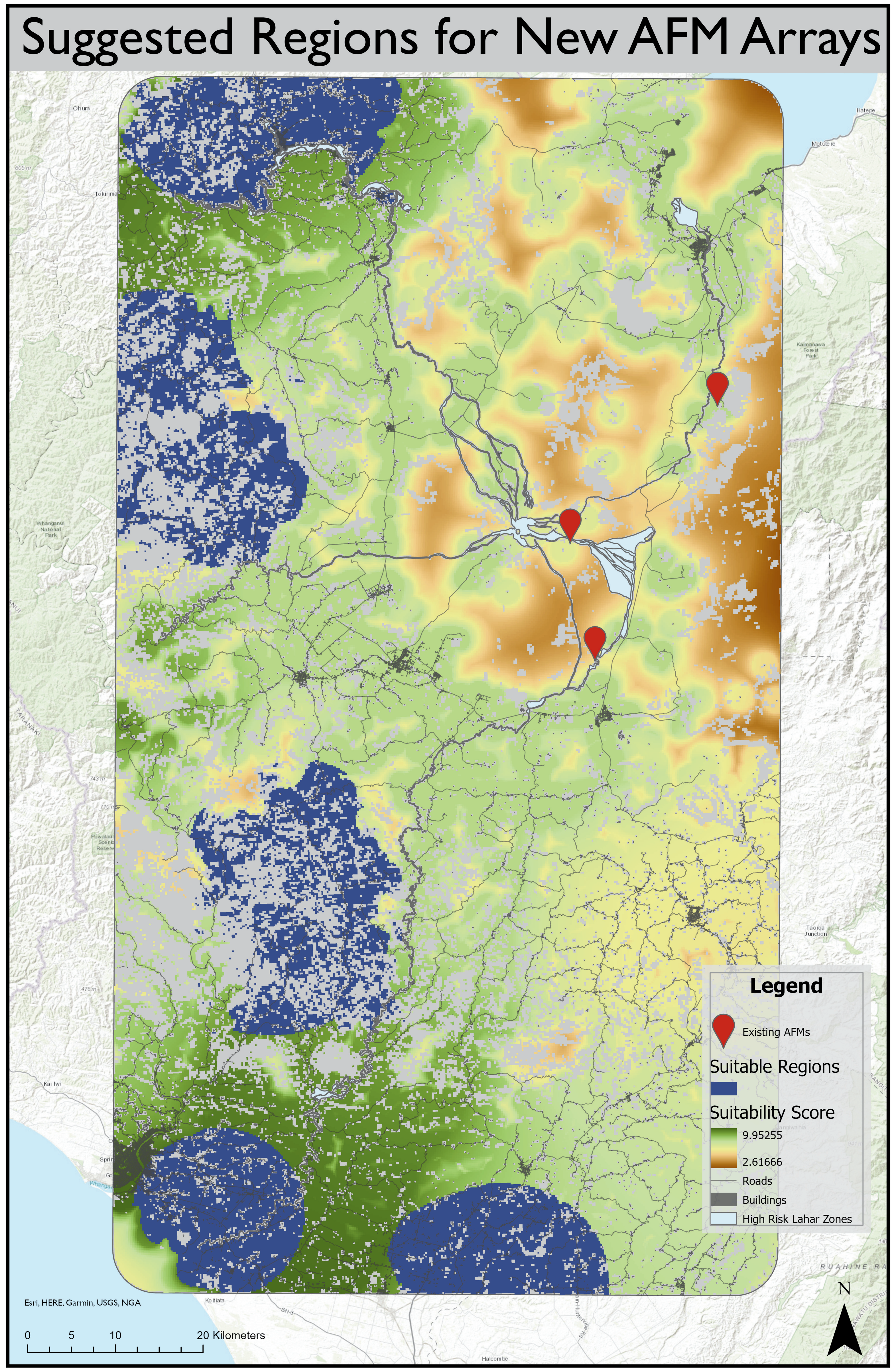

Fig. 3 - Final Suitability Analysis

Key Findings

- 5 suitable regions are distributed along the southwest side of the mountain
- Suitability is highest in areas near roads, buildings, and high lahar risk zones, but away from the existing set of acoustic flow monitors

More Details

Fig. 4 - Digital Artifact Link

Analysis

198,449 200-meter fishnet cells were analyzed in our final suitability analysis, yielding **five suitable locations for new acoustic flow monitor (AFM) arrays.**

The criteria used in the suitability modeler include existing AFMs, distance to roads and buildings, and distance to lahar danger zones, and were weighed as seen in *Fig. 5*. We used the locate tool to select regions with high suitability scores at least 10 km away from each other in order to facilitate progression tracking.

Criteria were weighed with these factors in mind:

- Proximity to population centers
- Ability to track lahar progression
- Distance to lahar danger zones
- Ease of access for installation and repairs

Criteria

Input Rasters	Weight	Percent
dist_lahar_raster		25.00
dist_afm_raster		25.00
dist_buildings_raster		35.00
dist_roads_raster		15.00

Percent total 100

Fig. 5. Criterion Weights

Discussion

Application
Installation in these areas will **increase coverage of lahar detection, provide accurate progression monitoring, and increase evacuation times** for residents and guests near Mt. Ruapehu. In order to ensure an accurate model, we sourced our criteria from previous literature about AFM array installation. Both the excluded non-suitable areas and the weighting criteria were implemented to match the literature as best as possible.
The **optimal locations** for new AFM arrays on Mt. Ruapehu are indicated in navy blue. These areas **are accessible to roads and buildings, minimize redundancy with existing AFM locations, account for early detection in high-risk zones, and exclude absolutely unsuitable locations.**

Limitations
Ambiguities in existing AFM monitor placement criteria mean that we could not replicate their design. **Assumptions of ideal criteria were created** based on recent literature. The **MAUP (Modifiable Areal Unit Problem)** also potentially influenced the effectiveness of our suitable cells. If we were to expand on this project in the future, we may look for additional criteria to add to our model or experiment with different cell divisions.

Literature Cited

Thouret et al., 2020; Johnson et al, 2023; USGS, 2013

Acknowledgments

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