A GIS-BASED VOLCANIC HAZARD AND RISK ASSESSMENT OF ERUPTIONS SOURCED WITHIN VALLES CALDERA, NEW MEXICO

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ABSTRACT
The objective of this study is to evaluate the spatial extent of a possible future eruption using a GIS-based volcanic hazard tool designed to simulate pyroclastic flow and density currents (PDCs) as well as ash flows (1) and to assess the social and economic vulnerability of the area at risk. Simulated pyroclastic flow deposits originating from the El Cajete crater are calibrated to isopach and lithic isopleth maps of the Lower and Upper El Cajete as constructed by (2). The calibration of PDCs is based on the distribution and run-out of the Battleship Rock Ignimbrite. Once calibrated, hazards are simulated at two different vent locations determined from probability distributions of structural features. The resulting hazard maps show the potential distribution of pyroclastic flow, PDCs and lava flow, indicating areas to the S/SE of Valles Caldera to be at greatest risk.

To assess hazard preparedness, social vulnerability is evaluated for all census-designated places (CDP) within the study site. Based on methods by (3), twenty-four variables were selected as proxies of social vulnerability and a principal component analysis is used to generate eight components, which accounts for 84% of the total variance. The eight component scores are summed into a final score for each CDP and the standard deviations from the mean of the scores is mapped with the CDPs, allowing for an easy visualization of areas considered more socially vulnerable.

Economic vulnerability is evaluated through a multi-criteria evaluation of population, infrastructure, land use and (4). Each variable is categorized and assigned a value representing relative vulnerability based on cost and importance. The variables are assigned weights relative to one another through a pairwise comparison and summed together into a final score for each CDP, representing relative vulnerability based on cost and importance. The variables are assigned weights relative to one another through a pairwise comparison and summed together into a final score for each CDP, representing relative vulnerability based on cost and importance.

In order to evaluate the overall risk, the hazard maps and vulnerability assessments are aggregated through weighted linear combination and pairwise comparison matrices, creating a total of five risk maps. Although the actual maps provide greater detail, overall, based on the criteria chosen, the risk maps show that ash fall has the greatest impact, affecting areas up to 50 km S/SE of the caldera, including highly vulnerable cities, such as Los Alamos, White Rock, and Santa Fe. The PDCs and lava flow hazards, however, impact significantly smaller areas, primarily disturbing forested land. The methodology presented in this paper allows for a robust analysis of the risks posed by eruptions sourced from the Valles calderas and is especially useful in focusing mitigation strategies to reduce the loss from such hazard events.

BACKGROUND
• JVF is situated at the intersection of the Rio Grande Rift and Jemez Lineament in north-central New Mexico.
• Most recent activity at Valles caldera were the East Fork Member eruptions "55 to 40 ka - El Cajete Pyroclastic Beds - Battleship Rock Ignimbrite - Bancomito Lava Flow
• Valles caldera is currently dormant

METHODS: VOLCANIC HAZARD SIMULATIONS

Simulated PDCs impact significantly smaller areas, primarily disturbing forested land, but also posing an imminent threat, create great potential for destruction, life, property, and possessions if an eruption was to occur

Study site (JVF) is composed of a 75 x 80 km area encompassing 55 census designated places (CDPs), including major cities such as Los Alamos, Santa Fe, Española, and White Rock

Simulated ash fall calibrated at El Cajete crater within field data from the Lower and Upper El Cajete eruptions and modern wind data (8). Simulated PDCs with varying collapse equivalent heights and angles at El Cajete crater. Plume isopachs and lithic isopleths of the Lower and Upper El Cajete as constructed by (2). Risk maps showing the distribution of economic vulnerability, which is useful when used with the hazard maps for targeting areas for mitigation to reduce economic loss

METHODS: SOCIAL VULNERABILITY

Total Social Vulnerability

Ethnicity

Age

Poverty

Race

Wealth

Extraction Employment

Gender

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METHODS: ECONOMIC VULNERABILITY

Total Economic Vulnerability

Housing Units

Schools

Medical Facilities

Economic Production

Population

Land Use

Roads

High Economic Vulnerability

Low Economic Vulnerability

High Social Vulnerability

Low Social Vulnerability

High Risk

Low Risk

Each objective was assessed through the evaluation of a series defining factors by various methods:

1) Objective: social and economic vulnerability with a weighted linear combination

2) Objective: social vulnerability, and (3) economic vulnerability

3) Objective: through its own MCE of four economically significant factors - (population, land use, infrastructure, and economic production)

4) Objective: was evaluated through a principal component analysis of eight statistically significant components

5) Objective: was assessed through its own MCE of four economically significant factors - (population, land use, infrastructure, and economic production)

6) Objective: was assessed through a principal component analysis of eight statistically significant components

7) Objective: was evaluated through a principal component analysis of eight statistically significant components

8) Objective: was assessed through its own MCE of four economically significant factors - (population, land use, infrastructure, and economic production)

RESULTS

Economic Production

Schools

Medical Facilities

Housing Units

Population

Land Use

Roads

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