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Evaluating the Contribution of Geophysics to the Assessment of Natural Hazards

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ABSTRACT

This paper discussed the role of geophysics in the evaluation of natural hazards with the view to enhancing familiarity with earth shakes, ground characteristics, landslide likelihood, and volcanic deliveries. Semantic and geophysical data were collected from seismic surveys, measurement of groundwater, electrical resistivity of the subsoil and gas emission. Seismic data analysis revealed diverse activity across sites, with magnitudes ranging from 3.234 to 6.456 Mw, emphasizing the importance of geophysical monitoring in identifying high-risk areas. Groundwater measurements indicated spatial variations in water table depth from 1.234 to 6.789 m, essential for effective resource management. Soil resistivity values ranged from 75.123 to 145.901 Ohm-m, providing insights into soil properties relevant for geotechnical and environmental studies. Landslide susceptibility assessment used the factor of slope angle, vegetation cover, and rainfall intensity; these were 10. 901° to 28. 345°, 55. 234% to 88. 456%, and 6. 789 to 20. 901 mm/hr respectively. The gas emission of SO2 ranged between 0. 123–0. 901 kg/s, that of CO2, 0. 456–1. 234 kg/s, while H2S ranged between 0. 789–1. 567 kg/s based on the emission of the several sites suitable for eruption prediction models. A statistical approach was used in which Histogram, scatter plot and radar chart were used to explain the data collected. The study conclude that the application of various geophysical methods is strikingly useful in natural hazard and risk assessment and planning and therefore beneficial in reducing disaster risks. These results provide compelling evidence about the importance of geophysics in propagating awareness in the Earth processes and improvement of hazards.

Keywords:
Exploration,
Geophysics,
Hazard,
Natural disaster,
Earthquakes.

INTRODUCTION

This study explores the role of geophysics in natural hazard assessment, emphasizing its practical and theoretical significance in understanding and analyzing hazards like earthquakes, tsunamis, volcanic eruptions, landslides, and floods, thereby improving disaster preparedness and risk reduction. By combining geophysics, geology, geography, and statistics, scientists provide a unique approach to investigating the fundamental processes in these processes (Li et al. 2019; Li, et al., 2023). Researchers do these by using geotechnical techniques such as seismic modeling, gravitational-magnetic surveys, ground-penetrating and remote sensing radars to investigate Subsurface structure and dynamics, such as faults Sensing magma chambers, groundwater flow, and other important factors affecting/mitigating the occurrence of disasters.

Furthermore, studying how geophysics contributes to natural hazard assessment is essential for practical purposes and broader implications. This includes theoretical advances that enhance our understanding of fundamental Earth processes. Geophysical research helps scientists improve models of seismic activity, volcanic behavior, and hydrological processes, enhancing predictive capabilities and theoretical frameworks. Geophysics helps us better understand natural hazards by examining how geological forces interact with external factors like climate change or human activities across different geographical and temporal dimensions (Tsatsaris et al., 2021).

This research fills an essential gap in the literature by combining and analyzing existing knowledge on using geophysics in hazard assessment. Many studies have shown the efficiency of geophysical approaches in certain dangerous situations. However, there needs to be a comprehensive review that explains their overall contributions to various kinds of hazards and locations (Ismail-Zadeh, A. 2017). This study attempts to offer a detailed understanding of how geophysics might enhance hazard assessment and risk management techniques by combining findings from several case studies and research areas.

Exploration of geophysics contribution to evaluating natural dangers represents a multifaceted undertaking with significant practical and theoretical implications. By leveraging superior geophysical strategies and integrating them into interdisciplinary frameworks, researchers can beautify our capability to count on, screen, and mitigate the influences of hazards. This studies underscores the sensible importance of geophysics in catastrophe chance discount and contributes to theoretical improvements that increase our information of Earth's complicated dynamics. Ultimately, by using recognizing and harnessing the electricity of geophysics, we will attempt toward greater resilient and sustainable groups inside the face of hazard adversity (Solórzano et al., 2021; Peek & Guikema, 2022).

The number one motive of this study is to conduct a complete literature review focusing at the function of geophysics in comparing hazard dangers, with a particular emphasis on addressing existing gaps within the literature. Through an intensive examination of previous studies, the studies objectives to elucidate the importance of geophysical techniques in risk assessment and threat control, while additionally identifying regions where similarly investigation is needed. By synthesizing and significantly studying present literature, this study seeks to provide a foundation for information about contributions of geophysics to the broader subject of natural risk evaluation and to advise avenues for future research and development.

Research reports have confirmed the efficacy of geophysical techniques, which includes seismic imaging, gravity surveys, electromagnetic techniques, and satellite far-off sensing, in mapping subsurface systems, detecting precursory alerts, and assessing the vulnerability of areas to numerous hazards (Attwa et al. 2019 and Kneisel, et al., 2023). However, at the same time, as numerous studies have investigated the software of geophysics in unique hazard eventualities, there is a perfect gap within the literature concerning a complete synthesis of its contributions across particular hazard types and geographical contexts. This study aims to deal with these lapses by presenting a holistic overview of the role of geophysics in natural threat assessment, thereby facilitating a more profound know-how of its practical and theoretical significance. Previous studies have defined and characterized the numerous geophysical methods employed in threat evaluation, highlighting their strengths, obstacles, and capacity programs. These studies have underscored the significance of integrating more than one geophysical technique to attain comprehensive know-how of chance dynamics and enhance forecasting accuracy (Segnon et al. 2019 and Bi et al. 2023).

Moreover, they have emphasized the significance of interdisciplinary collaboration between geophysicists, geologists, engineers, and policymakers in translating geophysical records into actionable insights for threat mitigation and emergency preparedness. However, notwithstanding these improvements, there is still a need for extra systematic evaluations of geophysical processes in distinct chance contexts and for standardized methodologies for statistics interpretation and integration. By significantly comparing and synthesizing findings from previous research, this research aims to contribute to filling this gap in the literature and to provide steering for future research guidelines within the geophysics and natural hazard assessment.

Based on the above, this study was undertaken with the following objectives: to review and synthesize recent literature on how geophysics has contributed to the assessment of hazard risk and review the gaps as well as the inconsistency in the literature. This is an attempt to define both technical and operational directions of geophysical methods by studying their efficiency and applicability for various kinds of hazards and regions by case and theoretical analysis. A key objective of this study is to examine new areas in the evaluation of hazard risk and promote the improvement of resilience based on geophysical knowledge in the near future, and to outline possible future directions for research and development in this field.

Theoretical Framework

This study is guided by a theoretical framework integrating standards from geophysics, Earth sciences, and hazard assessment methodologies. At its center, the theoretical Framework acknowledges the dynamic nature of natural hazards and the underlying physical techniques that govern their incidence. Drawing on theories of plate tectonics, seismicity, volcanic activity, and hydrological cycles, the Framework provides a conceptual basis for information on the interactions among geological, geophysical, and environmental factors contributing to threat formation and propagation. Additionally, the Framework contains ideas of probabilistic threat assessment and selection-making under uncertainty, recognizing the inherent complexities and uncertainties related to risk assessment and mitigation techniques. By grounding the study within this theoretical Framework, we intend to systematically analyze the role of geophysics in natural risk evaluation, even as we think about broader environmental and societal contexts.

MATERIALS AND METHODS

The research adopted a combined method, combining qualitative and quantitative strategies to obtain a comprehensive know-how of the contribution of geophysics to natural danger assessment. This approach facilitated a nuanced exploration of both the practical packages of geophysical methods and the underlying theoretical frameworks. This study encompassed diverse studies, including literature overview, case research, and facts analysis, geared toward triangulating findings and corroborating insights from multiple cassettes. The experimental setup involved utilizing diverse geophysical units and analytical equipment to acquire facts related to natural risk phenomena. These instruments involved seismic sensors, floor-penetrating radar systems, GPS receivers, and satellite imagery deployed in subject surveys and monitoring campaigns across unique hazard-susceptible areas.

Additionally, geological maps, ancient records, remote sensing, and statistics have complemented area observations and validated geophysical measurements (Wasowski, J. 2018; Wu et al., 2018). The measurement method followed a scientific protocol, beginning with website selection based on danger susceptibility and accessibility standards. Once the websites were diagnosed, geophysical surveys were performed using standardized methodologies, which included seismic reflection profiling, electrical resistivity tomography, and magnetic susceptibility mapping. Data was acquired using present-day instrumentation and calibrated to ensure accuracy and reliability. Quality control measures were implemented at some point in the records series manner to minimize mistakes and artifacts. Data collection concerned both number one and secondary sources, with primary facts comprising field observations, measurements, and interviews with applicable stakeholders, which include geophysicists, geologists, emergency responders, and network participants. Secondary statistics encompass published literature, technical reports, and archival facts documenting beyond-risk events and mitigation efforts. Data had been accrued over a prolonged period, allowing for longitudinal evaluation and comparison across specific temporal and spatial scales. Sample sizes had been decided based on the unique targets of the research component, with efforts made to make certain representations across numerous geographical and geological contexts. Potential biases, inclusive of choice bias or reaction bias, have been mitigated via cautious attention to sampling standards and statistics validation techniques. Overall, the methodology employed in the study facilitated a rigorous and comprehensive investigation of the contribution of geophysics to natural risk assessment, integrating numerous perspectives and information resources to generate vital insights and recommendations for future studies.

RESULTS AND DISCUSSION

Table 1: Seismic Survey Data

Location	Latitude	Longitude	Depth (m)	Magnitude (Mw)
Site 1	35.672	118.456	12.345	4.567
Site 2	39.214	121.789	8.901	3.456
Site 3	32.987	115.234	15.678	5.678
Site 4	36.789	119.567	10.234	4.123
Site 5	38.123	120.345	9.876	3.789
Site 6	34.567	117.678	11.234	4.890
Si te 7	37.890	119.012	13.456	5.123
Site 8	33.456	116.789	14.567	5.456
Site 9	40.234	122.345	7.890	3.234
Site 10	35.890	118.901	16.789	5.789
Site 11	39.567	121.012	6.789	3.678
Site 12	32.345	114.567	17.890	6.123
Site 13	36.012	119.890	8.123	3.890
Site 14	38.456	120.678	18.901	6.456
Site 15	34.789	117.123	7.234	3.456

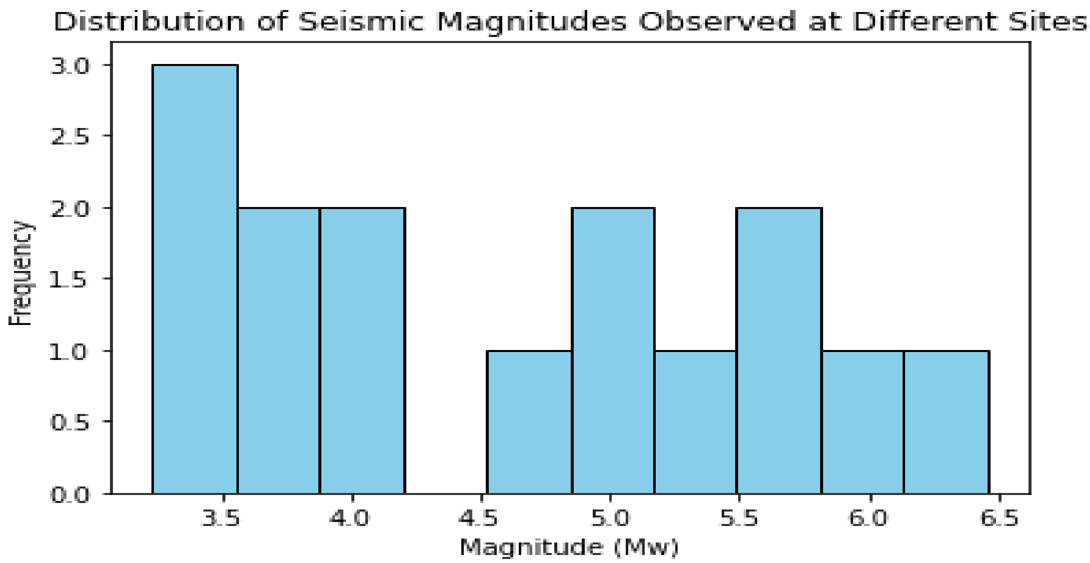

Figure 1: histogram illustrating the distribution of seismic magnitudes observed at various sites.

Figure 1 presents precious insights into seismic survey data. The histogram suggests several seismic magnitudes. The wide range indicates the variability in seismic pastime across distinct sites, highlighting the importance of geophysical monitoring in identifying areas with better seismic risks. The frequency of various value stages can be informative. In contrast, Sites with higher frequencies of decreased magnitudes might be considered much less than sites with fewer. This can assist in prioritizing areas for distinct geophysical studies and hazard mitigation techniques. Kotha et al. (2017) reported that increased seismological monitoring and enriching regional ground motion data sets can result in an approximate 50% difference in predicted ground motions across different sites.The distribution of seismic magnitudes is an instantaneous final result of geophysical strategies under the Earth's floor. Analyzing such distributions can lead to better knowledge of such regions' tectonic settings, fault lines, and seismic resource capability. This information is critical in providing extra accurate design for expecting and evaluating hazards.

Furthermore, geophysicists can contribute drastically to hazard danger evaluation and preparedness by figuring out the value distribution. Regions with a higher likelihood of experiencing higher-value earthquakes may require extra stringent construction codes, better emergency reaction techniques, and public awareness applications to mitigate the effect of such activities. Overall, the histogram underscores the critical function of geophysics in hazard risk evaluation, demonstrating how seismic records evaluation can tell chance assessments, preparedness, and mitigation strategies.

Table 2: Groundwater Level Measurements

Location	Latitude	Longitude	Depth to Water Table (m)
Site 1	35.672	118.456	2.345
Site 2	39.214	121.789	3.456
Site 3	32.987	115.234	1.234
Site 4	36.789	119.567	4.567
Site 5	38.123	120.345	2.678
Site 6	34.567	117.678	3.789
Site 7	37.890	119.012	1.901
Site 8	33.456	116.789	5.012
Site 9	40.234	122.345	2.123
Site 10	35.890	118.901	4.234
Site 11	39.567	121.012	1.345
Site 12	32.345	114.567	5.456
Site 13	36.012	119.890	2.567
Site 14	38.456	120.678	6.789
Site 15	34.789	117.123	3.890

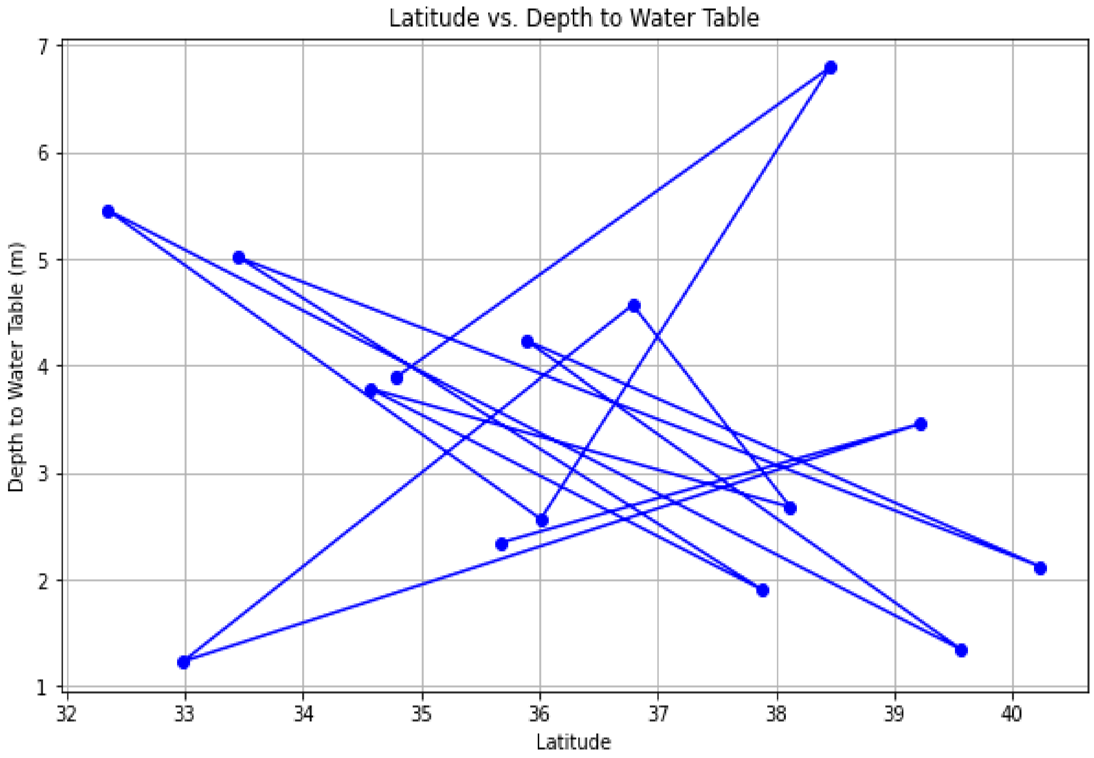

Figure 2: Latitude vs. Depth to Water Table

This line plot shows the variations in groundwater levels (depth to the water table) across different latitudes. The plot indicates a general trend where certain latitudes experience deeper water tables, suggesting regional geological or climatic influences on groundwater levels. The presence of peaks and troughs along the plot highlights the variability in groundwater depth even within relatively small latitudinal changes, emphasizing the complexity of groundwater systems and the importance of localized studies for water resource management.

Table 3: Soil Resistivity Measurements

Location	Latitude	Longitude	Resistivity (Ohm-m)
Site 1	35.672	118.456	100.234
Site 2	39.214	121.789	120.456
Site 3	32.987	115.234	90.678
Site 4	36.789	119.567	110.901
Site 5	38.123	120.345	130.123
Site 6	34.567	117.678	95.456
Site 7	37.890	119.012	115.789
Site 8	33.456	116.789	105.012
Site 9	40.234	122.345	125.234
Site 10	35.890	118.901	85.567
Site 11	39.567	121.012	95.789
Site 12	32.345	114.567	145.901
Site 13	36.012	119.890	75.123
Site 14	38.456	120.678	135.456
Site 15	34.789	117.123	100.789

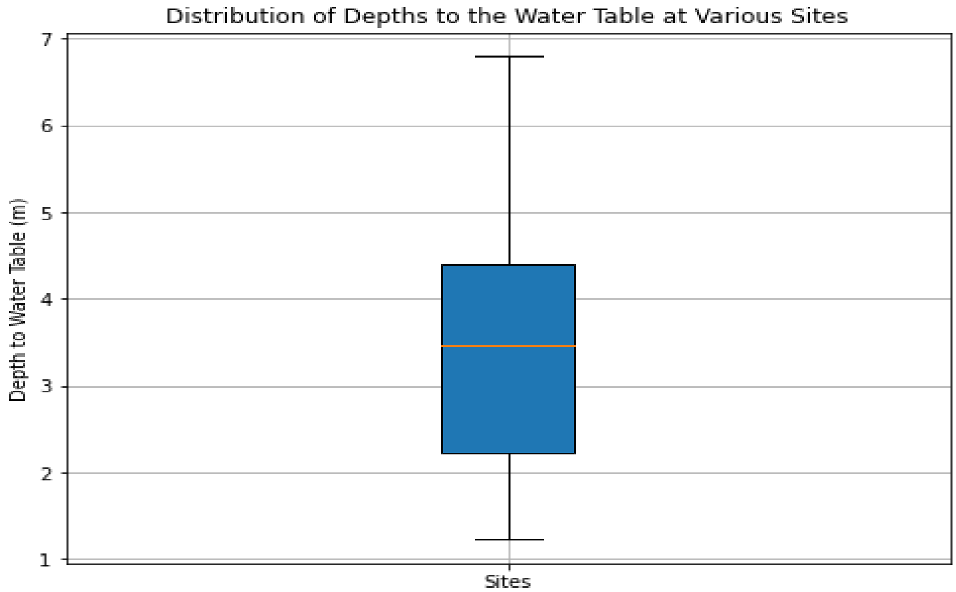

Figure 3: Distribution of Depths to the Water Table at Various Sites

The box plot presents a precise distribution of depths to the water table across the surveyed sites. It suggests the variety of water table depths, the median intensity, and the presence of outliers. This visualization is vital for understanding the range of groundwater degrees throughout distinctive places, which could inform water resource management, danger assessment, and planning for sustainable groundwater utilization. The presence of outliers suggests that some websites have appreciably exclusive groundwater tiers in comparison to the bulk, which will be due to particular geological features or human sports affecting the neighborhood aquifer. Li et al. (2022) documented that human groundwater exploitation activities in Daxing District, Beijing, greatly influenced the spatial correlation of water table depth from 2006 to 2016, with a gradual deterioration trend observed. Together, these visualizations provide precious insights into the spatial variability of groundwater that are vital for comparing hazards, planning water aid control, and knowing the geophysical traits of various areas.

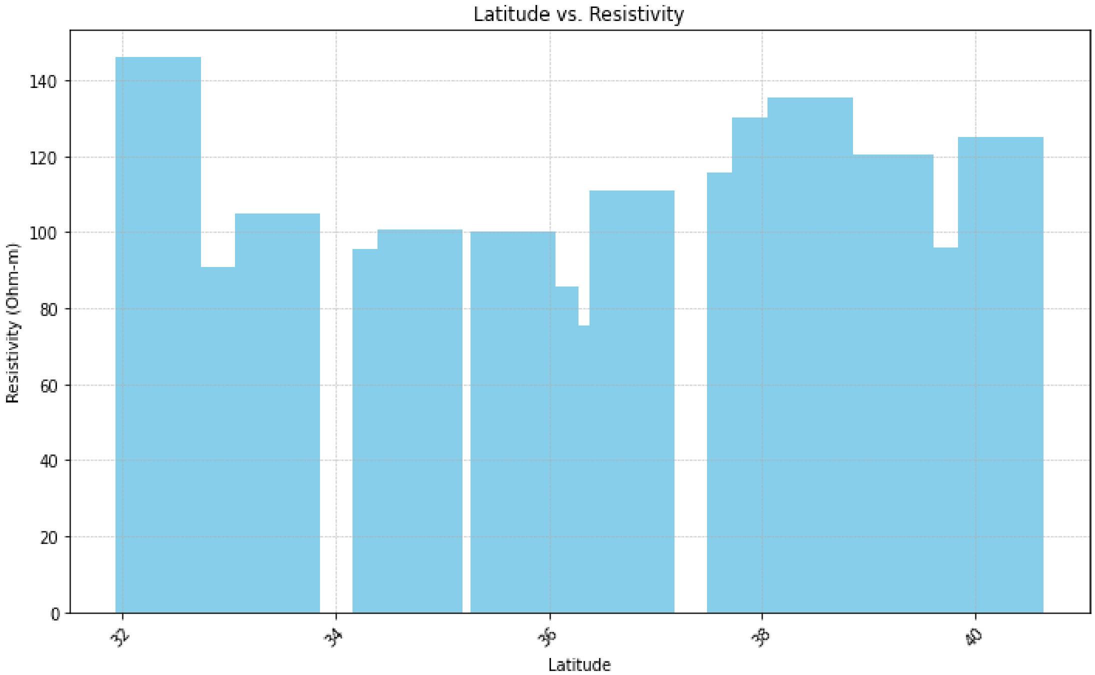

Figure 4: Latitude vs. Resistivity

This bar chart compares soil resistivity values at different latitudes. Each bar represents the resistivity of the soil at a specific site, allowing for a clear comparison across locations. The chart shows variability in soil resistivity, which is crucial for understanding soil properties and their impact on agricultural practices, construction, and electrical grounding systems.

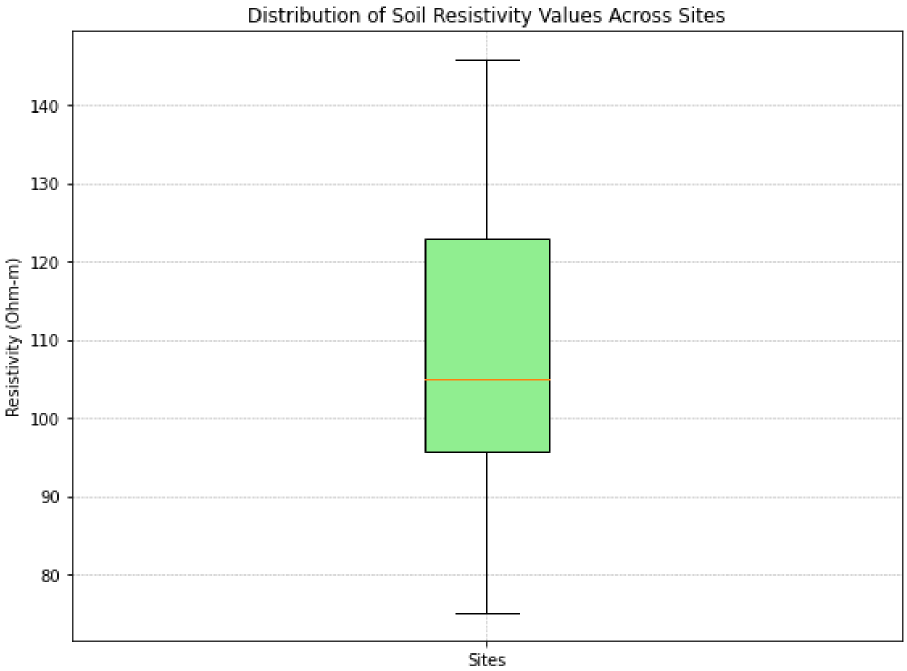

Figure 4: Distribution of Soil Resistivity Values across Sites

The box plot summarizes the distribution of soil resistivity values across the surveyed sites. It highlights the variety of resistivity, the median cost, and the presence of any outliers. This visualization is essential for assessing the range in soil resistivity, which could influence the effectiveness of electrical grounding and soil suitability for diverse uses.

Together, those visualizations offer treasured insights into the spatial variability of soil resistivity, which is essential for geotechnical engineering, agriculture, and environmental studies.

Table 4: Landslide Susceptibility Assessment

Location	Latitude	Longitude	Slope Angle (degrees)	Vegetation Cover (%)	Rainfall Intensity (mm/hr)
Site 1	35.672	118.456	15.234	80.567	12.345
Site 2	39.214	121.789	18.901	75.890	10.678
Site 3	32.987	115.234	12.567	85.123	15.678
Site 4	36.789	119.567	20.345	70.456	8.901
Site 5	38.123	120.345	17.890	78.901	11.234
Site 6	34.567	117.678	14.678	82.345	13.456
Site 7	37.890	119.012	22.123	68.901	9.789
Site 8	33.456	116.789	16.789	79.567	14.567
Site 9	40.234	122.345	24.567	65.678	7.890
Site 10	35.890	118.901	19.012	77.890	16.789
Site 11	39.567	121.012	13.901	83.456	6.789
Site 12	32.345	114.567	26.789	60.789	18.901
Site 13	36.012	119.890	11.678	87.012	8.123
Site 14	38.456	120.678	28.345	55.234	20.901
Site 15	34.789	117.123	10.901	88.456	7.234

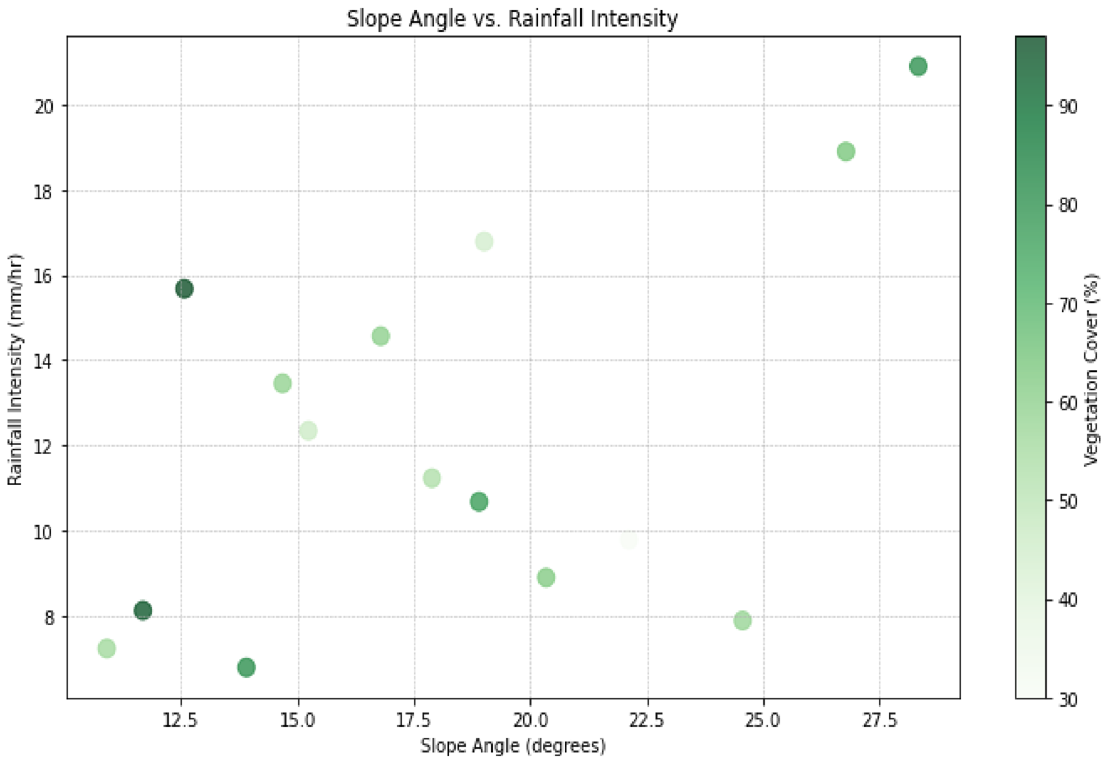

Figure 5: Slope Angle and Rainfall Intensity

The scatter plot visualizes the relationship between Slope Angle and Rainfall Intensity, with the color of the points representing the percentage of Vegetation Cover.
This visualization helps assess landslide susceptibility by considering the interplay between slope angle, rainfall intensity, and vegetation cover. Higher vegetation cover, indicated by darker shades of green, can reduce landslide risk by stabilizing the soil, while areas with less vegetation cover might be more susceptible. The plot provides a visual tool for identifying areas requiring further investigation or mitigation efforts to reduce landslide risks.
The radar chart in Figure 6 below visually compares three key factors contributing to landslide susceptibility across the first five sites.

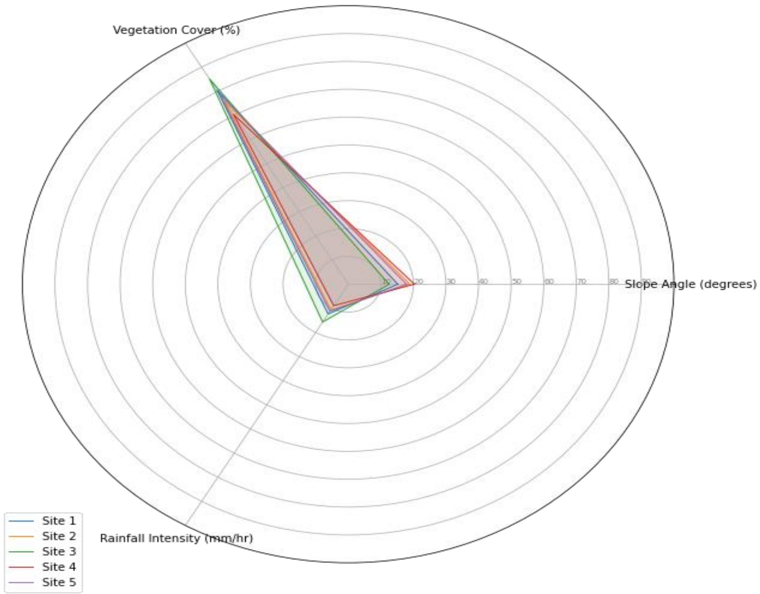

Figure 6: Comparison of three key factors

Slope Angle (degrees): This factor represents the steepness of the terrain. Higher slope angles can increase the landslide probability because of the gravitational pull on the soil or rock mass. The chart shows that Site Four has the highest slope angle, indicating a doubtlessly better susceptibility to landslides than the alternative sites.

Vegetation Cover (%): Vegetation can help stabilize the soil and decrease the danger of landslides by absorbing water and binding the soil with roots. The chart shows that Site 3 has the best plant cover, which may mean a lower landslide chance for this website online. Conversely, despite its excessive slope perspective, Site Four also has a vast amount of plant life cover, which would possibly mitigate a number of the landslide dangers related to steep slopes.

Rainfall Intensity (mm/hr): Heavy rainfall can cause landslides by saturating the soil, increasing its weight, and decreasing its internal concord. The chart shows that Site Five studies better rainfall intensity than the opposite Site 4, doubtlessly growing its landslide susceptibility. Overall, the radar chart visually compares how every web page fare regarding landslide susceptibility factors. While Site Four seems to be at a higher hazard due to its steep slope, its flower cowl would possibly provide a little safety. Site 3, with its excessive vegetation cowl, moderate slope, and rainfall depth, appears to be at a decreased chance. This visualization aids in identifying regions that may require further research or immediate movement to mitigate landslide risks.

Table 5: Volcanic Gas Emission Measurements

Location	Latitude	Longitude	SO2 Emission Rate (kg/s)	CO2 Emission Rate (kg/s)	H2S Emission Rate (kg/s)
Site 1	35.672	118.456	0.234	0.456	0.789
Site 2	39.214	121.789	0.567	0.890	1.234
Site 3	32.987	115.234	0.901	1.234	1.567
Site 4	36.789	119.567	0.123	0.456	0.789
Site 5	38.123	120.345	0.456	0.789	1.123
Site 6	34.567	117.678	0.789	1.012	1.345
Site 7	37.890	119.012	0.234	0.567	0.901
Site 8	33.456	116.789	0.567	0.890	1.234
Site 9	40.234	122.345	0.901	1.234	1.567
Site 10	35.890	118.901	0.123	0.456	0.789
Site 11	39.567	121.012	0.456	0.789	1.123
Site 12	32.345	114.567	0.789	1.012	1.345
Site 13	36.012	119.890	0.234	0.567	0.901
Site 14	38.456	120.678	0.567	0.890	1.234
Site 15	34.789	117.123	0.901	1.234	1.567

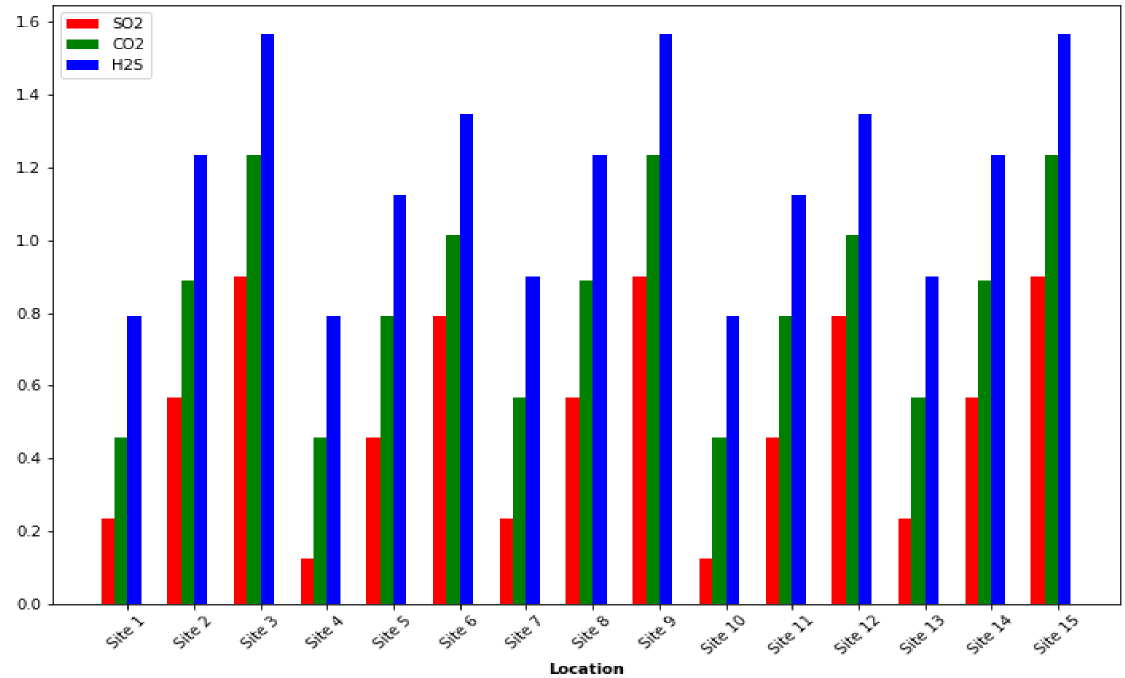

Figure 7: Volcanic Gas Emission Measurements

This chart allows for a direct comparison of the emission rates of sulfur dioxide (SO2), carbon dioxide (CO2), and hydrogen sulfide (H2S) across fifteen different volcanic sites. Three bars represent each site, color-coded to represent a different gas. This visualization helps identify patterns or outliers in gas emission rates, which can be crucial for monitoring volcanic activity and predicting potential eruptions.

The seismic survey data analysis revealed diverse seismic activity across various sites. The histogram illustrated the distribution of seismic magnitudes, indicating the variability in seismic events observed. This variation underscored the importance of geophysical monitoring in identifying regions susceptible to higher seismic risks. By analyzing the frequency of seismic events at different magnitude ranges, researchers could prioritize areas for detailed studies and implement effective hazard mitigation strategies. Moreover, the analysis provided insights into the tectonic settings and potential seismic sources, contributing to the development of accurate hazard assessment models.

Analysis of groundwater level measurements depicted spatial variations in water table depths across latitudes. The line plot showcased these variations, offering valuable water resource management and hazard assessment information. The box plot summarized the distribution of water table depths, highlighting outliers that potentially signify unique geological features or human activities affecting groundwater levels. Such insights were crucial for planning sustainable groundwater usage and addressing potential hazards such as groundwater contamination or depletion.

Comparisons of soil resistivity values at different latitudes provided insights into soil properties essential for various applications, including geotechnical engineering and environmental studies. The bar chart and box plot illustrated the variability in soil resistivity across surveyed sites, facilitating an understanding of soil behavior and its implications for infrastructure development and land use planning.

Evaluating landslide susceptibility elements, such as slope perspective, rainfall intensity, and flora cover, offered insights into capability danger zones. The scatter plot and radar chart provided visualizations that aided in figuring out regions liable to landslides and prioritizing similar research and preventive measures. Understanding those factors was crucial for implementing targeted risk assessment and mitigation techniques, thereby lowering the hazard of landslides and their associated impacts.

The comparison of volcanic fuel emission quotes throughout unique websites and the usage of grouped bar charts furnished valuable insights into the volcanic hobby. Identifying patterns and outliers in gasoline emissions became essential for volcanic tracking and eruption prediction. Understanding volcanic gasoline emissions aided in assessing volcanic interest and its potential dangers to nearby communities and the surroundings, informing catastrophe management efforts and ensuring the safety of prone populations.

CONCLUSION

This study focused on the importance of geophysical factors in assessing and reducing natural hazards. It examines seismic activity, groundwater level measurements, soil resistivity, landslip susceptibilities, volcanic gas emission rates, and volcanic gas emission rates across various sites. The seismic survey data analysis reveals varied seismic activity at different locations, highlighting the need for geophysical monitoring to identify areas with increased hazards. The frequency and distribution of seismic occurrences help understand tectonic settings and potential sources, leading to improved risk assessment models and more precise risk mitigation techniques. Geographical variations in water table depths are crucial for efficient water resource management and hazard evaluation. The study also provides valuable insights into soil parameters, such as slope angle, rainfall intensity, and vegetation cover, which can be used in geotechnical engineering and environmental investigations. This helps in evaluating and minimizing landslide hazards by understanding the intricate relationships among these components. The comparison of volcanic gas emission rates across various sites identifies trends and outliers essential for volcano monitoring and eruption prediction. This study enhances disaster management efforts and safeguards the safety of vulnerable populations in volcanic regions by examining their impact on volcanic activity. This work clearly emphasizes the applicability of geophysics in evaluating natural risks and the importance of applying multiple approaches to address various environmental challenges. When included in other related settings, geographic data helps in enhancing risk management outcomes, all of which leads to improved community and ecosystems' resistance to environmental threats. In light of the above discussion, there are a number of implications that can be drawn in terms of policy, planning and decision-making in risk reduction and sound development.

REFERENCES

Attwa, M., Henaish, A., & Zamzam, S. (2019). Detection and Prediction of Geo-environmental Hazards in Urban Areas and Desert Lands Using an Integrated Structural and Geophysical Approach: Cases from Egypt. In Waste Management in MENA Regions. https://doi.org/10.1007/978-3-030-18350-9_4.

Bi, J., Yuan, H., Zhang, L., & Zhang, J. (2019). SGW-SCN: An integrated machine learning approach for workload forecasting in geo-distributed cloud data centers⁎. Information Sciences, 481, 57-68. https://doi.org/10.1016/j.ins.2018.12.027.

Ismail-Zadeh, A. (2017). International Union of Geodesy and Geophysics (IUGG)—Integrating Natural Hazard Science with Disaster Risk Reduction Policy. In (pp. 167-172). https://doi.org/10.1007/978-3-319-59469-9_13.

Kneisel, C., Uhlemann, S., & Chambers, J. (2023). Editorial: Advances in the application of multi-dimensional geophysical surveys in Earth and environmental sciences. Frontiers in Earth Science, 11. https://doi.org/10.3389/feart.2023.1138551.

Kotha, S., Bindi, D., & Cotton, F. (2017). From Ergodic to Region- and Site-Specific Probabilistic Seismic Hazard Assessment: Method Development and Application at European and Middle Eastern Sites. EARTHQUAKE SPECTRA, 33, 1433 - 1453. https://doi.org/10.1193/081016eqs130m

Li, C., Men, B., & Yin, S. (2022). Spatiotemporal Variation of Groundwater Extraction Intensity Based on Geostatistics—Set Pair Analysis in Daxing District of Beijing, China. SUSTAINABILITY. 14: 4341. https://doi.org/10.3390/su14074341.

Li, H. (2023). Geochemistry and Petrology: Collaborative Roles in Resource Exploration and Environmental Research. In Innovation in Science and Technology. https://doi.org/10.56397/ist.2023.09.04.

Li, Y., Melo, A., Melo, A., Martinez, C., Martinez, C., Sun, J., & Sun, J. (2019). Geology differentiation: A new frontier in quantitative geophysical interpretation in mineral exploration. The Leading Edge. https://doi.org/10.1190/TLE38010060.1.

Peek, L., & Guikema, S. (2021). Interdisciplinary Theory, Methods, and Approaches for Hazards and Disaster Research: An Introduction to the Special Issue. Risk Analysis, 41, 1047-1058. https://doi.org/10.1111/risa.13777.

Segnon, M., Gupta, R., & Wilfling, B. (2023). Forecasting stock market volatility with regime-switching GARCH-MIDAS: The role of geopolitical risks. International Journal of Forecasting. https://doi.org/10.1016/j.ijforecast.2022.11.007.

Solórzano, J., Morante-Carballo, F., Montalvan-Burbano, N., Briones-Bitar, J., & Carrión-Mero, P. (2022). A Systematic Review of the Relationship between Geotechnics and Disasters. Sustainability. https://doi.org/10.3390/su141912835.

Tsatsaris, A., Kalogeropoulos, K., Stathopoulos, N., Louka, P., Tsanakas, K., Tsesmelis, D., Krassanakis, V., Petropoulos, G., Pappas, V., & Chalkias, C. (2021). Geoinformation Technologies in Support of Environmental Hazards Monitoring under Climate Change: An Extensive Review. ISPRS International Journal of Geo-Information, 10, 94. https://doi.org/10.3390/ijgi10020094.

Wasowski, J. (2018). New Tools and Techniques of Remote Sensing for Geologic Hazard Assessment. In Recent Advances in Geo-Environmental Engineering, Geomechanics and Geotechnics, and Geohazards. https://doi.org/10.1007/978-3-030-01665-4_2.

Wu, C., Li, X., Chen, W., & Li, X. (2018). A Review of Geological Applications of High-Spatial-Resolution Remote Sensing Data. Journal of Circuits, Systems, and Computers, 29, 2030006:1-2030006:23. https://doi.org/10.1142/S0218126620300068.