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Peer Review

Review of: "Turkey’s Earthquakes: Damage Prediction and Feature Significance Using A Multivariate Analysis"

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The manuscript titled "Turkey’s Earthquakes: Damage Prediction and Feature Significance Using a Multivariate Analysis" addresses the critical issue of earthquake damage prediction in Turkey. It evaluates various machine learning models, identifying Random Forest as the most effective method for predicting fatalities and damages. While the topic is highly relevant and the study demonstrates potential, there are several areas that require improvement for the manuscript to achieve its full impact.

The introduction provides a general overview of the importance of earthquake damage prediction but lacks depth in its motivation. The authors should better articulate why machine learning approaches are necessary and how they improve upon traditional models. While the RECAST and ETAS models are briefly mentioned, a more detailed comparison with existing methodologies would strengthen the paper.

The data and methodology section raises concerns about the compatibility and representativeness of the datasets. The use of pre-1950 earthquake data combined with 2022 socioeconomic factors could introduce biases. The authors should explicitly address how these limitations were managed. Additionally, the reliance on a circular approximation for damage prediction simplifies the analysis but overlooks the complexity of seismic wave propagation. Acknowledging this limitation and discussing its potential impact on model accuracy is crucial.

The manuscript evaluates the performance of machine learning models using MAPE and MAE. However, the rationale for selecting these metrics is not sufficiently explained, and the lack of additional metrics like R-squared or F1 scores limits the robustness of the evaluation. Moreover, concerns about overfitting are raised for the linear regression model but not adequately addressed for more complex models like neural networks. Validation techniques such as k-fold cross-validation should be included.

The results section highlights population density and earthquake magnitude as significant factors influencing damage. While this is an important finding, its implications for seismic risk mitigation and urban planning are not fully explored. The discussion should be expanded to connect these results to practical applications, such as improving building codes or

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disaster response strategies. Additionally, while the Random Forest model is identified as the best-performing method, a deeper analysis of why it outperformed other models is needed.

The manuscript's figures and visualizations are functional but could be more intuitive. Clearer legends and better visual representations would enhance reader comprehension. Additionally, the language in the manuscript requires minor revisions for grammatical accuracy and fluency. The references section includes some outdated sources, and incorporating more recent studies would improve the manuscript's credibility.

In conclusion, this study has the potential to make a significant contribution to earthquake damage prediction and mitigation. However, substantial revisions are required to improve its methodological clarity, address data limitations, and enhance the discussion of practical implications. It is recommended that the authors expand the introduction, explicitly address the limitations of their data and methodology, and provide a more detailed discussion of their results. With these improvements, the manuscript can serve as a valuable resource for seismic risk assessment and disaster management.

Damage prediction is a critical area of research, particularly in seismically active regions like Turkey. With thousands of earthquakes occurring annually, understanding the factors influencing damage is essential for disaster preparedness and mitigation strategies. Previous studies have utilized probabilistic models and advanced statistical techniques to forecast earthquake magnitudes and assess their potential impacts. For example, Özel Kadılar et al. (2024) investigated earthquake magnitude prediction in Turkey using deep learning, ARIMA, and singular spectrum analysis, highlighting the strengths and weaknesses of these methodologies for different seismic scenarios. This work underscores the importance of integrating advanced machine learning techniques into earthquake studies to enhance predictive accuracy.

> **Citation**: Öncel Çekim, H., Karakavak, H. N., Özel, G., & Tekin, S. (2024). Earthquake magnitude prediction in Turkey: a comparative study of deep learning methods, ARIMA, and singular spectrum analysis. *Journal of Earthquake Engineering and Prediction*, 12(4), 301–318.

Similarly, Ünal, Özel, and Azak (2023) applied Markov chains to analyze earthquake sequences in the Aegean Graben system of Turkey, demonstrating the potential of probabilistic models to capture the temporal dependencies in seismic data. These approaches provide a foundation for understanding earthquake patterns and their potential impact.

> **Citation**: Ünal, C., Özel, G., & Azak, T. (2023). A Markov chain approach for earthquake sequencing in the Aegean Graben system of Turkey. *Earth Science Informatics*, 16(2), 145–162.

Beyond these regional applications, global studies have also advanced the field. The RECAST model (Dascher-Cousineau et al., 2023) integrates machine learning and dense seismic networks for earthquake forecasting, offering insights into location, magnitude, and timing. Additionally, initiatives like DrivenData’s earthquake damage prediction competition have underscored the value of combining building and socioeconomic data with seismic models to assess risk. However, these efforts often lack a comprehensive focus on integrating regional socioeconomic factors into damage prediction.

> **Citations**:
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> Dascher-Cousineau, K., Shchur, O., Brodsky, E. E., & G\u00fcnnemann, S. (2023). Using deep learning for flexible and scalable earthquake forecasting. *Geophysical Research Letters*, 50(17), e2023GL103909.

DrivenData. (2019). Open Machine Learning Competition for Earthquake Damage Prediction. Retrieved from https://www.drivendata.org/.

Building on this foundation, the present study employs machine learning techniques to predict earthquake damage severity in Turkey, focusing on factors such as population density, building stability indices, and earthquake magnitude. By leveraging these variables, this research aims to bridge the gap between theoretical models and practical applications, offering a robust framework for disaster risk management.

Declarations

Potential competing interests: No potential competing interests to declare.