Journal of Computer Science Advancements, 1(6) - December 2023 260-267

Optimisation of Evacuation Route Determination in an Earthquake Natural Disaster Scenario Using an Excel Solver

Nurul Izzah[1], Asri Barokatul Jannah[2]
[1,2]Universitas Islam Madura Pamekasan, Indonesia

Corresponding Author: Nurul Izzah, E-mail; nurulizzahreal@gmail.com

Article Information:
Received October 10, 2023
Revised October 19, 2023
Accepted December 1, 2023

ABSTRACT

Earthquake natural disasters can cause significant infrastructure damage, hindering community access and mobility. In such a situation, determining the shortest path for evacuation becomes very important. This research uses linear programming by utilising Excel Solver to determine the shortest evacuation route for earthquake natural disasters. Excel Solver is a feature in Microsoft Excel that serves as an analytical tool to solve linear optimisation problems. Excel solver can be used to find solutions that maximise or minimise the objective function, with respect to predetermined constraints. This research utilises relevant earthquake natural disaster simulation data as constraints in the optimisation model. The results show that the model can generate shortest paths that fulfil various constraints and criteria. The model can also be used to predict the time required to reach the destination. This research makes an important contribution to the development of tools and methods for shortest path optimisation in natural disaster scenarios. The optimisation model developed in this research can be used to assist decision makers in improving the efficiency and effectiveness of evacuation and disaster relief operations.

Keywords: *Evacuation, Natural Disasters, Optimization, Shortest Path, Solver Excel*

Journal Homepage https://journal.ypidathu.or.id/index.php/jcsa

How to cite: Izzah, N., & Jannah, B, A. (2023). Optimisation of Evacuation Route Determination in an Earthquake Natural Disaster Scenario Using an Excel Solver. *Journal of Computer Science Advancements*, 1(6). 259-267 https://doi.org/10.70177/jsca.v1i6.1132
Published by: Yayasan Pendidikan Islam Daarut Thufulah

INTRODUCTION

Earthquake natural disasters are events that threaten and disrupt people's lives and livelihoods caused by natural and or non-natural factors as well as human factors, resulting in human casualties, environmental damage, property losses and psychological impacts (Almeida, 2022). This definition states that earthquake disasters are caused by natural, non-natural and human factors (Bagloee, 2019). Therefore, Law No. 24/2007

emphasises that Disaster Management activities are basically a series of activities both before, during and after a disaster that are carried out to prevent, reduce, avoid and recover from the impact of disasters (Dhamala, 2023).

The importance of our role and also the government as fellow humans to help each other victims in natural disaster management efforts is to find the shortest way or path to optimise natural disaster evacuation routes, namely finding the fastest and safest way from the point of disaster to the safest central point, while avoiding various obstacles or congestion that may appear along the path (Liang, 2019). Finding the shortest path is one of the key aspects that determine the way to rescue disaster victims (Bi, 2019).

The research we conducted for mitigation or prevention of natural disasters can reduce the risk of disaster occurrence by optimising the search for the shortest path for victims of earthquakes using the excel solver method (Y. Wang, 2022). Excel solver is a tool contained in Microsoft Excel that can be used to solve optimisation problems, this step is important in finding evacuation routes or the safest place for victims (Cao, 2022).

The negative impacts caused by natural disasters on human life, such as casualties, injuries, evacuation, and property damage, therefore we must create scenarios to optimise the shortest path to evacuate victims By considering various factors, such as distance, road conditions, evacuation sites, and availability of foodstuffs, it is hoped that the evacuation process can run smoothly and minimise risks for victims (Tanaka, 2021).

The benefits of this research are expected to provide a way to improve evacuation efficiency in earthquake natural disaster situations, minimise casualties in earthquake natural disaster situations, assist the government and related organisations in planning and implementing evacuations in natural disaster situations (Yazdani, 2023a). The scope of the research is focused on the optimisation of shortest path determination in earthquake natural disaster scenarios using excel solver (Rahman, 2020).

The main objective of this research is to minimise the evacuation time of victims of natural disasters to a safe place because the faster the victims are evacuated, the greater their chances of survival (Yazdani, 2023b). This is especially important in natural disaster situations where time is of the essence. With the shortest path system we can save time and minimise casualties (Zhao, 2020). Also, with the excel solver method, we can optimise the evacuation path of the users to increase the level of safety and comfort of the victims (Vinh, 2023). Thus, this research is expected to provide a significant solution in helping victims of earthquake natural disasters.

Linear Programming and Excel Solver Linear programming is a technique in operations research used to solve optimisation problems by maximising or minimising an objective function in accordance with specified constraints (Soltani, 2019). Solver Excel is an analytical tool in Microsoft Excel that can be used to solve linear optimisation problems (Tanaka, 2021). Solver Excel uses the simplex method to solve linear programming problems (Sitepu, 2023). Here are the general steps in using Solver Excel:

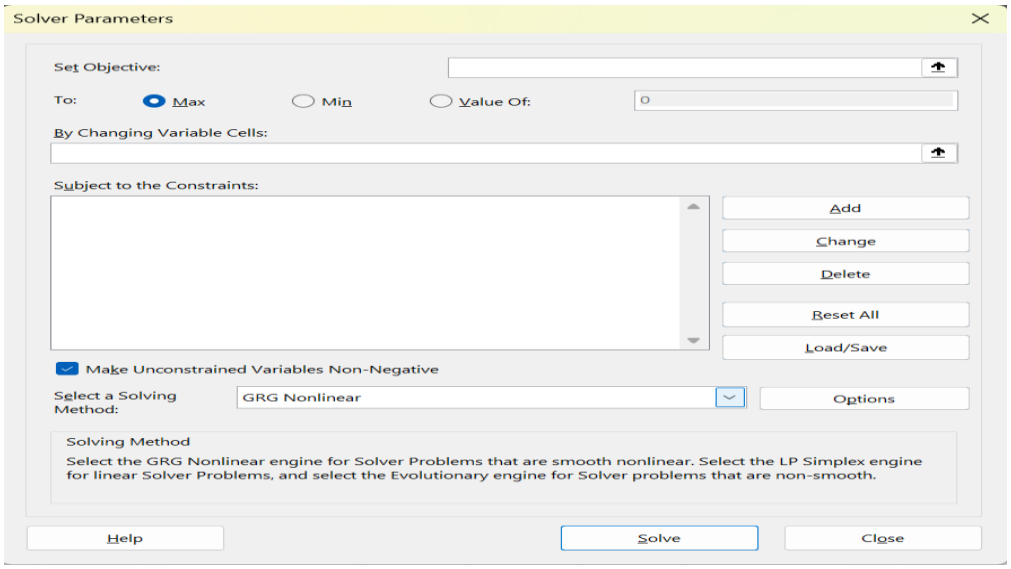

Figure 1. Initial View to Start the Solver

Initial Display for Solver

Description:

1. Define the objective cell (objective function) to be optimised.

2. Defines the decision variable cell that will be changed by the Solver to achieve the optimal value.

3. Define the applicable constraints using logical functions such as '>=', '<=', or '='.

4. Set the Solver parameters as needed, such as solving method, non-negative constraints, etc.

5. Run the Solver to obtain the optimal solution:

Some commonly used formulas in Excel Solver:

1. Objective Function

Formula: =SUMPRODUCT(coefficient_objective,variable_decision)

Example: =SUMPRODUCT(B2:B12,D2:D12)

2. Constraints

Formula: =SUMPRODUCT(coefficient_constraint,variable_decision) <=/>=/= value_constraint

Example: =SUMPRODUCT(C2:C12,E2:E12) <= F4

3. Binary Constraints

Formula: =INT(decision_variable) = decision_variable

Example: =INT(C4) = C4

1. Non-Negativity Constraints

Formula: decision_variable >= 0

Example: C4 >= 0

Modelling with Excel Solver involves understanding the concept of linear programming and its application in the context of the problem at hand. In the case of determining the shortest path for evacuating victims of an earthquake natural disaster, a linear programming model can be built by defining an objective function (e.g., minimising the evacuation path of victims of an earthquake natural disaster) and constraints such as considering disaster-damaged road conditions, road capacity, and evacuation time limits.

RESEARCH METHODOLOGY

This research is a type of applied research that uses case studies in five cities and four villages (Liu, 2022). The data sources used include evacuation data of earthquake victims in the cities and villages, as well as socio-economic data and other information relevant to the evacuation criteria (Pathirana, 2019). The data collection technique was conducted in a secondary manner through available websites, thus facilitating access to the required information.

Modelling was conducted using an Excel solver with several key steps. Firstly, the identification of decision variables included the choice of the shortest evacuation route considering the condition of disaster-damaged roads, road capacity, and evacuation time limit (Pan, 2019). The objective function was determined to minimise the shortest evacuation route given the criteria and constraints. The calculated constraints include disaster-damaged road conditions, road capacity, and evacuation time limit. Excel solver was used to solve the optimisation problem by inputting the objective function, decision variables, and constraints. Model validation was conducted by testing using

sample data to verify the accuracy of the model. Sensitivity analysis was also applied to test the robustness of the model to changes in parameters or constraints, ensuring the model is robust and reliable in real-life situations.

RESULT AND DISCUSSION

Excel Solver Testing

This research shows that Excel Solver is an effective tool for shortest path optimisation in natural disaster scenarios. The application of this method can assist evacuation teams in saving lives and minimising losses due to natural disasters.

The Excel solver finds the optimal solution that determines the shortest path from the starting point to the destination point. The total travel time or cost is minimised accordingly. The solver ensures that the resulting solution meets all given constraints, such as time constraints, road conditions, and resource capacity. The solution found by the Excel Solver shows the shortest route that can be taken to reach the destination point efficiently and effectively. The Excel Solver can also provide information on the sensitivity of the solution to changes in parameters, such as changes in travelling time or road conditions.

The use of an Excel Solver increases efficiency in determining the shortest path by minimising the time and resources required. The solution generated by the Excel Solver is reliable as it is based on a proper mathematical model and considers all the given constraints. The Excel solver can generate several alternative solutions depending on the given parameters and allows users to choose the solution that best suits their needs and preferences.

Thus, the test results of the Excel Solver show that the tool is effectively used for the optimisation of shortest path determination in natural disaster scenarios, assisting disaster management organisations in making informed and responsive decisions in emergency situations.

Working on Simplex Method with Microsoft Excel Solver Function

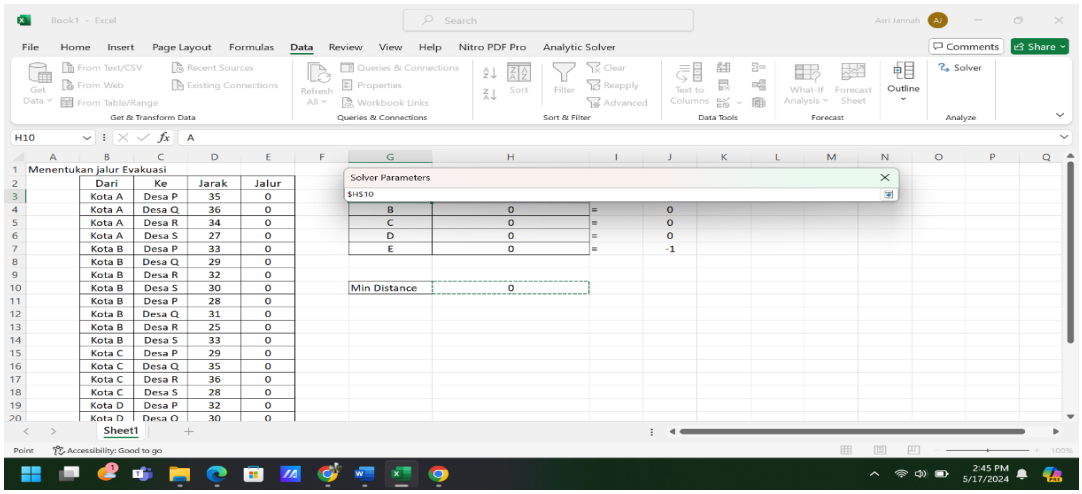

Figure 2. Open the solver programme in excel

Description:

- Column B2: Place where the disaster occurred
- Column C2: Safest place (Evacuation point)
- Column D2: Evacuation distance from the scene to the safest place
- Column E2: Evacuation route
- Column G2: Nodes (series of paths)
- Column H2: Constraint =SUM(B3:B26,G3,E3:E26)-SUMIF(C3:C26,G3,E3:E26)
- Column J2: Constraint
- Column G10: Min distance =SUMPRODUCT(D3:D26,E3:E26)

Then run Solver:

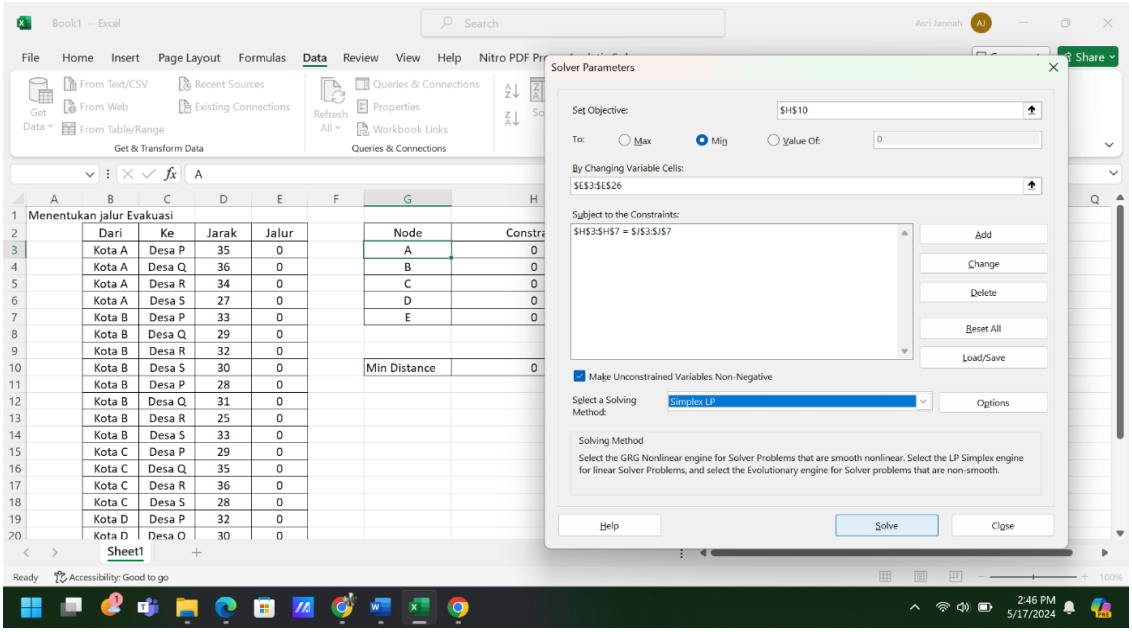

Figure 3. Solver Process by Entering the Formulas

Description:

- Set Objective: $H$10
- Equal to: Min
- By Changing Variable Cells: $E$3:$E$26 (decision variable)
- Subjet to the Constraints: $E$3:$E$26

Then Solve and the result:

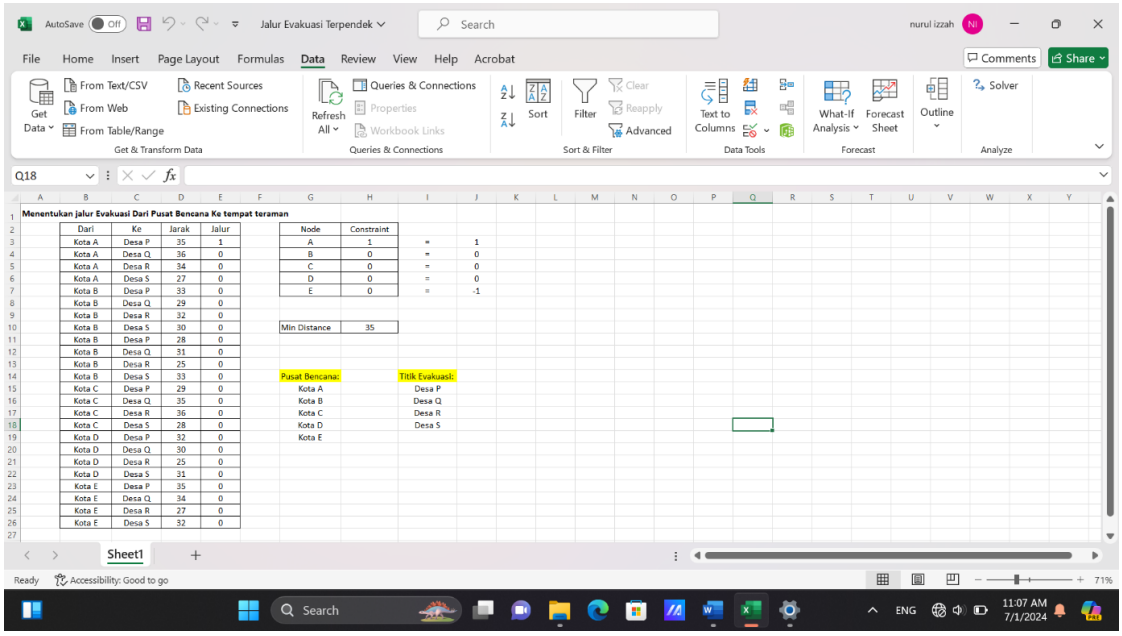

Figure 4. Data Results After Solve Process

Description:

- From the results of the solve that has been done, it means that the minimum path obtained is 35 km.

In the Excel Solver, the objective function and constraints can be modelled in appropriate cells, utilising the formulas and logic functions available (Wu, 2023). After defining the objective function, constraints, and other parameters, the Excel Solver can be run to find the optimal solution that satisfies the given constraints (Nadeem, 2020).

One of the main advantages of using Excel Solver in linear programming modelling is its ease of use (Q. Wang, 2022). The Excel Solver is integrated with Microsoft Excel, so modelling and analysis can be done directly in an environment that is familiar to the user.

CONCLUSION

Based on the results of this study, it is shown that Excel Solver is a powerful and effective tool for optimising the determination of the shortest evacuation route in an earthquake natural disaster scenario. The optimisation method developed utilises road map data, victim location, and destination location, and considers disaster-damaged road conditions, road capacity, and evacuation time limit. Natural disasters have a significant impact, and evacuating victims is a crucial step to save lives and minimise losses. Determining the shortest evacuation route is key to an effective and efficient evacuation process.

The benefits of this research are expected to provide a way to improve evacuation efficiency in natural disaster situations, minimise casualties in natural disaster situations, assist the government and related organisations in planning and implementing evacuation in natural disaster situations. The scope of the research is focused on the optimisation of shortest path determination in natural disaster scenarios using excel solver.

REFERENCES

Almeida, L. S. (2022). An ant colony optimization approach to the multi-vehicle prize-collecting arc routing for connectivity problem. *Multimodal Transportation*, *1*(3). https://doi.org/10.1016/j.multra.2022.100033

Bagloee, S. A. (2019). A hybrid machine-learning and optimization method for contraflow design in post-disaster cases and traffic management scenarios. *Expert Systems with Applications*, *124*(Query date: 2024-07-22 21:44:20), 67–81. https://doi.org/10.1016/j.eswa.2019.01.042

Bi, H. (2019). A survey of algorithms and systems for evacuating people in confined spaces. *Electronics (Switzerland)*, *8*(6). https://doi.org/10.3390/electronics8060711

Cao, Y. (2022). Evaluation and Optimization of Refuge Green Space in the Central Area of Tianjin for Geological Disasters. *Sustainability (Switzerland)*, *14*(23). https://doi.org/10.3390/su142315507

Dhamala, T. N. (2023). FLOWLOC PROBLEMS WITH MAXIMUM EXCESS FLOW. *Journal of Industrial and Management Optimization*, *19*(12), 8851–8870. https://doi.org/10.3934/jimo.2023064

Liang, B. (2019). A risk-averse shelter location and evacuation routing assignment problem in an uncertain environment. *International Journal of Environmental Research and Public Health*, *16*(20). https://doi.org/10.3390/ijerph16204007

Liu, L. (2022). Intelligent Evacuation Route Planning Algorithm Based on Maximum Flow. *International Journal of Environmental Research and Public Health*, *19*(13). https://doi.org/10.3390/ijerph19137865

Nadeem, I. (2020). An integrated bus—Based routing and dispatching approach for flood evacuation. *Yugoslav Journal of Operations Research*, *30*(4), 443–460. https://doi.org/10.2298/YJOR190415028N

Pan, Y. (2019). Analysis of natural lighting in underground street walking path from perspective of safety evacuation. *Xi'an Jianzhu Keji Daxue Xuebao/Journal of Xi'an University of Architecture and Technology*, *51*(4), 597–604. https://doi.org/10.15986/j.1006-7930.2019.04.019

Pathirana, D. (2019). Deep Learning based Flood Prediction and Relief Optimization. *2019 International Conference on Advancements in Computing, ICAC 2019*, *Query date: 2024-07-22 21:44:20*, 481–486. https://doi.org/10.1109/ICAC49085.2019.9103341

Rahman, M. R. (2020). Evacuation planning in natural disaster using multi objective optimization approach: The Rohingya refugee crisis in Bangladesh. *International Conference on Civil, Structural and Transportation Engineering*, *Query date: 2024-07-22 21:44:20*, 331–331. https://doi.org/10.11159/iccste20.331

Sitepu, A. (2023). THE OPTIMIZATION OF THE MOUNT SINABUNG DISASTER MANAGEMENT STRATEGY. *Journal of Law and Sustainable Development*, *11*(4). https://doi.org/10.55908/sdgs.v11i4.606

Soltani, A. (2019). A two-stage process for emergency evacuation planning: Shelter assignment and routing. *Lecture Notes in Geoinformation and Cartography*, *Query date: 2024-07-22 21:44:20*, 443–462. https://doi.org/10.1007/978-3-030-19424-6_24

Tanaka, T. (2021). Evacuation shelter decision method considering non-cooperative evacuee behavior to support the disaster weak. *Sustainability (Switzerland)*, *13*(9). https://doi.org/10.3390/su13095106

Vinh, T. L. (2023). TEVAC: Trusted Evacuation System based Fog Computing. *Proceedings of 2023 International Conference on System Science and Engineering, ICSSE 2023*, *Query date: 2024-07-22 21:44:20*, 164–169. https://doi.org/10.1109/ICSSE58758.2023.10227231

Wang, Q. (2022). Construction of flood adaptation network and planning response of strategy urban agglomeration in the Min Delta based on scenario simulation. *Shuili Xuebao/Journal of Hydraulic Engineering*, *53*(7), 876–889. https://doi.org/10.13243/j.cnki.slxb.20220208

Wang, Y. (2022). A Multi-objective Location Decision Making Model for Emergency Shelters Giving Priority to Subjective Evaluation of Residents. *International Journal of Computers, Communications and Control*, *17*(4). https://doi.org/10.15837/ijccc.2022.4.4749

Wu, Y. (2023). Forest fire emergency rescue and evacuation path planning based on improved APF. *EM-GIS 2023 - Proceedings of the 8th ACM SIGSPATIAL International Workshop on Security Response using GIS 2023*, *Query date: 2024-07-22 21:44:20*, 1–6. https://doi.org/10.1145/3615884.3629421

Yazdani, M. (2023a). A dynamic emergency planning system for relocating vulnerable people to safe shelters in response to heat waves. *Expert Systems with Applications*, *228*(Query date: 2024-07-22 21:44:20). https://doi.org/10.1016/j.eswa.2023.120224

Yazdani, M. (2023b). Elderly people evacuation planning in response to extreme flood events using optimisation-based decision-making systems: A case study in western Sydney, Australia. *Knowledge-Based Systems*, *274*(Query date: 2024-07-22 21:44:20). https://doi.org/10.1016/j.knosys.2023.110629

Zhao, X. (2020). A round-trip bus evacuation model with scheduling and routing planning. *Transportation Research Part A: Policy and Practice*, *137*(Query date: 2024-07-22 21:44:20), 285–300. https://doi.org/10.1016/j.tra.2020.05.008