JMI
Jurnal Multidisiplin Indonesia

Volume 5 Number 1, 2026
E-ISSN: 2964-9048 | P-ISSN: 2963-2900
https://jmi.rivierapublishing.id/index.php/rp

Performance Analysis of QGIS Plugin for Landslide Hazard Index Preparation

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Abstract

Landslides are a significant threat in Indonesia, with major impacts on social, economic, and infrastructure aspects. One important mitigation measure is the development of landslide hazard index maps. However, conventional methods using proprietary software such as ArcGIS or manual processing in QGIS are time-consuming and prone to technical errors. This study analyzes the performance of a QGIS plugin developed to accelerate and simplify the process of generating landslide hazard indices. The plugin was built using the Python programming language, GDAL and Rasterio spatial libraries, and an interface designed with Qt Designer through a Rapid Application Development (RAD) approach. Performance analysis was conducted by comparing processing duration and output consistency between the conventional method and the plugin. The test data included a Digital Elevation Model (DEM), Landslide Susceptibility Map (ZKGT), and administrative boundaries of Sanggau Regency. The results showed that the plugin reduced processing time from 410 seconds to 280 seconds while producing hazard index maps consistent with the manual method. In addition, the plugin reduced the risk of user errors in repetitive stages, such as reclassification and raster calculations. In conclusion, the developed QGIS plugin improves efficiency and reliability in landslide hazard index mapping. This performance analysis confirms that the plugin can serve as an effective open-source solution for disaster mitigation and reduce dependence on commercial software.

Keywords : Performance Analysis; QGIS Plugin; Hazard Index; Landslides; Efficiency

INTRODUCTION

Landslides are a type of natural disaster that often occurs in Indonesia, especially in areas with steep topography and high rainfall. The impacts include loss of life, damage to infrastructure, to social and economic disturbances (Prasetya, 2018). Therefore, mapping the landslide hazard index is an important step in disaster risk mitigation and reduction efforts (Frederika, 2023).

The preparation of landslide hazard indices is generally carried out with the help of Geographic Information System (GIS) software (Meena et al., 2021; Sari & Innaqa, 2017; Souisa et al., 2016; Yaa'cob et al., 2020). One of the most widely used software is ArcGIS. However, the software is paid and requires a special license, so not all institutions can access it (ESRI, 2022). Alternatively, Quantum GIS (QGIS) is the choice because it is open source and supports a wide range of spatial analyses (QGIS Development Team, 2025). However, manual analysis processes in QGIS often require repetitive stages that are time-consuming and prone to user error (Rahayu, 2016).

One solution to overcome these limitations is to develop custom plugins in QGIS (Chen et al., 2024; Duarte et al., 2018). The plugin allows the automation of complex spatial analysis stages to be more structured, efficient, and user-friendly (Pereira, 2022). Several studies have proven the effectiveness of plugins in accelerating spatial analysis, such as plugins for building density calculations (Azhari et al., 2022) and plugins for geological map access (Alif et al., 2020). However, an in-depth study of the QGIS plugin performance analysis on landslide hazard index mapping is still limited (Al-Thuwaynee et al., 2023; Daud et al., 2024; Joshi et al., 2025; Moresi et al., 2025).

This study aims to analyze the performance of the QGIS plugin developed to compile a landslide hazard index. The main focus of the study was to compare the processing time efficiency and consistency of results between conventional methods and plugin-based methods. Thus, the results of the research are expected to contribute to the development of open-source software to support disaster mitigation in Indonesia.

RESEARCH METHOD

The data utilized in this study consisted of three key components: a Digital Elevation Model (DEM), which was used for generating slope maps; the Soil Movement Vulnerability Zone (ZKGT), provided by the Center for Volcanology and Geological Disaster Mitigation (PVMBG), to assess the landslide vulnerability level in the study area; and the administrative boundaries of Sanggau Regency, including district and village boundaries for spatial analysis. Sanggau Regency was selected as the study area due to its high susceptibility to landslides, making it an ideal location for disaster mitigation research. These data sources were essential for the analysis of landslide risk and the development of risk assessment tools.

This research utilized several software tools, including QGIS version 3.30.3 for plugin development and testing, Python 3.10 as the primary programming language, and Qt Designer 5.15.3 to design the plugin interface. The plugin development followed the Rapid Application Development (RAD) methodology, which involved four key stages: Requirement Planning, where the plugin's needs were identified based on the BNPB's Technical Module for Landslide Risk Assessment; User Design, involving the creation of an interactive interface; Construction, which focused on coding the plugin using Python and QGIS APIs; and Cutover, where integration and testing ensured the plugin's functionality. The study also included performance analysis, comparing the processing duration, output consistency, and risk of human error between the manual and plugin methods, with final validation through white box testing to ensure the reliability and accuracy of the plugin's results.

RESULTS AND DISCUSSION

A. Performance Test Results

The test is carried out by comparing the processing duration between the conventional method (manual in QGIS) and the developed plugin. Testing was carried out on devices with specifications: AMD Ryzen 5 processor, 16 GB of RAM, 64-bit Windows 10 operating system, and QGIS version 3.30.3. Table 1 shows the results of the comparison of execution time at each stage of the process of compiling the landslide hazard index.

Table I. Comparison Of Processing Time Between Manual Methods And Qgis Plugins

Process Stages	Short Description	Manual Duration	Plugin Duration	Differences	Efficiency
Step 1: Slope Calculation	Calculating the slope of the DEM	23	13	10	43.48%
Step 2: Reclassification of the Slope	Classifying slope values	11	2	9	81.82%
Step 3: Raster Calculation	Advanced raster value processing	62	50	12	19.35%
Step 4: Landslide Zone Score	Combining ZKGT and tilt	15	5	10	66.67%
Step 5: Potential Landslide Source	Identify the area of the source of the landslide	11	2	9	81.82%
Step 6: Runout dan Path Distance	Material movement analysis	207	195	12	5.80%
Step 7: Runout Zone Score	Calculation of runout values	11	2	9	81.82%
Step 8: Landslide Hazard Index	Integration of runout and landslide scores	20	3	17	85.00%
Step 9: Hazard Classification	Classification of index values	10	3	7	70.00%
Step 10: Hazard Broad Tabulation	Calculation of the area of each class	40	5	35	87.50%
Total	—	410	280	130	31.7%

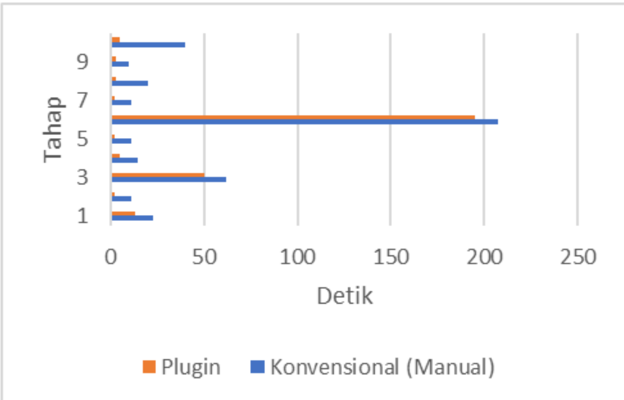

Figure 1. Comparison of Manual Processing Duration and QGIS Plugins.

B. *Efficiency Analysis*

Based on the results of Table 1, the QGIS plugin provides an average time efficiency of 31.7% compared to the manual method. The stages that show a significant increase are Slope Reclassification (Step 2) and Hazard Area Tabulation (Step 10) with an efficiency above 80%.

The biggest time savings occur because plugins can automate repetitive stages that previously required user interaction at each step, such as active layer selection, raster cropping, and manual classification. This is in line with the findings of Pereira (2022) that plugin-based automation can increase the efficiency of geospatial processing by more than 30% compared to conventional methods, and is supported by the results of research by Setiawan et al. (2023) and Rahmah and Pratama (2022) which show a significant improvement in the efficiency of disaster risk mapping using the open-source QGIS framework.

In contrast, the Runout and Path Distance stages (Step 6) show only a small efficiency (5.8%) because these processes rely heavily on the compute capacity and complexity of the raster data, rather than on the user's interface or workflow.

C. *Consistency of Spatial Results*

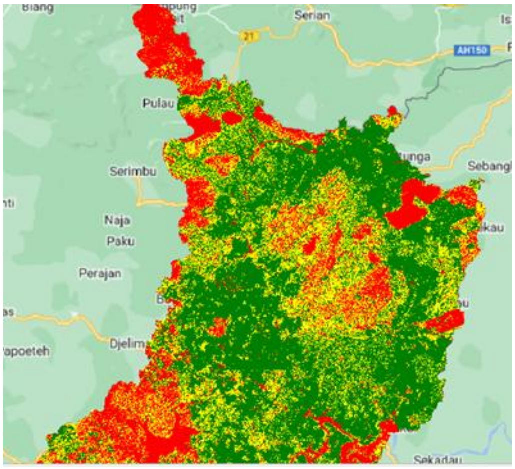

Figure 2. Output Plugin Results.

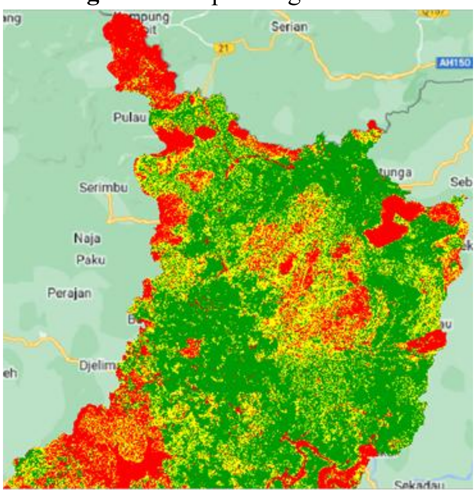

Figure 3. Manual Output Results

The overlay results between the hazard index map from the plugin and the manual method show a very high level of spatial conformity. No significant differences were found in the distribution of hazard classes, in both high-risk and low-risk areas. Thus, it can be concluded that the use of plugins does not change spatial accuracy but increases the speed of analysis.

D. *User Error Reduction*

In addition to improving time efficiency, plugins also reduce the risk of human error at stages such as: 1) Wrong selection of the active layer. 2) Wrong raster parameter input. 3) An error in the slope value classification setting. With a modular interface and input validation system, this risk can be kept to a minimum. These findings are in line with Azhari et al. (2022) who showed that an interactive plugin design can improve the reliability of spatial analysis results.

E. *General Discussion*

Overall, the results show that QGIS plugin development is capable: 1) Improve time efficiency and consistency of results. 2) Reduce technical complexity in the preparation of hazard indexes. 3) Supports the principle of open-source GIS, which can be used by various parties without license fees. This, this plugin can serve as a decision-support tool in landslide disaster mitigation that is efficient, inexpensive, and adaptable to different regions with different geospatial characteristics.

F. *Research Implications and Limitations*

This research makes a practical contribution to the development of a QGIS-based disaster risk mapping system. With increased efficiency and accuracy, the developed plugin can be applied by local government agencies, disaster mitigation agencies, and academics in risk mapping activities.

However, this study still has limitations in the aspect of input data, especially the use of rainfall factors and soil types that have not been included in the hazard index. In addition, performance testing is still limited to one study area, namely Sanggau Regency. Follow-up studies can expand the test area and add environmental parameters to make the mapping results more comprehensive.

CONCLUSION

This study analyzed the performance of a QGIS plugin, developed using Python, GDAL and Rasterio libraries, and Qt Designer interfaces, to accelerate and simplify landslide hazard index compilation. Test results demonstrated significant efficiency gains, reducing processing time from 410 seconds to 280 seconds (a 31.7% improvement), while producing hazard index maps with very high spatial consistency to manual methods and no differences in hazard classification. The plugin also minimized human errors in repetitive tasks like layer selection, reclassification, and raster calculations. Overall, it proved an effective open-source solution for geospatial processing in disaster mitigation, aligning with findings from Taufiq and Wibowo on integrating QGIS with open spatial data for local-level strengthening. For future research, integrating machine learning algorithms for automated parameter optimization and expanding the plugin to incorporate real-time rainfall data could further enhance its predictive accuracy and applicability in dynamic hazard forecasting.

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