Journal of Civil Engineering, Science and Technology

Volume 17, Issue 1, April 2026, 41-51

HARNESSING ASTER-DEM-DERIVED WATERSHED FEATURES FOR LANDSLIDE SUSCEPTIBILITY MAPPING

Nurul Najihah Rosedin[1], Abdul Rauf Abdul Rasam[1,2*], Nurhanisah Hashim[1], Siti Rashidah Hanum Abd Wahab[1] and Edzrie Shah Shaharudin[1]

[1]College of Built Environment, Universiti Teknologi MARA, 40450, Selangor, Malaysia

[2]Malaysia Institute of Transport (MITRANS), Universiti Teknologi MARA, 40450, Selangor, Malaysia

Date received: 05/02/2025 Date accepted: 21/08/2025

*Corresponding author's email: rauf@uitm.edu.my

DOI: 10.33736/jcest.8975.2026

Abstract — Acquiring the exact and unrestricted watershed delineation produced using Digital Elevation Model (DEM) data is challenging for landslide susceptibility modelling. High-resolution DEMs are crucial for accurate landslide susceptibility mapping, as they capture detailed terrain features, slope gradients, and watershed boundaries. Accurate watershed delineation requires high-resolution DEMs, but finding the data, managing the complex processing, and addressing the high costs involved can be challenging; thus, ASTER open-source DEMs, with their moderate resolution, offer a more accessible option when high-resolution data is not available. This study explores open-source capabilities for ASTER 30m satellite imagery from the Earth Data website to delineate the Hulu Langat watershed in Selangor. The DEM and landslide datasets (relief and slope, land use, proximity to rivers and roads, slope, lithology, and aspect) were transformed to the same projection and coordinate system. The ASTER 30m dataset was merged and clipped to the boundary lines of the Hulu Langat district. The watershed delineation for the entire Hulu Langat, Selangor, was then determined for all datasets using the Arc Hydro tools in the Geographical Information System (GIS) software. Maps of the Hulu Langat region's landslide susceptibility, showing the incredibly high, high, moderate, and low-risk zones, were produced using DEM watershed datasets from the National Geospatial Centre (PGN) and the open-source ASTER platform with ArcGIS Pro's overlay tool. A comparative study of classification techniques (Equal Interval and the Natural Breaks) and past landslide events was also conducted to explore the map's reliability and practicality. The regions vulnerable to landslides were then depicted on a map, created by spatially analysing these characteristics, for application in real situations in the study area. ASTER open-source DEMs offer a practical solution with moderate-resolution elevation data, making them useful for broad watershed delineation and improving landslide susceptibility mapping, especially when high-resolution data is hard to find.

***Keywords*:** ASTER DEM, landslide susceptibility map, remote sensing open-sources, watershed delineation

1.0 INTRODUCTION

In Malaysia and other hilly parts of the world, landslides pose a serious geological risk, resulting in thousands of cases of damage and countless deaths each year. The socioeconomic structure of a nation can be seriously impacted by these disasters, which frequently occur on uneven terrain and steep slopes. Monsoon-season landslides are dangerous due to high temperatures and heavy rainfall, which create unstable terrain and thick residual soil. The Minerals and Geoscience Department of Malaysia has confirmed ongoing instability near the landslide in Hulu Langat, Selangor, which endangers residents' lives [1]. Landslide susceptibility in Hulu Langat, Selangor, has also developed as a serious concern due to the region's topography and climate, which render it prone to landslides. In Malaysia's Selangor state, Hulu Langat is known for its hilly terrain, dense forests, and heavy rainfall, which increase the likelihood of landslides. Rising urbanisation and deforestation heighten this danger, making it critical to develop precise and reliable systems for assessing and mitigating landslides. Accurate landslide susceptibility mapping is crucial in Malaysia, given its diverse terrain and heavy rainfall, as it helps prevent disasters and ensure safety [2].

GIS and remote sensing (RS) technologies have revolutionised natural resource research and disaster response strategies, particularly for watershed delineation and landslide susceptibility assessments [3]. Traditionally, this process was performed manually using topographic maps, but recent advancements in GIS and DEM data have simplified the process and improved the accuracy of watershed delineation [4, 5]. Tools like ArcGIS are now extensively used to determine catchment and watershed boundaries, making the process more efficient and precise. The ability of GIS to simulate hydrologic processes comprehensively is precious, as it allows for detailed modelling of watersheds based on the highest surrounding elevations, thus defining the watershed divide. Remote sensing techniques, such as satellite and airborne photogrammetry, light detection and ranging (LiDAR), and radar systems, have further improved the quality and availability of DEM data, which is crucial for accurate watershed modelling [6].

A GIS is an array depicting square cells (pixels) individually assigned to a number representing the elevation at which they are located. It displays three-dimensional information about Earth's surface. DEM may also be represented in formats such as Triangulated Irregular Networks (TIN) and contour maps (Li et al., 2017). DEM is now accessible via techniques used in RS and GIS. The DEM data may be derived from various sources, such as open data. The watershed can be delineated more quickly with advanced technology. Data from DEMs and river lines can be used to process the watershed. Delineation of a watershed is required for several aspects of hydrologic and environmental evaluation, including the calculation of runoff, the modelling of water quality, and the evaluation of flood risk. In addition, a DEM with a coarser resolution can represent larger basins with shorter streams, flatter slopes, and minor elevation changes, all of which reduce heterogeneity and accuracy [7].

The study uses DEM data to delineate watersheds in Hulu Langat, Selangor. It aims to delineate watersheds, assess the accuracy of DEM resolution and tools, and produce detailed watershed maps using GIS techniques. This approach saves time and resources compared to manual delineation and enhances the precision of hydrological models. The study underscores the value of high-quality DEM data and effective GIS methods in advancing watershed management and hydrological research, offering significant benefits for both academic and practical applications.

GIS is a computer system that records, saves, queries, examines, and displays data about geographic locations. The GIS framework is well-suited for analysing watersheds, obtaining model inputs, and visualising model results [8]. The technique of determining stream networks and watersheds by utilising DEMs to trace water flow is called watershed analysis. Watershed boundaries have often been shown on topographic maps as hand-drawn lines. The person responsible for drawing the borders relies on the map's elevation profiles to establish the limits. Preliminary watershed borders can be generated using GIS and DEMs in a fraction of the time required by conventional techniques. In the United States, the Watershed Boundary Dataset (WBD) was created using an automated delineation approach to define watershed boundaries on a global scale [9].

Landslide susceptibility indicates the likelihood of landslides occurring in each area based on local conditions. Due to its hilly terrain and heavy rainfall, Hulu Langat, Selangor, is particularly vulnerable. GIS technology is essential for evaluating and mapping landslide susceptibility. GIS integrates various datasets, such as topography and rainfall, to create detailed susceptibility maps. [10] demonstrated the use of GIS to combine multiple factors, revealing its critical role in analysing landslide susceptibility at Hulu Langat. Several GIS-based modelling techniques have been applied to predict landslide susceptibility in Hulu Langat. [11] used logistic regression and artificial neural networks within a GIS framework, finding these models effective for hazard management. Other studies employed the frequency ratio method and the analytic hierarchy process (AHP), which are statistical and multi-criteria decision-making approaches, respectively, to rank landslide-contributing factors [11].

Accurate landslide susceptibility maps are crucial for disaster management and mitigation in Hulu Langat. Using advanced modelling techniques, GIS provides precise mapping to identify high-risk zones. [12] highlighted the importance of using high-resolution data and incorporating land cover changes to enhance the accuracy of susceptibility maps, aiding planners and emergency responders in effective decision-making. Accurate watershed delineation using DEM data is crucial for environmental modelling [13–15], including landslide susceptibility modelling, because high-resolution DEMs capture detailed terrain features, slope gradients, and boundaries [16]. However, at moderate resolution, ASTER open-source DEMs offer a more accessible option when high-resolution data is unavailable [17], as they avoid the complex processing and high costs associated with high-resolution data. This study uses GIS and a hydrological model to delineate watersheds by exploring open-source ASTER 30m DEM data and landslide susceptibility mapping in the Hulu Langat.

2.0 MATERIALS AND METHODS

This section discusses the methods used for watershed delineation, utilising Arc Hydro and a DEM derived from ASTER. In addition, landslide susceptibility assessment was conducted using the weighted overlay method. Land use, road proximity, slope, lithology, aspect, and river proximity are among the characteristics integrated into the landslide susceptibility map for Hulu Langat. It involves structuring the decision hierarchy, pairwise comparisons of criteria, and synthesising judgements to generate susceptibility maps. Correctly completing all the work steps and including the method flow is essential. This research employs a quantitative approach, involving the systematic collection, analysis, and interpretation of numerical spatial data using GIS tools such as ArcGIS Pro and ArcMap. The methodology is based on measurable variables, including slope, land use, and proximity to environmental features, and relies on statistical techniques, such as classification and percentage analysis, to assess landslide susceptibility. This structured, data-driven framework aligns with the core principles of quantitative research. Figure 1 depicts the flowchart and work phases required to achieve the purpose and goal of this study. It comprises five stages: the preliminary study, data collection, data processing, analysis, and visualisation.

2.1. Study Area

This study focuses on Hulu Langat as the research area. Hulu Langat District is located between Kuala Lumpur and Negeri Sembilan in Selangor's southern corner. It is bounded to the east and north by the state of Pahang, to the north-west by the Gombak district, to the west by the Federal Territory of Kuala Lumpur and the Petaling district, to the south-west by the Sepang district, and to the south by the state of Negeri Sembilan.

2.2. Preliminary Study

Since there are concerns about the accuracy of quality digital elevation data (DEM) obtained from the internet via accessible sources, such as the USGS website, it can be validated by comparing it to the most significant elevation value as a benchmark for future application analysis. For this study, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data were selected to assess the accuracy of DEM data. Obtaining high-quality digital elevation model (DEM) data is crucial for this study. This includes finding suitable data sources, such as the quality of DEM data and how straightforward it is to obtain. Some of the DEM data that is very accurate is privately owned and cannot be used for free.

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data were downloaded from the USGS Earth Explorer and EarthData websites. This study examined the characteristics, specifications, accuracy, and errors of all data sets. In addition, using a weighted overlay method, variables such as land use, road proximity, slope, lithology, aspect, and river proximity are mapped along with their influence on landslides in Hulu Langat. A final map identifying high-risk locations is created by reclassifying these variables to a common scale and combining them according to the weights assigned to each element.

2.3. Data Acquisition

This section involves several GIS processes. First, for watershed delineation, open-source datasets available on the internet, namely ASTER for Hulu Langat, Selangor, Malaysia, can be obtained on the Earth Explorer site of the EarthData website. The Department of Irrigation and Drainage of Malaysia (DID) utilised river lines and watershed boundary data as references to verify the accuracy of watershed delineation using ASTER.

For landslide susceptibility, six characteristics were used: slope, lithology, land use, aspect, proximity to the road, and the river. The GIS software converts the vector data into a raster file format to prepare for the next step in the procedure. Data-like aspects and slope may be retrieved from the generated ASTER DEM. GIS proximity analysis is used to determine distances to road data. There are five classes based on the road buffer criteria: 40 – 80 metres, 80 – 120 metres, 120 – 160 metres, and 160 – 200 metres. The river proximity layer is calculated using three primary classifications: 0 – 50 m, 50 – 100 m, and 100 – 150 m — the map of lithology obtained from open sources. Afterwards, the USGS provided Landsat 8 imagery for creating a land cover and land use map, classified into five categories: water, bare land, urban area, forest, and vegetation.

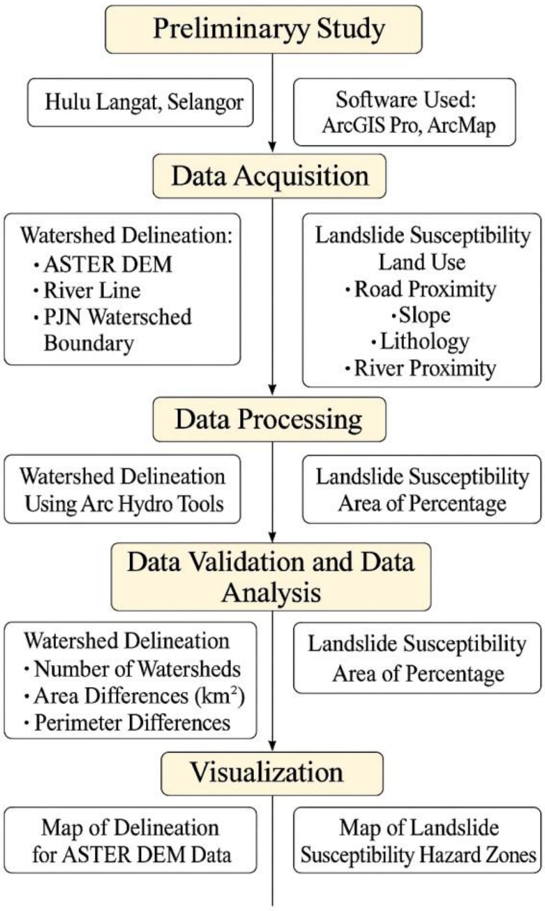


Figure 1 Research flowchart

2.4. Data Processing: Watershed Delineation and Weighted Overlay Process

Delineate the watershed by using Arc Hydro tools. Arc Hydro is an ArcMap extension function. Watershed modellers have commonly used this tool for terrain modelling and spatial hydrology. Although ArcMap already includes tools for hydrologic analysis, Arc Hydro provides a more step-by-step approach to watershed delineation. Dr David Maidment (University of Texas, Austin) created the initial version of the Arc Hydro model as a mapping tool for water resource experts. It provides for the spatial depiction of streamlines, integration with hydrologic and hydraulic modelling, and generation of watershed borders based on hydrology.

To complete the weighted overlay process, people have chosen to determine the degree of effect of each parameter using the prediction rate (PR) obtained from the probabilistic technique. The prediction rate yields a number that may be expressed as the proportion of influence assigned to each criterion. It utilises the weight overlay tool from the Spatial Analyst tool in conjunction with all six (6) raster images. Next, to ascertain which classification type is most useful for the analysis's objectives, the classification procedure was conducted using natural breaks and equal intervals [1].

2.5. Data Analysis

The outputs, which consisted of the watershed's number, perimeter, and area, were compared with the watershed boundary established by PGN for visualisation. The following comparison was made using the results of the watershed delineation, performed with Arc Hydro tools. The outcomes of the watershed delineation were then compared, both visually and numerically, with the watershed boundaries from PGN.

For landslide susceptibility, natural breaks and equal intervals were the two categorisation techniques used to compare the area percentages of landslide danger maps in the research region. The generated maps were analysed to determine the distribution of landslide susceptibility zones throughout the research region. To assess the accuracy of these zonation maps, they were also compared with data on past landslides. This comparative study aimed to determine whether the classification technique more accurately forecasts high-risk landslide regions by evaluating the relationship between the predicted danger zones and the sites of previous landslides. This comparative analysis yielded insights into how effectively each categorisation technique identified landslide-prone locations, thereby improving susceptibility mapping of the study area.

2.6. Visualisation

The last stage in creating a map involves switching from project layout to map layout and designing it according to map-making standards, which include inserting a legend, map grids, a north indicator, a scale bar, a title, and so on. The final outputs of this study are a map of the delineated watershed for ASTER DEM data and a map of landslide susceptibility hazard zones. This research effectively produced a thorough, comprehensive map across several categories. Specifically, concerning the mapping of landslide susceptibility in Hulu Langat, the information obtained from this method will be essential for determining the effectiveness of each approach.

3.0 RESULTS AND DISCUSSION

3.1. Watershed Analysis Using the Arc Hydro Tool

Various tools are also available in the Arc Hydro toolbar for defining watersheds and sub-watersheds. These methods use datasets obtained during terrain processing. Additionally, for batch watershed delineation, this function defines the upstream watershed for each point in the input batch of point features. Next, this study uses a batch watershed delineation tool to determine the watershed outflow. The objective is to establish a point where the flow exits the basin on the flow accumulation path, as shown by the flow accumulation grid. Figure 2 shows the result of the ASTER 30m watershed using the Arc Hydro tool.

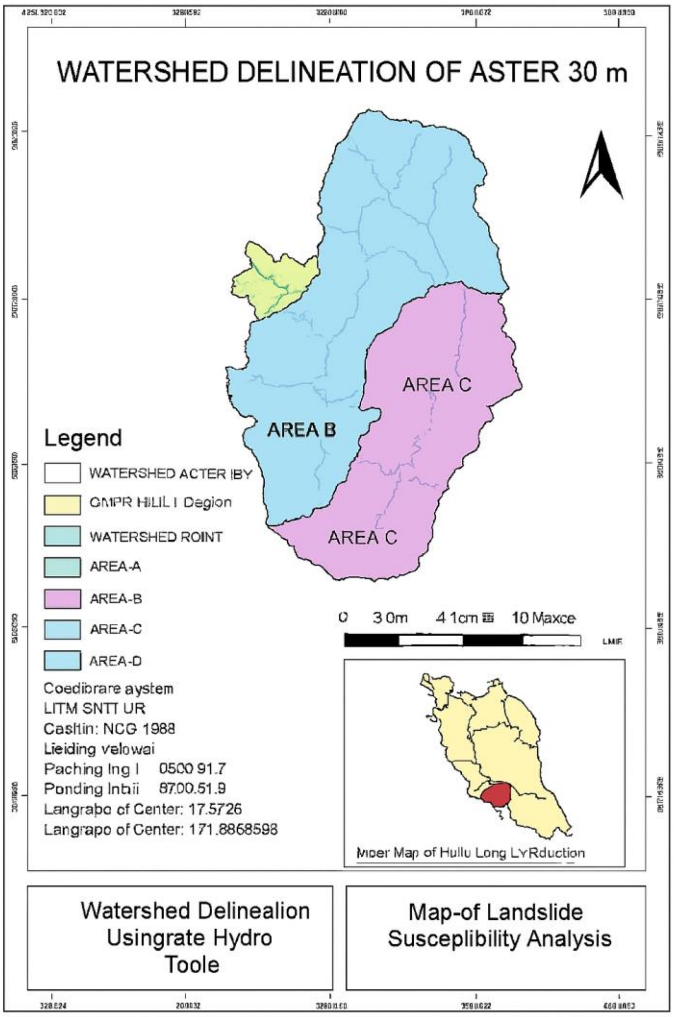


Figure 2 Watershed delineation using ASTER 30m in Arc Hydro tool

3.2. Comparative Visualisations between PGN and ASTER DEM Datasets

The watershed boundary delineated from ASTER 30 m data was compared with the watershed boundary from PGN data for visualisation. The watershed boundary from ASTER 30 m was also compared in terms of numbers, including the number, area, and perimeter of the watershed. In addition, PGN is used in this study as a benchmark for comparison, as it originated from JUPEM, which used high-resolution data, including InSAR, LIDAR, and contour data, to delineate watershed boundaries. Each watershed boundary analysis used the kilometre (km) unit. The ASTER 30-metre use of Arc Hydro results is the best watershed delineation because the different resolution closely matches the Pusat Geospatial Negara (PGN) data. For better temporal and geographic analysis, Arc Hydro is an additional extension module for ArcGIS that is used to create, manipulate, and depict hydrologic features. Figure 3 shows the comparison between the PGN watershed and the result of the watershed of ASTER 30m using the Arc Hydro tool.

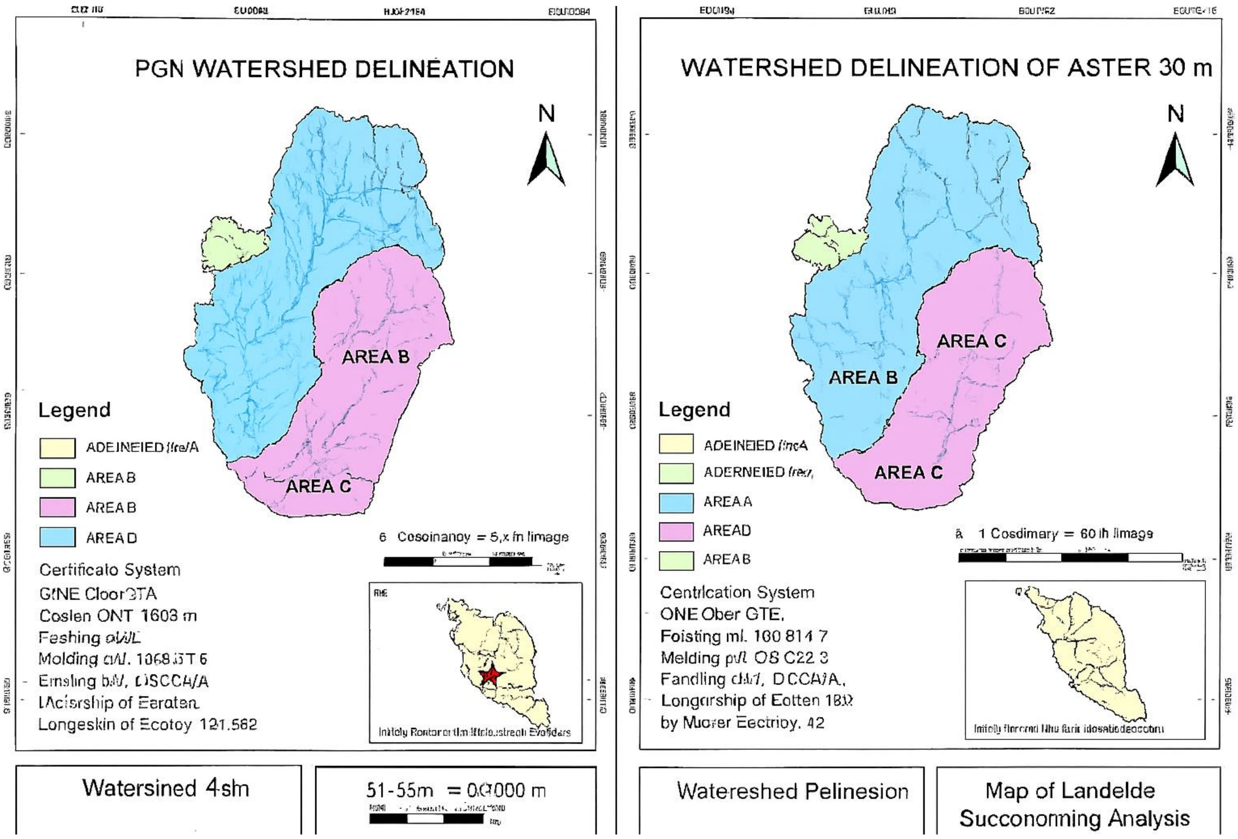


Figure 3 Watershed delineation from PGN datasets and ASTER 30m in the Arc Hydro tool

3.3. Number of Watersheds, Area and Perimeter Different

Figure 4 demonstrates that ASTER 30 m is the best visualisation choice since it closely matches the Arc Hydro tools' PGN data for ASTER 30 m. Because there are four watersheds at each resolution, the same number of watersheds are processed by ASTER 30 m using Arc Hydro, resulting in the best watershed delineation. The use of ASTER 30 m and Arc Hydro tools resulted in the best watershed delineation because they processed the same number of watersheds, with four watersheds for each resolution.

Numerical values, including the number, area, and perimeter of the watershed, were tabulated for the delineated watershed boundary from ASTER 30 m. Table 1 shows the area and perimeter of the ASTER DEM at 30-metre resolution, calculated using Arc Hydro tools. In addition, the four watersheds identified in the ASTER DEMs, and analysed using Arc Hydro methods, are identical to those identified in the PGN findings. Figure 4 shows the number of watersheds labelled A, B, C, and D, while Table 1 presents the area and perimeter of the watershed for the ASTER DEM.

Finally, four processes and functions in Arc Hydro are not included in hydrology tools: Catchment Grid Delineation, Catchment Polygon Processing, Drainage Line Processing, and Adjoint Catchment Processing, which distinguish the methods used by Arc Hydro from those used by hydrology tools. Furthermore, journals and previous studies demonstrate the satisfactory results yielded by Arc Hydro tools. JUPEM also used Arc Hydro's tools for watershed delineation. They are making Arc Hydro tools more efficient and accurate for DEM watershed delineation.

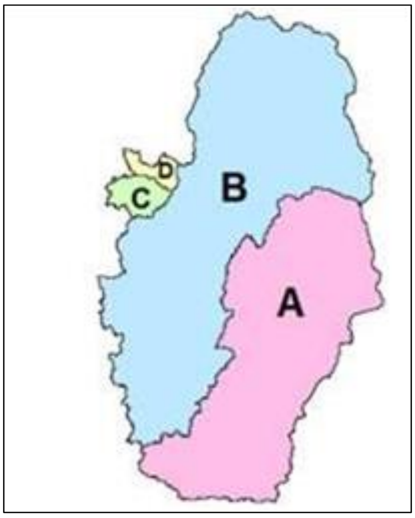


Figure 4 Watershed ID

Table 1 Numerical Area and Perimeter for ASTER DEM

DEMs	ASTER	
Resolution	30 m	
Watershed ID	Area of Watershed (km^2)	Perimeter of Watershed (km)
A	315.4277	142.3591
B	453.1116	191.5203
C	16.1359	27.854
D	9.5293	24.5191

3.4. Comparison of Area Percentage between Natural Breaks and Equal Interval and Historical Landslide Cases Using the Weighted Overlay Method

The weighted overlay method is used to compare the area percentages of natural breaks and equal interval classifications, revealing significant variations in risk distribution in Table 2. Under Natural Breaks, most of the land is rated as moderate risk (45.77%), with a significant section classified as high risk (39.65%). Low and very high-risk zones are relatively modest, with 10.29% and 4.28%, respectively. In contrast, the equal interval technique significantly skews the risk distribution towards the moderate group, which accounts for an astounding 67.15% of the area. This technique yields a higher proportion of low-risk regions (14.64%) and a lower proportion of high-risk areas (18.17%). The very high-risk group is almost nonexistent in the equal interval category, accounting for only 0.08%. These contrasts illustrate the importance of categorisation techniques in risk assessment, with equal intervals producing a more generalised and narrower risk distribution than natural breaks. These findings align with [18], who stressed that natural breaks tend to highlight abrupt changes in susceptibility values, resulting in a sharper delineation of high-risk zones. Equal intervals, on the other hand, apply uniform class widths, which can dilute the representation of extreme values and lead to underestimation of critical zones [19].

Table 2 Area Percentage between Natural Breaks and Equal Interval

Risk Ranking	Weighted Overlay	
	Natural Breaks (%)	Equal Interval (%)
Low	10.29	14.64
Moderate	45.77	67.15
High	39.65	18.17
Very High	4.28	0.08

Based on Table 3, the accuracy of Natural Breaks and Equal Interval classifications using the Weighted Overlay Method is assessed against historical landslide cases, revealing significant variances in risk categorisation. Both approaches consistently rate some places as low risk, including Ampang Jaya, Mutiara Condominium, Taman Cheras Awana, and Jalan Saga 21, indicating agreement in low-risk zones. However, differences exist in higher-risk categories. For example, Taman Bukit Permai and Taman Koperasi Uda are classified as High Risk under Natural Breaks but just Moderate under Equal Intervals. Additionally, Pekan Batu 14 and Taman Permai Jaya are classified as moderate risk by Natural Breaks but are downgraded to low risk by Equal Intervals. These contradictions show that Natural Breaks identifies more locations as high risk than the equal interval technique, which appears to balance risk levels and results in lower risk classifications. Natural mays might provide a more exact evaluation of high-risk locations, closely matching documented landslide events. These discrepancies suggest that Natural Breaks may offer a more precise reflection of actual landslide occurrences, consistent with findings by [20], who noted that natural breaks-FR methods yielded a higher spatial concentration of landslides within warning zones. Overall, the comparison points out the value of selecting classification techniques in susceptibility mapping. While equal intervals provide a smoother and more generalised output, natural breaks appear to better capture localised risk intensities, enhance alignment with documented landslide events, and improve hazard zoning accuracy [18, 21].

Table 3 Comparison of zoning classification between Natural Breaks and Equal Interval

Name Of Cases	Weighted Overlay	
	Natural Breaks	**Equal Interval**
Ampang Jaya, Selangor	Low	Low
Mutiara Condominium, Ampang, Selangor	Low	Low
Taman Bukit Permai	High	Moderate
Jalan Memanda, Ampang Jaya	Moderate	Moderate
Taman Cheras Awana, Cheras, Selangor	Low	Low
Children's Hidayah Madrasah Al-Taqwa Orphanage	Moderate	Moderate
Pekan Batu 14 Hulu Langat, Selangor	Moderate	Low
Jalan Saga21, Taman Bukit Teratai, Ampang	Low	Low
Taman Mulia Jaya, Ampang	Moderate	Moderate
Taman Permai Jaya, Ampang	Moderate	Low
Taman Koperasi Uda, Hulu Langat	High	Moderate
Kampung Lembah Jaya Selatan, Ampang	Moderate	Moderate
Taman Melur, Ampang	Moderate	Moderate
Taman Sri Watan, Ampang	Moderate	Moderate
Jalan Teratai2/7b, Taman Bukit Teratai, Ampang	Moderate	Moderate
Taman Desa Sentosa, Hulu Langat, Selangor	Low	Low
Taman Mulia Jaya, Ampang, Selangor	Moderate	Moderate
Taman Bukit Teratai	Moderate	Moderate

3.5. Criteria Induced to Landslide in Hulu Langat

Landslide susceptibility in Hulu Langat has been estimated using a weighted overlay approach that considers land use, road proximity, slope, lithology, aspect, and river proximity. Each criterion is weighted according to its influence on landslides, and the thematic layers combine to create a complete susceptibility map. This technique seeks to provide a quick yet detailed assessment of landslip risk in the area, assisting in informed decision-making and risk mitigation strategies. Table 4 shows the criteria that induced the landslide in Hulu Langat.

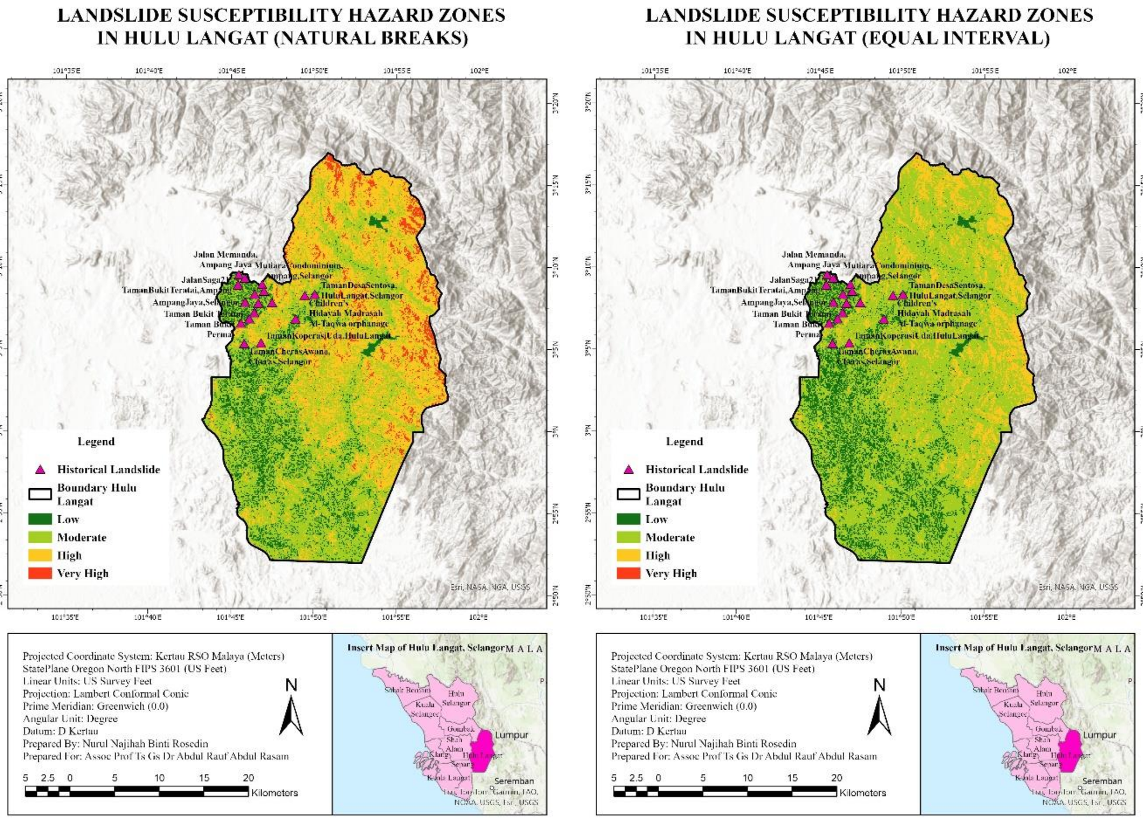
Table 4 Criteria induced to landslide in Hulu Langat

Factor	Class	Weight
Slope	0-5 degrees	1
	16-25 degrees	2
	26-35 degrees	3
	>35 degrees	4
Road	40m	1
	80m	2
	120m	3
	160m	4
	200m	5
River	50m	1
	100m	2
	150m	3
Geology	Devonian	1
	Silurian	2
	Triassic	3
Land Use	Water	1
	Urban Area	3
	Bare Land	4
	Forest	2
	Vegetation	5
Aspect	North	1
	Northeast	2
	East	3
	Southeast	4
	West	5
	Northwest	6

3.6. The Result of The Map of Landslide Susceptibility Hazard Zones Using the Weighted Overlay Categories: The Study Area into High-, Moderate-, And Low-Risk Zones

The result section describes the mapping of landslide susceptibility zones using the weighted overlay method. It divides the research region into high-, high-, moderate-, and low-risk zones based on slope, soil stability, and past landslide records. Steep slopes and unstable soils characterise high-risk zones, whereas moderate-risk zones exhibit moderate vulnerability. Stable soil and moderate slopes characterise low-risk areas. These results assist decision-makers in enhancing community resilience to landslide hazards by enabling efficient land-use planning and prioritising mitigation activities.

Figure 5(a) displays the final map generated using the weighted overlay method combined with the Natural Breaks classification. This map highlights regions identified as high-risk based on historical landslide events. The Natural Breaks technique successfully pinpointed two high-risk zones: Taman Bukit Permai and Taman Koperasi Uda in Hulu Langat. Other areas are categorised as having moderate to low landslide risk. Figure 5(b) presents the map produced using the weighted overlay method with an equal interval classification. Unlike the natural breaks approach, the equal interval map does not indicate any areas as highly susceptible to landslides, suggesting a generally lower perceived risk across the region. These findings suggest that the Natural Breaks classification provides a more sensitive and realistic representation of landslide-prone areas in the study region, making it a more appropriate method for hazard assessment and decision-making.



(a) Natural Breaks (b) Equal Interval

Figure 5 Landslide susceptibility mapping using weighted overlay with Natural Breaks and Equal Interval

4.0 CONCLUSION

Using open-source DEMs for landslide susceptibility mapping in Malaysia is practical because they are more affordable and accessible. These datasets provide the necessary elevation data for watershed delineation, especially when high-resolution, costly data is not available. This research investigates the open-source capabilities of ASTER 30m satellite imagery from the EarthData website to map the Hulu Langat watershed in Selangor. The research was successful, as the study's main aim was to delineate the watershed of the study area and produce a landslide-susceptibility map for the Hulu Langat region showing high, moderate, and low-risk zones. The first key finding was achieved by downloading the open-source ASTER dataset from the internet and evaluating its ability to create a landslide-susceptibility map of the Hulu Langat region, depicting high-, moderate-, and low-risk zones using a weighted overlay. By utilising cost-effective, reliable, and free internet data sources, this research can help users create watershed delimitation in a relevant way. In addition, it helps users and academics reduce the time and cost of gathering elevation data and creating DEMs for watershed boundary delineation. It can also assist users in choosing their preferred resolution, such as 30 metres or 90 metres, to delineate watersheds within specific or large areas of interest. Using open-source RS and GIS datasets for landslide susceptibility mapping in Malaysia offers significant advantages, including affordability, straightforward access to critical data, and the ability to conduct analysis without incurring high costs or licensing difficulties.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Acknowledgement

We thank the Institut Pengajian Siswazah (IPSis), UiTM, for generous support through the Conference Support Fund (CSF). Input from ICONBEE 2024 enabled us to attend the conference, share the researcher's findings, and learn from fellow scholars' insights.

References

[1] Samsul, S. N. A., Idris, R., Zulkarnain, S. H., Ahmad, C. B., Rasam, A. R., & Idris, M. R. (2023). Landslide Susceptibility Mapping in Ampang Jaya: Comparing Probabilistic Method and Weighted Overlay Method. IOP Conference Series: Earth and Environmental Science, 1240(1), 012016. https://doi.org/10.1088/1755-1315/1240/1/012016

[2] Lee, C., & Yeo, S. (2020). *Landslide Susceptibility Mapping in Malaysia: A Review and Perspectives*.

[3] Majid, N. A. (2020). Historical landslide events in Malaysia 1993-2019. Indian Journal of Science and Technology, 13(33), 3387–3399. https://doi.org/10.17485/ijst/v13i33.884

[4] Amir, M. S. I. I., Khan, M. M. K., Rasul, M. G., Sharma, R. H., & Akram, F. (2014). Watershed delineation and cross-section extraction from DEM for flood modelling. Proceedings of the 19th Australasian Fluid Mechanics Conference, AFMC 2014. Retrieved from http://hydrosheds.cr.usgs.gov

[5] Daffi, R., & Ahuchaogu, I. (2017). Delineation of River Watershed and Stream Network Using ILWIS 3.7.1 Academic. Asian Journal of Environment & Ecology, 4(4), 1–8. https://doi.org/10.9734/AJEE/2017/35972

[6] Mustaffa, A. A., Mohd, B. S., & Tan, L. W. (2016). Sub Catchment Area Delineation by Pour Point in Batu Pahat District. In Proceeding of the World Conference on Integration of Knowledge, 495-500.

[7] Datta, S., Karmakar, S., Mezbahuddin, S., Hossain, M. M., Chaudhary, B. S., Hoque, M. E., Abdullah Al Mamun, M. M., & Baul, T. K. (2022). The limits of watershed delineation: implications of different DEMs, DEM resolutions, and area threshold values. Hydrology Research, 53(8), 1047–1062. https://doi.org/10.2166/nh.2022.126

[8] Sukaesih Sitanggang, I., & Hasmadi Ismail, M. (2011). A Simple Method for Watershed Delineation in Ayer Hitam Forest Reserve using GIS. Bulletin Geospatial Sektor Awam, 1(1), 14–19. Retrieved from https://www.researchgate.net/publication/267385418

[9] Chang, K.-T. (2016). *Introduction to Geographic Information Systems (Chang, Ed.; Eighth)*.

[10] Pradhan, B., & Youssef, A. M. (2010). Manifestation of remote sensing data and GIS on landslide hazard analysis using spatial-based statistical models. Arabian Journal of Geosciences, 3(3), 319–326. https://doi.org/10.1007/s12517-009-0089-2

[11] Lee, S., & Pradhan, B. (2007). Landslide hazard mapping at Selangor, Malaysia using frequency ratio and logistic regression models. Landslides, 4(1), 33–41. https://doi.org/10.1007/s10346-006-0047-y

[12] Mohit, M. A., & Pradhan, B. (2014). Enhancing landslide susceptibility mapping through advanced GIS-based modelling techniques. Journal of Geographical Research, 56(2), 78–91.

[13] Li, X., Shen, H., Feng, R., Li, J., & Zhang, L. (2017). DEM generation from contours and a low-resolution DEM. ISPRS Journal of Photogrammetry and Remote Sensing, 134, 135–147. https://doi.org/10.1016/j.isprsjprs.2017.09.014

[14] Saraf, N. M., Kamarolzaman, K. N., Saad, N. M., Khalid, N., Abdul Rasam, A. R., & Othman, A. N. (2020). Data Verification of LiDAR-Derived DEM from Different Interpolation Techniques. In N. Alias & R. Yusof (Eds.), Charting the Sustainable Future of ASEAN in Science and Technology (pp. 361–375). Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-3434-8_31

[15] Mohamad, N. M., Halim, M. A., Hashim, N. I., Hashim, N., Naharudin, N. I. +A. C. Y.-R., & A., A. R. (2020). Identification of Groundwater Potential Zones in Langkawi Through Remote Sensing and Geographic Information System (GIS) Techniques, 2020 IEEE 10th International Conference on System Engineering and Technology (ICSET). Shah Alam, Malaysia, 2020, 26–31. https://doi.org/10.1109/ICSET51301.2020.9265145

[16] Abdul Rasam, A. R., Mardie, D., Mohd Said, M. S., Hashim, N., & Ghazali, R. (2023). Landslide susceptibility index and network mapping for spotting the affected and alternative planning routes. PLANNING MALAYSIA, 21(26). https://doi.org/10.21837/pm.v21i26.1266

[17] Khalid, N., Halim, M. A., & Shahimi, S. N. A. (2021). A Comparative Study of Delineated Watersheds Using ASTER and A Comparative Study of Delineated Watersheds Using ASTER and SRTM in Johor, Malaysia. International Journal of Geospatial and Environmental Research, 8(2). Retrieved from https://dc.uwm.edu/ijger/vol8/iss2/2

[18] Huang, F., Yang, Y., Jiang, B., Chang, Z., Zhou, C., Jiang, S.-H., Huang, J., & Yu, C. (2025). Effects of different division methods of landslide susceptibility levels on regional landslide susceptibility mapping. Bulletin of Engineering Geology and the Environment, 84. https://doi.org/10.1007/s10064-025-04281-4

[19] Ke, C., He, S., & Qin, Y. (2023). Comparison of natural breaks method and frequency ratio dividing attribute intervals for landslide susceptibility mapping. Bulletin of Engineering Geology and the Environment, 82, 384. https://doi.org/10.1007/s10064-023-03392-0

[20] Zhao, X., & Chen, W. (2020). Optimization of computational intelligence models for landslide susceptibility evaluation. Remote Sensing, 12(14), 2180. https://doi.org/10.3390/rs12142180

[21] Hilmin, A. W. (2024). *Landslide risk assessment in Hulu Langat, Selangor using weighted overlay method +AFs-Bachelor+IBk-s thesis, Universiti Teknologi MARA+AF0*. UiTM Institutional Repository.