JOURNAL FOR SOCIAL SCIENCE STUDIES
An International Peer-Reviewed Open Access Journal

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

ASSESSING FLOOD SUSCEPTIBILITY IN LALITPUR, NEPAL: A GIS-BASED MULTICRITERIA ANALYSIS USING THE ANALYTIC HIERARCHY PROCESS (AHP)

Saba Nazir Ahmad[1], Sumaira Kousar[*2], Laraib Gulzar[3], Qadeer Nazir[4], Sidra-Tul-Ain-Abbas[5]

[1,*2,3,4]*Department of Geography, University of the Punjab, Lahore 54000, Pakistan.*

[*2]sumaira.geog@pu.edu.pk

DOI: https://doi.org/10.5281/zenodo.22766320

Keywords
Topographic Wetness Index (TWI), Land use/Land cover (LULC), the Normalized Difference Vegetation Index (NDVI), Analytic Hierarchy Process (AHP), Geographic Information System (GIS

Article History
Received: 15 July 2026
Accepted: 01 September 2026
Published: 15 September 2026

Corresponding Author: *
Sumaira Kousar

Abstract
Flooding remains among the most recurrent and economically damaging natural hazards confronting mountainous and valley settlements across South Asia, and the rapidly urbanizing Kathmandu Valley of Nepal, of which Lalitpur forms an integral part, is no exception This study assesses the spatial susceptibility of Lalitpur district to flooding by integrating a Geographic Information System (GIS) with the Analytic Hierarchy Process (AHP), a multicriteria decision-making technique first formalized and applied widely to flood-hazard problems worldwide. Ten physical and hydrological criteria the Topographic Wetness Index (TWI), elevation, slope, precipitation, land use/land cover (LULC), the Normalized Difference Vegetation Index (NDVI), distance from rivers, distance from roads, drainage density, and soil type were derived in ArcGIS from a digital elevation model and ancillary spatial layers and compared pairwise using Saaty's nine-point scale. The resulting weights (distance from rivers, 14.1%; TWI, 13.8%; precipitation, 13.5%; elevation, 12.1%; slope, 9.9%; drainage density and soil type, 9.3% each; LULC, 6.6%; NDVI, 5.9%; and distance from roads, 5.6%) were combined through a weighted overlay to generate a flood susceptibility map. The results show that the low-lying, gently sloping southern part of Lalitpur, closer to drainage channels and with higher topographic wetness, is markedly more susceptible than the steep northern terrain a pattern consistent with comparable AHP-GIS studies elsewhere in the Kathmandu Valley and one that reinforces the case for embedding susceptibility mapping into local land-use planning and disaster

INTRODUCTION
Flood susceptibility describes the degree to which a location is predisposed to inundation as a function of relatively stable physical characteristics topography, land cover, soil, and hydrological connectivity as distinct from flood hazard, which

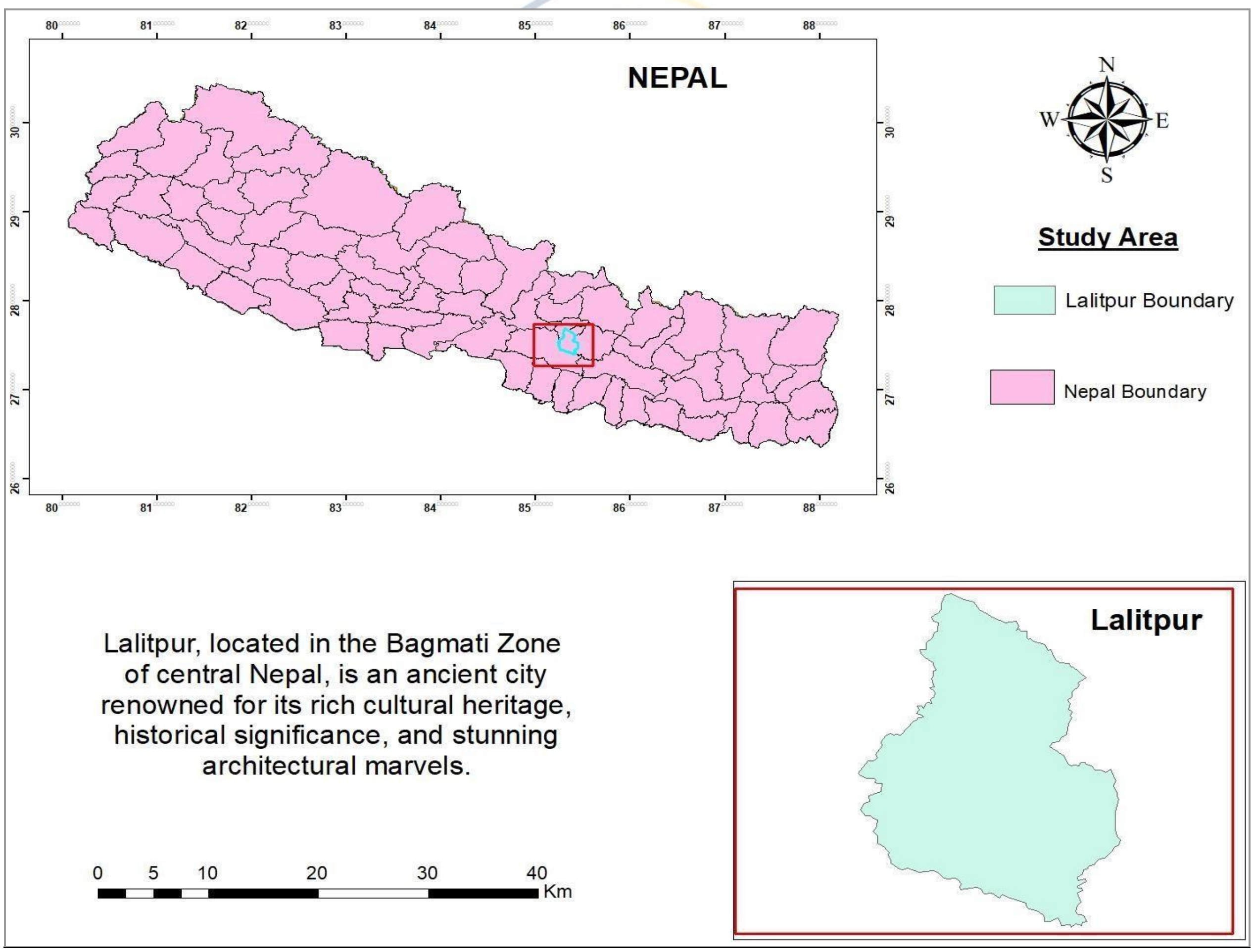
additionally incorporates the probability and magnitude of a triggering rainfall event (Merz et

JOURNAL FOR SOCIAL SCIENCE STUDIES
An International Peer-Reviewed Open Access Journal
ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

al., 2021). Mapping this spatial pattern is a prerequisite for almost every downstream disaster-management task, from zoning and evacuation planning to drainage design (Kader et al., 2024).

Nepal ranks among the more flood-exposed countries in South Asia, and within it the Kathmandu Valley comprising Kathmandu, Bhaktapur, and Lalitpur has seen a particularly steep rise in flood losses over the past three decades, driven less by any dramatic shift in rainfall climatology than by unplanned urban expansion, river encroachment, and the loss of natural floodplain storage (Thakuri et al., 2022; Thapa et al., 2024; Lamichhane et al., 2025). The catastrophic September 2024 floods, which struck Lalitpur's Bagdol area and the Nakkhu corridor particularly hard, are the most recent and severe illustration of this vulnerability and have renewed attention on the need for locally resolved susceptibility maps rather than valley-wide generalisations (Sharma et al., 2025; Chaudhary et al., 2024).

Against this backdrop, the present study applies a GIS-based Analytic Hierarchy Process to Lalitpur district to identify which parts of the landscape are structurally more flood-prone. AHP was chosen because it allows a transparent, expert-informed weighting of multiple incommensurable physical criteria without requiring long historical flood-event inventories, and because it has already performed well in comparable data-scarce, monsoon-influenced settings, including the wider Kathmandu Valley itself (Chaulagain et al., 2023; Chaudhary et al., 2024; Adhikari, 2025).



Location Map of Lalitpur District, Kathmandu Valley, Nepal

Lalitpur, one of the three districts of the Kathmandu Valley in Bagmati Province, is drained principally by the Bagmati and Nakkhu rivers and their tributaries. Its topography ranges from a low-lying, gently sloping floodplain in the south to steep hill terrain toward the north, with elevations across the wider area varying from roughly 1,300 to 2,200 metres above sea level. This gradient bears directly on flood behaviour: the southern floodplain, close to the Bagmati corridor, has repeatedly been identified as the area most exposed to monsoon inundation, a pattern corroborated by post-event assessments of the 2024 floods (Sharma et al., 2025; Thapa et al., 2024). Like the rest of the valley, Lalitpur has urbanised rapidly and largely without regulation over the past three decades, a process widely implicated in intensifying flood impacts even where rainfall totals have not correspondingly increased (Thapa et al., 2024; Lamichhane et al., 2025).

The Analytic Hierarchy Process, developed by Saaty (1980, 1984), decomposes a complex decision into a hierarchy of criteria, derives relative weights through pairwise comparison, and checks the logical consistency of those judgements through a consistency ratio. Because flood susceptibility is inherently multidimensional shaped simultaneously by terrain, climate, land cover, and drainage AHP has become one of the most widely applied multicriteria tools in flood-hazard research, precisely because, unlike statistical or machine-learning approaches, it does not require long historical flood-event inventories (Rahmati et al., 2016; Ghosh & Kar, 2018; Adhikari, 2025). International applications span highly diverse settings: Hammami et al. (2019) and Dahri and Abida (2017) in Tunisia, Ghosh and Kar (2018) and Ali et al. (2019) in West Bengal, Dutta and Deka (2024) in Assam's Brahmaputra floodplain, Shadmaan and Hassan (2024) and Kader et al. (2024) in Bangladesh, Latif and He (2025) in Punjab, Pakistan, Restianto et al. (2024) in Indonesia, and Pimenta et al. (2025) in urban Amazonia each confirming that proximity to drainage, low elevation, and gentle slope consistently dominate flood susceptibility even as the exact rank order of criteria shifts with local geomorphology.

Within Nepal, AHP-based flood mapping has gained momentum only recently, with the Kathmandu Valley receiving the closest scrutiny given its population density and repeated losses. Chaulagain et al. (2023) found proximity to rivers and low elevation to dominate susceptibility in Kathmandu Metropolitan City, a conclusion echoed by Chaudhary et al. (2024) in a valley-wide watershed assessment; machine-learning alternatives have also been explored by Maharjan et al. (2024) in the Mohana-Khutiya basin and Duwal et al. (2023) in the Karnali basin. Adhikari (2025) further showed that a lean, open-data AHP model built around only six criteria can still generate a credible susceptibility map for a data-scarce municipality, directly relevant given the similar absence of comprehensive gauge records in much of Lalitpur. A parallel body of post-disaster research Thapa et al. (2024) on sediment-driven channel risk, and Sharma et al. (2025) and Lamichhane et al. (2025) on the September 2024 event attributes the valley's escalating losses to extreme rainfall compounding four decades of encroachment and floodplain-storage loss. This literature converges on two points that motivate the present study: a small, physically meaningful criterion set is generally sufficient for reliable susceptibility mapping even where data are scarce (Adhikari, 2025), and the criteria that govern susceptibility elsewhere in the valley are equally relevant to Lalitpur given the shared physiography of the valley floor.

Materials and Methods

Ten flood-conditioning layers were derived in ArcGIS. A digital elevation model (DEM) supplied the base surface from which slope, aspect, hillshade, elevation classes, the Topographic Wetness Index, and the stream network were derived through standard terrain analysis. LULC and NDVI were extracted from satellite imagery, soil type from available pedological mapping, and precipitation was interpolated from valley station

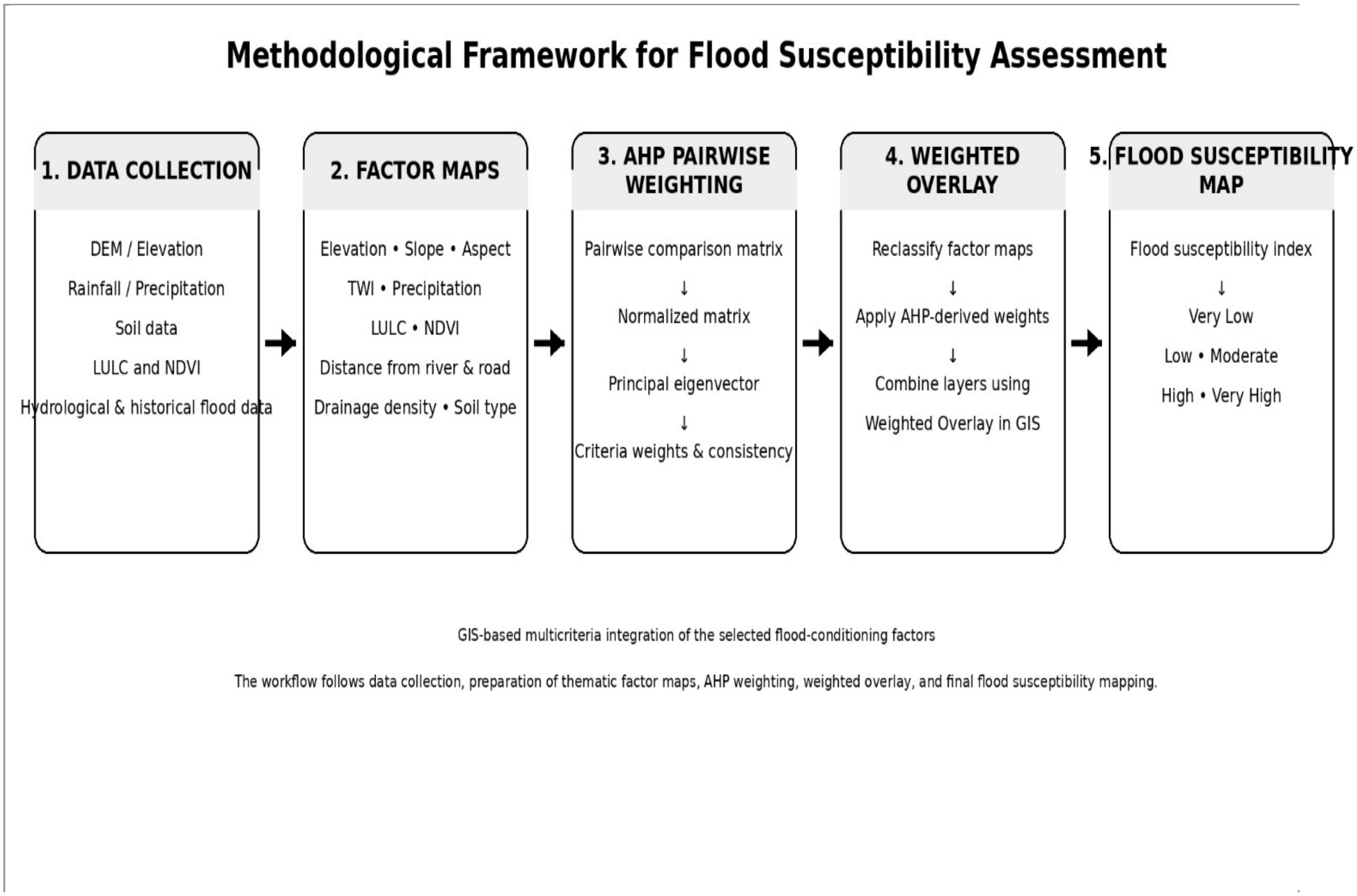
JOURNAL FOR SOCIAL SCIENCE STUDIES
An International Peer-Reviewed Open Access Journal
ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

records. Distance-from-river and distance-from-road layers were generated by Euclidean distance analysis of the digitised networks, and drainage density was computed as channel length per unit area a criterion set that mirrors comparable AHP studies in South Asia and beyond (Kader et al., 2024; Chaulagain et al., 2023; Rahmati et al., 2016; Pimenta et al., 2025).

Following Saaty (1980, 1984), the ten criteria were arranged into a single-level hierarchy beneath the goal of flood susceptibility, and every pair of criteria was compared using Saaty's nine-point scale, in which 1 denotes equal importance and 9 denotes extreme importance, with reciprocals assigned automatically. The principal eigenvector of the resulting matrix, once normalised, yielded the relative weight of each criterion, and internal consistency was verified through the Consistency Index (CI) and Consistency Ratio (CR):

$CI = (\lambda^{max} - n) / (n - 1)$ $CR = CI / RI$

where λmax is the principal eigenvalue, n the number of criteria, and RI Saaty's random consistency index for a matrix of that size; a CR below 0.10 indicates acceptable consistency (Saaty, 1980), a threshold the matrix used here satisfied. Each criterion layer was then reclassified into five ordinal susceptibility classes and combined through a weighted linear overlay, following the same general procedure used in comparable AHP-GIS flood studies in Nepal and elsewhere (Adhikari, 2025; Hammami et al., 2019).



Methodological framework for flood susceptibility assessment using the Analytic Hierarchy Process (AHP) and weighted overlay analysis in Lalitpur, Nepal.

Flood-Conditioning Factors

The ten criteria fall naturally into three thematic groups, each discussed below with the individual parameter maps referenced in Figure 2.

Results and Discussions

Terrain factors: elevation, slope, aspect, hillshade

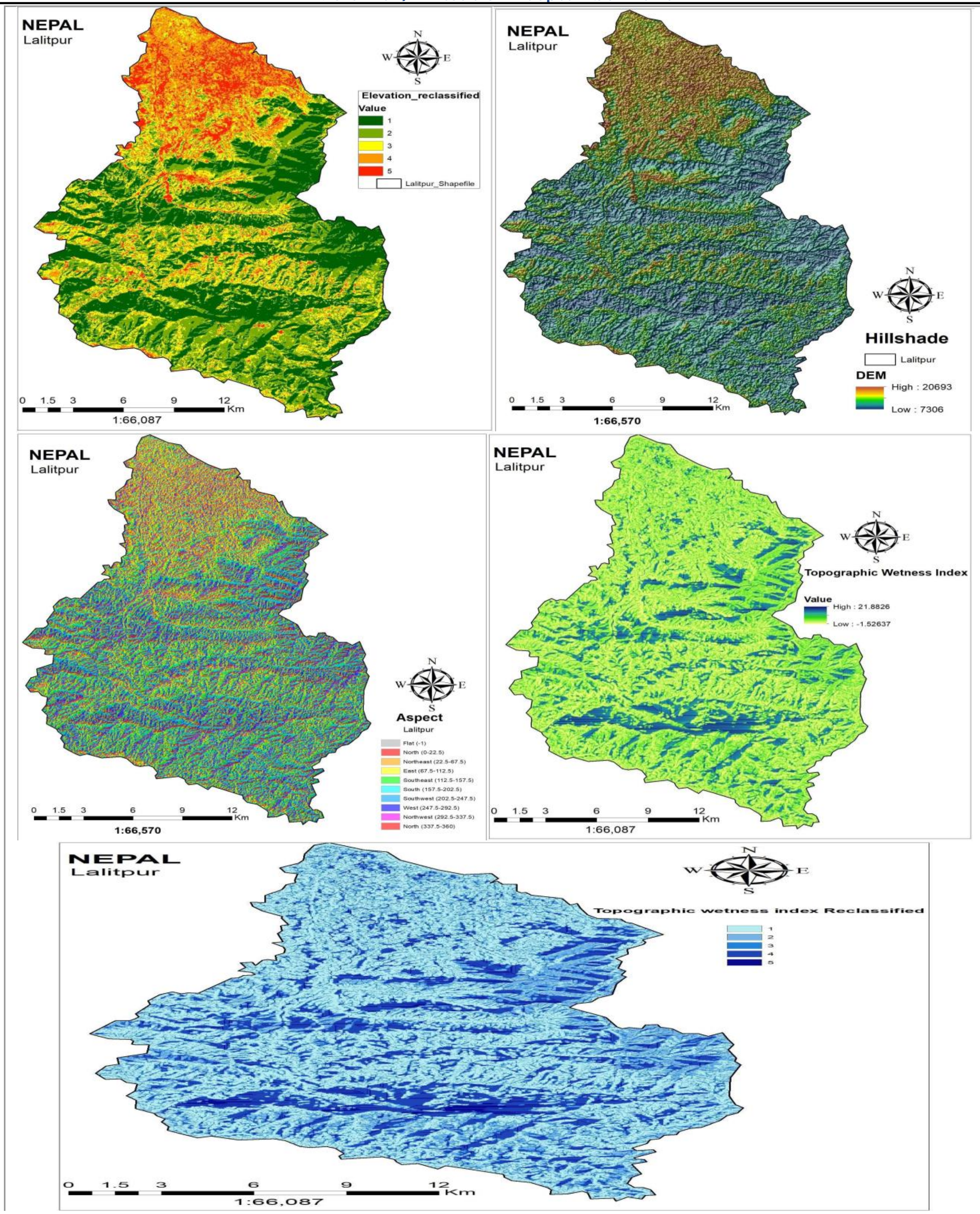
Elevation across the wider study area ranges from roughly 1,300 to 2,200 metres, and lower-lying zones are consistently more susceptible because they represent the natural collection points for surface and channel flow (Rahmati et al., 2016; Adhikari, 2025); it received the second-highest weight overall (12.1%). Slope governs runoff velocity and infiltration time, and in Lalitpur the gentle, low-lying south contrasts sharply with the steep north, mirroring the pattern reported by Hammami et al. (2019) and Selvam and Antony Jebamalai (2023), for a weight of 9.9%. Aspect, which shapes solar exposure and orographic rainfall distribution, shows south- and southwest-facing slopes more directly exposed to moisture-laden monsoon winds (Adhikari, 2025), while hillshade offers a complementary visual check on the relief pattern already captured by slope and elevation. The Topographic Wetness Index, which estimates moisture accumulation from upslope contributing area and local slope, received the single highest weight of any criterion (13.8%), with high-TWI zones concentrated along the valley floor consistent with its prominence in comparable regional assessments (Kader et al., 2024; Vilasan & Kapse, 2022).

JOURNAL FOR SOCIAL SCIENCE STUDIES

An International Peer-Reviewed Open Access Journal

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063

Volume 4 • Issue 5 • September 2026



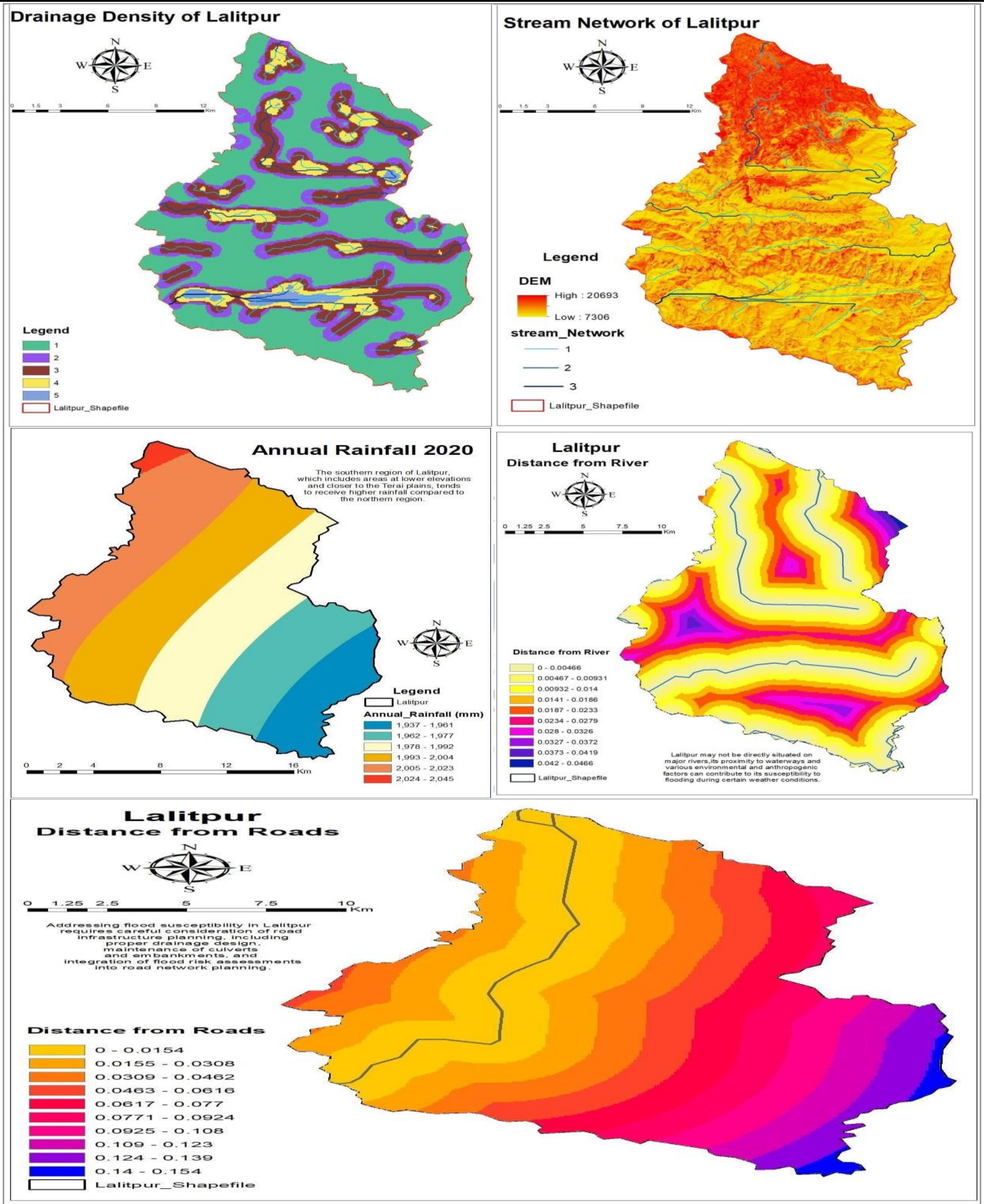
Five-panel composite figure (terrain factor maps of lalitpur

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

Hydrological factors: precipitation, drainage density, and distance from rivers and roads

Precipitation, the ultimate driver of flood generation, is expected to be orographically higher on Lalitpur's windward southern slopes and received the third-highest weight (13.5%), consistent with its dominant or co-dominant role in comparable AHP models (Dutta & Deka, 2024; Restianto et al., 2024). Drainage density, expressed as channel length per unit area, captures how efficiently a landscape conveys storm runoff and received a weight of 9.3% (Pimenta et al., 2025), with high-density zones aligning closely with the TWI and river-proximity results. Distance from rivers, the most direct determinant of susceptibility since flooding originates at the channel and propagates outward across adjacent low land (Selvam & Antony Jebamalai, 2023; Ghosh & Kar, 2018; Ali et al., 2019), received the single highest weight of all ten criteria (14.1%), underscoring the particular importance of the Bagmati and Nakkhu corridors. Distance from roads, which alters natural drainage through compaction and impervious surfacing but generally exerts a more modest influence than purely hydrological variables (Chaulagain et al., 2023), received the lowest weight overall (5.6%).

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026



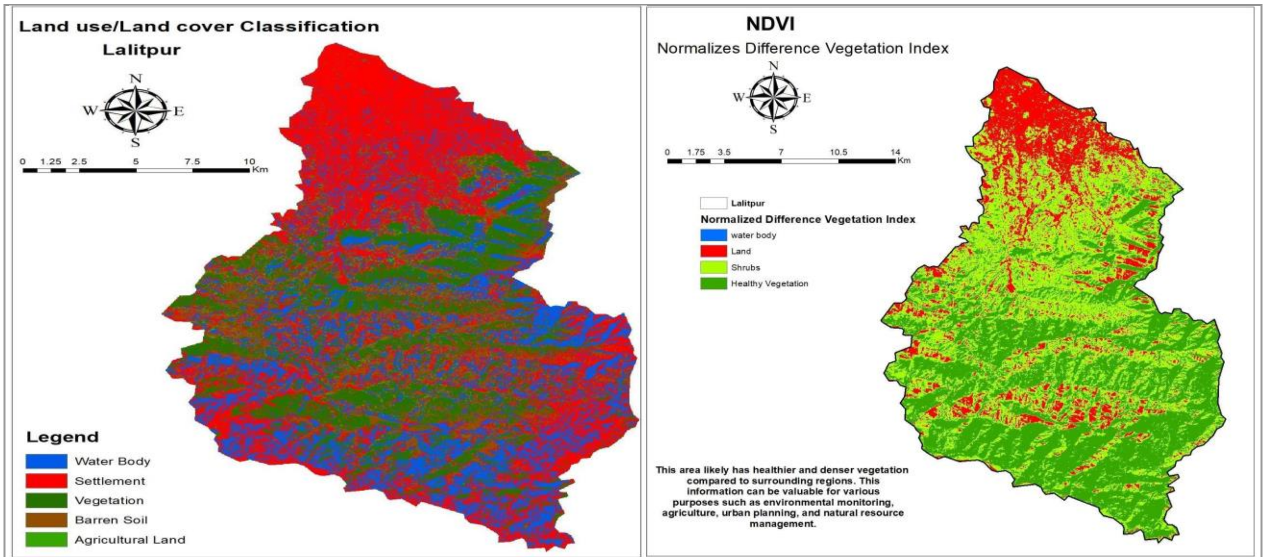
Five-panel composite figure (hydrological factor maps of lalitpur)

JOURNAL FOR SOCIAL SCIENCE STUDIES
An International Peer-Reviewed Open Access Journal

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

Land-cover factors: LULC, NDVI

Land use and land cover determine the share of rainfall converted to runoff, with impervious built-up surfaces generating substantially more runoff than vegetated land; Lalitpur's more built-up north contrasts with its greener south, mirroring the valley-wide urbanization pattern documented since 1990 (Lamichhane et al., 2025; Thapa et al., 2024), and LULC received a weight of 6.6%. NDVI, a proxy for vegetation density and rainfall interception, received a comparatively modest weight of 5.9%, consistent with its secondary role in comparable studies (Pimenta et al., 2025).



Two-panel composite figure (land-cover factor maps of lalitpur)

Soil type, which governs infiltration versus runoff through texture and permeability, received a weight of 9.3%, tied with drainage density, in line with its treatment as a distinct criterion in numerous flood-susceptibility frameworks (Pimenta et al., 2025; Vilasan & Kapse, 2022).

Results: AHP Weights and Flood Susceptibility Map

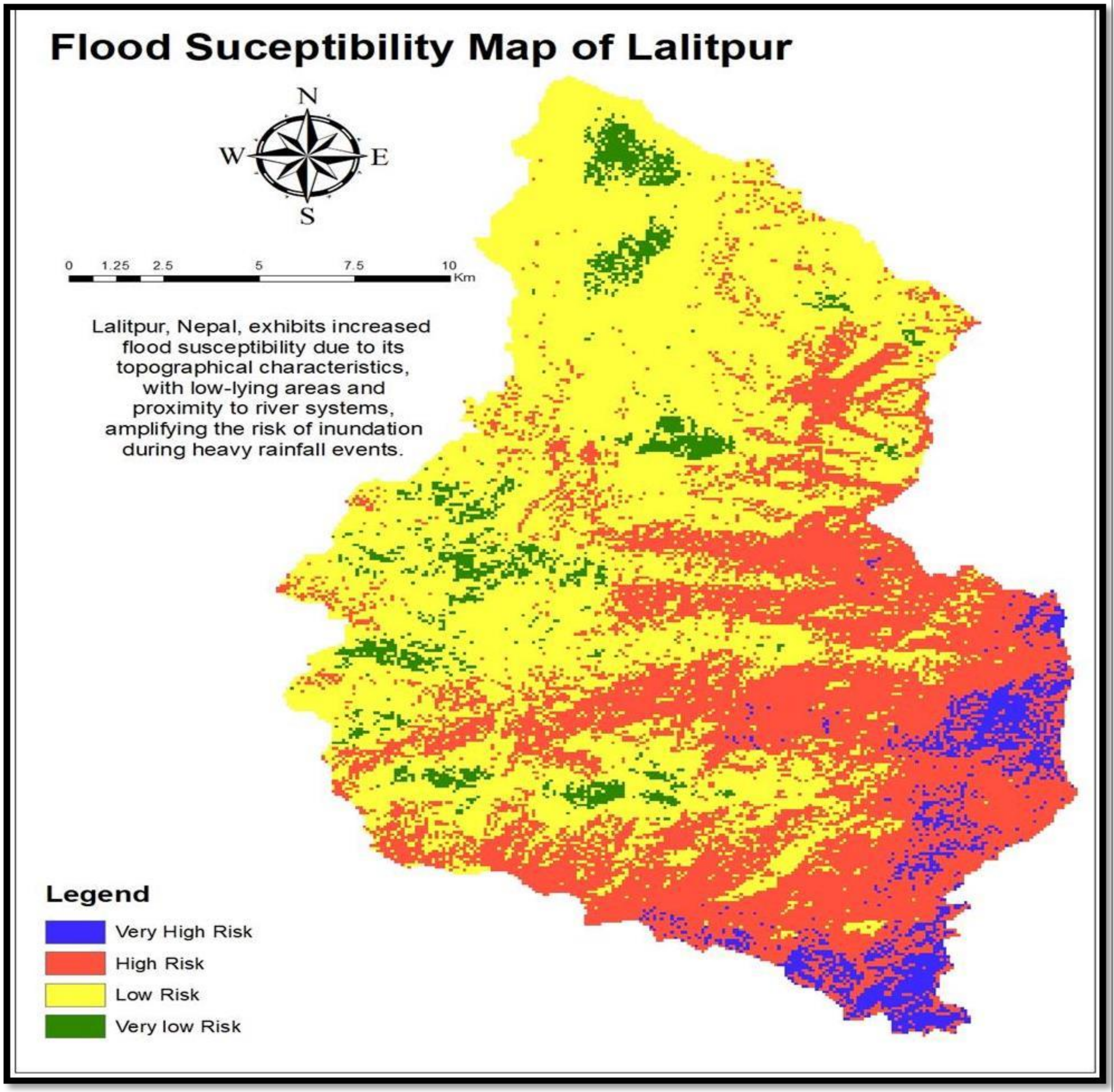
Table 1 summarizes the normalized criterion weights derived from the pairwise comparison matrix. Distance from rivers (14.1%) and TWI (13.8%) emerged as the most influential criteria, followed closely by precipitation (13.5%) and elevation (12.1%); slope, drainage density, and soil type occupied an intermediate tier (9.3–9.9%), while LULC, NDVI, and distance from roads contributed the smallest weights (5.6–6.6%). This ranking is broadly consistent with the pattern reported for the wider Kathmandu Valley by Chaulagain et al. (2023) and Chaudhary et al. (2024), both of whom likewise found drainage proximity and topographic wetness to outweigh land-cover and infrastructural criteria.

Table 1. Normalized AHP weights of flood-conditioning criteria for Lalitpur, Nepal.

#	Criterion	Normalized Weight (%)	Rank
1	Distance from Rivers	14.1	1st
2	Topographic Wetness Index (TWI)	13.8	2nd
3	Precipitation	13.5	3rd
4	Elevation	12.1	4th
5	Slope	9.9	5th

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

#	Criterion	Normalized Weight (%)	Rank
6	Drainage Density	9.3	6th (tie)
7	Soil Type	9.3	6th (tie)
8	Land Use / Land Cover (LULC)	6.6	8th
9	NDVI	5.9	9th
10	Distance from Roads	5.6	10th

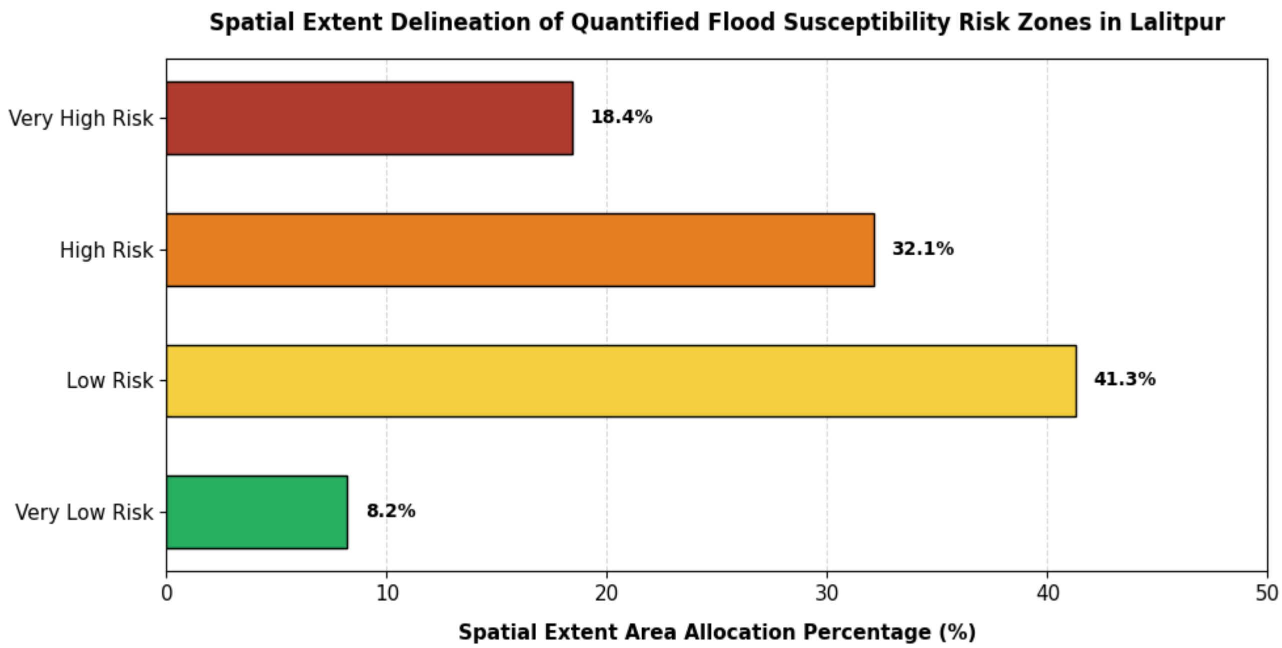


FINAL FLOOD SUSCEPTIBILITY MAP
Flood Susceptibility Map of Lalitpur (Weighted Overlay of All Ten Criteria, Classified from Very Low to Very High Susceptibility)

JOURNAL FOR SOCIAL SCIENCE STUDIES
An International Peer-Reviewed Open Access Journal
ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

The composite map shows a clear north–south gradient: very high and high susceptibility concentrate along the low-lying southern floodplain adjacent to the Bagmati and Nakkhu corridors, moderate susceptibility spans the transitional mid-elevation zone, and very low to low susceptibility is confined to the steep, forested north. This pattern is consistent with the individual-criterion results above and with the documented flood impacts in Lalitpur's Bagdol area along the Bagmati corridor during the September 2024 event (Sharma et al., 2025).

These results reinforce a conclusion that now recurs across nearly every AHP-based flood assessment in the Kathmandu Valley and comparable monsoon-influenced settings: susceptibility is overwhelmingly a function of proximity to drainage and moisture-retention capacity rather than of land cover or infrastructure alone (Chaulagain et al., 2023; Chaudhary et al., 2024; Kader et al., 2024). That distance from rivers and TWI together account for nearly 28% of the composite weight here echoes the emphasis on hydrological proximity in Tunisian, Bangladeshi, and Brazilian AHP studies alike (Hammami et al., 2019; Shadmaan & Hassan, 2024; Pimenta et al., 2025), suggesting a genuinely cross-regional physical regularity rather than a local artefact.



The comparatively modest weights on LULC and NDVI should not be read as evidence that land-cover change is unimportant: the AHP model isolates structural terrain susceptibility, whereas post-2024 research on the valley shows that unplanned urban expansion and river-corridor encroachment have been decisive in converting a structurally susceptible landscape into one that now floods more often and more severely (Lamichhane et al., 2025; Thapa et al., 2024). As in comparable open-data AHP studies, the weights here rest on expert-informed pairwise judgement rather than a long historical flood inventory, so future work should validate the map against documented inundation extents for instance via ROC-AUC analysis, as used elsewhere (Kader et al., 2024; Vilasan & Kapse, 2022) and incorporate finer-resolution elevation and rainfall data where available (Adhikari, 2025)

JOURNAL FOR SOCIAL SCIENCE STUDIES

An International Peer-Reviewed Open Access Journal

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063

Volume 4 • Issue 5 • September 2026

	Criterion	Comment	Weights	+/-
1	TWI		13.8%	5.7 %
2	Elevation		12.1%	2.7 %
3	Slope		9.9%	4.1 %
4	Precipitation		13.5%	5.5 %
5	LULC		6.6%	3.7 %
6	NDVI		5.9%	2.4 %
7	Distance from river		14.1%	6.2 %
8	Distance from road		5.6%	2.4 %

Result										
	Eigenvalue					Lambda:	10.730		MRE:	40.4 %
	Consistency Ratio	0.37	GCI:	0.20	Psi:	#REF!	CR:	5.5%		

Matrix		TWI	Elevation	Slope	Precipitation	LULC	NDVI	Distance from river	Distance from road	Drainage density	Soil type	normalized principal Eigenvector
		1	2	3	4	5	6	7	8	9	10	
TWI	1	1	1	1	1	3	5	1	3	1	1	13.78 %
Elevation	2	1	1	1	1	2	3	1	3	1	1	12.07 %
Slope	3	1	1	1	1	3	1	1/2	1	1	1	9.90 %
Precipitation	4	1	1	1	1	3	2	2	3	1	1	13.45 %
LULC	5	1/3	1/2	1/3	1/3	1	1	1/3	3	1	1	6.62 %
NDVI	6	1/5	1/3	1	1/2	1	1	1/5	1	1	1	5.87 %
Distance from river	7	1	1	2	1/2	3	5	1	3	1	1	14.08 %
Distance from road	8	1/3	1/3	1	1/3	1/3	1	1/3	1	1	1	5.59 %
Drainage density	9	1	1	1	1	1	1	1	1	1	1	9.32 %
Soil type	10	1	1	1	1	1	1	1	1	1	1	9.32 %

JOURNAL FOR SOCIAL SCIENCE STUDIES
An International Peer-Reviewed Open Access Journal

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

Conclusion

This study applied a GIS-based Analytic Hierarchy Process to assess flood susceptibility across Lalitpur district, integrating ten physical and hydrological criteria into a single weighted composite map. Distance from rivers, TWI, and precipitation emerged as the three most influential determinants, together accounting for well over a third of the total weight, while land use, vegetation cover, and road proximity played a comparatively secondary role. The resulting map identifies the low-lying southern part of Lalitpur, adjacent to the Bagmati and Nakkhu corridors, as the zone of greatest concern a finding that aligns with the wider AHP literature on the Kathmandu Valley (Chaulagain et al., 2023; Chaudhary et al., 2024) and with the documented pattern of damage during the September 2024 disaster (Sharma et al., 2025; Lamichhane et al., 2025). Given the valley's continuing rapid urbanisation, these findings support embedding susceptibility mapping of this kind into local land-use planning, building-permit review, and disaster-preparedness protocols, so that future development in Lalitpur can be steered away from its most structurally flood-prone areas.

REFERENCES

Adhikari, P. (2025). Spatial multi-criteria-based assessment of susceptibility of flood using open-source data in ungauged local government region: A case of Dhanpati Sub-Metropolitan City, Nepal. Journal of Nepal Geological Society, 69, 59–68.

Ali, S. A., Khatun, R., Ahmad, A., & Ahmad, S. N. (2019). Application of GIS-based analytic hierarchy process and frequency ratio model to flood vulnerable mapping and risk area estimation at Sundarban region, India. Modeling Earth Systems and Environment, 5, 1083–1102.

Chaudhary, U., Shah, M. A. R., Shakya, B. M., & Aryal, A. (2024). Flood susceptibility and risk mapping of Kathmandu Valley watershed, Nepal. Sustainability, 16(16), 7101.

Chaulagain, D., Rimal, P. R., Ngando, S. N., Nsafon, B. E. K., Suh, D., & Huh, J.-S. (2023). Flood susceptibility mapping of Kathmandu metropolitan city using GIS-based multi-criteria decision analysis. Ecological Indicators, 154, 110653.

Dahri, N., & Abida, H. (2017). Monte Carlo simulation-aided analytical hierarchy process (AHP) for flood susceptibility mapping in Gabes Basin (southeastern Tunisia). Environmental Earth Sciences, 76(7), 302.

Dutta, P., & Deka, S. (2024). A novel approach to flood risk assessment: synergizing geospatial-based MCDM-AHP modelling, multicollinearity, and sensitivity analysis in the Lower Brahmaputra Floodplain, Assam. Journal of Cleaner Production, 467, 142985.

Duwal, S., Liu, D., & Pradhan, P. M. (2023). Flood susceptibility modeling of the Karnali river basin of Nepal using different machine learning approaches. Geomatics, Natural Hazards and Risk, 14(1), 2217321.

Ghosh, A., & Kar, S. K. (2018). Application of analytical hierarchy process (AHP) for flood risk assessment: A case study in Malda district of West Bengal, India. Natural Hazards, 94, 349–368.

Hammami, S., Zouhri, L., Souissi, D., Souei, A., Zghibi, A., Marzougui, A., & Dlala, M. (2019). Application of the GIS-based multi-criteria decision analysis and analytical hierarchy process (AHP) in the flood susceptibility mapping (Tunisia). Arabian Journal of Geosciences, 12(21), 653.

Kader, Z., Islam, M. R., Aziz, M. T., Hossain, M. M., Islam, M. R., Miah, M., & Jaafar, W. Z. W. (2024). GIS and AHP-based flood susceptibility mapping: A case study of Bangladesh. Sustainable Water Resources Management, 10(5), 170.

ISSN (Online): 3006-2071 | ISSN (Print): 3006-2063
Volume 4 • Issue 5 • September 2026

Lamichhane, K., Khadka, B., Acharya, B., Vishwakarma, K., Adhikari, S., K.C., R., Danegulu, A., Bhattarai, S., Regmi, A., & Subedi, M. (2025). Unraveling the causes and impacts of increasing flood disasters in the Kathmandu Valley: Lessons from the unprecedented September 2024 floods. Natural Hazards Research.

Latif, R. M. A., & He, J. (2025). Flood susceptibility mapping in Punjab, Pakistan: A hybrid approach integrating remote sensing and analytical hierarchy process. Water, 17.

Maharjan, M., Timilsina, S., Ayer, S., Singh, B., Manandhar, B., & Sedhain, A. (2024). Flood susceptibility assessment using machine learning approach in the Mohana-Khutiya River of Nepal. Natural Hazards Research, 4(1), 32–45.

Merz, B., Blöschl, G., Vorogushyn, S., Dottori, F., Aerts, J. C. J. H., Bates, P., Bertola, M., Kemter, M., Kreibich, H., Lall, U., & Macdonald, E. (2021). Causes, impacts and patterns of disastrous river floods. Nature Reviews Earth & Environment, 2(9), 592–609.

Pimenta, L., Duarte, L., Teodoro, A. C., Beltrão, N., Gomes, D., & Oliveira, R. (2025). GIS-based flood susceptibility mapping using AHP in the urban Amazon: A case study of Ananindeua, Brazil. Land, 14(8), 1543.

Rahmati, O., Zeinivand, H., & Besharat, M. (2016). Flood hazard zoning in Yasooj region, Iran, using GIS and multi-criteria decision analysis. Geomatics, Natural Hazards and Risk, 7(3), 1000–1017.

Restianto, M. O., Poniman, A., & Supriyatno, M. (2024). Analysis of flood susceptibility in Pati Regency using Geographic Information Systems (GIS) and Analytical Hierarchy Process (AHP). International Journal of Humanities Education and Social Sciences, 3(5).

Saaty, T. L. (1980). The analytic hierarchy process: Planning, priority setting, resource allocation. McGraw-Hill.

Saaty, T. L. (1984). The analytic hierarchy process: Decision making in complex environments. In R. Avenhaus & R. K. Huber (Eds.), Quantitative assessment in arms control (pp. 285–308). Springer.

Selvam, R. A., & Antony Jebamalai, A. R. (2023). Application of the analytical hierarchy process (AHP) for flood susceptibility mapping using GIS techniques in Thamirabarani river basin, Srivaikundam region, Southern India. Natural Hazards, 118(2), 1065–1083.

Shadmaan, M. S., & Hassan, K. M. (2024). Assessment of flood susceptibility in Sylhet using analytical hierarchy process and geospatial technique. Geomatica, 76(1), 100003.

Sharma, S., et al. (2025). Yesterday's extremes, today's new normal: Flood risk in the Kathmandu Valley, Nepal. Natural Hazards, 121(16), 19409–19423.

Thakuri, S., Parajuli, B. P., Shakya, P., Baskota, P., Pradhan, D., & Chauhan, R. (2022). Open-source data alternatives and models for flood risk management in Nepal. Remote Sensing, 14(22), 5660.

Thapa, S., Sinclair, H. D., Creed, M. J., Mudd, S. M., Attal, M., Borthwick, A., Ghimire, B. N., & Scott Watson, C. (2024). The impact of sediment flux and calibre on flood risk in the Kathmandu Valley, Nepal. Earth Surface Processes and Landforms, 49(2), 706–727.

Vilasan, R. T., & Kapse, V. S. (2022). Evaluation of the prediction capability of AHP and F-AHP methods in flood susceptibility mapping of Ernakulam district (India). Natural Hazards, 112(2), 1767–1793.