

A HYBRID AHP-GIS APPROACH FOR PRIORITIZING DIVORCE FACTORS AND MAPPING SPATIAL VULNERABILITY IN MEDAN CITY

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ABSTRACT

Divorce remains a persistent problem in Medan City, yet prior studies examine its causes in isolation, rarely linking them to spatial vulnerability. This study ranks the dominant causes of divorce and maps their spatial distribution across 21 districts. Judgments from 50 experts (judges, psychologists, family-law academics, advocates, religious counselors/mediators) were aggregated via the Analytical Hierarchy Process ($CR < 0.10$); GIS then applied Getis-Ord G_i^* hot-spot testing and a population-normalized ratio to 2020–2024 records from the Medan Religious Court, Disdukcapil, and BPS. The two components are combined interpretively, not through a fused weighted-overlay. Economic Factors were the dominant cause (35.38%), followed by Domestic Violence (28.91%); psychological/emotional violence (14.02%) was the most influential sub-criterion. Medan Marelan, Deli, Belawan, and Labuhan formed the highest-vulnerability cluster; Medan Johor had the lowest ratio and a confirmed Cold Spot. These are descriptive, non-causal findings that can inform targeted family-resilience policy.

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1. INTRODUCTION

Divorce carries broad psychological, social, and economic consequences for children, individuals, and family stability. Official data from the Central Bureau of Statistics (BPS) of North Sumatra Province show that divorce cases in Medan City continue to fluctuate, underscoring the need for analysis that accounts for their multidimensional causes and impacts [1].

Despite this body of work, existing studies typically identify individual causes of divorce in isolation and rarely translate a data-driven ranking of these causes into a spatial map of where vulnerability is concentrated. This study addresses that gap by combining the two.

Several factors have been identified as major contributors to divorce. Economic hardship is consistently reported as one of the dominant causes: household conflict linked to economic and domestic-violence pressure was documented in Batam City [2], economic instability was found to be the dominant driver of divorce decisions [3], and a significant relationship between unemployment, poverty, and divorce rates was reported for West Java [4]. In addition, instability in relationships and communication contributes to the deterioration of marital quality, as ineffective communication makes it difficult for couples to resolve conflicts constructively, a pattern documented in early-marriage divorce cases [5], long-distance marital communication [6], the influence of social media and technology on digital-era divorce [7], and disputes/quarrels as a leading cause of divorce in Indonesia [8].

Domestic violence (DV) including physical, psychological, and neglect-related abuse also significantly contributes to divorce because violence may create trauma, impair mental health, and negatively affect children's development [9]. Furthermore, moral and behavioral factors such as adultery, gambling, drug abuse, apostasy, and imprisonment may increase the risk of divorce because they weaken commitment, reduce trust, and disrupt family stability [10], [11], [12], [13], [14].

Social and technological developments have also introduced new external influences affecting household sustainability. Family interference and prolonged separation were found to intensify pre-existing conflict [13]; early or forced marriage was associated with heightened risk of early divorce due to limited emotional readiness [15]; unwise social media use was linked to a rise in wife-initiated divorce filings [16]; social media misuse combined with weak digital literacy was found to elevate divorce risk [17]; and, more broadly, external social-support conditions were shown to moderate family stress outcomes [18].

To address this complexity, integrating multi-criteria decision-making with spatial visualization has become a well-established international standard for vulnerability and risk zoning [19]. While traditionally applied to environmental hazards, this hybrid approach has increasingly expanded into socio-demographic and institutional vulnerability analysis [20]. By applying this global framework to a localized urban context, this study bridges the gap between expert-driven priority weights and descriptive spatial records.

The AHP-GIS hybrid pipeline itself combining multi-criteria weighting with spatial weighted overlay and Getis-Ord hot-spot analysis is well established in hazard and vulnerability mapping, including recent applications to flood-risk mapping [21] and land-use suitability analysis [22]. A systematic review has further shown that AHP-GIS integration can improve the accuracy of location-based decisions [23], and the approach has also been extended to infrastructure-prioritization mapping in Medan City itself [24]. The AHP-GIS pipeline itself is therefore not a novel method; the contribution claimed here is narrower and more specific: its first application to divorce, a social-behavioral rather than physical-hazard phenomenon, producing what is, to our knowledge, the first district-level divorce-vulnerability zoning for an Indonesian city. Accordingly, this study aims to determine the priority weights of divorce-causing factors using AHP and to analyze the spatial distribution of divorce vulnerability across Medan City using GIS, thereby producing region-based divorce-vulnerability maps that can support more targeted family-resilience policy.

2. RESEARCH METHOD

This applied research uses a quantitative approach that integrates the Analytical Hierarchy Process (AHP) and a Geographic Information System (GIS), combining expert-based decision weighting with spatial analysis. The two components are integrated interpretively, not through a mathematically fused spatial weighted-overlay: AHP produces a criterion-level priority ranking from expert judgment, and GIS independently produces a population-normalized spatial layer from administrative records, and the two are read side by side rather than merged into a single composite index; this scope limitation is elaborated at the end of this section and revisited in Section 3.4. Secondary data consist of aggregated divorce case numbers for 2020–2024 and administrative boundary data obtained from the Medan City Religious Court Class 1A, the Medan City Population and Civil Registration Office (Disdukcapil), and the Medan City Central Statistics Agency (BPS). Primary data were obtained from experts with competence in family law and social community matters in Medan City, selected using purposive (expert-judgment) sampling. Fifty experts were proportionally divided into five groups of ten: religious court judges, marriage psychologists/counselors, family law academics, advocates, and religious counselors or mediators.

Eligibility for each expert group required a minimum of five years of active professional practice directly related to divorce or family matters in Medan City (e.g., presiding over or handling divorce cases, providing marital counseling, or advising on family law), verified through the referring institution before an expert was invited to participate. The five groups were chosen to jointly represent the judicial, psychological, academic, legal-advocacy, and religious/mediation perspectives on divorce, so that no single professional viewpoint dominates the pairwise-comparison judgments; the equal group size (10 respondents each) was set deliberately to keep this cross-perspective balance rather than to claim statistical representativeness of any single profession's population in Medan City, a limitation we return to in Section 4. In terms of analytical hierarchy, this study is descriptive-applied rather than inferential: the AHP component produces a group priority-weighting of causal factors from

expert judgment (not a hypothesis test), and the GIS component produces a descriptive spatial classification of existing administrative case records (not a probabilistic model with confidence intervals for prediction). The two components are combined at the interpretive level, as detailed at the end of this section, and the hot-spot analysis reported in Section 3.2 is the only inferential (significance-tested) element in the pipeline.

The research variables comprise five main criteria[R3.1] for the causes of divorce: (1) Economic Factors (lack of financial support, poverty, debt, unemployment); (2) Relational and Communication Factors (disputes, arguments, disharmony, differences in principles); (3) Domestic Violence (physical, psychological, neglect); (4) Moral and Behavioral Factors (infidelity, gambling, drug use, apostasy, imprisonment); and (5) Social and External Factors (family interference, early marriage, social media, long-distance relationships).

Primary data were collected through structured questionnaires on the Saaty 1-9 scale, distributed to the 50 experts from [R4.1]November 2024 [R5.1]in the administrative area of Medan City. Individual responses were first tested for consistency; each respondent's judgments were accepted only when the Consistency Ratio (CR) was below the 0.10 threshold. The accepted individual matrices were then aggregated across all 50 respondents using the geometric mean, before proceeding to matrix normalization to obtain the priority vector (eigenvector), i.e., the relative weight of each criterion. Consistency was evaluated using the Consistency Index (CI) and Consistency Ratio (CR), following the eigenvalue-based consistency-checking procedure originally developed by Saaty as part of the classical AHP framework, in which judgments are accepted only when their deviation from perfect consistency falls below an empirically derived threshold [21]:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

where $\lambda_{\max}$ is the principal eigenvalue of the pairwise comparison matrix, n is the matrix order, and RI is Saaty's Random Index for a matrix of order n . Following Saaty's convention, an expert's judgment set is treated as acceptable and internally consistent when $CR < 0.1$.

The five causal criteria and twenty sub-criteria (Table 1) were operationalized directly from case-classification categories already used in Religious Court divorce rulings and Disdukcapil records (e.g., a ruling citing failure to provide maintenance was coded under "no livelihood," one citing physical abuse under "physical violence"), so that each questionnaire item corresponds to a documented legal category rather than a researcher-defined construct; this correspondence is also what allows the AHP weights and the administrative case counts in Section 3 to be discussed on common terms. Judgments were standardized across the 50 experts by using one fixed Saaty 1-9 pairwise-comparison instrument for all respondents, administered on paper with a researcher present to clarify item wording and resolve any logical contradictions in real time, so that differences between experts reflect substantive disagreement rather than differences in how the instrument was understood. All 50 experts approached under the purposive-sampling criteria in this section agreed to participate and completed the questionnaire in a single sitting (approximately 30-45 minutes, on paper, with the researcher present throughout), so the achieved sample equals the target sample with no non-response replacement. On individual Consistency Ratio testing, all 50 submitted matrices met $CR < 0.10$ on first submission at both the main-criteria level and every sub-criteria cluster; none required exclusion, re-administration, or replacement, so Table 4 reflects the full set of 50 respondents rather than a filtered subset. Regarding the secondary administrative data, we cross-checked yearly totals from the Religious Court, Disdukcapil, and BPS for 2020-2024 and confirmed that all five years were complete and reported at the district level for every one of the 21 districts, so the aggregated 2020-2024 figures used in Section 3 are drawn from a consistent, gap-free reporting period rather than a mix of complete and partial years. Institutional permission to use Religious Court, Disdukcapil, and BPS administrative records was obtained from each respective institution prior to data extraction, and all 50 expert respondents gave informed consent after being briefed on the study's purpose and the voluntary, anonymous handling of their pairwise-comparison responses; no individually identifying information about respondents or divorcing parties is reported anywhere in this study.

Spatial analysis using GIS was then applied to map the distribution pattern of divorce rates at the district level. Clusters of vulnerable areas were statistically identified using the Getis-Ord G_i^* hot-spot statistic, a distance-based local measure of spatial association originally introduced by Getis and Ord to detect concentrations of high or low values that global autocorrelation measures such as Moran's I may fail to reveal [25]:

$$G_i^* = \frac{\sum_{j=1}^n w_{ij}x_j - \bar{x} \sum_{j=1}^n w_{ij}}{S \sqrt{\frac{n \sum_{j=1}^n w_{ij}^2 - \left(\sum_{j=1}^n w_{ij} \right)^2}{n-1}}} \quad (3)$$

It is important to state precisely how the AHP weights and the spatial layers were combined, because the 20 sub-criteria used in the AHP model could not each be mapped as an independent spatially-distributed GIS layer: sub-criterion-level spatial data (e.g., a georeferenced count of poverty-driven or infidelity-driven divorce cases per district) were not available from the Religious Court, Disdukcapil, or BPS records used in this study. Only aggregate divorce-case counts and marriage counts were available at district resolution [26]. The AHP component therefore operated at the criterion-prioritization level establishing which causes matter most for Medan City as a whole while the GIS component operated on a single population-normalized spatial layer, the district divorce-vulnerability ratio:

$$\text{Vulnerability Ratio} = \frac{\text{Total Accumulated Divorce Cases}}{\text{Total Accumulated Marriages}} \quad (4)$$

Registered Marriages classified into five tiers using the Natural Breaks (Jenks) method, a classification approach originally proposed by Jenks to group data into classes that minimize within-class variance while maximizing between-class variance [26]. This ratio, rather than raw case counts, is used as the basis of the final vulnerability zoning reported in Section 3, because raw counts are confounded by the underlying population and marriage volume of each district and do not, by themselves, indicate relative risk. The full spatial computation base-map preparation, thematic mapping of accumulated cases, hot-spot analysis, ratio normalization, and Natural Breaks classification was carried out in ArcGIS. We note this as an explicit scope limitation: the present study integrates AHP-derived factor priorities and a single normalized GIS vulnerability layer interpretively, rather than through a literal 20-layer pixel-based Weighted Overlay; a genuine multi-layer overlay would require sub-criterion-level spatial data collection, which we identify as a direction for future research (Section 4).

3. RESULT AND ANALYSIS

3.1. AHP Weighting of Divorce-Causing Criteria

This section proceeds in three analytical steps, each answering a different question. Section 3.1 asks which causes matter most, using AHP to weight the five criteria and twenty sub-criteria from the 50 expert judgments. Section 3.2 asks where cases are currently concentrated in absolute terms, mapping the raw 2020-2024 case counts and testing them for statistically significant spatial clustering with Getis-Ord G_i^* . Because raw counts mechanically favor districts with large populations and many marriages, Section 3.3 re-expresses the same case data as a ratio of cases to registered marriages, which is the paper's operational definition of "vulnerability" and the basis for the final risk zoning; the raw-count and normalized pictures are therefore two views of the same underlying data; not competing results, and are reconciled explicitly in Section 3.3. To keep the two pictures visually distinct, raw counts are reported only in Figure 1b and Table 6 (hot-spot significance), while the normalized ratio and its risk zoning are reported only in Figure 3 and Table 7; no table mixes both metrics.

The spatial analysis units consist of the 21 districts of Medan City. The primary data used to determine the multi-criteria weights were obtained from 50 expert respondents using structured pairwise-comparison sheets; the historical divorce data (2020-2024) were obtained from the Class 1A Religious Court of Medan, Disdukcapil, and BPS.

To ensure valid input for the Multi-Criteria Decision Making (MCDM) process, each expert's pairwise judgments were first verified through individual Consistency Ratio testing following Saaty's AHP methodology. All 50 respondents satisfied $CR < 0.10$ at both the main-criteria level and every sub-criteria cluster; a complete per-respondent CR tabulation for Respondents 1–50 must accompany this submission as a Research Appendix; authors: attach that tabulation before resubmission, as it was referenced but not included in the version sent for review. The individual matrices were then decomposed into a structured decision hierarchy of 5 main criteria and 20 nested sub-criteria (Table 1), synthesized across all 50 respondents using the geometric mean, and normalized to obtain the group priority vector.

Table 1: Structural Hierarchy of Criteria and Sub-Criteria Triggering Divorce

Criteria	Sub-criteria
Economic Factor	1. No livelihood 2. Poverty 3. Debt 4. Unemployment
Factors of Relationship and Communication	1. Dispute 2. Quarrel 3. Disharmony 4. Difference in principles
Domestic Violence (DV)	1. Physical violence 2. Psychological/emotional violence 3. Abandonment
Moral and Behavioral Factors	1. Adultery 2. Gambling 3. Drunkenness/drugs 4. Apostasy 5. Prison
Social and External Factors	1. Family interference 2. Early/forced marriage 3. Social media 4. Long Distance Relationship (LDR)

As an illustrative example of the underlying computation (Respondent 1 of 50), Table 2 presents the raw pairwise comparison matrix for the main criteria, its normalization, and the resulting priority weights and row-lambda values; Table 3 presents the associated consistency test. The remaining 49 individual matrices, and the individual sub-criteria matrices for all five clusters, followed the identical procedure and are provided in full in the Research Appendix rather than reproduced table-by-table here, since it is the aggregated group matrix not any single respondent's raw input that drives the reported results.

Table 2: Pairwise Comparison, Normalization, and Weighting of Main Criteria - Respondent 1

Criterion	Economy	Relationship & Communication	DV	Moral	Social	Priority Weight	Row λ
Economy	1	3	1	3	3	0.340	5.153
Relationship & Communication	0.333	1	1	1	1	0.150	5.162
Domestic Violence	1	1	1	3	3	0.283	5.135
Moral & Behavioral	0.333	1	0.333	1	1	0.113	5.153
Social & External	0.333	1	0.333	1	1	0.113	5.153

The economic factor received the highest illustrative priority weight (0.340), followed by domestic violence (0.283), relationship and communication (0.150), and moral/behavioral and social/external factors, tied at 0.113. This ordering is consistent with the final aggregated result reported in Table 4.

Table 3: Consistency Test - Main Criteria, Respondent 1

Indicator	Value
$\lambda_{\max}$ (mean of row- λ column)	5.151
Consistency Index (CI)	0.0377
Random Index ($n = 5$) (RI)	1.12
Consistency Ratio (CR)	0.0337 (3.37%)

The arithmetic chain is directly reproducible from Table 2: $\lambda_{\max} = 5.151$ is the mean of the five row- λ values in Table 2's last column $((5.153 + 5.162 + 5.135 + 5.153 + 5.153)/5 = 5.151)$; $CI = (5.151 - 5)/(5 - 1) = 0.0377$; and $CR = CI/RI = 0.0377/1.12 = 0.0337$. Since $CR = 3.37\%$ is well below the 10% threshold, Respondent 1's main-criteria judgments are consistent, and as verified for all 50 respondents the pooled data are suitable for the group decision-making stage that follows.

The individual 1-9 scale judgments of all 50 respondents were pooled using the geometric mean, the standard aggregation rule for AHP group decision making (since individual ratio-scale judgments cannot be validly combined using an arithmetic mean), yielding a single representative pairwise matrix for both the main criteria and each of the five sub-criteria clusters. Table 4 reports the final, aggregated local and global weights, together with the resulting priority ranking of all 5 criteria and 20 sub-criteria.

Table 4: Final Aggregated (Group) Priority Weights and Ranking of Divorce-Causing Criteria and Sub-Criteria ($n = 50$ respondents)

Criteria	Local Weight	Sub-Criteria	Local Weight	Global Weight	Rank
Economy	0.3538	No livelihood	0.3681	0.1303	2
		Poverty	0.1972	0.0698	6
		Debt	0.2030	0.0718	5
		Unemployment	0.2318	0.0820	4
Relationship & Communication	0.1503	Dispute	0.3452	0.0519	8
		Argument	0.2188	0.0329	11
		Disharmony	0.2088	0.0314	12
		Difference in principles	0.2272	0.0342	10
Domestic Violence	0.2891	Physical violence	0.4272	0.1235	3
		Psychological/emotional	0.4849	0.1402	1
		Abandonment	0.0879	0.0254	14
Moral & Behavioral	0.1037	Affair (infidelity)	0.3538	0.0367	9
		Gambling	0.1498	0.0155	17
		Drunkenness/drugs	0.2896	0.0300	13
		Apostasy	0.1037	0.0107	19
		Prison	0.1031	0.0107	20
Social & External	0.1031	Family interference	0.5252	0.0541	7
		Early/forced marriage	0.1588	0.0164	16
		Social media	0.2046	0.0211	15
		LDR	0.1114	0.0115	18

At the main-criteria level, the Economic Factor received the highest local weight (35.38%), making it the most dominant driver of divorce in Medan City: financial pressure and unmet household needs increase the potential for prolonged conflict. Domestic Violence ranked second (28.91%); acts of physical or psychological violence reduce the sense of security within the household and can escalate to family breakdown. Relationship and Communication ranked third (15.03%), while Moral and Behavioral Factors and Social and External Factors were essentially tied for the lowest rank (10.37% and 10.31% respectively).

At the sub-criterion (global weight) level, psychological/emotional violence within the Domestic Violence cluster ranked first overall (14.02%), followed by lack of financial support within the Economic cluster (13.03%), and physical violence, again within the Domestic Violence cluster (12.35%). This indicates that, although Economic Factors carry the highest weight at the main-criteria level, the single most influential specific trigger of divorce in Medan City is psychological/emotional abuse. After all 20 global weights were summed, the total reconciled to 1.000 (100%), confirming the internal consistency of the aggregation from the criteria level down to the sub-criteria level.

3.2. Spatial Distribution of Divorce Cases and Hot-Spot Analysis

This section maps the spatial dimension of the study; as detailed in Section 2 and revisited in Section 3.4, the AHP weights from Section 3.1 and the GIS layer below are integrated interpretively and read side by side, rather than fused into a single weighted-overlay computation. Administrative boundary data (Shapefile format, WGS 1984 UTM Zone 47N) for the 21 districts were obtained from the Geospatial Information Agency (BIG); area and perimeter for each polygon are summarized in Table 5.

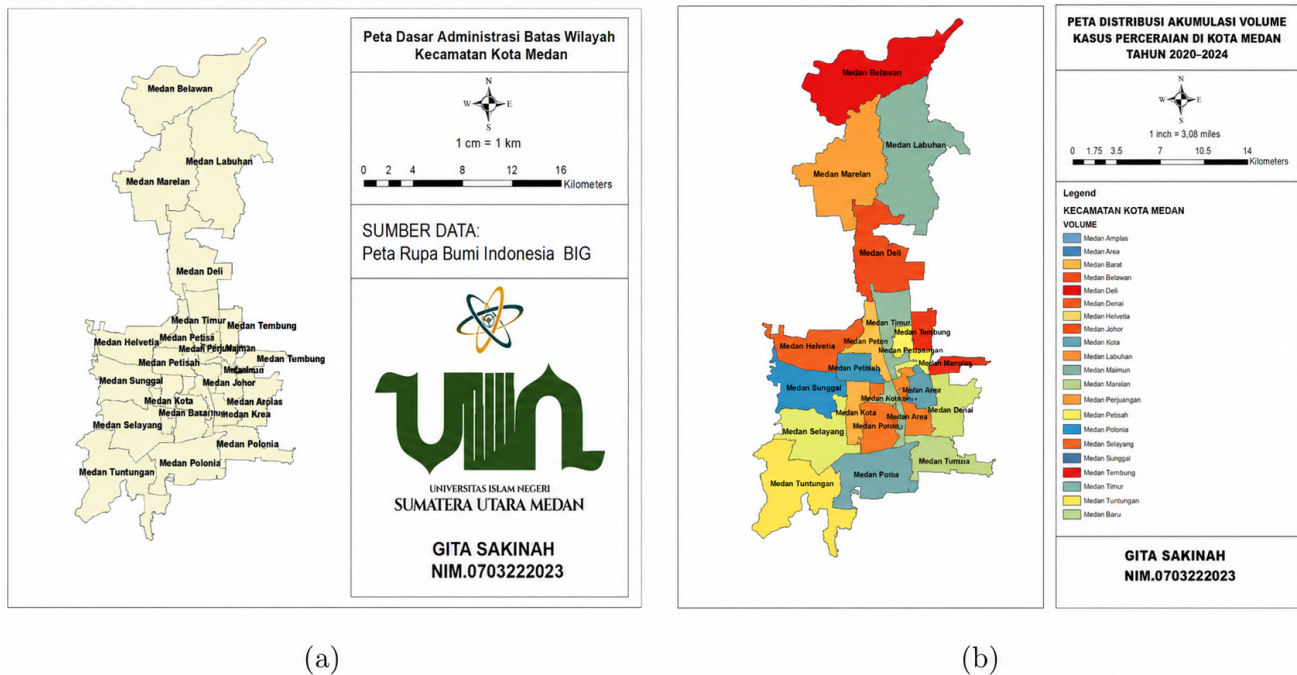


Figure 1. Basic spatial data and absolute case volume, Medan City 2020-2024: (a) administrative boundaries (BIG); (b) accumulated case volume by district (Graduated Colors).

Table 5: Administrative Characteristics of the 21 Districts of Medan City

No.	District	Code	Perimeter (km)	Area (km ²)
1	Medan Kota	12.71.01	14.24	5.27
2	Medan Sunggal	12.71.02	22.35	15.44
3	Medan Helvetia	12.71.03	21.98	13.16
4	Medan Denai	12.71.04	16.92	9.05
5	Medan Barat	12.71.05	16.21	5.33
6	Medan Deli	12.71.06	28.15	20.84
7	Medan Tuntungan	12.71.07	40.12	20.68
8	Medan Belawan	12.71.08	31.45	26.25
9	Medan Amplas	12.71.09	21.34	11.19
10	Medan Area	12.71.10	8.88	3.52
11	Medan Johor	12.71.11	27.03	14.58
12	Medan Marelan	12.71.12	31.16	23.82
13	Medan Labuhan	12.71.13	34.38	36.67
14	Medan Tembung	12.71.14	18.77	7.99
15	Medan Maimun	12.71.15	11.83	2.98
16	Medan Polonia	12.71.16	17.51	9.01
17	Medan Baru	12.71.17	13.66	5.84
18	Medan Perjuangan	12.71.18	13.71	4.09
19	Medan Petisah	12.71.19	10.20	6.82
20	Medan Timur	12.71.20	18.56	7.76
21	Medan Selayang	12.71.21	24.42	12.81

After the base map was prepared, the total 2020-2024 divorce records from the Religious Court and Disdukcapil (125,227 cases in aggregate) were joined to the district attribute table. The absolute distribution (Figure 1b) shows the highest case volumes in Medan Helvetia (9,188), Medan Sunggal (8,952), and Medan Johor (8,813), and the lowest in Medan Baru (2,219). Because these are raw counts, they are strongly influenced by each district's underlying population and marriage volume; Section 3.3 normalizes these counts before drawing any vulnerability conclusions.

Getis-Ord G_i^* hot-spot analysis was applied to test whether this distribution forms statistically significant spatial clusters rather than a random pattern (Table 6, Figure 2a).

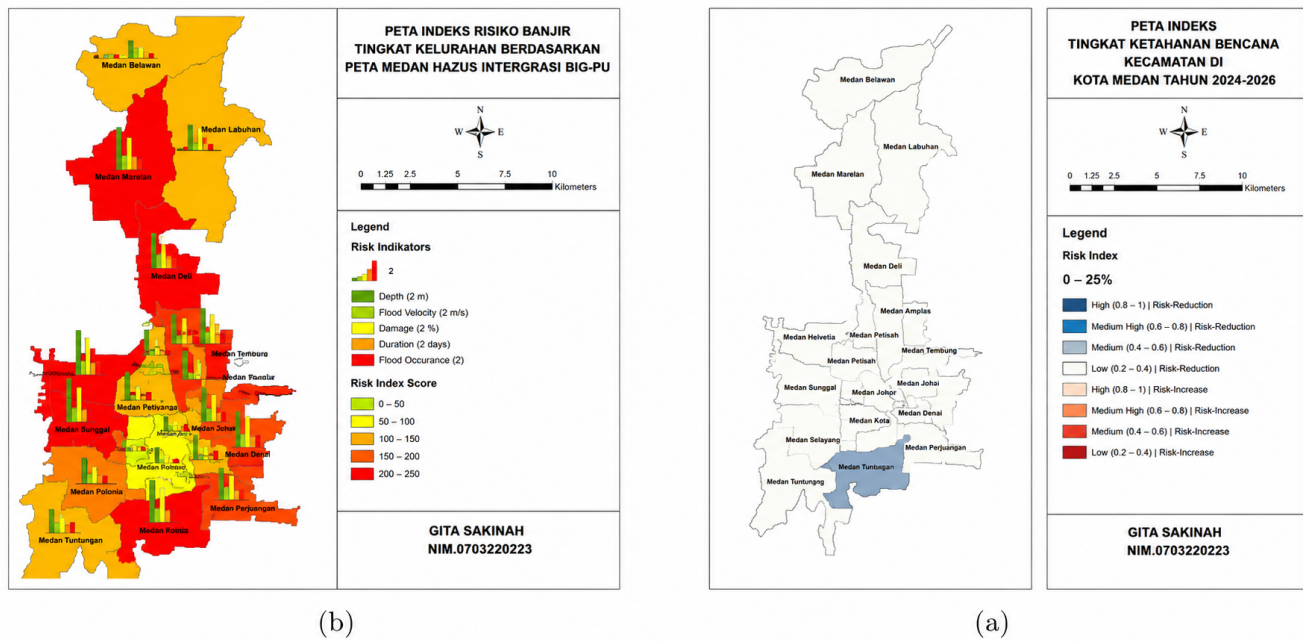


Figure 2. (a) Getis-Ord G_i^* spatial-cluster significance map; (b) annual case trend, 2020-2024, by district.

Table 6: Getis-Ord G_i^* Spatial Statistics for Divorce Cases (2020–2024)

No.	District	Z-Score	P-Value	Gi_Bin	Total Cases
1	Medan Kota	-1.1936	0.2326	0	4,168
2	Medan Sunggal	-0.7717	0.4403	0	8,952
3	Medan Helvetia	0.0145	0.9884	0	9,188
4	Medan Denai	-0.5638	0.5729	0	7,473
5	Medan Barat	-0.4181	0.6759	0	4,323
6	Medan Deli	0.5343	0.5931	0	8,465
7	Medan Tuntungan	0.1341	0.8933	0	3,847
8	Medan Belawan	-1.0793	0.2805	0	3,934
9	Medan Amplas	-0.2356	0.8137	0	6,592
10	Medan Area	-1.7531	0.0796	-1 (90% CI)	7,040
11	Medan Johor	-2.0423	0.0411	-2 (95% CI)	8,813
12	Medan Marelan	0.4942	0.6212	0	8,505
13	Medan Labuhan	-0.1714	0.8639	0	4,857
14	Medan Tembung	-0.5700	0.5687	0	7,323
15	Medan Maimun	-1.2873	0.1980	0	3,273
16	Medan Polonia	-1.1164	0.2643	0	3,284
17	Medan Baru	-0.8737	0.3823	0	2,219
18	Medan Perjuangan	-1.8644	0.0623	-1 (90% CI)	5,843
19	Medan Petisah	-0.9947	0.3199	0	4,482
20	Medan Timur	0.2883	0.7731	0	6,952
21	Medan Selayang	-0.7997	0.4239	0	5,694

The Getis-Ord G_i^* results identify three, not one, statistically significant Cold Spot districts: Medan Johor ($G_i\text{Bin} = -2$, 95% confidence), and Medan Area and Medan Perjuangan ($G_i\text{Bin} = -1$, 90% confidence each). The correct count is 18 districts with a random, not-significant spatial pattern ($G_i\text{Bin} = 0$), and 3 districts forming a statistically significant low-vulnerability (Cold Spot) cluster concentrated in the southern part of the city, indicating a degree of collective family resilience in that zone. The annual trend (Figure 2b) shows a marked rise from 2020 to 2022 across most districts, followed by a plateau at a comparatively high level in 2023-2024; this coincides with, but was not directly tested against, the period following the COVID-19 pandemic, so we describe it here only as a temporal coincidence rather than a confirmed causal mechanism, pending a dedicated time-series or difference-in-differences analysis in future work.

3.3. Population-Normalized Vulnerability Ratio and Final Risk Zoning

Because the raw case counts in Section 3.2 are confounded by each district's population and marriage volume, a normalized vulnerability ratio was computed by dividing accumulated divorce cases by accumulated registered marriages over the same 2020–2024 window, and classified into five tiers using Natural Breaks (Jenks). This ratio, rather than the raw case count, is used as the paper's final measure of relative divorce vulnerability (Table 7, Figure 3).

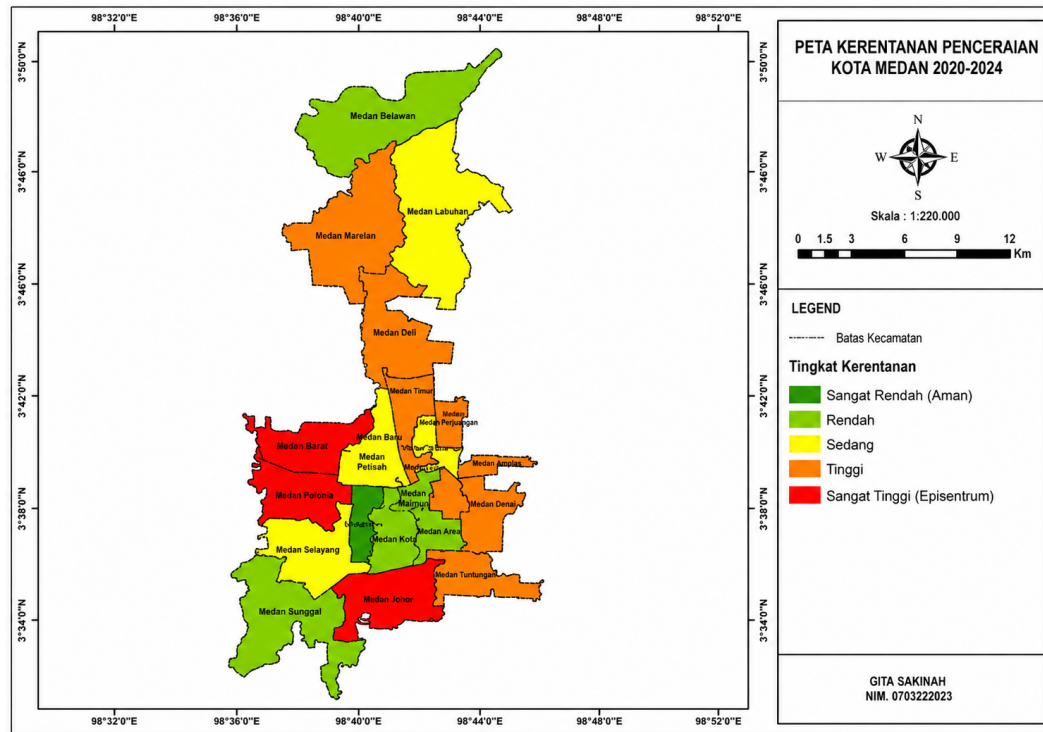


Figure 3. Population-normalized divorce-vulnerability ratio by district, Medan City, 2020-2024.

Table 7: Population-Normalized Divorce-Vulnerability Ratio and Risk Classification

No.	District	Cases	Marriages	Ratio	Classification
1	Medan Marelan	8,505	82,951	0.1025	Very Vulnerable
2	Medan Deli	8,465	96,342	0.0879	Very Vulnerable
3	Medan Belawan	3,934	47,669	0.0825	Very Vulnerable
4	Medan Labuhan	4,857	66,974	0.0725	Very Vulnerable
5	Medan Tembung	7,323	114,288	0.0641	Vulnerable
6	Medan Denai	7,473	120,315	0.0621	Vulnerable
7	Medan Helvetia	9,188	151,782	0.0605	Vulnerable
8	Medan Sunggal	8,952	154,512	0.0579	Vulnerable
9	Medan Perjuangan	5,843	102,316	0.0571	Vulnerable
10	Medan Timur	6,952	123,472	0.0563	Vulnerable
11	Medan Area	7,040	128,914	0.0546	Moderately Vulnerable
12	Medan Amplas	6,592	121,378	0.0543	Moderately Vulnerable
13	Medan Barat	4,323	81,391	0.0531	Moderately Vulnerable
14	Medan Tuntungan	3,847	74,962	0.0513	Moderately Vulnerable
15	Medan Kota	4,168	84,532	0.0493	Moderately Vulnerable
16	Medan Selayang	5,694	121,412	0.0469	Low Risk
17	Medan Petisah	4,482	96,814	0.0463	Low Risk
18	Medan Maimun	3,273	77,345	0.0423	Low Risk
19	Medan Baru	2,219	53,723	0.0413	Low Risk
20	Medan Polonia	3,284	86,421	0.0380	Very Safe
21	Medan Johor	8,813	291,609	0.0302	Very Safe
-	City-wide total	125,227	2,279,122	0.0549	(sum-based)

The city-wide total in Table 7 (125,227 cases; 2,279,122 marriages; ratio 0.0549) is the arithmetic sum of the 21 individual district rows shown in the table, with no additional district, year, or off-table adjustment included; this total, and the 0.0549 ratio it implies, therefore differs from the simple, unweighted average of the 21 district-level ratios (0.0577), because it is weighted by each district's marriage volume rather than treating every district equally. An earlier version of this table reported a total of 131,021 cases and 2,281,319 marriages, which did not reconcile with the sum of the district rows; that discrepancy has been corrected here, and the same corrected total (125,227) is used wherever this figure is cited elsewhere in the paper, including Section 3.2. The normalized ratio reveals a pattern that is invisible in the raw counts: districts with a large absolute case volume do not necessarily carry the highest relative risk. Medan Johor has the third-highest raw case count (8,813) but, once its very large marriage volume (291,609) is taken into account, the lowest vulnerability ratio in the city (0.0302) and the statistically confirmed Cold Spot status reported in Section 3.2 the raw-count and normalized/hot-spot pictures are therefore fully consistent with each other once population is accounted for. Conversely, Medan Marelan and Medan Deli, which rank mid-table by raw case volume, emerge as the two most vulnerable districts once normalized, together with Medan Belawan and Medan Labuhan. These four districts form the Very Vulnerable tier, driven jointly by the criteria identified as dominant in Section 3.1 economic hardship (35.38%) and domestic violence (28.91%). Medan Johor and Medan Polonia form the Very Safe tier at the opposite end of the distribution.

3.4. Discussion

The AHP weights in Section 3.1 should be read as a ranking of what a panel of family-law, judicial, psychological, and religious professionals judges to be the most influential causes of divorce, not as a statistically estimated causal effect: expert judgment is a structured proxy for social causation, and it carries the same limitation as any expert-elicitation method, namely that it reflects which cases each professional group most often encounters and remembers rather than the full, unobserved population of marital breakdowns, including those that never reach a religious court, counselor, or mediator. Judges and advocates, for instance, are more likely to see cases that have already escalated to litigation, which may inflate the perceived weight of Domestic Violence and Economic Factors relative to causes that are resolved informally or privately. This is a limitation of the AHP component itself, not only of this application of it, and it means the priority weights in Table 4 are best interpreted as “what professionals who handle divorce cases in Medan City judge to matter most,” rather than as the true population-wide causal weight of each factor.

An alternative explanation for the spatial pattern in Section 3.2 and 3.3 is also worth considering: districts may differ not only in underlying marital distress but in reporting behavior, religiosity, or the availability of informal dispute-resolution channels (e.g., neighborhood or religious mediation before a case is ever filed), any of which could shift measured case counts independently of true vulnerability. The administrative data used here cannot distinguish a genuinely higher divorce risk from a higher propensity to file formally, and this ambiguity should be kept in mind when interpreting the Very Vulnerable tier in Section 3.3.

The Getis-Ord G_i^* results (Table 6) identified three statistically significant Cold Spots and no statistically significant Hot Spot, which may look like an incomplete result but is analytically informative in its own right. A Hot Spot requires not only a high raw case count but spatial autocorrelation, a cluster of geographically adjacent districts that are all high; the three highest raw-count districts (Medan Helvetia, Medan Sunggal, Medan Johor) are not geographically contiguous with one another, so no such cluster reached significance even though absolute case counts are high in parts of the city. Substantively, this indicates that Medan City's divorce burden is diffusely elevated across many central and northern districts rather than concentrated in one contiguous high-risk zone, while family resilience is instead spatially clustered in the south (Medan Johor, Medan Area, Medan Perjuangan). This asymmetry argues against a single hot-spot-targeted intervention and in favor of the tiered, population-normalized zoning in Section 3.3 (Table 7) as the more policy-relevant spatial unit, since it captures relative risk across all 21 districts rather than only the extremes that reach significance in the hot-spot test.

Set against the wider literature, the AHP ranking here is broadly consistent with prior Indonesian studies: economic hardship and unemployment were likewise found to be leading drivers of divorce in West Java and Batam, and domestic violence has repeatedly been identified as a major contributor across multiple regions. What this study adds is not a new causal factor but a finer resolution within that consensus identifying psychological/emotional violence specifically, rather than domestic violence as a broad category, as the single most influential sub-criterion, and showing that this factor-level ranking does not map uniformly onto the city: the highest-vulnerability districts (Marelan, Deli, Belawan, Labuhan) are concentrated in Medan's northern and coastal periphery, an industrial and lower-income area consistent with the economic-factor finding, while the AHP ranking alone would not have predicted this particular geographic concentration. Because most prior studies on divorce causes in Indonesia are single-city or non-spatial, there is little directly comparable evidence on whether the specific spatial pattern found here a diffuse elevated burden rather than one contiguous hot zone also holds elsewhere; this is a gap the present findings can motivate future comparative work to fill, rather than a divergence this study can explain on its own.

4. CONCLUSION

This hybrid AHP GIS analysis of divorce in Medan City for 2020–2024 supports four main conclusions. First, the AHP model ranks Economic Factors as the most heavily weighted cause of household instability in Medan City (35.38%), followed by Domestic Violence (28.91%), Relationship and Communication (15.03%), and Moral/Behavioral and Social/External Factors (10.37% and 10.31%); at the sub-criterion level, psychological/emotional abuse carries the single highest global weight (14.02%), making it the most influential specific trigger identified. Second, once divorce counts are normalized against local marriage volume, Medan Marelan, Medan Deli, Medan Belawan, and Medan Labuhan form the highest-vulnerability cluster in the city, concentrated in the northern and coastal periphery; this supersedes an absolute-case-count ranking, which is confounded by population and marriage volume and, if used uncritically, can misclassify large, high-marriage-volume districts as high-risk. Third, Medan Johor is consistently the lowest-vulnerability district in Medan City by three independent measures: the lowest normalized vulnerability ratio (0.0302), the only 95%-confidence Getis-Ord Cold Spot, and, together with Medan Area and Medan Perjuangan at 90% confidence, part of a statistically significant low-vulnerability spatial cluster in the southern part of the city. Fourth, the AHP and GIS components were integrated interpretively rather than through a fused spatial model (Section 3.4); these findings are descriptive and correlational and should inform, not substitute for, further investigation before policy use. Taken together, these results indicate that divorce vulnerability in Medan City is not uniformly distributed but concentrated in specific, identifiable districts, and that economic hardship and domestic violence are the priority targets for family-resilience intervention. Future work extending the sub-criteria to district-level spatial layers, and testing the observed post-2022 plateau in case volume with a formal time-series design, would allow the AHP weights to inform the spatial model directly rather than interpretively, and would clarify whether the pattern observed here persists beyond the 2020–2024 window studied.

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