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Spatial Distribution and Cluster Analysis of Zakat Allocation: Identifying Hotspots and Coldspots

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ABSTRACT

Research Originality: This study applies spatial autocorrelation to assess the efficiency of zakat distribution, highlighting hotspot–coldspot patterns and proposing a spatially aligned framework to reduce regional disparities and support inclusive development.

Research Objectives: This study analyzes the spatial patterns of zakat distribution and their implications for distribution efficiency and reducing regional inequality.

Research Methods: Spatial autocorrelation analysis was conducted using Moran's I, Local Indicators of Spatial Association (LISA), and Getis–Ord Gi* to identify spatial linkages among regions.

Empirical Results: The results indicate significant spatial clustering in zakat distribution, with hotspots concentrated in urban and economic centers due to strong institutional capacity, while coldspots are found in remote areas with high poverty and weak institutions, potentially reinforcing spatial inequality.

Implications: These findings emphasize the importance of spatial mapping as the basis for region-based zakat distribution. Overall, zakat has the potential to become a strategic instrument for reducing inequality and driving inclusive economic development if it is integrated into evidence-based regional development policies.

Keywords:
zakat distribution; spatial mapping; clustering; regional patterns.

How to Cite:

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INTRODUCTION

Spatial mapping of zakat recipients and poverty clusters has become an important approach to improving the accuracy and effectiveness of zakat distribution and social protection programs by identifying vulnerable groups based on geographic and socio-economic conditions rather than relying solely on administrative boundaries. Through spatial analysis methods such as Moran's I and Local Indicators of Spatial Association (LISA), researchers and policymakers can detect poverty concentration, regional disparities, and the socio-economic interconnections between neighboring areas, thereby providing a deeper understanding of poverty patterns and helping reduce targeting errors, overlap of assistance, and exclusion of eligible beneficiaries. Consequently, poverty mapping enables more precise, efficient, and equitable interventions across regions (Li, Luo, & Wu, 2026; Sholihin et al., 2024; Ru, Tennant, Matteson, & Barrett, 2026).

Mapping zakat distribution through spatial analysis not only improves targeting accuracy but also helps reduce regional inequality by identifying over- and underserved areas, enabling zakat funds to be distributed more proportionally to disadvantaged, remote, and structurally poor regions while encouraging cross-regional redistribution. Spatial mapping provides an evidence-based foundation for policymakers and zakat institutions to optimize social support programs, strengthen equitable development, and position zakat as an instrument of spatial equity that complements government fiscal and social policies (Kanbur & Venables, 2005; OECD, 2019). Furthermore, spatial mapping supports the planning of productive zakat programs by identifying regional economic potentials such as MSMEs, agriculture, and livestock, thereby transforming zakat from consumptive assistance into a sustainable economic empowerment instrument that can increase the income and independence of poor households (Barrientos, 2012; Banerjee et al., 2015).

From a governance perspective, the integration of spatial data in zakat management enhances efficiency, transparency, and accountability by optimizing distribution logistics, reducing operational costs, and enabling systematic monitoring, which in turn strengthens public and muzaki trust in zakat institutions through data-driven decision-making (Gupta, Keen, Shah, & Verdier, 2017). Furthermore, integrating zakat mapping with national social registries such as DTKS and DTSEN supports stronger coordination between zakat distribution and government social protection programs, including PKH, PIP, BPNT, and BLT, thereby reducing overlap, minimizing inclusion and exclusion errors, and improving targeting accuracy for vulnerable households (The SMERU Research Institute, 2022). Through cross-sector collaboration and harmonized data systems, zakat can function as a complementary policy instrument that addresses gaps in state interventions and strengthens the overall effectiveness of poverty alleviation and social protection programs (Kuntjorowati, Andari, Soegiharto, & Yuniarti, 2024).

Spatial analysis using methods such as Moran's I and LISA enables policymakers to identify hotspots, coldspots, and spatial clustering in zakat distribution and poverty, thereby improving the precision of geographically targeted interventions and evidence-based resource allocation (Chen et al., 2022; Li et al., 2023). In West Java, spatial

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analysis is particularly important due to significant regional disparities, where metropolitan areas such as Greater Bandung, Bodebek, and Karawang possess high zakat potential. In contrast, regions such as Garut, Tasikmalaya, Cianjur, and Pangandaran continue to experience structural poverty and limited public services. Spatial mapping helps prevent excessive concentration of zakat in urban areas, encourages spillover effects toward poorer neighboring regions, and improves the integration of zakat with government social protection systems through data integration with DTKS and Dapodik.

A place-based zakat policy approach is needed because each district and city in West Java has different socio-economic conditions and mustahik characteristics, making spatial analysis essential for designing locally tailored productive zakat programs such as agricultural, MSME, and educational assistance. In addition, hotspot–coldspot mapping and indicators such as Moran's I and LISA strengthen monitoring, evaluation, transparency, and accountability in zakat management, enabling BAZNAS and local governments to improve targeting, reduce regional inequality, and enhance zakat's role as a redistribution instrument for poverty alleviation, inclusive growth, and sustainable regional development (Karim et al., 2020; Pratama, 2023; Arbi et al., 2024).

Spatial analysis using methods such as Global Moran's I and LISA is essential in West Java to identify spatial mismatches between zakat sources and poverty pockets, enabling zakat institutions to design more equitable, efficient, and evidence-based distribution policies. Without aligning zakat distribution with the spatial concentration of poverty, zakat funds tend to remain concentrated in economically advanced areas, limiting spillover effects to poorer regions and weakening zakat's role as an instrument for welfare redistribution, poverty reduction, and regional equality. Research shows that spatially inaccurate zakat distribution has only a limited impact on reducing poverty and improving welfare, as reflected in the CIBEST Model, indicating that the effectiveness of zakat depends not only on the amount distributed but also on the spatial accuracy of its allocation (Beik, 2016).

Zakat distribution that is not aligned with poverty maps risks reducing its effectiveness in reaching poor areas, weakening its multiplier effect on regional development, increasing regional inequality, and potentially creating new pockets of poverty in West Java (Karim, 2020). Therefore, spatial analysis methods such as Global Moran's I and LISA are essential for identifying disparities between zakat collection and poverty concentrations, enabling more targeted, equitable, and data-driven distribution policies. Spatial-based zakat mapping also improves targeting accuracy, supports cross-regional redistribution from urban to rural areas, and strengthens productive zakat planning by identifying regions with economic potential for MSMEs, agriculture, and livestock development, thereby transforming zakat into a sustainable economic empowerment instrument. In addition, integrating spatial data into zakat governance enhances efficiency, transparency, accountability, and systematic monitoring, ultimately strengthening public and muzaki trust in zakat institutions.

METHODS

This study uses data on the distribution of productive and consumptive zakat across 26 cities and districts in West Java province during 2018–2023, drawn from the zakat distribution reports of BAZNAS cities/districts in West Java province. Notably, the COVID19 pandemic significantly influenced zakat distribution patterns, as its economic and social impacts increased both the demand for zakat and the volume of funds distributed. Consequently, a larger number of recipients, particularly among vulnerable populations, received zakat support, resulting in more pronounced spatial clustering in certain cities and districts in West Java. This phenomenon underscores the importance of analyzing temporal changes in zakat distribution alongside external shocks, such as pandemics, which can alter both the intensity and geographic concentration of aid.

This study employs Global Moran's I to examine spatial autocorrelation in zakat distribution across cities and districts in West Java Province. Spatial autocorrelation analysis is important for identifying whether neighboring regions exhibit similar or different zakat distribution patterns, thereby providing insights into the effectiveness and equity of zakat allocation in supporting inclusive economic growth and social welfare. Positive spatial autocorrelation indicates that nearby regions tend to have similar zakat characteristics and form clusters, while negative autocorrelation reflects dispersed and contrasting patterns. Moran's I, with values ranging from −1 to 1, is widely used to detect spatial clustering and randomness, where positive values indicate clustering, negative values indicate dispersion, and values close to zero suggest no significant spatial pattern. To confirm the existence of spatial autocorrelation, a significance test of Moran's I is conducted.

In spatial analysis, methods such as Local Indicators of Spatial Association (LISA) and the Getis–Ord Gi* statistic are widely used to identify localized clustering patterns, spatial heterogeneity, and regional disparities in socio-economic phenomena, including zakat distribution, by detecting statistically significant hotspots and coldspots based on spatial autocorrelation, z-scores, and p-values (Baeza-Gonzalez & Kamakura, 2025; Zhang et al., 2024; Wu et al., 2022; Bhunia et al., 2024). Zakat distribution hotspots represent High–High spatial clusters where areas with high zakat allocation are surrounded by neighboring regions with similarly high values, often occurring in economically active urban centers, although excessive concentration may create regional inequality (Belay et al., 2024; Bouchair & Chabbi-Chemrouk, 2020). Conversely, coldspots indicate Low–Low spatial clusters characterized by persistently low zakat distribution in underserved regions, highlighting areas that require prioritized interventions and more equitable allocation of social assistance and financial resources to improve the effectiveness of zakat and social protection policies (Bhunia et al., 2020; Kanbur & Venables, 2005; Arbia & Nardelli, 2024).

RESULTS AND DISCUSSION

Spatial autocorrelation analysis is an important tool for evaluating the efficiency, equity, and socio-economic impact of zakat distribution because it reveals how zakat allocation in one region is spatially related to neighboring areas, thereby identifying

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patterns of clustering, regional inequality, and interregional dependency. Positive spatial autocorrelation or high–high clusters may indicate that zakat funds are concentrated in geographically connected regions. At the same time, other areas with similar poverty levels or mustahik needs remain underserved, reflecting weaknesses in the distribution system caused by limited beneficiary data, unequal institutional capacity, or location bias. By understanding these spatial patterns, zakat institutions can optimize resources through integrated area-based programs such as productive zakat and community-based MSME development, which can reduce distribution costs, strengthen economic spillover effects, and improve local economic activity, purchasing power, and social stability through regional synergies and economies of scale. However, if zakat clusters remain concentrated only in certain urban areas, zakat may unintentionally reinforce spatial inequality and weaken its role in promoting inclusive economic growth.

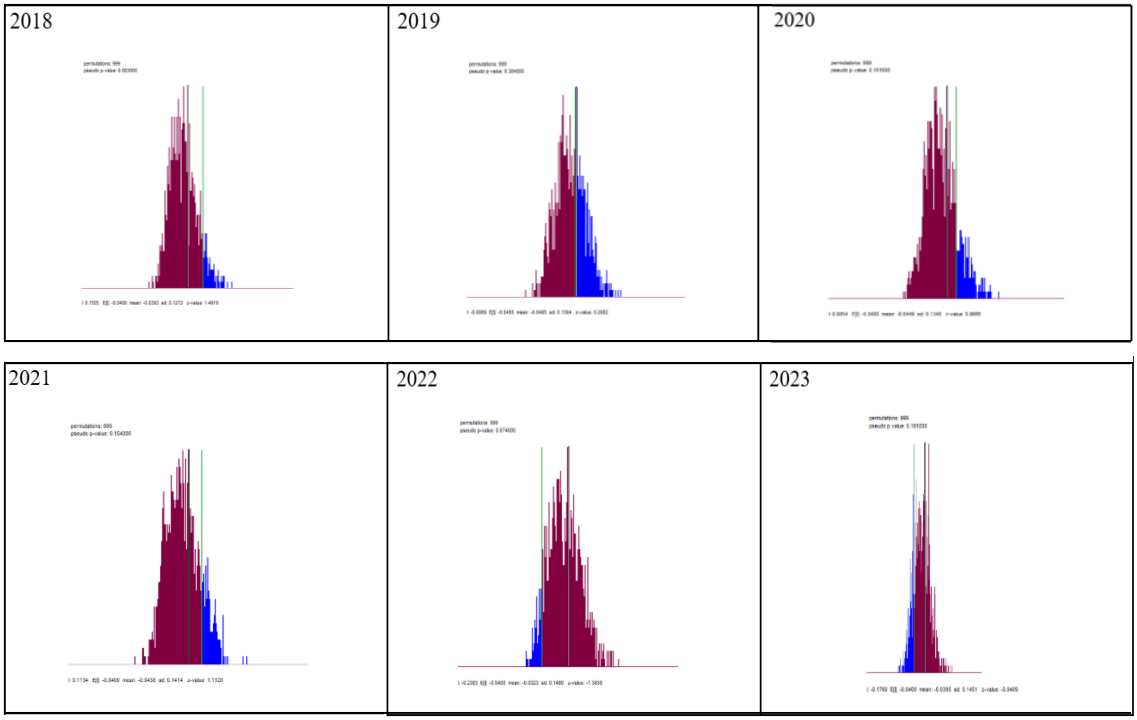
Within the context of inclusive and sustainable regional development, zakat has substantial potential as an Islamic social finance instrument for reducing poverty and regional inequality when integrated with public policy, social protection, education, and economic empowerment programs. However, empirical findings in West Java during 2018–2023 show Moran's Index values close to zero, indicating that zakat distribution patterns remain relatively random and are not yet systematically aligned with spatial poverty concentrations, thereby limiting the effectiveness of targeted and integrated interventions (Beik & Arsyianti, 2016; Karim et al., 2020; Bhunia et al., 2024). The absence of strong and stable spatial clustering also reflects weak socio-economic integration and limited spillover effects between regions with high and low zakat capacity, suggesting that the current zakat distribution system remains spatially uncoordinated and may contribute to widening regional welfare disparities. Therefore, stronger spatial analysis, interregional collaboration, institutional integration, and coordination between zakat institutions and local governments are needed to transform zakat into a more equitable and effective instrument for inclusive and sustainable regional development (Campos et al., 2024; Fitriani et al., 2026; Arbia & Nardelli, 2024).

Figure 1 shows the results of the Global Moran's I analysis, which indicate the presence or absence of spatial autocorrelation in the distribution of zakat funds across cities/districts in West Java Province.

Moran's Index values close to zero during the 2018–2023 period indicate that zakat distribution in West Java generally lacked strong and statistically significant spatial autocorrelation, meaning that zakat allocation across regions tended to be relatively random at the provincial level. However, annual analysis reveals dynamic spatial tendencies, where weak positive autocorrelation emerged in 2020–2021, suggesting limited local clustering of regions with similar high zakat values, while negative Moran values in 2018, 2019, 2022, and 2023 reflected spatial contrasts and local anomalies between neighboring regions with high and low zakat distributions. These differences may have influenced temporal variations in distribution policies, regional economic conditions, data reporting quality, and the presence of zakat collection center outliers. Therefore, complementary spatial analyses such as LISA, spatial weight matrix sensitivity testing, and outlier detection are

needed to identify local hotspots and support more targeted, evidence-based, and effective zakat redistribution policies.

Figure 1. Global Moran's I Analysis Result



The COVID-19 pandemic temporarily altered the spatial distribution of zakat in West Java during 2020–2021 by increasing localized poverty and shifting zakat priorities toward emergency assistance in regions most affected by economic disruption, job losses, and mobility restrictions, leading to weak positive spatial autocorrelation around major zakat collection centers and pandemic-affected areas. However, the weak and statistically insignificant Moran's I values indicate that these changes were only short-term adjustments rather than permanent structural transformations in zakat distribution patterns. Spatial fluctuations were also influenced by regional socio-economic disparities, where urban and industrial areas such as Bandung, Bekasi, and Depok experienced stronger zakat collection during post-pandemic recovery. In contrast, agrarian regions such as Indramayu, Tasikmalaya, and Garut remained dependent on small-scale consumptive zakat. These conditions created inconsistent spatial patterns and highlighted the absence of strong integration between urban zakat potential and rural mustahik needs. Therefore, spatially informed policies, including interregional zakat redistribution mechanisms, integrated zakat information systems, and localized spatial analyses such as LISA, are essential for developing evidence-based and geographically targeted interventions that strengthen zakat's role in reducing regional inequality, promoting economic empowerment, and supporting inclusive and sustainable development (Pratomo & Rahman, 2021; BAZNAS, 2022; Bhunia et al., 2024; Fitriani et al., 2026; Arbia & Nardelli, 2024).

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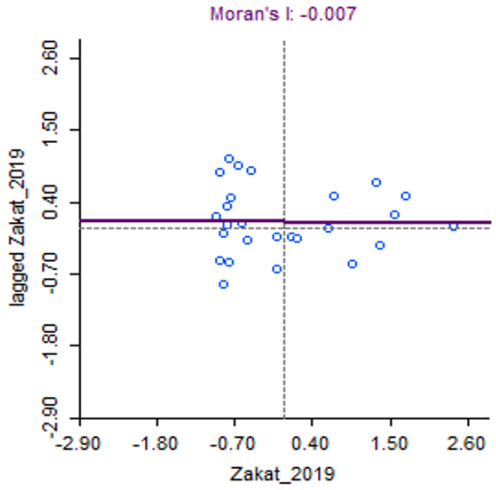
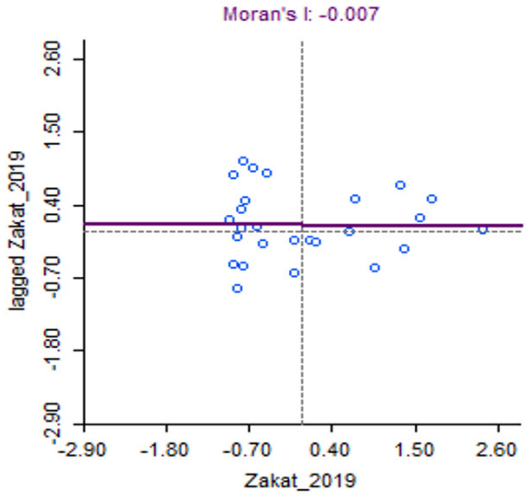
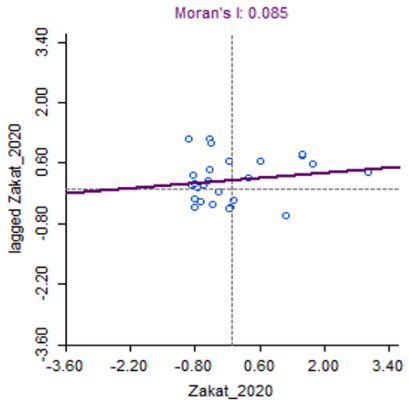
The results of Global Moran's I testing on inter-city/district zakat in West Java Province show positive spatial autocorrelation. This is evident in Moran's I index, which yielded values between 0 and 1. It can be seen that zakat has Global Moran's I values of 0.1041, 0.1179, 0.1073, and 0.1138 over the four years of observation. Although the values obtained are not identical, the differences are not significant. It can be seen that the four years still obtained a Moran's I index of 0.1.

Shifts in Moran's Index values in West Java during 2018–2023 were influenced not only by institutional factors but also by regional socio-economic conditions, where industrial and urban areas such as Bandung, Bekasi, and Depok experienced increased zakat collection alongside post-pandemic economic recovery, while agrarian and poorer regions such as Indramayu, Tasikmalaya, and Garut continued to depend mainly on small-scale consumptive zakat. These differences caused spatial patterns to fluctuate from weak positive clusters during 2020–2021 to more dispersed and contradictory patterns in later years, particularly in 2023 when zakat distribution became more focused on emergency response and economic recovery needs.

Figure 2. Scatter Plot Hotspot and Coldspot

Scatter-Plot	
2018	2019
	
HH Ciamis, Kuningan, Sumedang	HH Bandung, Ciamis, Indramayu, Kuningan, Subang, Sumedang
HL Bandung, West Bandung, Bandung City, Subang, Sukabumi	HL Cianjur, Karawang, Bandung City, Sukabumi
LH Bekasi, Cirebon, Garut, Indramayu, Banjar City, Cimahi City, Cirebon City, Depok City, Majalengka	LH Bekasi, Cirebon, Garut, Banjar City, Depok City, Sukabumi City, Tasikmalaya City, Majalengka, Purwakarta
LL Bogor, Cianjur, Karawang, Bekasi City, Bogor City, Sukabumi City, Tasikmalaya City, Purwakarta, Tasikmalaya	LL West Bandung, Bogor, Bekasi City, Bogor City, Cimahi City, Cirebon City, Tasikmalaya

2020



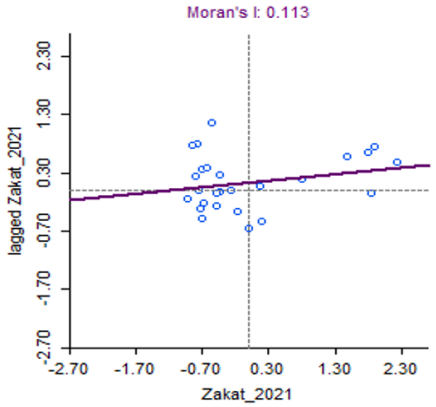
HH
Bandung, Ciamis, Indramayu, Subang, Sumedang

HL
Cianjur, KotBandung, Sukabumi

LH
Bekasi, Cirebon, Garut, Banjar City, Cimahi City, Cirebon City, Depok City, Sukabumi City, Tasikmalaya City, Kuningan, Majalengka

LL
West Bandung, Bogor, Karawang, Bekasi City, Bogor City, Purwakarta, Tasikmalaya

2021



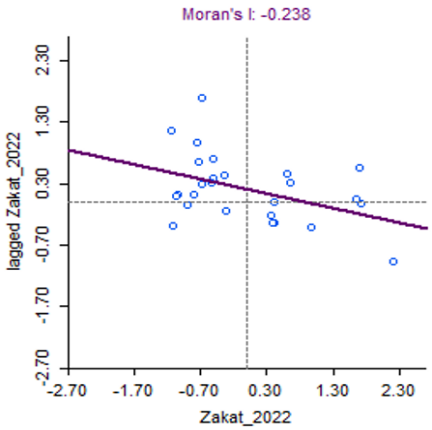
HH
Bandung, Ciamis, Subang, Sumedang

HL
Cianjur, Indramayu, Bandung City, Bekasi City, Sukabumi

LH
Bekasi, Cirebon, Garut, Banjar City, Depok City, Sukabumi City, Tasikmalaya City, Majalengka

LL
Wset Bandung, Bogor, Karawang, Bogor City, Cimahi City, Cirebon City, Kuningan, Purwakarta, Tasikmalaya

2022



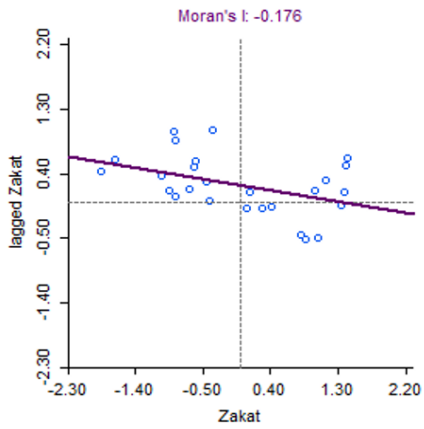
HH
Indramayu, KotBekasi, Sukabumi, Tasikmalaya

HL
Bekasi, Bogor, Ciamis, Cianjur, Cirebon, Bandung City, Sumedang

LH
Garut, Bogor City, Tasikmalaya City, Kuningan, Purwakarta

LL
Bandung, West Bandung, Karawang, Banjar City, Cimahi City, Cirebon City, Depok City, Sukabumi City, Majalengka, Subang

2023



HH
Indramayu, Bekasi City, Sukabumi, Tasikmalaya

HL
Bekasi, Bogor, Ciamis, Cianjur, Cirebon, Bandung City, Sumedang

LH
Garut, Bogor City, Tasikmalaya City, Kuningan, Purwakarta

LL
Bandung, West Bandung, Karawang, Banjar City, Cimahi City, Cirebon City, Depok, Sukabumi City, Majalengka, Subang

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Overall, these dynamics indicate that zakat collection and distribution in West Java remain strongly influenced by annual policy priorities, regional economic disparities, and differences in institutional capacity, resulting in a lack of spatial consistency between urban zakat potential and rural mustahik needs. Therefore, spatial-based policies such as interregional zakat redistribution mechanisms and integrated provincial zakat information systems are needed to ensure that zakat distribution is both socially fair and geographically equitable (Pratomo & Rahman, 2021; BAZNAS, 2022).

Ciamis, Kuningan, and Sumedang are classified as High–High clusters in the LISA analysis because they possess strong and innovative zakat institutions, productive community economic structures, and strong socio-economic and religious connectivity, particularly through Islamic boarding school networks and Islamic economic activities, which create positive spatial spillover effects in zakat distribution across neighboring regions (Karim et al., 2020). In contrast, Bandung City, Bandung Regency, West Bandung Regency, Subang, and Sukabumi fall into the High–Low category, indicating that these economically developed urban areas have high zakat collection values but are surrounded by neighboring regions with relatively low zakat capacity, reflecting local negative spatial autocorrelation and spatial inequality in zakat distribution. This pattern suggests that zakat resources remain concentrated in urban economic centers and have not been optimally redistributed to surrounding poorer regions, highlighting the need for stronger interregional zakat redistribution mechanisms, expansion of zakat institution networks, and integrated cross-district zakat management to strengthen zakat's role as an instrument of spatial equity and inclusive economic development.

The LISA analysis identifies Bekasi, Cirebon, Garut, Indramayu, Majalengka, Banjar City, Cimahi City, Cirebon City, and Depok City as belonging to the Low–High (LH) category, meaning these regions have relatively low zakat collection or distribution values despite being surrounded by areas with high zakat capacity, indicating local negative spatial autocorrelation and spatial inequality in zakat distribution (LeSage & Pace, 2009). Economically, this pattern reflects that some areas with strong economic activity, such as Bekasi and Depok, still experience limited formal philanthropic participation due to low zakat literacy and weak local zakat institutions. In contrast, regions near major zakat and Islamic economic centers like Greater Bandung have not fully optimized their zakat potential (Huda & Sawarjuwono, 2019). Nevertheless, the existence of spatial dependence suggests that these low-potential regions could benefit from neighboring high-capacity areas through stronger redistribution mechanisms and institutional collaboration (Amalia & Pratama, 2020).

These findings support the study of Pratomo and Rahman (2021), which explains that Low–High (LH) areas in West Java function as potential mustahik regions requiring cross-regional zakat redistribution policies, reflecting the concentration of zakat collection in urban centers such as Bandung, Bogor, and Purwakarta while surrounding regions primarily act as beneficiaries. This urban-centric zakat distribution pattern may reinforce spatial inequality in zakat benefits across regions (Hassan et al., 2022), highlighting the need for integrated interregional zakat management systems, expansion of LAZ/UPZ units, strengthening of

digital zakat networks, and improved public literacy on Islamic economics and formal zakat payment in line with RPJMN 2020–2024 and BAZNAS recommendations. In addition, LISA analysis identifies several regions, including Bogor, Cianjur, Karawang, Purwakarta, Tasikmalaya, Bekasi City, Bogor City, Sukabumi City, and Tasikmalaya City, as Low–Low (LL) clusters characterised by low zakat collection surrounded by neighbouring regions with similarly low values, indicating localized spatial disparities and structural inequalities that reinforce the importance of spatial analysis for designing more targeted, equitable, and inclusive zakat policies (Baeza-Gonzalez & Kamakura, 2025; Arbia & Nardelli, 2024; Zhang et al., 2024; Wu et al., 2022; Bhunia et al., 2024).

The Low–Low spatial pattern in zakat distribution in West Java reflects clusters of poverty and weak zakat institutional capacity in regions characterized by low to medium economic activity, dominance of agricultural and informal sectors, limited Islamic financial infrastructure, weak zakat literacy, and low formal zakat collection. Although some regions such as Bogor have strong macroeconomic conditions, formal zakat collection remains limited due to preferences for informal philanthropy. In contrast, regions such as Cianjur, Karawang, Purwakarta, Tasikmalaya, and Sukabumi depend largely on agriculture, small trade, and home industries, resulting in lower zakat values compared to metropolitan areas like Bandung and Bekasi (Amalia & Pratama, 2020). This condition creates a "zakat deficit zone" in southern and central West Java. It highlights the need for structural and institutional interventions, including strengthening Zakat Collection Units (UPZ) at local levels, expanding zakat institution coverage, improving zakat literacy and digitisation, and enhancing interregional redistribution collaboration between High–Low (HL) and Low–High (LH) areas to reduce regional inequality and promote more equitable zakat distribution in line with the RPJMN 2020–2024 agenda (Hassan et al., 2022; Huda & Sawarjuwono, 2019; Pratomo & Rahman, 2021; Bappenas, 2021).

The spatial autocorrelation analysis of zakat distribution reveals significant hotspot and coldspot patterns influenced not only by regional poverty levels and economic potential but also by the fragmented, independent institutional structure of regional zakat agencies (BAZDA) in Indonesia. Strong zakat collection centers, particularly in urban economic regions, tend to redistribute funds within their own administrative areas, reinforcing spatial concentration and inequality, while coldspot areas characterized by structural poverty, remoteness, and weak institutional capacity remain underserved and dependent on limited local zakat resources (Karim et al., 2020). The absence of integrated interregional zakat redistribution mechanisms further strengthens unequal spatial dependency patterns, causing hotspot regions to dominate the zakat network. At the same time, coldspot areas remain trapped in persistent low-resource conditions, thereby limiting zakat's effectiveness in reducing poverty and improving welfare (Beik & Arsyianti, 2016). Consequently, significant policy reforms are needed, including stronger coordination by central BAZNAS, integrated national zakat data systems, and evidence-based spatial redistribution policies to improve institutional integration, close regional distribution gaps, and strengthen zakat's role as an instrument for equitable welfare distribution and inclusive economic development.

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CONCLUSION

Spatial analysis methods Moran's I, LISA, and Getis–Ord Gi* are important tools for identifying geographical interdependencies, spatial autocorrelation, and hotspot–coldspot patterns in zakat distribution. Hotspots generally emerge in urban economic centers with strong zakat institutions and high collection capacity, while coldspots are commonly associated with structurally poor, remote, and institutionally weak regions. These spatial patterns reflect the degree of socio-economic integration and interregional dependency, where hotspot areas generate multiplier and spillover effects through increased economic activity. In contrast, coldspot areas indicate structural isolation, weak institutional connectivity, and persistent regional inequality. Spatial clustering analysis also shows that regions with strong zakat capacity often influence neighboring areas, while regions with weak spatial interaction tend to remain trapped in low–low clusters. Therefore, mapping zakat hotspots and coldspots provides an important evidence-based foundation for integrating zakat with social protection and regional development policies to promote inclusive and sustainable economic growth.

Based on these findings, several policy recommendations can be proposed to improve the effectiveness, equity, and inclusiveness of zakat allocation across regions. Zakat institutions should prioritize coldspot areas through geographically targeted distribution strategies, while hotspot regions should focus on strengthening productive zakat and economic empowerment programs rather than merely increasing allocations. Stronger interregional coordination, integrated zakat management systems, and alignment between zakat distribution and regional poverty conditions are also necessary to reduce spatial mismatches and improve redistribution efficiency. In addition, integrating zakat with broader social protection, financial inclusion, and regional development policies, alongside strengthening GIS-based analytics, digital infrastructure, institutional capacity, and governance, is essential for supporting evidence-based policymaking and more effective spatially informed zakat distribution.

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